Aircraft Type and Registration:	Avro 146-RJ100, G-CFAD
No & Type of Engines:	4 Lycoming LF507-1F turbofans
Year of Manufacture:	2000
Date & Time (UTC):	26 August 2003 at 0656 hrs
Location:	London City Airport, London
Type of Flight:	Public Transport (Passenger)
Persons on Board:	Crew - 6 Passengers - 110
Injuries:	Crew - None Passengers - None
Nature of Damage:	Lower rear fuselage scraped, tail bumper strip removed, skin, stringer and frame damage
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	35 years
Commander's Flying Experience:	3,283 hours (of which 110 were on type) Last 90 days - 96 hours Last 28 days - 38 hours
Information Source:	AAIB Field Investigation

Synopsis

After an uneventful flight the aircraft was positioned onto the ILS approach to Runway 10 which has a 5.5° glidepath. During the manually flown final stages of the approach the aircraft descended slightly below the glidepath. In regaining the glidepath insufficient power was used to correct for the resultant decay in airspeed and the thrust levers were closed early during the landing flare. These factors led to the aircraft being 8 kt below the correct speed at touchdown. In an attempt to arrest the rate of descent in the flare, an abnormally high pitch attitude was reached resulting in the aircraft striking its tail on the runway.

History of flight

The crew were operating the first sector of their duty and had taken off from Glasgow Airport at 0530 hrs for London City Airport with the co-pilot acting as handling pilot. The takeoff and cruise went without incident and shortly before descent, the commander briefed for an ILS approach and landing to Runway 10, with the co-pilot flying the approach and the commander taking control for the landing. The co-pilot had been seconded to the RJ Fleet from another part of the parent company; he had more than 8,000 hours flying experience with 413 hours on type.

ATC cleared the aircraft to descend to an altitude of 2,000 feet and provided radar vectors to establish it on the ILS localiser for Runway 10. This runway has a 'steep' approach with a 5.5° glideslope. In accordance with company Standard Operating Procedures (SOPs) the pilots configured the aircraft with full flaps and landing gear down prior to intercepting the glideslope and reducing the speed to the final approach speed (VAPP) of 127 kt. This equated to the reference speed (V_{REF}33) of 122 kt for the aircraft's landing weight of 39,179 kg with an additional 5 kt added, as per the SOPs. The surface wind was light so the crew did not need to increase the approach speed to protect against gusts.

When the aircraft was fully established on the ILS approach, the speed brake was extended. Visibility was good and with the runway in sight, the commander took control at about 800 feet agl for the landing. He disengaged both the autopilot and autothrust and at 500 feet agl the co-pilot confirmed to the commander that the aircraft was stable on the approach.

At between 100-200 feet agl the commander stated that he increased the aircraft's pitch slightly as the PAPIs were indicating three red lights. The radar altimeter 'autocall' then announced that the aircraft was passing 100 feet agl, at which point the commander slowly brought the power levers back to idle. Both pilots commented that they noticed the aircraft seem to sink slightly, and the commander stated that he again increased the aircraft's pitch to compensate for the sink. At this point the co-pilot noticed the airspeed was about 120 kt, which appeared normal to him in relation to the expected threshold speed of 122 kt (V_{REF}33).

The aircraft's touchdown was described as normal by both pilots, although the co-pilot stated that the pitch was slightly higher than usual and the commander described the handling as being "a little spongy". At the time he attributed his perception to the aircraft being at a relatively heavy landing weight. During the subsequent landing rollout the co-pilot resumed control and the pilots heard ATC transmit a request for a runway inspection. On enquiring whether something had been seen falling from the aircraft, ATC advised that they suspected the aircraft had struck its tail on landing. The pilots were then instructed to backtrack the runway and taxi to stand where, after a normal shutdown, evidence of a tailscrape was confirmed.

Weather conditions

At the time of the accident a light wind was reported of 030°/06 kt, visibility was 10 km and the cloudbase was broken at 4,500 feet. There were no reports of any turbulence or windshear on the approach.

Company SOPs

Within the 'Approach-General' section of the operator's SOPs is the statement:

> *"On all approaches the P2 must continue to monitor the flight instruments until nosewheel touchdown, calling attention to any discrepancies and making standard callouts."*

Instructions within the company Operations Manual for airspeed control during a 'steep' ILS approach' are to maintain $V_{REF}33 + 5$ kt + gust factor[1] for the glideslope descent with landing gear, 33° flap and the airbrake extended. When approaching the runway, speed should be reduced to cross the threshold at $V_{REF}33$ + gust factor.

Operator's tail strike information

The operator published a Flight Operations Bulletin (Number R03/06) as a result of previous tail strikes suffered by its RJ fleet. In it, when discussing the causes of tail strikes, it states:

> *"The second most likely cause is an approach where because of higher than expected ground closure rate – (as in a Steep Approach) – the pilot flares too early (causing subsequent 'sink' in the flare) or again prolongs the flare with a similar eventual effect. This 'sink' or rapid ground closure can provoke or tempt a further flare or over-rotation, again causing a heavy landing with a likely Tail Strike."*

It further states:

> *"There is no fixed advice on pitch angles for a correct landing, indeed, the pilot should clearly be looking out at this point rather than at the PFD. For guidance, it is rather unusual to require more than four degrees pitch up in a correctly executed flare-to-land manoeuvre, and usually less."*

[1] The gust factor is defined as half the gust, irrespective of gust direction, up to a maximum of 15 kt

Engineering Investigation

Damage to the aircraft comprised a region of severe scuffing and abrasion over a region extending from frame 36 (approximately in line with the centre of the rear cargo hold access door) to frame 36Y, a total longitudinal distance of approximately 1.7 metres. The tail bumper - an inverted top hat channel section forming, in effect, a lightweight longitudinal keel member fixed externally on the underside of the rear fuselage - had been largely ground away over this region. The damage became progressively more severe towards the forward end of the affected region, where the abrasion spread increasingly to involve the adjoining fuselage skins up to a maximum spread of approximately 27 centimetres about the centre line. Examination of the internal fuselage structure revealed that the principal frames over the affected region (36, 37, 38 and 39) were buckled locally in the area of the lower chord consistent with the observed external damage. The intermediate frames over this same region, which have a lighter form of construction, displayed characteristic bowing of the web elements; again, consistent with the observed external damage. Overall, the extent of damage did not appear to pose any immediate threat to structural integrity.

A distinctive scrape mark was found on the runway, consistent with the external damage to the rear fuselage of G-CFAD, at a location approximately one metre to the right of the centre-line and 200 metres beyond the start of the 'piano key' markings at the threshold of Runway 10. This mark, which began as a single point-contact, progressively broadened to approximately 20 centimetres after a distance of 5.3 metres at which stage it ran across the raised casing of a runway light. Thereafter, it extended a further 1.7 metres, and broadened to a maximum width of 27 centimetres, before fading out and becoming indistinguishable. No other evidence of structural contact was apparent on the runway and it was evident that the damage to G-CFAD had been produced by a single strike occurring at, or very close to, initial wheels touch and that the touch down itself took place within the normal area for aircraft landing on Runway 10.

Flight recorders

The aircraft was installed with a 25 hour duration Flight Data Recorder (FDR) and a 2 hour duration Cockpit Voice Recorder (CVR). The CVR and FDR recordings contained the time history of the entire flight from Glasgow to London City.

The CVR audio from the cockpit area microphone could not be utilised in this investigation. This was due to a 400-hertz signal being recorded which rendered the background audio unintelligible. Audio was successfully recovered from the remaining CVR audio channels.

Flight data indicates the autopilot and autothrust were disconnected at about 800 feet agl by which point Flap 33 had already been selected and the landing gear extended. The airspeed at that time was 125 KIAS and the aircraft was maintaining both the ILS localiser and glideslope.

At 500 feet agl an automatic altitude callout was recorded on the CVR and the aircraft was still established on the localiser and glideslope, maintaining 125 KIAS with a thrust of 53% N1. Engine power remained stable at 53% N1 from the point the autothrust had been de-selected, however at 420 feet agl the power was reduced slightly to 50% N1. No significant change to thrust was made subsequently until thrust was reduced during the landing flare.

At about 280 feet agl the aircraft began to descend below the glideslope. At 190 feet agl the aircraft was 0.58 dots below the glideslope and at 175 feet agl the aircraft was 0.72 dots below the glideslope. Deviation below the glideslope continued to increase to a maximum value of 0.92 dots when the aircraft was descending through 128 feet agl, at which point a small increase in engine thrust of about 1% N1 was made.

After the aircraft had begun to descend below the glideslope the pitch had been gradually increased from 3.0° nose-down to a maximum value of 0.8° nose-up. The pitch had then decreased again and at 75 feet radio altitude the aircraft momentarily regained the glideslope at a pitch of 1.75° nose-down and an airspeed of 119 KIAS. The pitch then immediately started to increase again as the aircraft began its transition into the flare.

The time interval between flare transition and weight on wheels activation was 5 seconds with an average rate of change of radio altitude (derived descent rate) over this time of 636 feet per minute. Half a second prior to weight on wheels activation the derived descent rate had reduced to 480 feet per minute.

The transition of the weight on wheels parameters occurred at an indicated airspeed of 107 kt, this was coincident with a pitch up attitude of 7.82 degrees and a normal acceleration value of 1.775g, both were the maximum recorded values for each parameter during the landing. Deployment of the yellow hydraulic system ground spoilers occurred one-quarter second later, followed two seconds later by the green hydraulic system ground spoilers.

Seven seconds after weight on wheels the co-pilot took control. During the landing rollout ATC requested that the runway be inspected at the western end. Some 77 seconds after touchdown, the co-pilot asked ATC "DID WE DROP SOMETHING". ATC responded with "I THINK YOU JUST TOUCHED THE TAIL ON LANDING, YOU SCRAPED IT A BIT ABOUT FIVE TO TEN METRES ALONG THE RUNWAY".

Analysis

There had been an adequate period of rest for the flight crew prior to the flight and despite the early start of the duty period, neither pilot complained of feeling fatigued.

The aircraft had been correctly configured for the approach and had the correct approach speed of 127 kt selected for the landing weight. At 500 feet agl the FDR trace and co-pilot's statement both confirm that the aircraft was stable on the approach. This is defined in the company's operations manual as aircraft in the landing configuration, established on the glideslope with the approach power set and an indicated airspeed no more than V_{REF} + 20 kt.

When the aircraft had begun descending below the glideslope at 280 feet agl, the commander had attempted to regain the correct profile by increasing the pitch, however he had failed to compensate for the resulting increase in drag (and consequent loss in airspeed) with an adequate increase in engine thrust. As a result, although he managed to regain the glideslope (momentarily and late in the approach), the airspeed had decayed 8 kt below the correct approach speed.

The aircraft normally loses about 7 kt speed during the flare and so the ideal touchdown speed should be $V_{REF}33$ + gust factor – 7 kt; that equates to an ideal touchdown speed of 115 kt for this flight whereas the aircraft touched down at 107 kt. The aircraft lost too much airspeed in the final stages of the approach because the commander closed the thrust levers as the aircraft entered the flare instead of adding thrust to counteract the trend towards becoming both low and slow. In order to arrest the rate of descent for touchdown at this low speed, a higher than normal pitch attitude, 7.82 degrees, was required. Information provided by the manufacturer indicates a tail strike will occur at pitch attitudes on touchdown in excess of 6.9 degrees.

No reference to airspeed was made by either pilot once the aircraft had descended below 500 feet agl. At this point the handling pilot's attention would have been drawn increasingly outside the cockpit, rather than looking in at his flight instruments. The role of the non-handling pilot in monitoring the aircraft parameters below this point is, therefore, very important. Whilst the co-pilot noticed the speed was low when passing 100 feet agl, he made the incorrect assumption that in relation to their target threshold speed, it was acceptable at this late stage of the approach.

Conclusion

The weather report and additional evidence gathered gave no indication that a shift in either wind strength or wind direction occurred. Consequently, a late change in wind conditions can be discounted as a causal factor. It was the lack of sufficient thrust during the latter stages of the approach that allowed the aircraft's speed to decay and it touched down at 107 kt ($V_{REF}33$-15 kt) which was some 8 kt too slow. The loss in airspeed late in the approach was aggravated by an early thrust reduction during the landing flare and the pitch attitude required to arrest the sink rate just prior to touchdown was such that on landing, the aircraft struck its tail on the runway. The commander's inattention to the loss of airspeed was compounded by the co-pilot's lack of warning about the significant deviation below the correct approach speed. In view of their overall flying experience (commander 3,283 hours and co-pilot 8,000 hours) although neither pilot was paying sufficient attention to airspeed control, the relatively low experience on type for each pilot (commander 110 and co-pilot 413) were not considered to be causal factors by the investigators. The commander acknowledged that his lack of speed awareness was the main contributory factor. However, he also stated that he believed his inexperience on type and on aircraft of this weight category were contributory factors. He had never before flown an aircraft in the 20 tonne category that had a tail strike risk and he believed he was following company advice to retard the throttles at 100 feet agl for a steep approach.

The steep approach and restricted runway length (1,508 metres) presented by London City Airport provide challenges to flight crews landing there. In particular, there is a natural tendency to avoid getting high or fast on the approach profile; however, as this accident demonstrates, there are also dangers present in allowing the aircraft to become too slow and/or too low. Moreover the role of the non-handling pilot in monitoring the aircraft parameters may occasionally be made more difficult by the steep approach in that the external view presented is both attractive and distracting.

Safety actions taken

As a result of this accident the operator reviewed its RJ100 pilot conversion training to ensure that it imparted a thorough understanding of the principles of thrust management once past the stabilised approach gate at 500 feet, including the relationship between aircraft weight and inertia. Training was also revised to ensure pilots are not unduly influenced in their management of thrust by the automated call out of radio heights when approaching the landing flare.

In order to reinforce the information contained in Flight Operations Bulletin Number R03/06 a letter on the topic of avoiding tail scrapes prepared by an experienced test pilot flying for the company was sent to all its RJ100 pilots. In addition, existing written guidance on the avoidance of landing tail strikes issued to RJ100 pilots already current on type was to be reviewed to improve its effectiveness.

Aircraft Type and Registration:	Boeing 737-33A, 9H-ADH	
No & Type of Engines:	2 CFM56-3C1 Turbofan engines	
Year of Manufacture:	1998	
Date & Time (UTC):	1 September 2004 at 1836 hrs	
Location:	Glasgow Airport, Scotland	
Type of Flight:	Public Transport (Passenger)	
Persons on Board:	Crew - 5	Passengers - 138
Injuries:	Crew - None	Passengers - None
Nature of Damage:	Burst tyre. Flaps, left main landing gear sidestay and hydraulic control lines damaged	
Commander's Licence:	Airline Transport Pilot's Licence	
Commander's Age:	33 years	
Commander's Flying Experience:	7,000 hours (of which 5,000 were on type) Last 90 days - 187 hours Last 28 days - 60 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot and subsequent enquiries by the AAIB.	

Synopsis

During the takeoff from Glasgow Airport, the left inboard (No 2) tyre shed its tread. This led to the loss of the A system hydraulic contents, failure of the landing gear to retract and failure of the left main landing gear (MLG) green 'down and locked' light to illuminate in the cockpit. After holding for three hours to burn off fuel, the aircraft landed safely. The tyre failure was most probably due to fatigue in the sidewall. The tyre was at its sixth retread and close to its wear limit and may have reached its ultimate fatigue life prematurely for an undetermined reason; the retread limit for this tyre was R-6. The operator has since put in place several safety actions to prevent recurrence. No recommendations are made in this report.

History of flight

The intention of the flight was to fly from Glasgow to Malta. Preparations for the flight had been carried out with no identified problems and the aircraft taxied uneventfully to Runway 23. The takeoff, flown by the commander, appeared to the crew to be normal but, in the first stages of the climb out, the first officer (FO) noticed that the A system hydraulic quantity was rapidly reducing. At the same time the commander requested the landing gear to be raised. On selecting the gear lever to UP; the landing gear failed to retract, the three red gear unsafe warning lights for each landing gear illuminated, two green gear 'down and locked' lights also illuminated (the left MLG light was not illuminated) and the HYD master caution light also came on. The commander levelled the aircraft at 3,000 feet and informed ATC that they had a technical problem which needed to be observed. ATC offered an immediate return to Glasgow, which was declined by the crew.

Some five seconds after takeoff the ground movement controller at Glasgow noticed a white stream emanating from the underside of the aircraft and informed the tower. This information was passed to the crew of 9H-ADH, who then confirmed that they had lost their A hydraulic system. They calculated that they would have been overweight for an immediate landing and so they decided to hold in the vicinity to burn off fuel.

Following three aircraft movements on the runway, the crew aboard a recently landed Boeing 757 notice tyre debris on the runway. ATC were informed and the runway was then closed for an inspection, which indeed revealed tyre debris. This was cleared and the runway subsequently reopened.

During this time the crew of 9H-ADH tried to establish the condition of the left MLG, as there was no green down and locked indication. Using a 'gear viewer' in the cabin floor, they confirmed that the gear appeared to be down, but were unable to see the wheel and tyre. So that they could fully understand the situation, the crew requested a fly past of the tower at Glasgow, with an engineer available on the ground to visually assess the landing gear. During the flypast, the engineer was able to establish that the left inboard main wheel (No 2) tyre was either missing or damaged and that the left MLG was down. The aircraft then re-entered the holding pattern to burn off more fuel to reduce its weight in preparation for landing.

Some three hours later the aircraft landed safely at Glasgow.

Aircraft Examination

A subsequent examination of 9H-ADH revealed that the No 2 tyre had shed its tread, deflated and had become detached from the rim of the wheel. Tyre debris had been flung upward and rearward, becoming lodged against the left rear spar close to aileron and spoiler control cables; debris was also found wrapped around the left MLG actuator. Hydraulic lines feeding the MLG transfer unit, which is supplied by A hydraulic system, were damaged and this allowed the leakage of hydraulic fluid. It also led to a subsequent failure of the No 1 engine hydraulic engine driven pump (EDP). Structurally, the left inboard trailing edge flap, mid flap and fore flap also suffered damage from the debris. There was also evidence of tyre debris striking the fuselage above the wing and the lower surface of the left horizontal stabiliser.

The left MLG side stay lock link had been hit by debris, causing it to bend to the extent that the ground lock pin could not be inserted. This also meant that the gear down and locked safety proximity sensor, mounted on the lock link, was out of proximity, preventing the illumination of the left MLG green down and locked light in the cockpit.

Tyre History

The tyre was a H40 x 14.5 x 19 with a 24 ply rating, which was manufactured in 2000. It had been retreaded on the 5 February 2004 with its sixth retread (R-6), which would have been its last retread as the limit is R-6. The shoulder to shoulder Shearography, following the retread, did not show any anomalies. The tyre was fitted to 9H-ADH on the 22 July 2004 and had completed 230 cycles prior to the accident.

The operator carries out tyre pressure checks every 24 hours and, in the days leading up to the accident, the values recorded were all within 5% of the required tyre pressure. The aircraft manufacturer defines the tyre pressures in the maintenance manual (MM) and states:

> *'a) if the measured tire pressure is below the necessary pressure by no more than 5%, inflate the tire to the necessary pressure.'*

Tyre Examination

The aircraft operator sent the tyre to the aircraft manufacturer for a detailed examination. The tyre had suffered a full shoulder to shoulder tread loss with the separation occurring at the outermost fabric layer. From the limited amount of retrieved tread pieces, this examination showed that the tyre was close to its fully worn condition. There were two ruptures to the sidewall of the tyre and severe damage had occurred to the inner liner. This was considered to be consistent with a tyre running with little or no tyre pressure. From the splits in the inner liner and sidewall of the tyre, it was evident that the nylon cords of several plys were broken. The damage was considered to be due to fatigue of the sidewall.

There were no signs of damage from foreign objects or evidence of cuts. Additionally there were no signs of manufacturing defects.

The conclusion of the manufacturer's examination was that the probable cause of the tyre tread loss was fatigue in the nylon cords of the lower sidewall. This allowed the tyre inner liner to split, air to then pressurise the carcass, which then led to the rupture of the sidewall and tyre deflation. It was not possible to ascertain if the tread loss occurred prior to or following the loss of pressure in the tyre.

The wheel assembly was tested with a new tyre installed, and this did not show any signs of leakage. The companion wheel and tyre (No 1) was also removed and tested, again with no signs of tyre pressure leakage, but it did exhibit signs of damage consistent with running overloaded, an expected condition brought about due to the failure of the No 2 tyre.

Discussion

The loss of the tyre tread on 9H-ADH was assessed as being due to fatigue of the sidewall of the tyre. Every tyre has an ultimate fatigue life, which is determined by the type of operation and the maintenance of the tyre during its life. Fatigue life is reduced by a tyre which is run under-inflated or run over-loaded at any time in the past, tyre damage or by having a lower natural tolerance due to manufacturing imperfections. Unfortunately, the only way to determine the fatigue life is to destructively test the tyre and carry out tensile tests of sections of the tyre. So that a tyre never reaches its fatigue life in service, a retread limit is set on the tyre which should never be exceeded. The retread limit is determined through destructive testing of sample tyres at various lives, and a determination made as to whether the tyre type would survive another retread level or not. In this case, the tyres used on 9H-ADH had a retread limit of R-6; the tyre that failed was at this retread level. The failed tyre was also close to its wear limit, meaning that it would soon have been removed and scrapped. Therefore, the tyre had probably reached its ultimate fatigue limit at an earlier age than predicted by the sample testing on other tyres.

When a tyre is retreaded it is subjected to a Non Destructive Test (NDT) inspection called Shearography; this is designed to identify any abnormalities not only with the retread but also with the carcass itself. The problem with this type of inspection is that it will not identify an impending fatigue failure; it can only show a problem once it has occurred. Therefore, it is difficult to predict from Shearography whether a tyre will survive the operational cycle before its next retread. The best chance of detecting a problem is to carry out a full bead to bead Shearography, which should also detect any problems with the tyre sidewall. However, in most cases only a shoulder to shoulder Shearography check is carried out to examine the area which has been subjected to the retread. This was the case with the failed tyre.

From the indications received by the crew in the cockpit shortly after takeoff, the tyre lost its tread at rotation, the point where the tyre would have been under greatest stress. The loss of the A hydraulic system was directly attributable to tyre tread debris damaging the hydraulic lines to the left MLG transfer unit. The landing gear is retracted using pressure from the A hydraulic system and, with the loss of the hydraulic contents, the gear would not have been able to retract when commanded. The failure of the green 'down and locked' indication on the left MLG was, again, attributable to damage from the tread debris. The left side stay lock link, which carries the proximity sensor for the cockpit light, had been distorted, moving the sensor out of proximity with its target, even though the gear was down and in the locked position. The most concerning aspect of the tread failure was the piece of debris which had become lodged near to the control cables for the spoilers and ailerons on the left wing. This had the potential to result in a control restriction during a critical phase of flight.

Actions taken by the operator

Since this accident the operator has put in place various measures to prevent a recurrence, these include:

1. A new retread limit of R-3 on all tyres fitted to Boeing 737-300 aircraft.

2. Full bead to bead Shearography to be carried out following a retread, as opposed to the previous shoulder to shoulder Shearography.

3. A maintenance instruction was issued to clarify the correct tyre pressures for every aircraft in the operator's fleet and engineers were briefed on the importance of tyre pressure management.

4. Any tyres manufactured in 2000, or with a retread of level 4 and above, have been removed from service.

5. For flights from Malta, takeoffs to be carried out with flaps 5 only.

6. Flight crews briefed on vigilance of the tyre condition during the pre-flight inspection.

In consideration of the above, and the fact that the aircraft manufacturer is aware of the damage caused to 9H-ADH as a result of this tyre failure (loss of the A hydraulic system and the potential for tyre debris to cause a control restriction), it was not considered necessary to make any safety recommendations.

INCIDENT

Aircraft Type and Registration:	Airbus A320-200, C-FTDF	
No & Type of Engines:	2 IAE V2500-A1 turbofan engines	
Year of Manufacture:	1993	
Date & Time (UTC):	3 August 2003 at 2325 hrs	
Location:	Cardiff International Airport, South Glamorgan	
Type of Flight:	Public Transport (Passenger)	
Persons on Board:	Crew - 7	Passengers - 162
Injuries:	Crew - None	Passengers - None
Nature of Damage:	Rupture of three main landing gear tyres and damage to a landing gear light	
Commander's Licence:	Air Transport Pilot's Licence	
Commander's Age:	28 years	
Commander's Flying Experience:	7,500 hours (of which 1,700 were on type) Last 90 days - 140 hours Last 28 days - 50 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot plus additional inquiries and data analysis by the AAIB and the aircraft operator	

Synopsis

The aircraft was landing on Cardiff's Runway 30. On finals, the Electronic Centralized Aircraft Monitoring (ECAM) display showed a STEERING caption and the crew cycled the A/SKID & N/W STRNG switch in an attempt to reset the Brake and Steering Control Unit (BSCU). The indications were that it was successfully reset but after touchdown the aircraft did not decelerate normally. The commander pressed the brake pedals to full deflection without effect. He then selected maximum reverse thrust and the co-pilot cycled the A/SKID & N/W STRNG switch. The commander again attempted pedal braking, without effect, and the crew selected the A/SKID & N/W STRNG switch to OFF. The commander then braked to bring the aircraft to a halt about 40 metres from the end of the runway, bursting three mainwheel tyres. There was no fire and the passengers were deplaned on the runway through the normal exit doors.

Analysis showed that it took 10 to 13 seconds for the commander to recognise the lack of pedal braking and there was no overt warning from the ECAM of the malfunction of the BSCU. Two safety recommendations were made to the aircraft manufacturer regarding improved warnings and crew procedures.

History of the flight

The aircraft was returning to Cardiff from Tenerife. The winds at Cardiff Airport were light, there was no cloud and the visibility was good. The air temperature was 15°C and the runway was dry. At the time of the occurrence the crew had been on duty for approximately 10 hours.

Before the descent, the commander had briefed for an ILS approach to Runway 30 and, to comply with local noise abatement procedures, to use only idle reverse thrust after landing. The published landing distance available for this runway is 2,201 metres and the crew selected LOW autobrake. The descent and initial approach were uneventful and, after interception of the localiser and the glideslope at 2,000 feet, the expected 'CAT III DUAL' caption illuminated and the landing gear was selected DOWN at approximately 1,700 feet.

At about 1,000 feet on the final approach to Runway 30, the aircraft's approach status changed to the downgraded 'CAT III SINGLE' (where a single system failure will terminate the automatic approach) and the crew noted that the WHEEL page on the ECAM (Electronic Centralized Aircraft Monitoring) display showed the 'STEERING' caption in amber. The crew cycled the 'anti-skid & nosewheel steering' switch (A/SKID & N/W STRNG) whereupon the WHEEL page indications returned to normal, with the approach status returning to 'CAT III DUAL'. The commander could not later recall whether or not the crew reselected autobrake after the cycling the switch.

The aircraft landed normally and idle reverse thrust was selected. However, the aircraft did not appear to be decelerating normally and the first officer announced "Manual Braking" because the autobrake panel showed that autobrake was not functioning. The commander pressed the brake pedals progressively "all the way to the floor" but sensed no braking response and so he then selected maximum reverse thrust. Next he instructed the co-pilot to cycle the A/SKID & N/W STRNG switch. Once this had been done, the commander tried the brake pedals again and, with no retardation response, he ordered the co-pilot to turn the A/SKID & N/W STRNG switch to OFF, in order "to get alternate braking pressure from the hydraulic accumulator". He then applied sufficient wheel braking to stop the aircraft on the paved surface, coming to a halt about 40 metres from the end of the runway. In achieving this braking, however, three tyres of the main landing gear burst and the fourth was badly scuffed.

After the aircraft stopped the commander advised the cabin crew to remain seated and contacted the control tower for the emergency crews to check for smoke around the main wheels. The emergency personnel confirmed that there was no need for an emergency evacuation and the crew and passengers left the aircraft 15 minutes later, without further incident. The aircraft remained on the runway for about 3 hours after the incident as wheels and tyres needed replacement before the aircraft could be safely moved.

Systems description

In the A320 the wheel brakes operate on two separate and independent systems. The 'normal' system uses 'green' hydraulic pressure and the 'alternate' system uses 'yellow' hydraulic pressure, backed by a hydraulic accumulator.

Anti-skid and autobrake functions are controlled by a two-channel Brake and Steering Control Unit (BSCU), a computer which transmits brake commands either from the pilots' brake pedal positions or from the autobrake system. Autobrake is armed by the crew through a push-button panel on the flight deck and operated in MAX (maximum, for rejected takeoffs), MED and LOW (medium and low, for landings). In LOW setting, autobrake applies brake pressure four seconds after spoiler deployment on landing and has a target deceleration rate of 5.6 ft/sec/sec (0.17g).

There is an 'anti-skid & nosewheel steering' switch (A/SKID & N/W STRNG) with simple 'ON' and 'OFF' selections. With this switch OFF there is no anti-skid protection to the brakes and pilots should refer to the triple pressure indicator (showing left, right and accumulator), keeping brake pressures at the wheels to below 1,000 psi to prevent the tyres from skidding and bursting.

The wheel braking system can operate in four modes:

1) Normal braking - with autobrake available and anti-skid operating (Green hydraulic system).

2) Alternate braking with anti-skid - pedal braking by crew with anti-skid operating (Yellow hydraulic system).

3) Alternate braking without anti-skid - pedal braking by crew with no anti-skid, either due to BSCU failure and/or A/SKID & N/W STRNG switch OFF. Crew maintain brake pressures below 1,000 psi to avoid locking a wheel.

4) Parking brake - primarily used for aircraft parking but this may be used as an emergency brake in short and successive applications.

Note: The triple brake pressure gauge does not indicate wheel brake pressure when the brakes are operating in 'normal' mode, hence the operation of the wheel brakes cannot always be determined by inspecting the gauge.

Technical examination

After the incident at Cardiff the BSCU from C-FTDF was returned to the manufacturer of the brake system and subjected to an extensive investigation, including tests to reproduce the fault codes triggered during this event. The investigation included repetitive flight cycle simulations, hot and cold soaking and the application of a range of conditions designed to induce BSCU faults. In spite of this testing, the manufacturer was unable to repeat the fault conditions which were recorded in flight by the BSCU built-in test equipment (BITE), the Central Fault and Display System (CFDS) and the Flight Data Recorder (FDR). However, a 'micro-cut' test of the BSCU (a power interruption test where electrical power is removed for very short periods) did reveal a problem in the separate power supplies for both BSCU channels and it is likely that this was related to the faults recorded.

Flight recorders

The CVR was recovered from the aircraft but had overrun and the recording did not include either the approach or the landing.

Data from the FDR was analysed by the aircraft manufacturer and the analysis agreed with the sequence of events reported by the pilots. On the approach, data was lost from the BSCU (as indicated by the brake pedal position transducers and 'autobrake fault' parameter) for a period starting 53 seconds before touchdown, corresponding to the airborne cycling of the A/SKID & N/W STRNG switch at about 1,000 feet. The changes at about this time in the discrete autobrake parameters indicate that the cycling of the switch resulted in a change of active channel in the BSCU and the loss of autobrake arming.

The FDR traces showed that, after the touchdown, the spoilers extended in about two seconds and reverse thrust was initiated at the same time. The deceleration rose to 0.18g in the six seconds after touchdown, due to the spoilers and idle reverse thrust, but, by the time the pilot brake pedal inputs started (eight seconds after touchdown), the rate of deceleration was reducing. The brake pedals were progressively applied over a period of 10 seconds to maximum and back to zero deflection over the next three seconds. This confirms that pedal braking was not effective, even at large deflections. The decline in deceleration rate was arrested 19 seconds after touchdown with the application of maximum reverse thrust by the crew, which alone resulted in the deceleration rate reaching 0.19g. Evidence of pedal braking was apparent 28 seconds after touchdown, with a rapid rise in longitudinal deceleration to about 0.4g, punctuated by three sharp 'spikes', probably corresponding to the rupture of the three mainwheel tyres. The aircraft came to rest 50 seconds after touchdown.

Data was again lost from the BSCU for a period starting 23 seconds after touchdown (at about 78 kt ground speed), consistent with the crew's reported cycling, and then turning off, the A/SKID & N/W STRNG switch. Effective pedal braking was apparent at 28 seconds after touchdown, five seconds later.

A simple analysis of the available FDR traces by the AAIB indicated that the runway distance covered during the 10 seconds of the gradual initial application of pedal braking was some 590 metres. The analysis also showed that this would have been reduced if full reverse thrust had been selected with the initial application of pedal braking. By comparison, the cycling of the A/SKID & N/W STRNG switch covered about 120 metres of runway, as it occurred over a much shorter period and at a lower ground speed.

Procedure

For a loss of braking action, the following actions are detailed in the operator's FCOM (flight crew operating manual) as memory items:

LOSS OF BRAKING

- **IF AUTOBRAKE IS SELECTED**:
  - BRAKE PEDALS .... PRESS
    (this will override the autobrake)

- **IF NO BRAKING AVAILABLE**:
  - REV .... MAX
  - BRAKE PEDALS .... RELEASE
  - A/SKID & N/W STRG ....OFF
    (braking system reverts to alternate mode)
  - BRAKE PEDALS .... PRESS
  - MAX BRK PR ....1000 PSI

- **IF STILL NO BRAKING**:
  - PARKING BRK .... SHORT AND SUCCESSIVE APPLICATIONS

Commander's comments

The commander had filed the appropriate safety reports following the incident. He was contacted by the AAIB later for additional comments, following the analysis of the technical information.

Concerning the cycling of the A/SKID & N/W STRNG switch at about 1,000 feet, the commander commented that, had the action not been effective in removing the amber STEERING caption on the ECAM display, he would have performed a missed approach. He was uncertain as to whether the crew had then re-armed the autobrake for the landing.

The first officer's "Manual braking" call had surprised the commander. Concerning his initial response, he commented that, in an aircraft which provides a wide range of visual and aural warnings, the lack of a compelling ECAM warning suggested to him at the time that any autobrake discrepancy would be a problem with the selector switch rather than with the braking system. Regarding the 10 seconds from initial application of brake pedals to full deflection, he commented that this was partly due to concern for passenger comfort and the sensitivity of the A320 pedal brakes, partly his sense that this was just a switch discrepancy, and partly that this was happening at the end of a long duty day. It was only during the last stages of pedal deflection that he realised that he had a serious braking problem.

On his decision to order the cycling of the A/SKID & N/W STRNG switch, before selecting it OFF, the commander agreed that it did not match the memory drill but, after successfully cycling the switch on approach, he had been reluctant to lose the steering function on the runway. He also confirmed that this had added only about two seconds before the switch was selected OFF and braking became available through the pedals.

Analysis

The evidence recorded by the Brake and Steering Control Unit (BSCU) built-in test equipment (BITE), and other onboard systems, showed that the initiating factor in this incident was the behaviour of the BSCU. It has not been possible fully to explain this behaviour. But it is important to consider how, in good weather conditions and on an adequate runway, an overrun nearly occurred despite a 'memory item' drill designed to prevent it. One consequence of the lack of wheel braking during the major portion of the aircraft's ground roll was that the crew then applied pedal braking sharply and quickly burst three of the four tyres on the main landing gear. With the A/SKID & N/W STRNG switch at OFF, as the aircraft slowed, the commander's ability to maintain directional control was reduced and there was a potential for a runway excursion.

Following the cycling of the A/SKID & N/W STRNG switch in the air, permitted in the procedures, it appeared from the DFDR trace that the LOW autobrake arming was lost. This is consistent with the change of BSCU channel that would occur with this cycling.

In ordering the cycling of the A/SKID & N/W STRNG switch on the runway, when it became apparent that pedal braking was having no effect, the commander delayed the onset of substantial pedal braking. This braking became available when the A/SKID & N/W STRNG switch was then selected OFF. The cycling of the switch while in motion on the ground is not recommended in the FCOM and the 'Loss of Braking' procedure requires that, if no braking is available, this switch should be selected OFF. However, the FDR data showed that only five seconds elapsed between what appears to have been the start of the switch cycling and the achievement of substantial pedal braking. As the brakes should be applied gently in 'alternate mode without anti-skid', the time spent in cycling this switch was less than five seconds and likely to have been close to the two seconds estimated by the commander. The simple analysis of the FDR data indicated that only about 120 metres of runway were covered during this cycling of the switch.

A greater distance along the runway (some 600 metres) was traversed without wheel braking during the 10 to 13 seconds of the commander's initial pedal application, both because of the greater elapsed time and the higher ground speed. The commander's later comments indicate that factors in this relatively slow response were the lack of ECAM warning, concern for passenger comfort with sensitive pedal brakes and the effects of a long duty day. An additional factor in recognising the lack of pedal effect may have been that the aircraft was already decelerating from the effect of idle reverse thrust and the initial level of this deceleration (about 0.18g) was close to the target level (0.17g) automatically set for the LOW autobrake setting.

Analysis of the time and distance performance of C-FTDF in its landing roll therefore shows that a major factor in the near overrun was the low deceleration level (at idle reverse thrust) during the initial period the commander was attempting to apply pedal braking. The deceleration rate would have been significantly enhanced by earlier application of maximum reverse thrust. Crews may at times encounter a conflict between local airfield noise abatement procedures and the need to use greater than idle reverse thrust. The implications of delaying the selection of full reverse thrust when wheel braking appears to be less effective than anticipated can be punitive.

Conclusions

A number of factors were present in the crew's delayed recognition of the failure of the braking system, including its occurrence at the end of a long duty day. A major contributory factor was the lack of warning of the BSCU system problem to the crew because the Flight Warning Computer (FWC) does not provide active monitoring of the BSCU.

The records of typical UK operators of A319/320/321 aircraft indicate that 'loss of braking' events immediately following touchdown are infrequent. However, over a three-year period one UK operator of A320 aircraft reported a total of five ASRs (Air Safety Reports) featuring apparent failure of the braking system during landings. These incidents are potentially very hazardous, as shown in the report into the accident to a UK-registered Airbus A320-212, G-UKLL, at Ibiza Airport on 21 May 1998. This accident, where the aircraft substantially overran the runway and was steered into an earth embankment to avoid the sea, was investigated by the Spanish authorities with significant technical contribution by the AAIB.

Safety Recommendations

Incidents and accidents such as those to C-FTDF and G-UKLL highlight the need for early recognition of braking problems during a landing roll and early action to reduce the kinetic energy of the aircraft. Therefore, the AAIB makes the following Safety Recommendations:

Safety Recommendation 2004-82

It is recommended that Airbus improve the automated warnings to flight crews concerning the loss of braking system effectiveness following touchdown or a rejected takeoff.

Safety Recommendation 2004-83

It is recommended that Airbus amend the Flight Crew Operating Manuals, and related material, to advise application of maximum reverse thrust as soon as a loss of braking performance is suspected following touchdown, rather than delay the application whilst awaiting confirmation that no braking is available.

INCIDENT

Aircraft Type and Registration:	Boeing 737-73V, G-EZJX	
No & Type of Engines:	2 CFM56-7B20 turbofan engines	
Year of Manufacture:	2003	
Date & Time (UTC):	5 December 2004 at 0733 hrs	
Location:	Newcastle Airport, Tyne and Wear	
Type of Flight:	Public Transport (Passenger)	
Persons on Board:	Crew - 5	Passengers - 96
Injuries:	Crew - 1 (Minor)	Passengers - None
Nature of Damage:	None	
Commander's Licence:	Airline Transport Pilot's Licence	
Commander's Age:	34 years	
Commander's Flying Experience:	5,400 hours (of which 4,950 were on type) Last 90 days - 140 hours Last 28 days - 34 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

At 0733 hrs the aircraft commenced a takeoff from Runway 25, which was 2,329 metres (7,640 feet) in length. The weather conditions were good with a surface wind from 270º at 10 kt, visibility of 20 km, temperature 7ºC and the local sunrise was due at 0813 hrs. At a speed of around 115 kt the flight crew saw a flock of birds ahead on the runway and almost at the same time heard a loud 'bang', felt vibration through the aircraft and noticed the number one engine surge. The commander rejected the takeoff at a speed of 122 kt (V_1 was 127 kt), and brought the aircraft to a stop on the runway. From the position at which the aircraft came to a stop there was 1,067 metres (3,500 feet) of remaining runway length. The crew contacted the Airport Fire Service on frequency 121.6 MHz to check on the condition of the aircraft. They were advised that there was some smoke from the right main landing gear and so the commander decided to disembark the passengers on the runway. The aircraft was subsequently towed to the parking area.

An engineering inspection found evidence of three impacts with birds, two on the left engine and one on a left wing slat. There was no permanent damage to the aircraft.

The birds were identified as grey partridges, which when airborne typically fly close to the ground. During the winter season grey partridges live in small groups, known as coveys, and inhabit lowland areas of farmland feeding in open grass and vegetation. They are difficult to detect and flush out from long grass.

There are open areas of grass on the airfield which are mown to a grass length of approximately 8 inches (0.25 metres). There were three bird patrols carried out at the airport in the morning prior to the incident, the result for each was recorded in the log as *'nothing to report'*. On the day before this birdstrike incident an airport based Police Officer had gone out to speak with a shooting party, who were close to the northern boundary fence of the airfield, in response to concerns that beaters were driving birds towards the airfield and that guns were being carried close to the airfield. The airport operator has since written to the farmer of the land adjacent to the boundary requesting that shooting activities are not carried out in the vicinity of the airfield.

In the prevailing light conditions the crew would have had little opportunity to see the birds before impact but they were certain that they at hit at least one and probably more. With the aircraft approaching V_1 speed the commander had a very short time in which to make his decision whether to continue the takeoff or to stop. The physical evidence of at least one engine suffering damage probably contributed to his decision to stop, and in the event the aircraft came safely to a stop with sufficient runway available.

INCIDENT

Aircraft Type and Registration: Cessna 550 Citation, G-FCDB

This report has been intentionally withdrawn
and will published next month.

INCIDENT

Aircraft Type and Registration:	Fokker F28 Mark 0100, G-BXWE
No & Type of Engines:	2 Rolls-Royce Tay 650-15
Year of Manufacture:	1991
Date & Time (UTC):	14 August 2004 at 1940 hrs
Location:	London Heathrow Airport, London
Type of Flight:	Public Transport (Passenger)
Persons on Board:	Crew - None Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	Not known
Commander's Flying Experience:	Not known
Information Source:	AAIB Field Investigation

Synopsis

After recycling the landing gear, consulting with company engineers and carrying out the prescribed procedure for alternate landing gear lowering, the crew were committed to landing the aircraft with a nose landing gear unsafe indication. The aircraft landed with out incident; the nose landing gear indicated safe during the landing roll. Subsequent engineering investigations revealed that the Aircraft Maintenance Manual (AMM) procedure for checking the nose landing gear downlock plunger clearance was ambiguous, in that it did not make it clear that it is necessary to apply a rearward force on the nose landing gear when checking the downlock plunger clearance. It is believed that this caused the nosed landing gear downlock to be misrigged. In response to the airline's recommendation, the aircraft manufacturer has agreed to amend the AMM procedure.

History of flight

The aircraft was on a scheduled passenger flight from Brussels to London Heathrow. When the landing gear was selected down on final approach to London Heathrow the nose landing gear 'down and locked' green light failed to illuminate. This was accompanied by landing gear unsafe visual and double-chime aural warnings. A go-around was flown and the landing gear was recycled, but the same warnings recurred. The Quick Reference Handbook (QRH) procedure for alternate landing gear lowering ('ALT LG PROC') was then carried out, with the same result. The flight crew advised the cabin crew and passengers of the problem and contacted ATC to advise them of the situation.

The aircraft then proceeded to the 'Biggin' hold, where the crew discussed the problem with their operations and engineering departments on the company radio frequency. Following the advice given, the crew declared a 'MAYDAY' and the commander briefed to the Senior Cabin Attendant for the 'LANDING WITH GEAR UP/UNSAFE' condition, so that the passengers could be briefed prior to landing.

On the final approach to land, the nose gear unsafe warnings recurred and as the aircraft descended through 1,000 feet, the red 'LG NOT DOWN' message appeared, accompanied by the master caution triple-chime aural warning. The tower at London Heathrow advised the crew that all three landing gear and the main gear doors appeared to be down. The aircraft landed normally and was slowed using 'emergency maximum' reverse thrust, with normal braking being used only after the ground speed had decreased to below 10 kt. The aircraft stopped on the runway and contact was established with the emergency services by radio and via an open cockpit window. After disembarking the passengers via steps, the aircraft was recovered by engineers to the company's hangar at Heathrow.

Flight recorders

The aircraft was equipped with a solid state flight data recorder (SSFDR) of 50 hours duration and a solid state cockpit voice recorder (SSCVR) of 30 minutes duration.

The data for the final approach to land showed the following sequence of events (see Figure 1). At 1837 hrs, at about 2,000 feet amsl with the autopilot and autothrust engaged, at an airspeed of 130 kt, and flap 42 selected, the aircraft turned onto a heading of 270° and established the localiser and glideslope. The aircraft then started to descend. The left and right main gear indicated down and locked. The nose gear indication was in the up position.

At about 920 feet radio altimeter (RA) a master warning was recorded. The descent continued and 45 seconds later the autopilot was disengaged at an airspeed of 131 kt.

At 50 feet RA the airspeed was 127 kt. Ten seconds later, at an airspeed of 124 kt, both the left and right weight on wheel parameters were momentarily recorded, the normal acceleration value was 1.23g and the pitch attitude was 2.37° nose-up. Over the next four seconds the pitch attitude increased slightly to 2.54° nose-up and then over the next two seconds decreased to 1.58° nose-up.

The airspeed had reduced to 114 kt at this time and the right weight on wheel parameter was then recorded. Reverse thrust was then selected.

During the next three seconds the pitch attitude increased slightly to 2.02° nose-up and the airspeed had reduced to 110 kt, the left weight on wheel parameter was then recorded. Over the next 3.5 seconds the pitch attitude decreased to a nose-down attitude of 0.08° and about one second later the nose gear was recorded in the down position, the master warning at this time was also no longer recorded. The aircraft continued to decelerate at an average of 1.5 metres per second until it came to a stop.

Nose landing gear downlock operation

The nose landing gear on the Fokker F28 Mark 0100 is of the forward-retracting type. The gear is locked in the down position by a spring-loaded plunger mounted on the top of the leg (see Figure 2). During gear extension, the plunger contacts a ramp on the downlock bracket, which compresses the plunger into it's housing against the force of the spring. When the gear is in the fully down position, the plunger lines up with a hole at the base of the ramp and extends under spring pressure, thus locking the leg in position. The extension of the plunger triggers the nose gear down and locked proximity sensors to illuminate the green gear indication light in the cockpit.

The downlock bracket is shimmed, to ensure that the downlock plunger is located centrally in the hole when the gear is down. If the clearance is incorrect, the downlock plunger may be prevented from fully extending due to the excessive friction caused by the plunger being forced against the sides of the hole. If the plunger is not fully extended, the down and locked proximity sensors may not be triggered.

The bottom of the downlock plunger is attached to a connecting rod, which is in turn connected to the nose gear retract actuator. During the early part of the retraction cycle, the retract actuator causes the connecting rod to move downwards, pulling the downlock plunger with it, thus unlocking the nose gear prior to retraction.

Engineering investigation

Examination of the aircraft was overseen by the AAIB. It was established that when the engineers visited the cockpit after the aircraft had stopped on the runway, the nose gear green down and locked light was illuminated. This corroborated the flight data recorder evidence that the nose gear had gone fully into lock during the landing roll.

Extensive troubleshooting in the hangar, including testing of the nose landing gear indication system and gear retraction/extension tests, failed to identify any defects. Following advice from the aircraft manufacturer, the nose landing gear downlock plunger clearance was measured; this was reported to be satisfactory. The aircraft was returned to service, with no further reports of problems.

The aircraft was subsequently on a Base Maintenance check between 19 and 28 September 2004, during which the downlock plunger clearance was rechecked after further consultation with the aircraft manufacturer. On this occasion, the clearance was found to be outside the Aircraft Maintenance Manual (AMM) limits of 0.003 to 0.020 inch and the shimming was adjusted to increase the clearance to bring it within limits. According to the aircraft manufacturer, too small a clearance increases the chances of the downlock plunger not fully engaging, due to the increased friction on the plunger caused by the misalignment.

A year earlier, on 26 September 2003, the aircraft had experienced a nose landing gear unsafe condition on approach. The aircraft landed safely and troubleshooting did not highlight any defects with the nose landing gear.

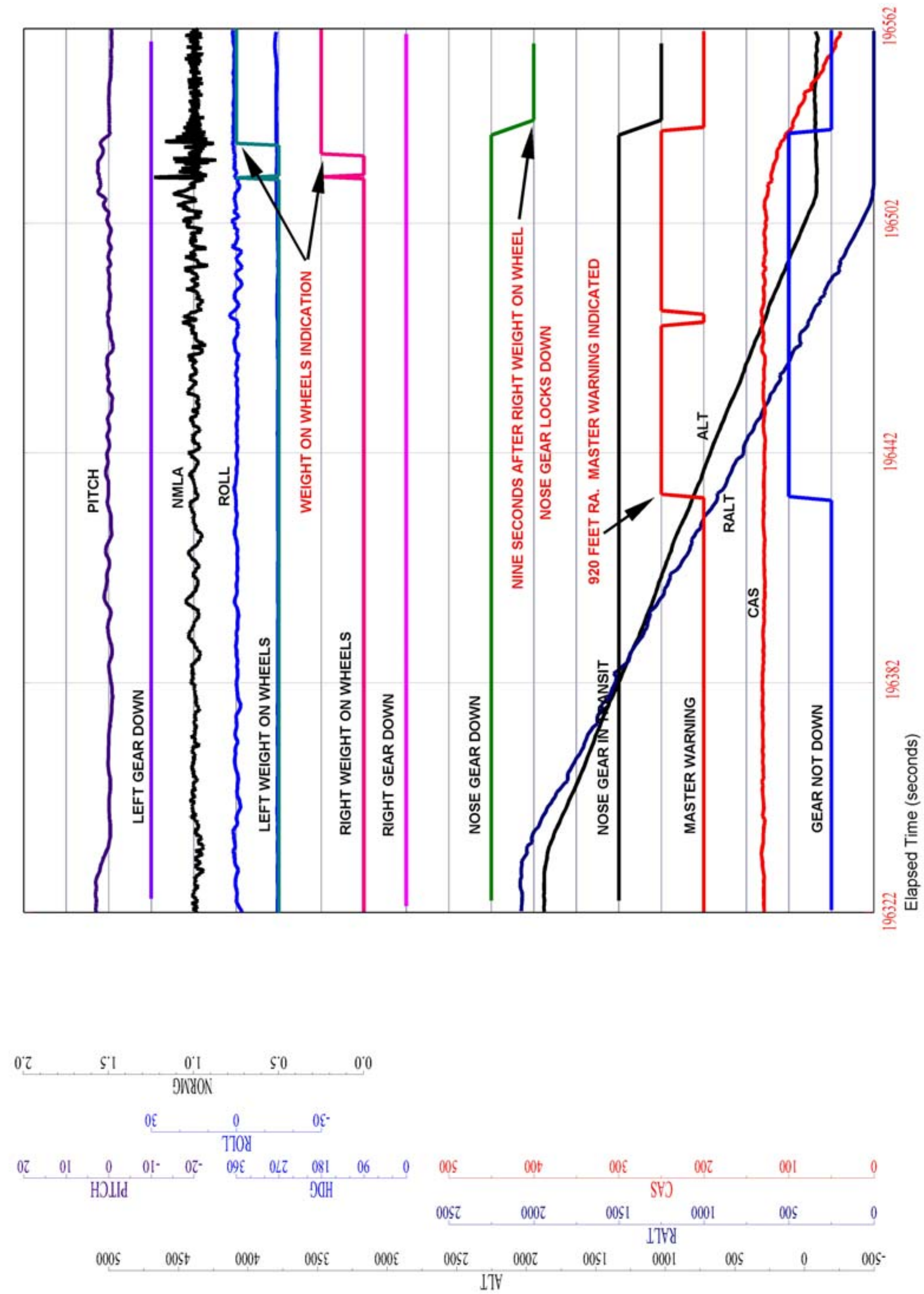
On reviewing the AMM procedure for checking the downlock plunger clearance, the airline's Engineering Quality Department noted that the procedure was ambiguous, in that it did not make it clear that it is necessary to apply a rearward force on the nose landing gear when checking the downlock plunger clearance. Failing to do so will result in an incorrect measurement being obtained.

The nose landing gear on G-BXWE was replaced in June 2003, following a towing incident. It is thought that the downlock plunger clearance may not have been correctly rigged after the nose gear was installed, because of the ambiguity in the AMM procedure. This might also explain why no anomalies were found during troubleshooting after this event and the previous event in September 2003. In-service wear tends to increase the downlock plunger clearance and thus too small a clearance could only have resulted from incorrect maintenance procedures.

Follow-up action

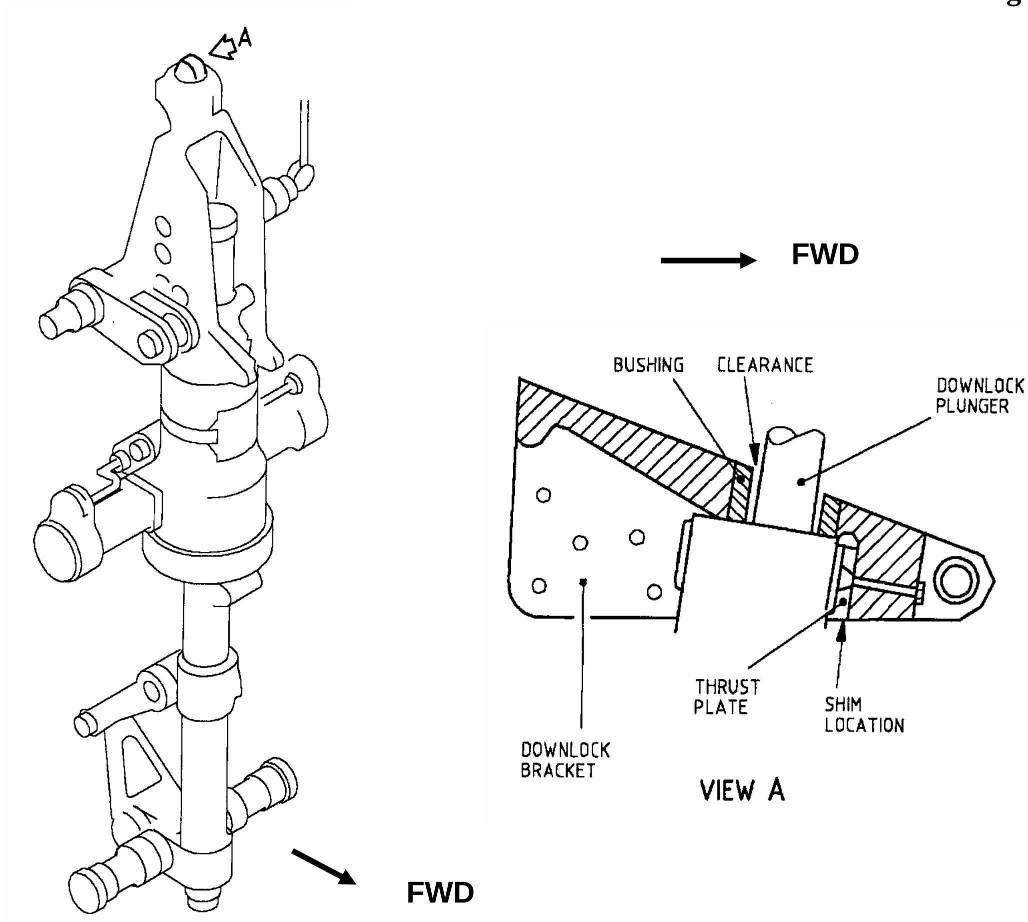
In response to the airline's recommendation, the aircraft manufacturer has agreed to amend AMM subtask 32-21-01-220-024-A00 and task 32-21-01-200-836-A to include a step to clarify that a second person is required to apply a rearward force to the nose gear when measuring the downlock plunger clearance, in order to obtain an accurate measurement.

Figure 1



G-BXWE Flight Recorder Data for Landing/Rollout

Figure 2



Nose Landing Gear Downlock Mechanism

(Diagrams taken from Fokker 100 Maintenance Manual)

AAIB Bulletin No: 2/2005 **Ref: EW/C2003/08/09** **Category: 1.2**

Aircraft Type and Registration:	Aero Vodochody L-39ZO Albatros, G-OTAF	
No & Type of Engines:	1 Ivchenko AI-25TL turbofan engine	
Year of Manufacture:	1982	
Date & Time (UTC):	2 August 2003 at 1421 hrs	
Location:	Field three miles south of Duxford Airfield, Cambridgeshire	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	Nose gear collapsed, minor damage to wings and nose	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	59 years	
Commander's Flying Experience:	1,574 hours (of which 50 were on type) Last 90 days - 8 hours Last 28 days - 6 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot plus post-accident engine testing and further enquiries	

Description of the aircraft

The Aero Vodochody L-39ZO Albatros aircraft is a two-seat tandem military jet trainer manufactured in the former Czechoslovakia. The aircraft has a maximum take-off weight of 5,600 kg and a maximum operating speed of Mach 0.80/490 KIAS. It is equipped with two ejection seats and is powered by an Ivchenko AI-25TL twin shaft bypass turbofan engine.

History of the flight

The pilot had already completed one uneventful flight during the morning. The accident occurred on his second flight whilst rejoining the circuit at Duxford. The weather was CAVOK (no cloud below 5,000 feet, visibility of 10 km or more and no significant weather) and the surface wind was light.

The pilot intended to carry out a 'run and break', flying parallel to the runway slightly offset to the north before turning crosswind to join downwind for a landing on Runway 24. The fuel level indicated 450 kg and the minimum recommended downwind fuel state is 300 kg. When it entered the circuit the aircraft was at 220 KIAS with a power setting of 85% RPM. As the pilot began to turn crosswind he retarded the throttle to IDLE and extended the speed brakes. After the airspeed had reduced through 180 KIAS he lowered the landing gear and advanced the throttle to a position that would normally result in about 90% RPM - the normal power setting for maintaining the appropriate speed with the gear down. At this point the speed was at approximately 175 KIAS so the pilot decided to leave the speed brakes extended until the aircraft had slowed to the maximum speed for flap extension of 165 KIAS.

The pilot then reported noticing a "change in the usual sound" of the engine. At this time the aircraft was descending through 850 feet agl (circuit height was 1,000 feet agl) so he instinctively applied full throttle. The engine did not accelerate and the pilot reported that it became apparent to him that the engine had failed or flamed out. He made a MAYDAY call to Duxford ATC and advised them of the problem. The pilot's attention was focused outside the aircraft and therefore he was neither sure if any captions had illuminated on the caution warning panel nor was he aware of the engine instrument indications.

The pilot selected the throttle to IDLE to initiate an engine re-light attempt but then he decided against trying to re-start the engine because the aircraft's height was low and he did not think there would be sufficient time to complete the procedure. He then realised that his two remaining options were a forced landing or an ejection. He decided to eject and grasped the ejection handle with both hands and depressed the firing trigger. Before pulling the handle he hesitated and re-considered his decision to eject because the aircraft was now descending rapidly and was very low. The pilot estimated that the aircraft was by then outside the safe ejection envelope and so he decided against ejecting. The aircraft then entered a light pre-stall buffet. The pilot released the ejector seat handle, applied forward pressure to the control stick to prevent a stall, and then committed himself to a forced landing.

He located a recently harvested wheat field and flew towards it. The aircraft touched down firmly but not heavily in the field and then while still travelling at high speed, it passed through a large hedge and came to rest in a second field consisting of standing wheat. At some point during the landing run the nose gear collapsed but the aircraft remained structurally intact. After it stopped the pilot turned off all the electrical services, opened the canopy, unbuckled his harness and vacated the aircraft unassisted. There was no fire so he returned to the aircraft and inserted the ejector seat safety pins.

The Duxford Airport fire service arrived on the scene within approximately 10 minutes followed shortly by paramedics and the police.

A photographer filmed the aircraft on video seconds after the MAYDAY was heard being declared on the radio. In the video the aircraft can be seen to porpoise nose up and down while descending rapidly, before disappearing from view behind a hill in a level pitch attitude. The landing gear appears to be extended and there is no visible plume of vapour or smoke trailing from the aircraft.

History of the aircraft

G-OTAF was delivered to the Libyan Air Force in 1982 where it accumulated 521 flying hours. In 1989 the aircraft was sold to the British Aerial Museum. Prior to the aircraft's ferry flight to the UK in April 1991, it was fitted with a replacement engine that had accumulated 217 hours. The history of the engine prior to this point is not known but the engine was manufactured in 1982 and installed by the aircraft manufacturer's engineers. Between April 1991 and April 1996 the aircraft logged 19 hours flight time which included the ferry time. In 1996 the aircraft had a CAA test flight and received it's Permit to Fly on 26 April 1996. In 2002 it was sold to the present owner and was being operated on the UK register with a Permit to Fly current at the time of the accident. The most recent maintenance was a 100 hour/annual inspection that was completed on 7 May 2003. At the time of the accident the aircraft and engine had accumulated 806 hours and 528 hours respectively.

Aircraft examination

The maintenance organisation at Duxford towed the aircraft to a nearby farm to carry out an initial examination. The nose gear had collapsed and there was minor damage to the nose and wing leading edges. The open canopy had detached from the aircraft, the speedbrakes were extended, the flaps were retracted and the landing gear doors were down. The Ram Air Turbine (RAT) was retracted.

Some of the circuit breaker switches on the right side of the cockpit, including 'fuel pump' and 'ignition', were found in the OFF position, but it was also noted that the seat harness buckle could reach the circuit breaker panel. The circuit breakers were switched ON and with electrical power applied, no fault or trip was encountered. The four circuit breaker switches in the nose cone of the aircraft were also found in the OFF position, two of these were redundant, but one controlled the engine fire extinguisher and another controlled the RAT. The Exhaust Gas Temperature (EGT) 730°C warning light did not illuminate when electrical power was applied. Had this warning light triggered in flight, the event would have been stored in the EGT control system until it was reset on the ground by pushing a reset button behind the rear ejection seat.

Powerplant examination

It was determined that approximately 450 kg of fuel remained in the tanks. The jet pipe was dry and there were no indications of fuel leakage from the aircraft. Although the air intake had internal debris from the hedge, the engine did not appear to have sustained any damage during the landing; therefore, the aircraft was prepared for an engine test. Two successful engine test runs were carried out. During the second run 'slam' checks were performed whereby the throttle was rapidly retarded from 80% RPM to IDLE and then after some period back to high power. The engine continued to operate but it was noted that when the throttle was 'slammed' to IDLE the RPM momentarily dipped to 53.5% before recovering to a stable 55%. The pilot carrying out the test considered this to be normal. The aircraft was then inspected for indications of contamination in the fuel system. No faults or contamination were found in the filters or the fuel control valve. After these engine tests the aircraft's wings were removed and it was transported back to Duxford Aerodrome for a more detailed examination.

The aircraft owner employed an L-39 consultant engineer to investigate the cause of the engine failure and a copy of the engineer's findings was sent to the AAIB. The engineer had considerable experience of the L-39, having maintained the type whilst serving in the German Air Force. He carried out a number of inspections and tests and concluded that an electrical fault was an unlikely cause of the engine failure. His significant findings from the engine examination related firstly to the Inlet Directing Body (IDB) of the high pressure compressor and secondly to the fuel consumption setting.

Inlet Directing Body

The Inlet Directing Body (IDB) of the High Pressure Compressor (HPC) helps to maintain stable airflow between the Low Pressure Compressor (LPC) and HPC by varying the angle of its blades between -5° and -15° depending upon RPM. At idle RPM the IDB is set to -15° and the blade angle increases with increasing RPM up to -5° at between 74% and 77% RPM. The IDB position is controlled by the fuel control unit via a hydraulic actuator which moves the blades and a connecting pointer which indicates the blade angle. Normally it is possible to move the blades by hand using the pointer but on G-OTAF the pointer could not be moved. The hydraulic actuator was disconnected to measure the torque required to move the pointer. However, the pointer could not be moved with the torque wrench and the torque applied exceeded the scale of 2.2 kpm (kilopon-meter or kilogram[force]-metres). It was the consultant engineer's opinion that the hydraulic actuator would not have been able to overcome the torque and therefore the IDB on G-OTAF was stuck at -15° at all engine RPM speeds.

Fuel consumption setting

The fuel consumption setting on the Fuel Control Unit (FCU) determines the minimum fuel flow at idle RPM and should be set to ensure that the engine does not flame out when the throttle is brought back to IDLE at any airspeed or altitude within the aircraft's flight envelope. During the engine test runs the RPM dipped to 53.5% before recovering to 55% during the throttle 'slam' checks. It was the consultant engineer's opinion that this dip in RPM was caused by a low fuel consumption setting. The adjustment screws for setting the fuel consumption setting on the FCU were found in their factory sealed condition. In the engineer's experience the fuel consumption setting on the L-39 was usually adjusted approximately every four years to maintain the idle setting at the nominal 56% RPM. However, the maintenance manual states that a momentary dip of up to 3% below the nominal RPM of 56% is permissible during a throttle 'slam' check to IDLE.

Bleed air valves

The consultant engineer also raised concerns about the operation of the bleed air valves. The engine has two bleed air valves which are designed to prevent the high pressure compressor from surging at low rotational speeds. The bleed air valve at the third compressor stage opens below 86% to 90% RPM and the bleed air valve at the fifth compressor stage opens below 74% to 78% RPM. At the time of the engineer's inspection, the wings were removed from the aircraft and therefore it was not in a condition for the engine to be test run.

In July 2004 the maintenance organisation rigged the aircraft up for another engine run to test the operation of the bleed air valves. The operation of the bleed air valves is tested by slowly increasing the power and checking for a slight increase in the high-pressure compressor RPM when the low-pressure compressor RPM is in the regions of 74% to 78% and 86% to 90%. The maintenance organisation reported that the engine passed this test satisfactorily. During this engine test they also ran the engine up to full power. A maximum RPM indication of 106% was obtained which is within the specified range of 106.8 ±1%. Additional throttle 'slam' checks were also carried out and the engine operated normally. This was despite the fact that the IDB blades were still seized. A borescope inspection was carried out but due to the location of the IDB it was not possible to determine whether there was any internal blockage preventing IDB movement.

Throttle lever examination

The throttle lever has a thumb actuated latch that when depressed permits the lever to move aft of the IDLE stop and into the fuel shutoff region. Inadvertent application of this latch while slamming the lever back to IDLE could result in an inadvertent engine shutdown. However, normal positioning of a hand around the throttle grip with one's thumb close to the airbrake switch on the side would make it extremely difficult to accidentally depress the latch. Multiple hard throttle slams were performed to check that the IDLE stop gate had not worn down and on no occasion did the throttle move aft of the IDLE stop. It is conceivable that a pilot might deliberately, albeit subconsciously, depress the latch while reducing the throttle to IDLE and thereby inadvertently shut the engine down. The German Air Force had two incidents whereby a low-time student pilot inadvertently shut down the engine in this manner. The aircraft manufacturer provides an optional modification that requires the throttle to be retarded to IDLE before the latch becomes effective.

Fuel pump

Fuel is delivered to the engine via an electric fuel boost pump and an engine-driven high pressure pump. The circuit breaker switch for the fuel boost pump was found in the OFF position. No electrical cause for the circuit breaker to have tripped could be found and the boost pump operated normally during the engine test. Had the switch been knocked to the OFF position in flight, the loss of fuel pressure could have contributed to a surge following a rapid throttle increase. The boost pump de-activation would also have much reduced the chances of an engine re-light. However, if the fuel pressure had dropped below the acceptable level the 'Master Caution' and 'Don't Start' captions would have illuminated. The pilot did not recall seeing either caption illuminate.

Ram air turbine

The ram air turbine (RAT) provides backup electrical power in the event of an engine shutdown or flame-out. It should extend automatically when main generator power is lost and should retract automatically when the nose gear 'squat' switch actuates on touchdown. The RAT was found retracted and the lack of dirt or grass inside the RAT indicated that the RAT was probably retracted prior to nose gear touch down. The circuit breaker switch in the nose of the aircraft labelled 'Seat Blocking Emergency Source' also controlled the RAT. This switch was found in the OFF position and had this switch been off in flight, it would have prevented RAT extension. According to the maintenance organisation there was some confusion over what the 'Seat Blocking Emergency

Source' switch did and that some pilots thought it should be turned off for single seat operation. The maintenance manual did not explain this switch's effect on the ejection system but a wiring diagram clearly showed that turning it off would deactivate the RAT and therefore the switch should be on for flight. The pilot stated that before flight, he would normally turn on all four circuit breaker switches in the nose cone, including the 'Seat Blocking Emergency Source'. All four switches were found in the OFF position and therefore it is possible that he forgot to turn them on. However, the pilot believes that damage to the nose cone structure may have knocked them off.

Maintenance procedures

The aircraft was maintained in accordance with technical manuals that had been produced in English by the aircraft manufacturer. The manuals did not specify a torque check of the IDB mechanism. However, the engine manufacturer issued a service bulletin on 7 February 1980 that called for a torque check of the IDB mechanism (Service Bulletin Ivchenko Progress 225000521); it was issued in response to an incident where the IDB blades had seized resulting in failure of the actuating pointer (the incident did not result in an engine failure). The service bulletin specified an IDB torque limit for a new or overhauled engine of 0.8 kpm and a torque limit of 1.1 kpm for an engine in service. This torque check was to be carried out at regular intervals. However, the service bulletin was only issued in Russian and Spanish. When the AAIB contacted the engine manufacturer, a representative stated that no English version of the service bulletin existed.

The aircraft was also maintained in accordance with its CAA Airworthiness Approval Note (AAN) No 24967 issued in April 1996. The AAN stated that the engine's time between overhauls (TBO) was 750 hours with a service life of 4,000 hours. This limit was stated in a letter to the aircraft owner from the aircraft manufacturer (MP/544/96). Since the engine had only accumulated 528 hours its TBO was not yet due at the time of the accident. No calendar time limit was specified in the AAN or in the letter from the manufacturer. The engine manufacturer and aircraft manufacturer have stated to the AAIB that the engine has a six-year calendar limit of operation and storage between overhauls and that this limit is clearly stated in the engine logbook. The engine's original Russian logbook was not available and had been replaced by a CAP (Civil Aviation Publication) 391 standard logbook which did not contain any overhaul limit information. The maintenance manual did not specify a six-year calendar limit for engine operation but it did include a six-year storage limit that required the engine to be overhauled if it had been stored for six years. There was no record in the logbooks of the engine having been overhauled since its installation on G-OTAF in 1991. In addition, the engine manufacturer did not have any record of the engine having been overhauled at their facility since its manufacture in 1982.

Discussion

From the evidence available it is possible that the engine began to surge when the throttle was rapidly retarded from 85% RPM to IDLE and this surge produced the unusual sound that the pilot reported hearing after he advanced the throttle. In large turbofan engines, surges usually produce loud 'bangs' but this does not necessarily occur in small, military, turbofan engines.

When the engine is operating normally, as the throttle is retarded to IDLE the bleed air valves open and the IDB blades rotate to -15°. The combination of these events helps to stabilise the airflow during the engine slowdown. In G-OTAF it appeared that the IDB was stuck at -15° and therefore could not rotate to compensate for the change in airflow. It is possible that this led to a surge and subsequent sub-idle compressor stall which was only recoverable by shutting down the engine and restarting it. Alternatively, a surge could have led to a flame-out of the engine, but a flame-out usually results in unburned fuel being exhausted from the engine. The jet pipe was found to be dry and the video footage of the aircraft's final moments did not show a fuel vapour trail. Therefore, a sub-idle stall is more probable than a flame-out.

The engine operated normally when test run on the ground despite the IDB blades being seized. The engine produced full power and did not surge or flame out when the throttle was slammed closed. However, the aircraft was flying at 175 KIAS when the engine failed to respond and this airspeed would have a different effect on the engine when compared to a ground run. It could be that the function of the IDB becomes more critical at higher airspeeds, particularly when coupled with a rapid throttle closure.

The engine manufacturer and G-OTAF's maintenance organisation did not believe that a seized IDB could lead to an engine surge. However, two independent propulsion experts considered that the seized IDB could, in some circumstances, lead to an engine surge.

The idle RPM was on the low side of the RPM tolerance. According to the consultant engineer, he would have adjusted the fuel consumption setting to increase the IDLE RPM and reduce the RPM undershoot during the throttle 'slam' check. It is possible that a low fuel consumption setting could have contributed to a surge or flame-out, but according to the maintenance manual, the IDLE RPM was within tolerance and therefore no adjustment was required. There is a procedure for checking the fuel consumption setting during a ground run but this was not carried out.

An electrical cause of the engine failure was also examined by the consultant engineer but no direct fault was found. The open ignition and fuel pump circuit breaker switches in the cockpit could not be explained but could have been struck by the seat's harness as the pilot vacated the aircraft. If these switches had been knocked during flight, an engine re-light could have been prevented.

An inadvertent engine shutdown by the pilot was considered but the throttle lever latch operated normally, the IDLE stop gate was intact, and accidental operation of the latch appeared to be very difficult. It is possible that the pilot subconsciously depressed the latch during the throttle slam, but his subsequent reapplication of throttle would have resulted in unburned fuel being exhausted from the engine. However, the video footage of the aircraft's final moments did not show a fuel vapour trail and so this explanation seems unlikely.

The aircraft and engine manufacturers had issued a service bulletin in 1980 calling for a torque check of the IDB mechanism. No such check had been carried out on G-OTAF because the maintenance organisation did not have a copy of the service bulletin and were not aware of its existence. In addition, no English version of the bulletin was available. The aircraft manufacturer no longer produces L-39 type aircraft and no longer provides service bulletins to new owners. The inadequate dissemination of this service bulletin and the lack of a version in English may have been a contributory factor to this accident, if the loss of thrust was indeed caused by the seized IDB.

The CAA has stated that it is the operator's responsibility for monitoring service information and that this responsibility is embodied in condition No 3 of the Permit to Fly which states: "The aircraft shall be maintained by an Approved Organisation (BCAR A8-20) in accordance with a recognised maintenance programme/schedule based on the manufacturer's and/or the previous military authority's published maintenance requirements." It may be implied in this statement, but the CAA should emphasise to operators of Permit to Fly aircraft that it is the operator's responsibility to obtain all relevant service information and if necessary translate the information from a foreign language into a language they understand.

It is not known what caused the seizure of the IDB blades - only an engine teardown would reveal this. It is possible that the blades were damaged on impact or by material ingested from the hedge. Alternatively, the age of the engine may have been a factor; it had only accumulated 528 hours but it was manufactured in 1982. There is no record of the engine having been overhauled since it was installed in G-OTAF in 1991. The engine logbooks prior to this date were missing but the engine manufacturer had no record of overhauling the engine since its manufacture. Since the engine TBO was 750 hours and no calendar limit was specified in the AAN, there was no regulatory requirement for the engine to be overhauled despite its age. However, the engine manufacturer and aircraft manufacturer have stated that the engine should be overhauled after six years of operation. The engine had been highly under-utilised as is common with privately owned aircraft when compared to military operated aircraft. Under-usage helps promote corrosion and the accumulation of dirt and dust. Dirt, dust, corrosion, or a combination of these factors may have contributed to the seizure of the bearings of the IDB blades. The maintenance organisation disputes the necessity to overhaul the engine every six years and pointed out that L-39 aircraft operated in the U.S.A. were not bound by an engine calendar limit. The AAIB believes that in light of this accident and given the engine overhaul requirements by the engine manufacturer, the Civil Aviation Authority should consider mandating a calendar limitation between overhauls for Ivchenko AI-25TL engines.

Conclusion

The AAIB could not determine the cause of the engine failure but the IDB blades were found seized and this could have been a contributory factor. The IDB mechanism seizure could have been avoided had the service bulletin been carried out or had the engine been overhauled. Therefore, the AAIB issued the following safety recommendations:

Safety Recommendation 2004-91

It is recommended that the UK Civil Aviation Authority considers mandating a calendar time limitation between overhauls for Ivchenko AI-25TL engines.

Safety Recommendation 2004-92

It is recommended that the UK Civil Aviation Authority takes appropriate action to inform owners, operators and maintainers of L-39 type aircraft of the need to check that the Inlet Directing Body (of the high pressure compressor) operates correctly in accordance with Service Bulletin Ivchenko Progress 225000521.

Safety Recommendation 2004-93

It is recommended that the UK Civil Aviation Authority emphasises to operators of Permit to Fly aircraft that it is their responsibility to ensure that they possess all published service information and that they regularly check for new service information published by the manufacturer.

Safety Recommendation 2004-94

It is recommended that the UK Civil Aviation Authority emphasises to operators of Permit to Fly aircraft that in situations where service information is only available in a foreign language, it is the operator's responsibility to obtain, if necessary, a translation of the service information into a language that the operator understands.

Aircraft Type and Registration:	Cessna 310, N310QQ	
No & Type of Engines:	2 Continental IO-470-V0 piston engines	
Year of Manufacture:	1973	
Date & Time (UTC):	15 June 2004 at 2030 hrs	
Location:	Elstree Aerodrome, Hertfordshire	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 1
Injuries:	Crew - None	Passengers - None
Nature of Damage:	Damage to left hand side of aircraft and left main landing gear	
Commander's Licence:	Commercial Pilot's Licence	
Commander's Age:	45 years	
Commander's Flying Experience:	875 hours (of which 334 were on type) Last 90 days - 24 hours Last 28 days - 12 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot and metallurgical examination of the failed components	

History of flight

A normal approach to Runway 26 was carried out with a wind of 330°/06 kt. The three green landing gear 'Down and Locked' indicator lights were illuminated and at approximately two miles from touchdown, full flap was selected and visually confirmed. The touchdown was smooth but during the landing roll the 'Gear Unsafe' warning horn sounded. The pilot looked down and noticed that the left main landing gear 'Down and Locked' green indicator light had extinguished and the red 'Gear Unsafe' indicator light had illuminated. Both the right main and nose landing gear 'Down and Locked' green indicator lights were illuminated. The left main landing gear collapsed a few moments later and the aircraft slewed to the left and came to rest in the grass area to the left of the runway. The pilot carried out the emergency shutdown drills and the aircraft was vacated without injury.

Conclusion

The left landing gear was examined by a metallurgist who found that all the failures were caused by a one-time overload force with no evidence of fatigue, corrosion or manufacturing defect.

The pilot/owner assessed that a possible cause may have been that the left main landing gear was slightly out-of-rig which allowed the side brace to unlock when running over a bump in the runway which resulted in the landing gear collapsing.

INCIDENT

Aircraft Type and Registration:	Miles M-65 Gemini 1A, G-AKKH
No & Type of Engines:	2 Blackburn Cirrus Minor II piston engines
Year of Manufacture:	1947
Date & Time (UTC):	24 August 2002 at 1300 hrs
Location:	Old Warden Aerodrome, Bedfordshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Left Propeller separated from aircraft in flight
Commander's Licence:	Basic Commercial Pilot's License
Commander's Age:	59 years
Commander's Flying Experience:	4,950 hours (of which 30 were on type)
Information Source:	Field Investigation

History of flight

The aircraft had been on a local flight when, whilst descending at a low throttle setting in the overhead of the airfield, the pilot heard a 'thump'. He then observed the left propeller, which had become detached from the engine, flying away after striking the nose of the aircraft. The aircraft returned to the airfield and landed without further incident. The propeller was recovered from a nearby field together with the hub sleeve; none of the propeller retaining bolts was found in the field but two of the bolt heads remained with the aircraft and were recovered from the cowling.

The owner of the aircraft had acquired it relatively recently and had flown it more frequently than had been the case in the recent past. The aircraft was being maintained to the Light Aircraft Maintenance Schedule (LAMS) and no special conditions or out-of phase maintenance items had been imposed. The last scheduled maintenance performed had been an Annual check, in February 2002, at which time the tightness of the attachment bolts of both propellers had been checked as required. Between that time and the incident, the aircraft had accumulated a further 24 hours flying time.

Attachment of the propeller to the propeller hub (Figure 1)

The propeller hub is fitted to the engine crankshaft on a keyed taper and secured by a nut and lock-washer. The eight propeller retaining bolts pass forward through the hub flange; these are retained loosely in place by the timing plate, which is a light, formed disc secured onto the rear of the hub. The hub sleeve, which centres the propeller, mounts on the hub with a friction disc interposed between the hub and sleeve flanges to transmit the engine torque to the sleeve. The propeller is clamped between the sleeve flange and the propeller boss flange plate; a thick plate which seats over the sleeve but is not keyed to it. The propeller retaining nuts have plain extensions which locate into the holes in the boss flange plate through which the retaining bolts pass. These nuts also retain the spinner back plate against the forward face of the boss flange plate. The retaining nuts are tightened to the required torque and are then turned on until the first available flat lies tangential to a circle about the hub centre and a nut locking plate is attached to the forward face of the spinner back plate. The torque to which the propeller retaining nuts should be tightened is not specified but has been established by practice at 18 lb.ft.

A review of the information available for the fitting of wooden propellers onto Cirrus Minor engines showed that there was some ambiguity over the correct assembly of the propeller onto the hub. The cross-section drawing of the propeller and hub assembly in the Cirrus Minor, Series II manual showed Belleville (dished) washers fitted between the propeller retaining nuts and boss flange plate. However, another illustration, showing the components needed for the assembly, and also the illustrated parts list showed no requirement for Belleville washers to be fitted; the propeller of the right engine was found to have been assembled onto its hub without Belleville washers.

Examination of detached hub components and propeller

The propeller hub, with the friction disc still adhering to its front face, had remained on the crankshaft. The friction disc material around the bolt-holes showed some very localised tearing distress and the rear face of the hub flange had hammered and polished areas around the bolt holes which were clearly the shape of the propeller retaining bolt heads. Whilst most of the bolt holes showed even polishing all round, two adjacent ones had polishing restricted to the counter-clockwise side when looking forwards (ie the advancing side). The bores of the bolt-holes were also polished and there was some bruising of the lips on the clockwise (retreating) side when looking forward.

The back face of the wooden propeller boss showed slight signs of heat build up and most of the bolt holes showed evidence of some hammering and polishing of the bores, close to the back face, on both the advancing and retreating sides. Two adjacent holes had been severely stretched in the driven (counter-clockwise looking forward) direction, this stretching reaching forward into both holes to about half the depth of the boss (Figure 2). All the other bolt holes in the propeller boss showed varying degrees of surface polishing and stretch.

The two propeller retaining bolt heads, which had remained with the aircraft, were submitted for metallurgical examination. This showed that both had been manufactured by machining from hexagonal steel bar and both had suffered fatigue due to reverse bending. On one, the fatigue progression had been relatively slow, predominantly from one side and the fatigue origins were almost diametrically opposite each other. On the second, the fatigue had been much more rapid and had also been predominantly from one side. On this second bolt, however, the origins were not diametrically opposite. In both cases the fatigue had originated in the machined radius between the bolt shank and the head.

The fractures observed on the two bolt heads recovered were typical of those which would be expected to result from running with insufficiently tightened propeller attachment bolts.

Maintenance of correct attachment of wooden propellers to their hubs

The organic characteristics of wood require particular and unusual considerations when establishing maintenance practices for the security of attachment of wooden propellers. The two principal considerations are the relatively low crushing strength of wood and the swelling and shrinkage of wood which occurs with increase and decrease of its moisture content. This latter consideration appears to be less relevant to the more modern wooden propellers which are, generally, thinner between the boss faces and have a more impervious surface finish. In general, in many of the older designs, the drive was transmitted from the crankshaft hub to the propeller boss by friction between the hub (or hub sleeve, in this case) and boss faces.

Because of the low crushing strength of wood, the propeller attachment bolts cannot be as heavily pre-loaded (torque tightened) as those for a metal propeller and are, consequently, liable to be in or close to a condition where engine/propeller loads can cause cyclic load variation in the bolts. The lower the pre-load in the attachment bolts, the greater is the possibility that there will be cyclic load variation in them and the more likely it will be that the bolts will suffer fatigue damage. An additional consequence of the low clamping forces exerted when bolt pre-load is low is an increased likelihood that the propeller will 'fidget' on the hub. This, in addition to causing bruising and fretting damage to the propeller boss clamping faces and bolt holes, may, in extreme cases, cause the boss faces to become charred. The wear caused by fidgeting will tend to decrease the insufficient clamping forces and thereby worsen the situation. If the attachment bolts become sufficiently loose they may tend to tip and consequently introduce cyclic bending into the bolt shank just below the head.

The retention of pre-load in a bolt depends both on the nut remaining stationary relative to the bolt thread and on the thickness of the assembly which is clamped between the nut and the bolt head remaining constant. The natural (unclamped) thickness of the boss of a wooden propeller varies with its moisture content which is influenced by changes in atmospheric conditions. Thus, once the retaining nuts have been set, the pre-load in the attachment bolts will increase if the wood swells and there will be an attendant risk of crushing the wood. This is likely to occur if the nuts have been tightened up when the propeller wood was very dry. Crushing resulting from pre-load may not be evenly distributed round the hub and can lead to an 'unsquare' condition which would result in some combination of bad tracking of the propeller blade tips and unequal blade pitch. Both of these conditions are conducive to propeller induced vibration. Conversely, if the propeller hub is fitted when the wood is moist and it dries out after the bolts have been tightened, the pre-load will reduce and the propeller retaining bolts will be subjected to cyclic loading and may suffer fatigue damage.

In some designs, in order to try to retain a more stable clamping force when propeller boss shrinkage or swelling occurs with climatic change, Belleville washers are used. These act as extremely high rate springs between the retaining nuts and the boss flange plate and allow the clamped thickness to vary over a very small range whilst minimising the resulting variation of clamping force. Belleville washers are usually, but not universally, used in the hub assemblies of older designs of wooden propeller. They have, theoretically, a more marked effect on the clamping stability of thicker propeller hubs where the difference in the moduli of elasticity of wood and steel and the potential for thickness variation with moisture content have the greatest significance.

Where Belleville washers, or similar, are not, by design, components of the hub (as is the case for the Gemini/Cirrus Minor installation), the clamping force exerted by the bolts will be dependent on the predominant short term (a few days) atmospheric conditions.

Maintenance of G-AKKH

This aircraft was being maintained to the CAA Light Aircraft Maintenance Schedule (LAMS) and no special conditions or out-of phase maintenance items, in particular any related to the propeller attachment, had been imposed. The organisation which had performed the most recent maintenance work on the aircraft had become responsible for it in February 2002, at which time the aircraft had accumulated a total flying time of 1,438 hrs. They performed an Annual Check on the aircraft at that time, during which a check of the security of the propeller attachment bolts was required and was recorded as having been completed on both propellers.

According to the requirements of the basic LAMS, the propeller tightness should be checked every 50 flying hours or 6 months. Following the maintenance in February, no further work was scheduled before the time at which the left propeller became detached in flight; at which time the aircraft had flown 24 hours since the Annual and was almost due for a 6 month check. Some unscheduled maintenance had been performed but none relating to the security of the left propeller. It was concluded that the security of both propeller attachments had been correctly maintained with reference to the approved schedule in force.

The propeller security was checked at a time when the wood would have been expected to have been in its most moist and swelled condition and the securing bolts at their coldest and therefore at their shortest length. The maintenance organisation's records show, however, that the aircraft had been in their heated hangar for some 10 days before this work was done and, as a result, the tightness of the nuts would have been checked in relatively warm and dry conditions. Following this maintenance, the aircraft would subsequently have been operated in winter conditions and this environmental change would have tended to alter the assembly into an effectively overtightened condition as the bolts shortened and the wood swelled. Since this propeller assembly does not have the clamping force stabilising effect of Bellville washers to compensate for these changes, this could have lead to some very slight crushing of the propeller which could have been exploited when the weather turned warmer.

Historical requirements for maintenance of the propeller attachment

During the investigation several mutually contradictory, legitimate, schedules for the maintenance of the security of the propeller attachment were found. The manufacturer's original Miles M-65 1A "Gemini" Aircraft Service Manual, dating from October 1946, required the tightness of the propeller attachment bolts to be checked every 10 flying hours. There was also the additional requirement, for newly fitted propellers, that the tightness of the bolts should be checked after two or three flights; this check being specified in both the 'Daily inspections' and in the '10 hour inspections'. No torque to which the nuts should have been tightened was given; this was not abnormal at the time that this Manual was compiled.

The engine manual, also dated 1946, contained a detailed description of the propeller attachment, but similarly did not specify a torque to which the nuts should have been tightened. This manual did not give any periodicity for checking the tightness of the nuts. Confusingly, this manual contained a cross-section illustration of the propeller hub assembly which suggested that Belleville washers should have been fitted between the retaining nuts and the hub front plate. However, these washers were not shown in the Illustrated Parts List, they were not shown in a photograph of the parts making up the assembly in the Manual and nor was any mention of them made in the manual text. The bolts of the right propeller hub of the incident aircraft were observed to be insufficiently long to accommodate the fitting of Bellvilles.

There was a Mandatory modification (AD), first issued in December 1946, applicable to the hub assembly of this engine type. This had been applied on the incident aircraft. The modification resulted in an increased area of the clamped surfaces on the front and back faces of the propeller boss. The requirement for this arose from the discovery of crushing and indentation damage to the clamped faces of a number of propellers which had resulted from tightening of the hub nuts.

In a later Engine Instruction Manual, issued by Bristol Siddeley in 1964, the Check 1 interval was set at 50 hours, which is the same as that for aircraft maintained to the LAMS Schedule. In this Manual, a Special Check was required if wooden propellers were fitted. This specified the intervals for checking the tightness of the propeller securing nuts. These were:- after the first flight following the fitting of a wooden propeller and after every subsequent 25 hours running.

Discussion

It would appear that, over time, the interval between checks of the security of the propeller, if the basic LAMS is followed, has been extended fivefold from its original period. In the case of this incident, the propeller separated from the aircraft less than 25 flying hours or 6 months after its last scheduled check, which was consistent with the most recent schedule published by the Type Certificate holder. Had the original schedule been in force, two intervening checks of the tightness would have been performed. It appears that, because the design of this assembly does not include the clamping stabilisation afforded by Bellville washers, it would be prudent to require the more frequent checking afforded by the original schedule.

In CAP 520, the CAA publication concerning Light Aircraft Maintenance, the need to consider 'customising' the LAMS for a specific aircraft type is stated with particular, though not exclusive, emphasis on mandatory requirements. Such items need to be recorded in CAP 543 which forms part of the schedule.

This investigation has shown that the general application of the basic LAMS schedule to historic aircraft may leave some of their less usual features inappropriately maintained. Although in this particular case the maintenance involved was restricted to the propeller attachment, there may be several areas in which the methods of construction and materials require more frequent maintenance than is usual with more modern constructions. As was seen in the original Gemini Service Manual, several items were scheduled for 10 hour, 20 hour and 40 hour maintenance intervals and it is most probably amongst these, and any items which may be seasonally affected, that requirements different from those of the basic LAMS may occur.

It is therefore recommended that:

Safety Recommendation 2004-104

The Civil Aviation Authority should, when approving the application of the Light Aircraft Maintenance Schedule to historic aircraft, review the appropriateness of the resulting inspection intervals against those of the original Maintenance Schedule, if this is available, and require out of phase maintenance actions where appropriate.

Figure 1a:-
Right propeller installation
(Spinner and lock plate removed)
Note NO Belleville washers

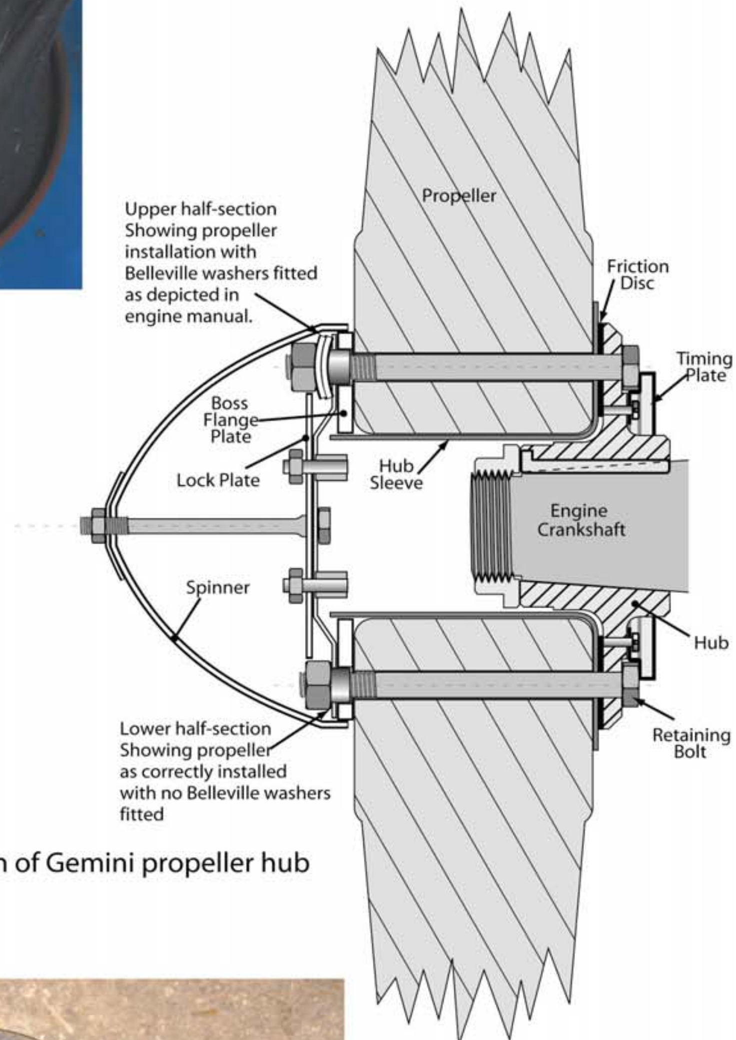


Figure 1:-
Cross section of Gemini propeller hub

Figure 2:- Aft face of left propeller (note elongated holes)

Aircraft Type and Registration:	Gulfstream AA-5B Tiger, G-BFZR
No & Type of Engines:	1 Lycoming O-360-A4K piston engine
Year of Manufacture:	1979
Date & Time (UTC):	15 October 2004 at 1545 hrs
Location:	1 mile west of Oxford Kidlington Airport, Oxfordshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 2
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damaged propeller, nose wheel leg and cowlings
Commander's Licence:	Private Pilot's Licence
Commander's Age:	31 years
Commander's Flying Experience:	1,020 hours (of which 5 were on type) Last 90 days - 40 hours Last 28 days - 15 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft, which had been parked outside for two months with each fuel tank less than three-quarters full, was subjected to a thorough pre-flight inspection that included the taking of fuel samples to check for water contamination. Shortly after departure the aircraft suffered a power loss necessitating a forced landing during which the nose landing gear collapsed. Subsequent examination of the fuel system revealed significant amounts of water in the fuel tanks, carburettor bowl, electric fuel pump filter and the fuel lines aft of the firewall. No water was evident from the four drains; one in each fuel tank and one in each sump tank.

History of flight

The pilot, a licensed engineer employed by the maintenance organisation, was demonstrating the aircraft to two potential buyers. He carried out a thorough pre-flight check, taking fuel samples before and immediately after refuelling and again just before the flight. He demonstrated this procedure to the sales manager who was overseeing the sale. On each occasion there was no water visible in any of the samples. A satisfactory power check was carried out using both fuel tanks, which were approximately three-quarters full for departure.

The aircraft lined up for takeoff with the right hand fuel tank selected. The fuel pump was selected on, in accordance with standard procedure, and a normal fuel pressure of 5.1 psi was observed. All engine indications were satisfactory and the aircraft accelerated normally after the brakes were released.

During the climb, at approximately 800 feet agl, the engine lost power suddenly and stabilised at about 1,500 RPM. The pilot responded by selecting the left fuel tank and applying carburettor heat, but was unable to restore power. During the subsequent forced landing, in a large field of recently sown crop, the nose landing gear leg collapsed but the uninjured occupants, who had all been wearing lap and diagonal harnesses, were able to exit the aircraft without difficulty using the aft-sliding canopy. Local fire services were called to the scene by ATC but were not required to assist.

The weather reported by the Oxford ATIS at the time of the accident was surface wind 270°/10 kt, visibility 10 km with a cloudbase at 2,900 feet, temperature +11°C, dew point +6°C and QNH 995 mbs.

Engineering inspection

The aircraft was recovered by road to Oxford Airport and inspected by another engineer employed by the same maintenance organisation. Damage to the propeller, cowlings and landing gear was consistent with the forces encountered during the forced landing and subsequent nose landing gear collapse. When the aircraft came to rest, part of the damaged engine cowling impinged upon the oil sump 'quick drain' valve, allowing most of the engine oil to drain away.

The aircraft has two fuel tanks, one located outboard of each wing root fairing, which feed into two sump tanks, one in each wing root fairing. There are four drains in the fuel system, one in each fuel tank and one in each sump tank. Samples taken from these after the accident revealed no evidence of water. However, the carburettor bowl, the electric fuel pump filter and the fuel lines aft of the firewall were found to contain significant amounts of rusty water. Visual inspection of the fuel tanks also revealed several large puddles of water in the remaining fuel. The inspecting engineer suggested that the sump drains might not have been at the lowest point of the system when the aircraft was parked.

Maintenance records showed that the fuel system was flushed on 15 March 2004. The aircraft then flew without incident for 30 minutes on 29 March and for 40 minutes on the 12 August 2004. From then until the accident flight it was parked outside with each fuel tank less than three-quarters full.

Previous occurrences

An accident report, in AAIB Bulletin No 11/2004, concerning a Gulfstream AA-5A, G-BGVW, describes a similar occurrence. Furthermore, an operator with considerable experience of the AA-5 mentioned a number of similar instances where pilots of the type had reported rough running. In each case, though the fuel tanks were drained during the pre-flight inspection until no water was present, subsequent examination of the fuel system revealed water in the fuel pump filter and carburettor bowl. On another occasion, three gallons of water were drained from the tanks of an aircraft that had been left outside for a long time. This was found to be due partly to poorly seated or perished fuel cap seals, which admitted water during wet weather.

Conclusion

Although the weather conditions at the time of the accident were conducive to carburettor icing at any power setting, it is most likely that the sudden loss of power was caused by the large amount of water present in the fuel system. The quantity of water present, and the type's reported history of fuel contamination, suggests that a considerable amount of water can collect in the system before causing engine failure, and that such an amount will not necessarily be detected by sampling fuel from the tank or collector drains alone.

Operators of all aircraft are reminded of the need to check the fuel system regularly for evidence of contamination. Pilots should be familiar with the position and operation of all drains provided for this purpose. Nevertheless, the absence of contaminants in fuel sampled in this way does not guarantee that the whole system is uncontaminated, particularly on aircraft such as the AA-5 which are not fitted with a strainer at the lowest point of the system or a drain associated with the fuel filter.

Aircraft parked outside with partially filled fuel tanks are particularly susceptible to water contamination both through condensation and by direct ingress through fuel filler caps. It is suggested that the entire fuel system of any aircraft stored in this manner should be thoroughly inspected immediately before flight.

Aircraft Type and Registration:	Piper PA-15 Vagabond, G-BOVB
No & Type of Engines:	1 Continental C85-12F piston engine
Year of Manufacture:	1948
Date & Time (UTC):	16 October 2004 at 1730 hrs
Location:	Whitefield's Farm, near South Molton, Devon
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew -1 (Minor) Passengers - 1 (Minor)
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	35 years
Commander's Flying Experience:	1,720 hours (of which 250 were on type) Last 90 days - 234 hours Last 28 days - 86 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and further enquiries by the AAIB

History of the flight

The pilot had landed the aircraft at the farm strip during the afternoon after an uneventful flight from South Molton Airfield. After visiting the farm house with his passenger, he prepared for a short onward flight to Eaglescott Airfield. The pilot had previously visited the field by car to assess its suitability, and checked it again by foot prior to departure. The field itself, at an elevation of 600 feet, is approximately 320 metres in length between a farm drive and a hedge, and is bounded on its northern side by trees and woodland. The available take-off direction is east-west, with a slight upslope followed by a marked downslope when taking off to the east, as the pilot intended to do. Weather reports were obtained from Exeter and Bournemouth Airports, timed at 1500 hrs. These reported a surface wind from the north-west, good visibility but with rain showers. Cloud was reported between 2,000 and 2,500 feet. The pilot estimated the surface wind at the farm to be from the north at 5 kt, and observed an isolated shower about 3 nm north of the farm. Surface temperature was estimated to be 8ºC.

The pilot started the engine and taxied along the strip over grass that he described as damp in places. There was 16 kg of fuel on board at this stage, which was a mixture of AVGAS and MOGAS in an approximate ratio of 4:1. Whilst taxiing, the pilot applied carburettor heat for between 20 and 30 seconds. Power checks and take-off checks were completed with no abnormalities noted and the pilot applied carburettor heat, as required by the checklist, for approximately 10 seconds. The aircraft was not equipped with wing flaps.

The takeoff itself appeared normal initially, with a satisfactory acceleration noted as the aircraft passed 50 mph airspeed. The field was similar in length to the pilot's home strip, and he considered that take-off performance was normal. Soon after becoming airborne the pilot sensed that it was not climbing as it should. The rate of climb reduced and became a gradual rate of descent, causing the aircraft to fly parallel to the sloping field. Beyond the take-off field was a further large field and the pilot decided to carry out a forced landing into it. However, the aircraft did not clear the hedge at the end of the take-off field, striking the upper part of the hedge with its main wheels. The aircraft pitched forward and landed on its main wheels in the field beyond. The propeller struck the surface and the aircraft continued to pitch forward until it inverted, sliding for a short distance. The pilot and his passenger sustained cuts and bruises but were able to vacate the aircraft through the right hand door. Both seats had maintained integrity and the lap straps and diagonal harnesses had prevented more serious injuries. However, the fire extinguisher had detached from its mounting bracket, causing damage to the discharge nozzle which would have prevented its use.

There was no fire but fuel was seen to be leaking from the filler cap. As a precaution the pilot telephoned the fire brigade who arrived soon after, accompanied by the police and ambulance service. The aircraft sustained extensive damage in the accident and was subsequently written off.

Meteorological information

An aftercast was obtained for the Whitefields Farm area for the time of the accident. The 2,000 feet wind was from 360º(M) at 15 to 20 kt and the 1,000 feet wind was from 360º(M) at 15 kt, giving a likely surface wind from 350º(M) at 7 to 12 kt. Visibility was 20 to 30 km, reducing to 10 km in showers. There was scattered cumulous cloud at 2,000 to 2,500 feet, increasing in amount in showers. The surface temperature was 11ºC and the dew point was 7ºC, giving a humidity of 76%.

Analysis

The pilot provided a very full report and considered some of the possible causes. He did not recall any unusual engine noises or changes of engine note during the takeoff. Fuel contamination was unlikely as samples taken before and after the accident were clear, and the previous flight had not shown any symptoms of contamination. The pilot and passenger both recalled the airspeed check at

50 mph and, as the initial climb-out speed is 55 to 60 mph, the pilot thought it unlikely that the aircraft got airborne at a significantly slower speed. He does not recall any unusual control requirements and does not believe that the aircraft was close to the stall when it first became airborne.

The throttle control was still in the fully open position after the accident and the friction control nut was tight. The engine showed no obvious signs of an internal mechanical failure. The weight and balance of the aircraft were within prescribed limits.

The northerly wind, combined with the presence of large trees to the north of the field suggested the possibility of unusual local wind effects that may have adversely affected the aircraft's performance. However, the pilot's own estimate of the surface wind was close to the aftercast wind and although there was the possibility of a slight tailwind, the conditions were unlikely to have generated a situation that exceeded the performance capabilities of the aircraft.

The combination of temperature and dew point indicate that a *'serious'* icing risk existed at all power settings, and this risk was further increased by the damp grass. The pilot reported that the aircraft had been stationary with the engine running in an area at the side of the field which was wetter than the rest of the field, which would also have increased the risk. The use of MOGAS further increases the risk of carburettor icing due to its increased volatility and higher water content. Given the prevailing conditions, the carburettor heat application prior to takeoff may not have been sufficiently long enough to completely clear any ice that may have formed.

The pilot, and others who flew the aircraft regularly, had only infrequently encountered carburettor icing in this aircraft. However, in the absence of other evidence, the possibility that carburettor icing caused a loss of power on takeoff cannot be ruled out.

Aircraft Type and Registration:	Piper PA-28-151 Warrior, G-BDGM
No & Type of Engines:	1 Lycoming O-320-E3D piston engine
Year of Manufacture:	1974
Date & Time (UTC):	28 October 2004 at 1430 hrs
Location:	Netherthorpe, Yorkshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 Passengers - N/A
Nature of Damage:	Engine fire - damage to both wings and landing gear
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	22 years
Commander's Flying Experience:	1,550 hours (of which 650 were on type) Last 90 days - 85 hours Last 28 days - 62 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft was departing from Runway 24 at Netherthorpe. With approximately 150 metres of the marked runway remaining, the pilot realised that the aircraft would not reach flying speed and aborted the takeoff. However, there was insufficient runway remaining to stop the aircraft before it struck a hedge at the airfield boundary and caught fire.

History of flight

While carrying out an engine run-up before takeoff, the pilot noticed a significant drop in RPM when operating on one magneto and, believing this to be due to moisture in the ignition system, leaned the mixture and continued to run the engine in an attempt to rectify the problem. After satisfying himself that the engine was running normally, he lined up for departure.

The pilot used a "short field" take-off technique, which involved setting two stages of flap and applying full power against the brakes before commencing the take-off run. With the aircraft stationary the engine produced approximately 2,200 RPM at full throttle and, after the brakes were released, the acceleration appeared normal, with RPM rising as airspeed increased. However, approximately 150 metres from end of the marked runway, the pilot realised that the aircraft would not reach sufficient speed to become airborne safely and decided to abandon the takeoff. He retarded the throttle and applied the toe brakes but, judging that the aircraft would not stop before hitting the airfield boundary, raised the nose slightly in an effort to cushion the inevitable impact. This caused the aircraft to become airborne very briefly before hitting a hedge and catching fire. The pilot, who had been wearing a lap and shoulder harness, suffered light bruising and whiplash. He turned off the battery master switch and fuel before exiting the aircraft. The airfield fire crew, who had been watching the departure, reached the scene shortly after the aircraft came to rest and quickly extinguished the fire using foam.

Airfield

Netherthorpe has four grass runways. Runway 06/24 is 553 metres long, has a take-off run available (TORA) of 490 metres, and slopes uphill with a gradient of 1.9% in the Runway 24 direction. Markings showing the south-western end of Runway 24 are placed approximately 146 metres from the airfield boundary. Runway 18/36 has a total useable length and TORA of 382 metres. The airfield is considered challenging by many that use it and the airfield operator insists on briefing pilots who are unfamiliar with it before their intended flight. Before departure, the pilot noted that Runway 24 was in use by other aircraft and decided that it was the most favourable runway for departure in the prevailing conditions. At the time of the accident the unofficial airfield weather report gave a southerly wind at 10-15 kt and a temperature of 10°C. The pilot assessed the runway as damp.

Aircraft performance

The operator provided performance and weight and balance information for G-BDGM, a PA28-151, which is the least powerful of the Warrior family of four seat tourers. The maximum permitted take-off weight of this aircraft is 1,054 kg. With approximately 98 kg of fuel and one pilot onboard, the estimated all-up weight of G-BDGM on departure from Netherthorpe was 857 kg. The performance section of the flight manual indicates that at this weight, from a dry, level and paved runway the take-off run required (TORR) is approximately 400 metres and the take-off distance required (TODR) to clear a 50 foot obstacle is 497 metres.

Safety Sense leaflet (SSL) 7B titled "*Aeroplane performance"*, published by the CAA, advises that take-off distance required should be increased by 30% for wet grass and by a further 10% for an uphill slope of 2%, giving a TODR of 707 metres. Using the same factors, the TORR is 570 metres.

However, the effect of slope and surface condition is proportionally greater on the ground run than on the take-off distance as a whole, and consequently the TORR is likely to be greater than 570 metres. SSL 7B recommends that TODR be increased by a further 33%, as required for Public Transport flights, to account for variations in technique, aeroplane condition and environmental factors, giving a TORR of at least 758 metres and a TODR of 940 metres.

Engineering inspection

After the aircraft was recovered to the airfield parking area, the engine was removed and taken to a repair facility. Unfortunately, the magnetos were returned to the manufacturer before inspection. However, inspection of the remaining components did not reveal any condition that might have contributed to the rough running experienced during the run-up.

Conclusion

It was not possible to determine if the engine was producing normal power during the take-off run. Even if it was, it is likely that there was insufficient runway available for a safe departure in the prevailing conditions.

The pilot reported that, although he considered the runway suitable for a safe takeoff, he thought that the accident might have been caused by a combination of the runway state, the prevailing conditions and a reduction in engine performance that was not obvious at the start of the take-off run.

Aircraft Type and Registration:	Piper PA-28R-200, G-BHIR
No & Type of Engines:	1 Avco Lycoming IO-360-C1C piston engine
Year of Manufacture:	1969
Date & Time (UTC):	21 August 2003 at 1315 hrs
Location:	Near Tatenhill Airfield, Staffordshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Serious) Passengers - N/A
Nature of Damage:	Substantially damaged
Commander's Licence:	Private Pilot's Licence
Commander's Age:	66 years
Commander's Flying Experience:	654 hours (of which 230 hours were on type) Last 90 days - 9 hours Last 28 days - 7 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and AAIB inquiries

Synopsis

A sudden loss of engine power shortly after takeoff forced the pilot to land the aircraft in a field. The landing was made with the landing gear retracted but the only available field was short and the aircraft over-ran and collided with trees, tearing off both wings and injuring the pilot. The power loss was caused by release of one of the engine connecting rods from the crankshaft due to fracturing of the big-end bolts. One of the bolts showed signs of extensive low-cycle fatigue cracking, consistent with the nut having been loose and it was possible that the nuts had not been adequately torque tightened during the last engine overhaul. The available evidence however, was limited by component damage and did not allow the cause of the engine failure to be positively determined.

History of flight

The aircraft, which was owned and operated by a flying group, had been at Tatenhill Airfield for maintenance work on the cockpit instrumentation. The pilot took-off from the airfield

(450 feet amsl) in good weather conditions at around 1410 hrs, with the intention of returning to the aircraft's base at Liverpool. In accordance with normal practice he reduced power at approximately 400 feet agl to the climb setting of 25 inches manifold pressure and 2,500 RPM. A short time later, at a height of approximately 850 feet agl, the engine made a rumbling noise and suddenly lost power. The pilot selected the gliding attitude, switched to the other fuel tank and checked the magneto switches but the engine did not restart. Oil then began to deposit onto the windscreen and the pilot made a MAYDAY radio call and attempted to locate a suitable field for a forced landing.

The pilot's distress call was heard by the crew of a second aircraft that had taken off from Tatenhill shortly before G-BHIR. The commander, aware that the A/G Radio at the airfield was unmanned, attempted to contact the London Information Distress & Diversion Cell; he was unable to make contact but a message was relayed by another aircraft. The crew of the second aircraft then began to search for G-BHIR.

When at around 550 feet agl, G-BHIR's pilot spotted a long field and headed for it. However, as he approached the field he saw that it was obstructed by transmission lines crossing the landing threshold end and turned left towards a second, shorter field, which was the only available alternative. He opted to leave the landing gear retracted to reduce the risk of pitching inverted on landing and had previously unlatched the cabin door. After touchdown, the aircraft slid across the ground on its belly before encountering a copse near the field boundary and coming to a halt. At this point the pilot was aware of an injury to his left shoulder, apparently due to impact with the control yoke.

The pilot exited the aircraft and phoned the emergency services, passing his position obtained from his Global Positioning System. A Police helicopter and an air ambulance helicopter were dispatched to attend the scene. The aircraft was largely hidden by the trees so the pilot walked into the centre of the field to enable the helicopter crews to locate him. He was later diagnosed with a fractured collar bone.

Accident site

Information on the accident site was obtained from the pilot's report, from an Engineer from a local aircraft maintenance company who assisted with recovery of the aircraft and from a subsequent site visit by the AAIB. The Staffordshire Police supplied a plot of the ground marks and wreckage distribution.

The evidence showed that G-BHIR had landed on an easterly track in a field measuring approximately 300 metres in the landing direction. In the area of the touchdown the ground, which was generally firm and covered with short grass, sloped gently downwards in the direction of landing.

The ground markings and aircraft damage characteristics indicated that the touchdown had been gentle, with the landing gear retracted, and that the aircraft had initially skipped. Markings showed that the propeller had been turning. Approximately 155 metres after initial touchdown the aircraft entered a small wood at the field boundary; the fuselage passed between two substantial trees but the wings then struck the trees and were both torn off. The aircraft came to rest very shortly afterwards, with the forward fuselage positioned above a stream and just short of a number of large trees. There was no fire.

Aircraft examination

The engineer who attended the site found that there was engine oil deposited on the aircraft's windscreen and fin leading edge. Two pieces of the engine crankcase were lying in the field a short distance before the start of the aircraft touchdown markings. The engine was removed and strip examined under AAIB supervision.

The Avco Lycoming IO-360 is a four-cylinder, horizontally-opposed reciprocating engine with a rated maximum power output of 200 shp at 2,700 RPM. Each connecting rod is attached to the crankshaft by a split, plain bearing retained by a bearing cap. The assembly is secured by two bolts, each passing through integral bosses formed on the connecting rod and the cap and retained by a nut. The nuts are not split-pined or otherwise positively locked but are meant to be retained by correct torque loading. It is intended that this is obtained on assembly by tightening the nut to achieve the required stretch in the bolt, which is designed to have an accurate unstretched length. The nut is initially tightened to 35 lb-ft torque and the torque progressively increased while checking the bolt length against a gauge. If the required stretched length is not obtainable with a maximum torque of 55 lb-ft the bolt should be rejected.

Examination of the engine found that the No 2 connecting rod big-end had disconnected from the crankshaft. The connecting rod had suffered severe impact damage and an approximately 6 x 8 inch hole had been punched in the upper left part of the crankcase. Both halves of the crankcase had fractured and the other internal components in the region of the No 2 cylinder had been severely battered and deformed. The damage was fully consistent with the effects of impact by the No 2 connecting rod while the engine had been turning and there was no evidence that any other malfunction had occurred.

The cap from the No 2 connecting rod was not recovered and it appeared likely that it had been ejected when the engine failure occurred. One big-end bolt was recovered from the engine, fractured roughly in half, with the thread generally intact but with the nut absent. Part of a nut was also found, severely impact damaged. Neither the bolt nor the nut showed signs of in-service damage to the threads. A portion of the second bolt, consisting of the head and upper shank, was found on site in the stream. It had suffered severe machining damage and showed signs of associated over-temperature effects; markings indicated that this had probably been caused by repeated contact with the No 2 big-end components after the bolt portion had detached, migrated and become embedded in the crankcase. Both bolts carried the part number 'SL75060 FAA-PMA'.

Detailed examination, by a materials specialist, found that evidence indicating the mode of fracture of the bolts had generally been obliterated by heavy mechanical damage to the fracture surfaces. However, features of the least damaged fracture face indicated that the separation had resulted from a fatigue mechanism and that this had involved high tensile stress over a very low number of cycles. This was consistent with the effects of engine operation with the bolt nut inadequately torque tightened. The big-end bolts for No 3 and No 4 connecting rods were found to be adequately torque-tightened (between 50-55 lb-ft) but substantial damage to the No 2 big-end cap and bolts prevented meaningful checks of their tightening torques.

Aircraft background

The engine had been repaired in late 2002 after metal debris had been found in the engine oil filter. The crankshaft had been replaced at this point. Following the repair the engine had accumulated approximately 115 flying hours at the time of the accident.

Discussion

The engine disruption and sudden loss of power had been caused by the release of the No 2 connecting rod from the crankshaft as the result of separation of the big-end cap from the connecting rod. A number of the relevant parts of the big-end assembly were not recovered, probably having been ejected through the hole in the crankcase in flight, and the parts of the big-end bolts and nuts that were recovered had been severely damaged. However, there was clear evidence that at least one of the bolts had suffered extensive low-cycle fatigue cracking before fracturing and the features of the fatigue were consistent with the nut having been loose while the engine had been operating. It was possible that the failure had resulted from inadequate torque tightening of the nut at the last engine overhaul but, in the absence of some of the parts, there was insufficient evidence to positively determine the cause.

Aircraft Type and Registration:	Piper PA-34-200 Seneca, G-BETT
No & Type of Engines:	2 Lycoming IO-360-C1E6 piston engines
Year of Manufacture:	1971
Date & Time (UTC):	22 July 2004 at 1630 hrs
Location:	Field in Frinstead area, near Maidstone, Kent
Type of Flight:	Private
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - 2 serious Passengers - N/A
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Private Pilot's Licence
Commander's Age:	66 years
Commander's Flying Experience:	7,500 hours (of which 25 were on type) Last 90 days - 60 hours Last 28 days - 25 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

History of the flight

The aircraft was being flown on a Continued Airworthiness Flight Test (CAFT) from Biggin Hill Airport in Kent as part of the Certificate of Airworthiness renewal process. The flight test pilot was flying in the left hand seat, with the aircraft owner flying as second pilot and observer in the right hand seat. The aircraft was prepared for flight with full fuel tanks and subjected to a thorough pre-flight inspection. All engine ground checks were completed in accordance with the flight test schedule. The aircraft departed Biggin Hill at 1552 hrs in conditions of light wind and good visibility with scattered cloud at 2,500 and 5,000 feet. The temperature was 20º C and dew point 13º C. After departure, the pilot was transferred to the approach controller and reported that he would be operating at 2,400 feet initially. He was subsequently asked to report when ready to recover to the airport. No further transmissions were made from the aircraft.

The flight test schedule called for an in-flight engine shut down and single engine climb. The right hand engine was shut down and the propeller was feathered. The climb rate was as expected, with the left hand engine behaving normally on maximum continuous power. The right hand engine was then re-started and, although the flight test schedule did not require it, the crew decided to repeat the exercise on the other engine. The right engine did not start as readily as expected but, once running, was allowed to warm up before the left engine was shut down and the single engine climb manoeuvre repeated. The pilot reported that the aircraft was at about 3,000 feet at this stage. After about 30 to 45 seconds into this single engine climb, the right hand engine experienced a sudden power loss, reducing to approximately 1,200 RPM, and did not respond to throttle movement. The pilot was not sure if the engine was running at reduced power or windmilling.

The pilot's first action was to attempt to re-start the left engine. The second pilot recalled that the left engine un-feathered but did not start, whilst the pilot reported that the engine did not un-feather, despite oil and fuel pressure and a healthy battery. The second pilot directed the pilot to concentrate on flying the aircraft while he attempted to start the engines. Suspecting that the engines were flooded, he selected the throttles fully open and set the mixtures off, expecting the engines to fire and recover, but they did not. The pilot reported that the fuel booster pumps were most probably selected off initially, but that he would have selected them on when it became clear that the engines were reluctant to start.

Both pilots expected to be able to re-start at least one engine. However, with the aircraft at a very low altitude and with reducing airspeed, the pilot realised that a crash landing was imminent and warned the second pilot. There was no time or altitude to manoeuvre the aircraft further and, with landing gear and wing flaps retracted, the pilot carried out a crash landing into a cornfield immediately ahead of the aircraft. After impact the aircraft ran onto softer ground and came to rest against a fence after a short ground slide of about 80 feet.

The aircraft sustained a major fuselage fracture aft of the wing and was written off. Both pilot seats and the cockpit area had distorted under the vertical deceleration although the main door operated normally and was used by the crew to escape from the aircraft. The pilot suffered a broken eye socket and broken wrist and was assisted out of the aircraft by the second pilot who suffered broken bones in his back and ribs. There was no fire. The second pilot alerted the emergency services using his mobile telephone.

Continued Airworthiness Flight Testing

Pilots proposing to carry out CAFT on aircraft under 5,700 kg maximum all-up weight (AUW) must be acceptable to the CAA in terms of flying experience and recency and must be briefed by the CAA prior to undertaking CAFT activity. The pilot of G-BETT met these requirements in all respects. In briefing such pilots, the CAA seeks to be satisfied that that the pilot concerned fully understands the significance and intent of the flight test as well as the techniques used to minimise any associated risk. The scenario of an engine failure during the single engine climb phase is considered during this briefing; the advice to pilots is to first attempt a re-start of the shut-down engine, as the pilot of G-BETT did.

The accident flight was conducted in accordance with Flight Test Schedule No 3, issue 2, which is applicable to twin, piston-engined, unpressurised aeroplanes up to 5,700 kg maximum AUW. The schedule lists the minimum flight conditions and stipulates a minimum of 3,000 feet above terrain for the single engine climb. The schedule calls for the climb performance to be recorded with the operative engine at maximum continuous power and with the inoperative engine's propeller feathered. The schedule allows the climb to be conducted with either engine inoperative, but there is no requirement for the climb to be repeated on the other engine.

Discussion

Both pilots thought that the indications of the initial power loss suggested an interruption of fuel to the right engine. The aircraft had not been flown for some time before the flight and was fuelled to full for the accident flight. Routine checks for water contamination were carried out and a post accident inspection showed that uncontaminated fuel was present in the associated fuel lines, pumps and filters. All magnetos on the aircraft had recently undergone overhaul and operated correctly when tested after the accident.

The aircraft owner had previously experienced cases of fuel flooding during warm engine starts on Seneca aircraft fitted with Lycoming IO-360 engines. Although there was no obvious cause for the power loss to the right engine, he was of the opinion that the re-start attempts failed for this reason. Enquiries with other Seneca operators supported the view that it is quite possible to flood the engine during a re-start, particularly if the fuel booster pump is on. However, the pilot of the accident aircraft did not think this was likely and believed he would have recognised the symptoms of a flooded engine.

Aircraft Type and Registration:	Robin DR400/180 Regent, G-FTIL
No & Type of Engines:	1 Lycoming O-360-A3A piston engine
Year of Manufacture:	1988
Date & Time (UTC):	26 September 2003 at 1510 hrs
Location:	Little Staughton Airfield near Bedford, Bedfordshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Nose landing gear and propeller damaged. Engine shock loaded
Commander's Licence:	Private Pilot's Licence
Commander's Age:	44 years
Commander's Flying Experience:	102 hours (of which 16 were on type) Last 90 days - 13 hours Last 28 days - 4 hours
Information Source:	AAIB Field investigation

History of flight

The aircraft was being flown to Little Staughton Airfield for some pre-arranged scheduled maintenance. The weather at Little Staughton was CAVOK with a surface wind from 250° at 10 kt. Shortly after a normal landing on Runway 25 the aircraft veered violently to the left and the nose landing gear (NLG) collapsed. The propeller contacted the ground, the engine stopped and the aircraft slid approximately 20 metres before coming to rest 5 metres from the edge of the runway.

Background information

The Robin DR400 has a fixed tricycle landing gear with a steerable nose wheel. The NLG is somewhat unconventional in that the oleo is offset to one side of the steering pivot axis. Two support plates located on the upper half of the oleo outer cylinder attach the nose leg to the steering pivot mechanism (see Figure 1). The upper support plate is braced by a diagonal tube, which is welded at its lower end to the side of the outer cylinder, the vertical landing gear loads being reacted as compression in this tube and tension in the upper support plate. The steering input rod is connected to the upper support plate. Both the upper and lower support plates are normally attached to the outer cylinder by circumferential fillet welds around the lower side only of each support plate.

There is a history of in-service problems of cracking in the circumferential weld of the lower support plate and of cracking in the strap section in the area under the nose wheel lock. To address these problems, the aircraft manufacturer, Avions Pierre Robin (now Apex Aviation), issued Service Bulletin (SB) No 101 in 1983, which is classified as mandatory and requires a repetitive dye penetrant inspection of the lower support plate and the weld. The latest revision of SB 101, Revision 3, does not permit any weld repairs to be carried out and, if cracks are found which are in excess of the allowable limits quoted in the SB, the NLG must be returned to the manufacturer for repair. In March 1982 the Bureau Veritas, France issued Airworthiness Directive (AD) No 83 206(A)R3 which mandated the manufacturer's SB 101. There is no requirement in SB 101 or the AD to inspect the upper support plate or its weld.

Engineering examination

The initial examination of the nose landing gear indicated that a possible fatigue failure may have occurred in the region of the upper support plate. The nose landing gear was submitted for a detailed metallurgical examination. This examination confirmed that a fatigue failure had occurred in the narrow strap section of the upper support plate (see Figure 1) which had been the result of normal in-service loads and circumferential separation of the fillet weld between the upper support plate and the outer cylinder. The weld was found to be of very poor quality. The cross-sectional dimensions of the weld were inadequate around the complete circumference for the type of joint and there was gross gas porosity in the area of the separation. Further examination revealed gross gas porosity throughout the complete circumference of the weld. The examination also revealed that the weld had been made using a Gas Tungsten Arc Welding method (more commonly known as the Tungsten Inert Gas (TIG) method) and that it was the original manufacturing weld.

G-FTIL's nose landing gear history

In February 1993 the aircraft had a landing accident (AAIB Bulletin 4/93) during which the nose landing gear was damaged. The aircraft repair organisation replaced the NLG with a new item supplied by the manufacturer's UK agent. This replacement NLG which was manufactured in 1978 had completed approximately 2,700 landings prior to its failure.

Previous accident to a DR400 aircraft G-BJUD

In November 2001 the nose landing gear of a DR400 aircraft, G-BJUD, collapsed on landing (AAIB Bulletin 8/2002). The investigation established that fatigue cracking had occurred in the narrow strap sections of the upper support plate which progressed to the extent that the weld was no longer capable of maintaining structural integrity under normal in-service loads and failed in tensile overload causing the NLG to collapse. It was noted that the upper support plate had been welded both top and bottom to the oleo outer cylinder, the top weld being unapproved and added sometime after manufacture by an unknown person. The bottom weld, made when the NLG was manufactured, was found to have poor penetration into the parent material and excessive gas porosity. The NLG was manufactured in 1986.

Welding requirements

At the time that the NLGs for G-FTIL and G-BJUD were manufactured it is understood that the aircraft manufacturer was using a military standard for welding called 'Norme Air 0191' and individual welders were qualified under section 'L'institut de soudure' of this military standard. There is no procedure within the French civil aviation regulations which stipulates this military standard. The European standards for welding practices and procedures in aerospace are currently being developed and written but already in existence are Euro Norms (EN's), that are not aerospace specific, but which give general guidelines for practices and procedures that should be incorporated into national requirements. In France the EN's are incorporated into the Association Frangaise de Normalisation (AFNOR) standards.

Safety Recommendations

Safety Recommendation 2004-86

It is recommended to the manufacturer, Apex Aviation, that Service Bulletin 101 be re-issued to include the inspection of the Upper Support Plate in the same areas as those specified on the Lower Support Plate.

Safety Recommendation 2004-87

It is recommended that the Director Generale de L'Aviation Civile (DGAC), France as lead agency for the European Air Safety Agency (EASA), re-issue Airworthiness Directive No 83-206(A) to include the inspection of the Upper Support Plate in the same areas as those specified on the Lower Support Plate.

Safety Recommendation 2004-88

It is recommended that the Director Generale de L'Aviation Civile (DGAC), France assess the standard of welding made by Apex Aviation to ensure that it meets the European and French requirements and standards for the manufacture of aviation components.

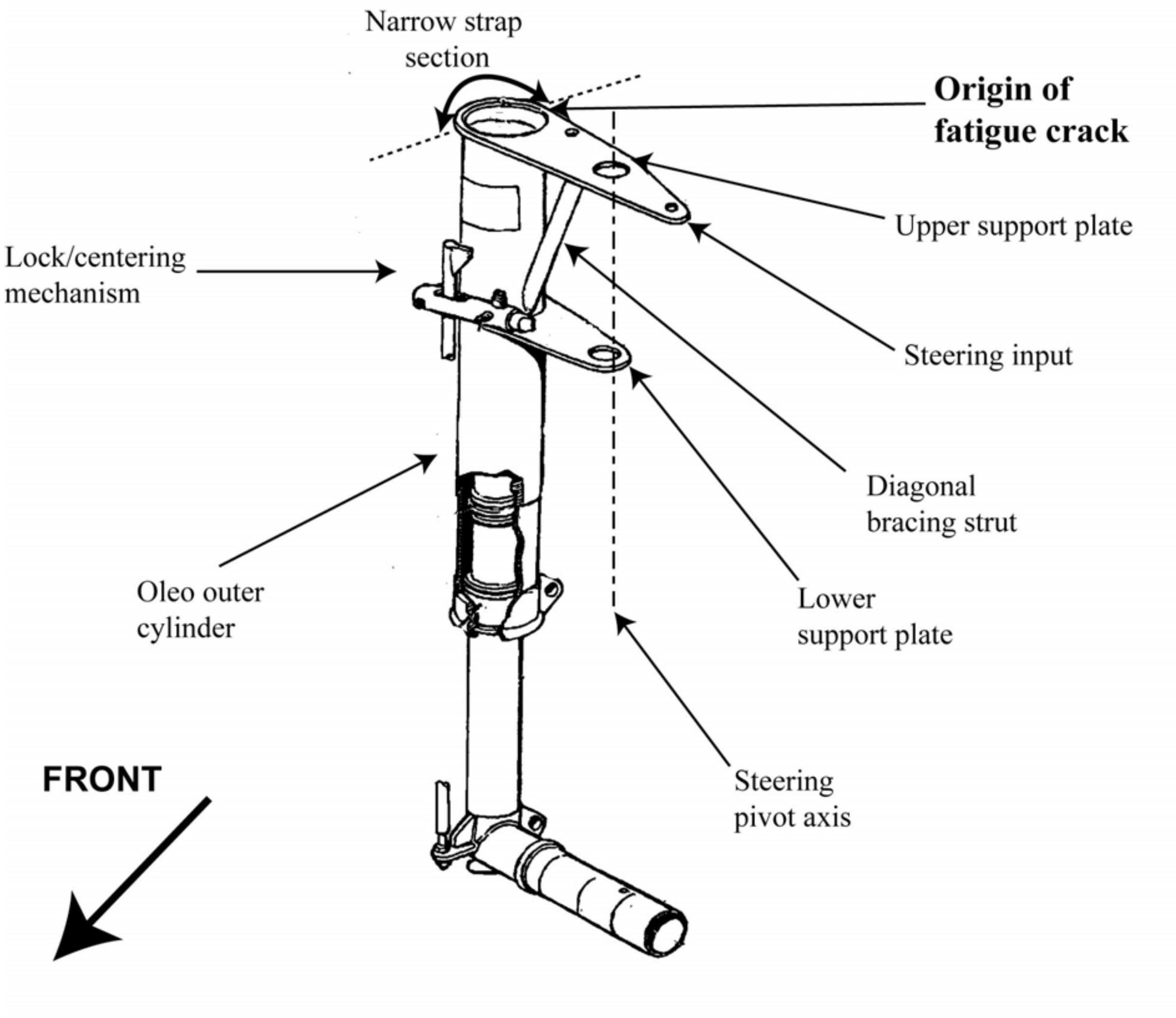


Figure 1 Robin DR400 NLG showing fatigue crack location

Adapted from a manufacturer's drawing

Aircraft Type and Registration:	Vans RV-6A, G-RVCG	
No & Type of Engines:	1 Lycoming O-320-3DG piston engine	
Year of Manufacture:	2001	
Date & Time (UTC):	1 September 2004 at 1545 hrs	
Location:	Wellesbourne Mountford Aerodrome, Warwick	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 1
Injuries:	Crew - None	Passengers - None
Nature of Damage:	Nose leg bent	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	69 years	
Commander's Flying Experience:	1,235 hours (of which 4 were on type) Last 90 days - 16 hours Last 28 days - 8 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot plus information from eye witnesses	

History of the flight

The pilot, who was not the owner, was performing a test flight on this amateur-built aircraft on behalf of the Popular Flying Association (PFA). This was the second flight of the day and the ninth landing since the aircraft was first flown.

The pilot reports that he had been airborne for some 95 minutes and returned for a landing on Runway 18 at Wellesbourne Mountford, an asphalt runway with a landing distance available of 912 metres. The pilot made what he considered a good landing and he opened the throttle with the intention of making it a 'touch-and-go'. At this point, he reports, the nosewheel seemed to make contact with the runway and, because he heard a 'grating' sound, the pilot decided to abandon the takeoff. The grating sound continued and the aircraft was brought to a slow halt within the remaining length of the runway.

Examination

After vacating the aircraft in the normal way the pilot saw that the nose leg was bent and that the yoke carrying the nosewheel had 'tucked under' (rotating rearwards) so that the nose of the aircraft was resting on this yoke. The pilot was surprised to see the nose leg distorted as he had expected to find that the nose tyre had deflated.

The RV-6A is a development of the very popular and widespread RV-6 side-by-side kit-built aircraft. The RV-6 is a tailwheel aircraft and for the RV-6A a simple nose leg assembly was added, with a steel leg attached to the engine mount and protruding forward to a free-castoring yoke and nosewheel, similar to the design of that fitted to the Grumman AA5 series of light aircraft. The AAIB has been notified of a total of three notifiable accidents, all minor, to RV-6A aircraft in the UK. Of these, two (G-BVRE on 21 April 2001 and G-HOPY on 4 September 1999) involved collapse of the nose leg.

In this accident the nosewheel yoke showed distinct marks from having scraped along the surface of the asphalt and the added drag from this abrasion would have generated further distortion of the leg. It was considered possible that excessive torque applied in the assembly of the nosewheel into the yoke could have generated high drag loads in the noseleg but the assembly torque appeared normal and the tyre did not show signs of skidding. A metallurgical test of the noseleg showed that the leg met the design specification.

It is likely that the leg was deflected by a vertical load at some point along the runway. Reports from a number of eyewitnesses suggest that the noseleg may have been subjected to a higher vertical load during the attempted touch and go sequence than the pilot appreciated, causing deflection so that the yoke contacted the runway surface.

INCIDENT

Aircraft Type and Registration:	Cessna 172S, G-CCTT	
No & Type of Engines:	1 Lycoming IO-360-L2A piston engine	
Year of Manufacture:	1999	
Date & Time (UTC):	7 December 2004 at 1430 hrs	
Location:	Caernarfon Airport, Gwynedd	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 1
Injuries:	Crew - None	Passengers - None
Nature of Damage:	Minor damage to nosewheel bracket	
Commander's Licence:	JAA Private Pilot's Licence	
Commander's Age:	64 years	
Commander's Flying Experience:	154 hours (of which 9 were on type) Last 90 days - 10 hours Last 28 days - 4 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

The approach to Runway 02 was normal, with full flap selected and the airspeed stabilised at 70 kt. The aircraft touched down at an estimated 65 - 70 kt, prior to the intersection with Runway 08/26, but bounced and then climbed rapidly. The pilot applied nose-up elevator control, but this failed to prevent a second bounce, during which the nose wheel contacted the runway heavily. He then applied power and executed a go-around. The weather conditions were good, with the wind at 020º/03 kt.

On the second approach, the flaps failed to operate when selected and it was observed that the flap system circuit breaker had tripped. The circuit breaker was reset, but the problem remained. A second, flapless landing was completed without incident.

The pilot was not certain that the flaps had reached the fully down position after selection on the first approach as he had not heard them running, due to the noise of radio transmissions from other aircraft in the circuit. In his opinion, the incident had been caused by a combination of the upslope of the runway and the flaps possibly failing to fully extend. The latter point he felt was reinforced by the rapid climb after the first bounce and the fact that there was no noticeable change in attitude on retracting the flaps from fully down to the second stage position on the go-around. Nevertheless, the flaps must have operated at some point during the go-around, as they were in the fully retracted position prior to commencing the second approach. Subsequent examination of the aircraft revealed minor damage to the nose landing gear attachment bracket.

Volume 1 of the Air Pilot's Manual (Trevor Thom) which covers the flying training aspects of the JAR PPL training syllabus, provides the following advice on how to deal with a bounce on landing:

> *'An inexperienced pilot should consider an immediate go-around following a bounce. With experience, however, a successful recovery from a bounce can be made (provided that the runway length is adequate), by relaxing the back pressure and adding power if necessary to reposition the aeroplane suitably to recommence the landing'.*

Aircraft Type and Registration:	Robinson R22 Beta, G-BYTD	
No & Type of Engines:	1 Lycoming O-360-J2A piston engine	
Year of Manufacture:	1999	
Date & Time (UTC):	13 October 2004 at 0845 hrs	
Location:	Between Brafield and Hackleton, near Sywell, Northants	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - None
Injuries:	Crew - Minor	Passengers - N/A
Nature of Damage:	Aircraft destroyed	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	50 years	
Commander's Flying Experience:	77 hours (all on type) Last 90 days - 5 hours Last 28 days - 1 hour	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

History of flight

The pilot took off from Sywell Aerodrome at about 0830 hrs on a solo flight. The pilot recalled checking the carburettor temperature gauge on leaving the airfield's air traffic zone and seeing that it was indicating above the yellow avoid arc. He nevertheless decided to apply still more carburettor heat to ensure the gauge needle indicated well clear of the yellow arc.

The pilot estimates he had been flying at 2,000 feet amsl and 80 kt for approximately ten minutes when he decided to descend to 1,500 feet amsl. As the aircraft approached 1,600 feet amsl the pilot started to level off, at which point he reported the tail of the aircraft began to swing violently left and right. Attempts to get the aircraft flying straight only seemed to make the problem worse and the aircraft quickly lost altitude.

Unable to rectify the problem the pilot decided to make a forced landing and turned the aircraft into wind whilst trying to identify a suitable landing site. He reduced the aircraft's speed from 80 kt whilst still trying to prevent it yawing from side to side and descended towards some fields he had identified. When at treetop height the pilot managed to straighten the aircraft in anticipation of doing a run-on landing; however, he then found himself heading straight for a tree in a hedgerow, which he just managed to avoid. Straightening the aircraft again he passed low over the hedgerow before touching down in the field beyond it at an estimated speed of 40 kt. The field had recently been cultivated and presented a flat smooth surface on which to land, although the surface was also soft.

Pictures submitted of the accident site suggest the aircraft touched down heavily on its right skid first before touching down on the left skid. The aircraft ran on with sufficient force to break the skids off the aircraft at this point. Impact marks also indicate one of the rotors then hit the ground and that the aircraft rolled over, causing considerable damage and shattering the canopy, before finally coming to rest lying on its right-hand side about 15 metres beyond the impact marks left by the skids.

The pilot reported passing out at about the point the aircraft rolled over and then regaining consciousness to discover fuel pouring out of the aircraft. He managed to vacate the aircraft through the broken canopy and then make his way to a roadside to summon help.

Carburettor heating system description

The aircraft involved in the accident was fitted with a manually selected carburettor heater and an additional carburettor heat assist device. A gauge on the instrument panel displayed the carburettor temperature and contained a yellow arc indicating the temperature range to be avoided. Below this gauge were the words:

"CAUTION BELOW 18 IN. MP, IGNORE GAGE (sic) *& APPLY FULL CARB HEAT"*

The section of the aircraft flight manual relating to the use of carburettor heat on the aircraft is reproduced on the next page.

The Civil Aviation Authority issued supplementary instructions on the use of the Carb Heat Assist (CAA Change Sheet No. 4 Issue 4 Ref RTR061 dated 1 August 2001). This instruction called for the following words to be inserted into the flight manual:

> *"The Carb Heat Assist does not apply automatically the correct amount of carb heat to keep the CAT gage needle out of the yellow arc at all flight conditions. The pilot must monitor the CAT gage, and manually apply carb heat as required. Following a large power change, especially a lowering and raising of collective, the CAT gage must be checked, as the original datum may have been lost.*
>
> *Before entering a descent or auto-rotation, FULL carb heat must be selected."*

USE OF CARBURETOR HEAT

When conditions conducive to carburetor ice are known or suspected to exist, such as fog, rain, high humidity, or when operating near water, use carburetor heat as follows:

At power settings above 18 inches MAP, apply carburetor heat as required to keep CAT gage needle out of yellow arc.

At power settings below 18 inches MAP, ignore gage and apply full carburetor heat (CAT gage does not indicate correct carburetor temperature below 18 inches MAP).

CAUTION

The pilot may be unaware of carburetor ice formation as the governor will automatically increase throttle and maintain constant manifold pressure and RPM. Therefore, the pilot must apply carburetor heat as required whenever icing conditions are suspected.

USE OF CARB HEAT ASSIST

A carburetor heat assist device is installed on R22s with O-360 engines. The carb heat assist correlates application of carburetor heat with changes in collective setting to reduce pilot work load. Lowering collective mechanically adds heat and raising collective reduces heat. Collective input is transmitted through a friction clutch which allows the pilot to override the system and increase or decrease heat as required. A latch is provided at the control knob to lock carburetor heat off when not required. It is recommended that the control knob be unlatched (to activate carb heat assist) whenever OAT is between 80°F (27°C) and 25°F (-4°C) and the difference between dew point and OAT is less than 20 F° (11 C°). Readjust carburetor heat as necessary following any change in power.

Aircraft Flight Manual Extract

Analysis

The air temperature at the surface and the dew point for the area at the time the aircraft was airborne were about 12°C and 9°C respectively, which gave a humidity of between 82% and 87%. Meteorological reports also indicated some cloud cover at 1,200 to 1,500 feet amsl, which would indicate higher humidity at that level. From the chart reproduced at the end of this report, it can be seen that these conditions are likely to cause serious carburettor icing, regardless of the power selected, if adequate carburettor heating is not applied.

Although the pilot stated he had applied some carburettor heating whilst airborne, had the temperature gauge not been regularly monitored it is possible that carburettor icing might have started to build up during the flight at 2,000 feet amsl. Whether or not this was the case, the pilot also stated he could not remember whether he had selected full carburettor heat before entering the descent. If he did not do so, it is highly likely that carburettor icing would have formed during the descent.

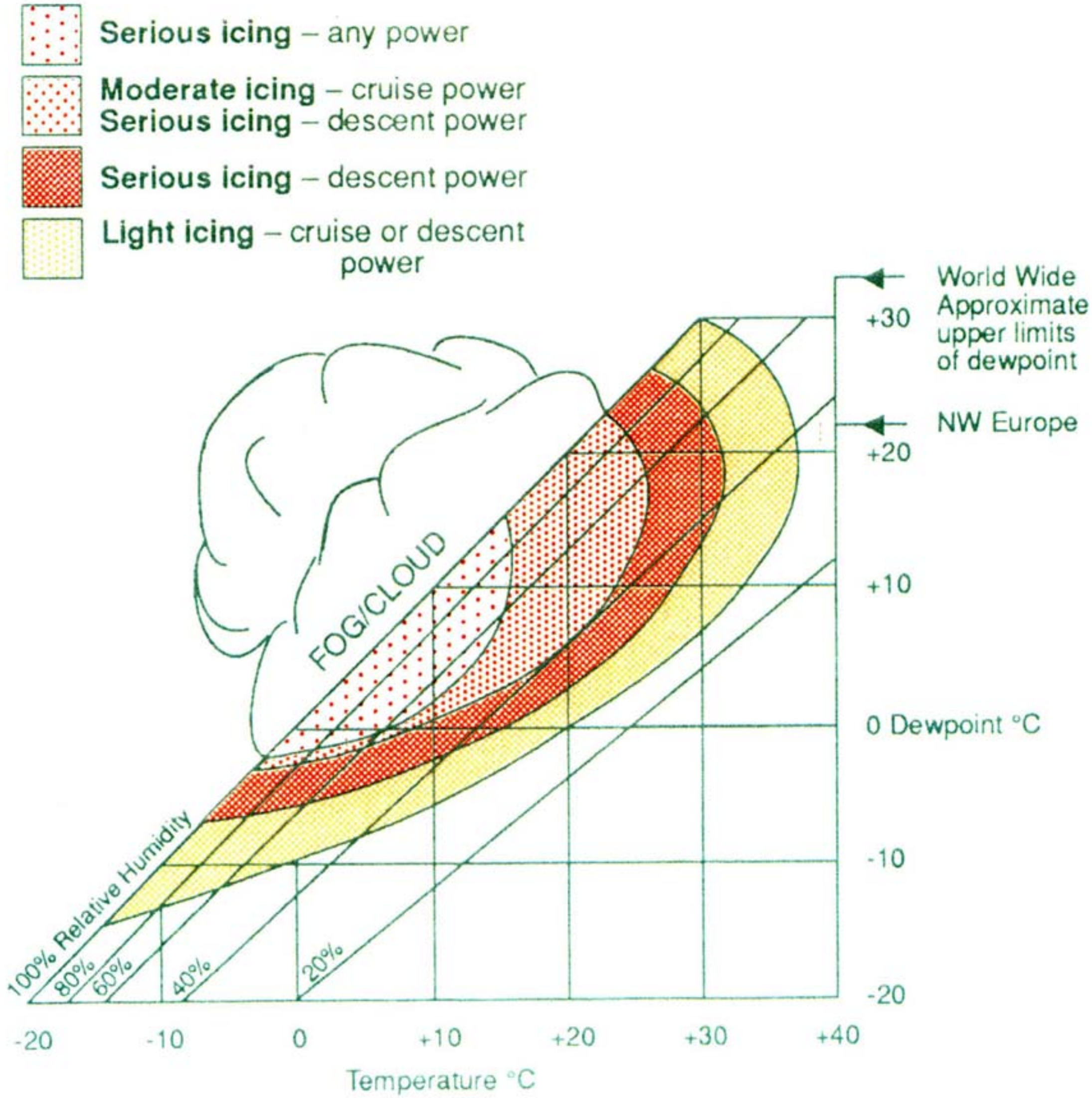
Either or both scenarios would have lead to the engine governor trying to compensate for the loss of power by increasing the fuel flow until it could not increase it any further. At this point the governor would 'hunt', increasing and reducing the fuel flow in an attempt to regulate the rotor RPM. These fluctuations would have caused the torque to increase and decrease as the power changed, leading in turn to the aircraft yawing from side to side. Due to the alternating direction of the yaw it is possible that an inexperienced pilot might, in an attempt to correct the yaw, exacerbate the situation by entering into a form of pilot induced oscillation.

Conclusion

From the pilot's description and the weather present in the area at the time it is likely that insufficient carburettor heat was applied, especially during the aircraft's descent, leading to a build up of carburettor ice. The relative inexperience of the pilot, together with the effects of the governor, made it difficult for him to recognise the situation he was in. Under the circumstances it is understandable that he wished to make a forced landing. However, again, his relative inexperience lead to difficulties in controlling the aircraft and resulted in a heavy and fast run-on landing.

More information on Robinson R22 carburettor icing is available for downloading from the website: www.morningtonsanfordaviation.co.uk under the heading 'No Ice, Thank You!'

CARB ICING


Serious icing – any power
Moderate icing – cruise power
Serious icing – descent power
Serious icing – descent power
Light icing – cruise or descent power
World Wide Approximate upper limits of dewpoint
NW Europe
FOG/CLOUD
100% Relative Humidity
80%
60%
40%
20%
+30
+20
+10
0 Dewpoint °C
-10
-20
-20
-10
0
+10
+20
+30
+40
Temperature °C

Aircraft Type and Registration:	Sky 260-24, G-KTKT	
No & Type of Engines:	None	
Year of Manufacture:	1998	
Date & Time (UTC):	1 November 2004 at 1530 hrs	
Location:	Near Braithwell, South Yorkshire	
Type of Flight:	Public Transport (Passenger)	
Persons on Board:	Crew - 1	Passengers - 12
Injuries:	Crew - None	Passengers - 1
Nature of Damage:	None to balloon	
Commander's Licence:	Commercial Pilot's Licence	
Commander's Age:	60 years	
Commander's Flying Experience:	More than 2,500 hours (of which 1,500 were on type) Last 90 days - 16 flights Last 28 days - 2 flights	
Information Source:	Aircraft Accident Report Form submitted by the pilot and subsequent telephone enquiries	

The balloon was on a pleasure flight with twelve passengers aboard. The passengers were standing in groups of three, in four separate compartments within the basket. The basket is padded internally and has sufficient rope handles to assist each passenger in adopting the brace position for landing. The pilot gave a safety briefing before flight and another prior to landing, which he re-enforced with further instructions just prior to the touchdown. The passengers were instructed to face away from the direction of travel and lean against the sides of the basket compartments.

The pilot reported that the balloon landed normally on the smooth surface of a farm field, but the basket toppled over after landing. A female passenger, who reported that the landing was "very sudden" and that the balloon "bumped and dragged" after landing, felt pain in her leg, which she believes was a consequence of a male passenger falling against her as the basket toppled. She was later taken to hospital by the pilot and her leg was X-rayed. No fracture was apparent, and she was discharged. However, a further X-ray examination carried out a week later revealed a fracture.

BULLETIN CORRECTION

AAIB File:	**Ref: EW/G2004/09/19**
Aircraft Type and Registration:	Piper PA-28-180 Cherokee, G-NINC
Date & Time (UTC):	19 September 2004 at 1745 hrs
Location:	Old Buckenham Airfield, Norfolk
Information Source:	Aircraft Accident Report Form submitted by the pilot and subsequent telephone enquiries

AAIB Bulletin No 1/2005, page 58 refers

The first line of the report stated:

> 'After a local area flight the pilot returned to the airfield to carry out a series of touch and go landings on **grass** Runway 25'.

The runway in use was, in fact, tarmac, and the first line should read:

> 'After a local area flight the pilot returned to the airfield to carry out a series of touch and go landings on tarmac Runway 25'.