Aircraft Type and Registration:	Boeing 737-59D, G-BVKC	
No & Type of Engines:	2 CFM56-3C1 turbofan engines	
Year of Manufacture:	1990	
Date & Time (UTC):	21 February 2004 at 2300 hrs	
Location:	Cardiff Airport, Wales	
Type of Flight:	Public Transport (Passenger)	
Persons on Board:	Crew - 6	Passengers - 114
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	Damage to left main landing gear	
Commander's Licence:	Airline Transport Pilot's Licence	
Commander's Age:	49 years	
Commander's Flying Experience:	8,160 hours (of which 3,800 were on type) Last 90 days - 203 hours Last 28 days - 71 hours	
Information Source:	AAIB Field Investigation	

Synopsis

The left main landing gear (MLG) began a violent shimmy (yaw oscillation) when the wheelbrakes were applied after a normal landing touchdown, probably damaging the MLG lower torsion link. The shimmying stopped when braking was reduced but restarted when braking was increased, causing the torsion link to fracture. Further higher amplitude shimmying of the left MLG ensued, resulting in severe MLG tyre, wheel and brake damage and substantial oscillatory loads on the aircraft structure. Steering difficulties were experienced during both shimmying episodes.

It was likely that the shimmying resulted from excessive wear of the torsion link apex joint that reduced the effectiveness of the shimmy damper. Maintenance records indicated that the MLG had been maintained in accordance with the manufacturer's recommendations, but it was considered that relevant Aircraft Maintenance Manual (AMM) procedures could be difficult to follow.

Similar failures had occurred over a number of years, which had been attributed by the aircraft manufacturer to excessive apex joint wear that had not been detected or adequately rectified during maintenance. One safety recommendation has been made.

History of flight

The aircraft had flown from Malaga to Cardiff with the commander as the handling pilot. After an uneventful cruise, the crew checked the weather at Cardiff Airport and were told that Runway 12 was in use with a surface wind of 040°/20 kt gusting 31 kt. As a wind from this direction is known to cause turbulence over the threshold of Runway 12 the crew requested, and were granted, an approach to the reciprocal, Runway 30. An ILS approach was made with anti-skid selected on, autobrake off and a final flap setting of 30°.

Although the approach was moderately turbulent, the commander was able to maintain a constant angle of drift throughout the latter stages where the wind readouts remained constant at 040°/20 kt with no gusts. The drift was reduced using rudder as the aircraft flared and touchdown was made after a short float.

Touchdown was described by the crew as firm, but not heavy, and without excessive sideways drift. Reverse thrust was selected and the handling pilot commenced manual braking without delay. Almost immediately, the crew experienced very heavy vibration and felt the aircraft pulling to the left. Braking application was reduced and the vibration lessened. Firm braking was again applied at an estimated 60 kt and extremely heavy vibration again occurred. Both pilots felt a significant lateral acceleration to the left. In the cabin, the vibration was severe enough to cause one of the overhead lockers to unlock and spill its contents. This time, the commander used the tiller in an attempt to regain the runway centreline and he brought the aircraft to a halt on the runway.

The Airport Fire Service (AFS) arrived at the aircraft and reported that there was no fire but that there appeared to be brake unit parts on the runway. Passengers were disembarked from the aircraft without incident whilst it remained on the runway and shutdown checks were completed by the crew before they vacated the aircraft.

On the day previous to this incident, another company pilot reported that, following a normal landing, an unusual juddering was felt through the rudder pedals when heavy braking was demanded. As the braking was eased, the vibration stopped and the aircraft was taxied onto stand without further incident. This judder was not felt by the non-handling pilot.

Aircraft description

The Boeing 737 main landing gear (MLG) leg consists of a cylinder/piston type shock-strut, with the cylinder attached to the wing structure and the lower end of the piston carrying an axle with two main wheels. The axle centreline is located 3.5 inches behind the shock-strut centreline to provide a castoring effect. MLG wheels and tyres are numbered 1 to 4, left to right, across the aircraft. A scissor linkage, made up of two torsion links, is intended to prevent rotation of the piston relative to the cylinder, while allowing axial movement of the piston within the cylinder to provide shock absorption, Figure 1. The upper torsion link is attached to the cylinder via a horizontal pivot joint and the lower torsion link is similarly pivoted onto the piston.

A damper is connected between the apexes of the upper and lower torsion links in order to control the rotary oscillation of the shock-strut piston relative to the cylinder and thereby prevent excessive MLG vibration during high-speed taxi and under heavy braking. The damping action is effected by a piston fitted in a fluid-filled cylinder in the damper body; a damping orifice in the piston controls the rate of displacement. The apex of the upper torsion link is bolted to the damper body and the apex of the lower link is connected to the damper piston rod via a bearing assembly. This consists of spherical bushes sandwiched between two thrust washers and is clamped against a shoulder on the rod by an end nut. Thus the torsion links can pivot relative to each other but horizontal displacement between their apexes is controlled by the damper action.

A fluid pressure of 30 to 70 psig is maintained within the damper by a compensator, in conjunction with two check valves. A further check valve allows fluid to enter the damper from the return side of the aircraft's Hydraulic System A to make up for leakage from the damper or to compensate for volume changes associated with temperature variation. Protection from excessive pressure resulting from thermal effects is provided by two relief valves. Air entering the damper during maintenance operations can be released via three bleed plugs.

Accident site

Runway 30 is 2,392 metres long and 46 metres wide, with a Landing Distance Available of 2,201 metres. The surface is generally concrete but tarmac in places. The aircraft had been removed by the time of AAIB arrival but runway tyre track markings, clearly associated with G-BVKC's landing roll, were apparent on the runway. These were continuous from touchdown to the point at which the AFS reported that G-BVKC had come to rest, Figure 2. Runway access was limited by heavy traffic and the measured distances were approximate.

The tracks started as two pairs of dense black MLG tyre tracks commencing approximately 754 metres from the Runway 30 threshold, towards the end of the normal touchdown area, as indicated by other tyre markings. The tracks showed that Tyre 4 had touched first, with the aircraft 2 metres left of the runway centreline, followed after 3.5 metres by Tyre 3 and after a further 6 metres by Tyres 2 & 1, indicating touchdown with some right bank. The markings showed that the aircraft initially ran straight for about 86 metres, while gradually regaining the centreline.

The left MLG tyre tracks then began a sinusoidal oscillation, with a wavelength of 4.8 metres and a half-amplitude of 5 to10 cm, that continued for 183 metres. After this the left MLG tracks became straight for 609 metres, with the aircraft diverging somewhat left of the centreline, before curving sharply to the right and commencing a second period of oscillation. The subsequent tracks were generally sinusoidal, with a wavelength of 2.3 metres and a half-amplitude of 15-20 cm, but part way through each swing to the left the wave was distorted and a dense black scrub mark was apparent. This was consistent with restraint of the yaw oscillation by contact of the No 2 wheel/tyre/brake assembly with the torque link/shimmy damper assembly as the axle approached its peak left yaw angle. The detached brake unit parts were found in the region of these second oscillation markings.

The apparently vigorous oscillation continued for 88 metres, to close to the point at which G-BVKC had come to rest, approximately 439 metres from the end of the runway. The total ground roll distance was around 1,008 metres.

Aircraft examination

In view of the substantial oscillatory loads on the aircraft reported by the crew, the MLG attachment structure was inspected; no damage was found. The outboard side of the left MLG No 2 wheel, tyre and brake had sustained significant damage, which could be matched with impact damage to the damper body and parts of the lower portion of the shock-strut cylinder. The parts found on the runway had originated from these components. Some localised damage had been caused to the No 1 wheelbrake. These effects had clearly been caused by large yaw excursions of the axle and wheel assembly.

The left MLG lower torsion link (Part Number 65-46102-21) had broken mid-way along its length, at a point where a cut-out in the flange of the link formed two 'T' section limbs, both of which had fractured. Specialist examination concluded that the fractures had resulted from overload, approximately in the plane of the link, with the left limb having failed first and the right limb fracture showing signs of very low cycle, very high stress load reversals. One of the five bolts attaching the upper torsion link to the damper body had fractured and the damper piston rod had bent. The inner part of the rod had been gouged and the apex joint spherical bushings had suffered local compression collapse, with bronze material from the bushings smeared onto the mating surface of the thrust washers. These features were consistent with the damage to both the torsion link and the damper having resulted from excessive loads associated with MLG shimmying.

It was also found that material had been lost from the mating faces of the inner thrust washer and the piston rod shoulder, apparently due to in-service wear, rather than the effects of shimmying. No hydraulic fluid leakage from the shimmy damper was evident and aircraft checks found that the hydraulic supply to the left MLG shimmy damper was normal.

Flight recorders

The Cockpit Voice Recorder (CVR) had not been isolated after the accident and the recording of the landing had been overwritten.

A satisfactory readout of the Flight Data Recorder (FDR) was obtained. Hydraulic system pressures and brake pressures were not recorded. The data indicated that the landing touchdown had not been heavy or made with excessive drift. Longitudinal deceleration of the aircraft increased to a level consistent with firm braking within approximately two seconds of touchdown. Two periods of elevated, oscillating lateral acceleration were experienced during the ground roll, the first between 140 and 120 kt groundspeed and the second between 35 and 0 kt.

Maintenance requirements

The applicable issue of the Aircraft Maintenance Manual specifies a number of checks and maintenance operations related to the MLG torsion links and the shimmy damper, as follows:

1. MLG Torsion Link Apex Joint Inspection (Task 32-11-00-206-053):

The procedure notes:

> *'The apex joint inspection is important to make sure the shimmy damper functions properly and the apex thrust washers or apex bushings are not worn such that the shimmy damper effectiveness is reduced.'*

A check of the clearance between the outer thrust washer and the apex nut is required (not illustrated). If this is less than 0.005 inch it is required that the tightening torque of the apex nut is checked (see Paragraph 2, below) and the minimum axial dimension of the apex bearing assembly (between the outer faces of the thrust washers) is measured. If this dimension is less than 2.700 inches, replacement of the apex bushings and/or thrust washers is required. If the thrust washer/apex nut clearance is greater than 0.005 inch, it is required that the apex joint is disassembled and:

> *'if necessary replace worn, fractured or cracked apex bushings or apex thrust washers'*.

After re-assembly of the joint a check of the minimum axial dimension of the apex bearing assembly is required. If this is greater than 2.700 inches the inspection is complete.

2. MLG Damper - Adjustment/Test (Task 32-11-81-705-001):

The procedure requires the damper piston to be positioned such that the end of the piston rod opposite the apex joint protrudes between 0.10 and 0.15 inches from the damper body, before the torsion link apex joint nut is tightened. If necessary, the dimension is to be achieved by jacking the MLG off the ground and levering the wheels with a length of wood to turn the lower torsion link. The apex nut is then tightened to 400 and 500 lb.inch, before being completely slackened and re-tightened to 50 and 150 lb.inch and locked. This is followed by a check of the gap between the outer thrust washer and the nut of the apex joint. If this is not more than 0.005 inches, no further adjustment is needed. If it is more than 0.005 inches it is required to:

> *'do a check on the apex thrust washers and the lower torsion link bushings for wear.'*

The apex joint inspection specified elsewhere in the AMM (see Paragraph 1 above) is not mentioned.

3. MLG Torsional Free Play Inspection (Task 32-11-00-206-001):

The procedure notes:

> *'The torsional free play of each main landing gear must be in tolerance to make sure the main landing gear shimmy is dampened. NOTE: It is important that you adjust the shimmy damper correctly and tighten the apex nut of the torsion link to specified torque* [see Paragraph 2 above] *before you do a check on the torsional play of the main landing gear (AMM 32-11-81/501).'*

The aircraft is jacked so that the MLG wheels are clear of the ground, the MLG shock-strut is depressurised and the damper is clamped to prevent the piston from moving. A torque is applied to the lower end of the MLG by pulling on a spring balance fitted to a 10 feet long 2 x 4 inch wooden beam placed between the shock-strut and the outboard wheel. The specified torque is that produced by applying a 30 lb pull to the beam at a point 100 inches from the shock-strut centreline. The fore and aft motion of the inboard wheel rim produced by applying the torque clockwise and then anti-clockwise is measured using a dial gauge located at a point on the forward side of the wheel in the horizontal plane through the axle centreline. The play obtained from averaging five measurements is required to be less than 0.14 inches. If the play exceeds the limit then inspection in five specified areas, and possibly component replacement, is required; the torsion link apex joint is not specifically included.

4. MLG Torsion Links – Inspection/Check (Chapter 32-11-51/601):

The section specifies wear limits for the torsion link pivot components, including the minimum overall axial dimension of the apex joint bushing/thrust washer assembly. The thrust washer/nut maximum gap is not included. The procedure for installing the torsion links references the AMM procedures given in Paragraph 1 and 2 above, but does not directly specify a check of either apex joint dimensional limit.

5. MLG Torsion Links – Removal/Installation (Chapter 32-11-51/401):

The section specifies the procedure for installing the torsion links. No dimensional checks of the apex bearing after installation are specified.

Aircraft background

Maintenance records indicated that the torsional free play check had last been carried out on G-BVKC's left MLG at a 2C Maintenance Check on 10 April 2003, 2,433 flight hours and 2,144 flight cycles before the accident. The free play was not recorded and there was no requirement to do so. The MLG had last been overhauled 19,413 flight hours and 18,329 flight cycles before the accident. At the time of the accident the aircraft had accumulated 31,210 flight hours and 33,633 flight cycles since new.

The report of a shudder through the brake pedals on a landing the day before the accident was not noticed by the non-handling pilot and appeared likely to have been due to operation of the anti-skid system.

Previous history

Several Boeing publications regarding MLG torsion link fractures on the 737 had been issued prior to the accident, applicable to the -100, -200, -300, -400 and -500 models, as follows:

1. Boeing Message to Operators M-7272-93-6740 and M-7272-93-6816, published 20 Dec 1993:

The message included a report that one operator had experienced fracture of both MLG lower torsion links and fracture of the shimmy damper piston.

2. Boeing 737 Service Letter 737-SL-32-057, published 5 July 1994:

The purpose of the Service Letter (SL) was:

> *'To advise operators of recommended maintenance to prevent main landing gear torsion link and shimmy damper piston fractures.'*

It noted that 13 cases of lower torsion link fracture had been reported since 1989 and that investigation of the latest cases had determined that excessive play was present at the apex joint. This had rendered the shimmy damper ineffective and resulted in torsion link loads that had been in excess of design loads, resulting in fractures. The joint was subject to:

> *'wear of the bushing inner diameters and flange faces'*

and regular scheduled maintenance was necessary to ensure that this remained within allowable limits. It was intended to revise relevant sections of the AMM to clarify the instructions for the free play check and adjustment of the torsion link apex joint and shimmy damper, and to add wear limits for the apex joint bearing. It was noted that the maximum nut/thrust washer gap was 0.005 inches and the minimum bearing assembly overall dimension was 2.700 inches. The SL noted that:

> *'Some operators have initiated a program where the torsion links are replaced at scheduled intervals, such as each C or 2C-check. Other operators may wish to evaluate this practice to help prevent unscheduled maintenance.'*

It also noted that improper bleeding of the shimmy damper, fitment of the wrong damper model or excessive gas pressure in the shock-strut, could also cause torsion link fracture.

3. Boeing Message to Operators M-7200-00-00924, published 20 April 2000:

This referenced the 1993 message and noted that since then Boeing had received additional reports of lower torsion link and shimmy damper fractures, including an instance in 1999 where both lower torsion links had fractured, along with both shimmy damper pistons. All the cases had occurred during the landing roll and none of the aircraft involved had departed the runway. It was concluded from investigation that the fractures had been the result of excessive apex joint play, apparently due to lack of proper maintenance, rather than damper malfunction. The information in the 1994 SL was reiterated. It noted changes to the Boeing AMM and Maintenance Planning Document (MPD), including:

> *'The apex joint must be correctly tightened as noted. The maximum gap in the joint is 0.005 inches. Correct tightening will eliminate any gap.'*

4. Boeing Maintenance Tip (MT) 737 MT 32-008, published 2 February 2001:

The MT noted that:

'Gaps common to the main landing gear torsion links apex joint have resulted in fractures of the torsion link and shimmy damper piston on airplanes in service. In all instances, heavy main landing gear vibration followed torsion link fractures.'

The dimensional limits given in the 1994 SL were restated, including:

'If a gap in excess of 0.005 inches is found . . . . the apex nut should be removed and the torsion link bushings and thrust washers inspected for wear or fracture.'

Discussion

It was clear that the vibration and steering difficulties experienced during the landing ground roll had resulted from MLG shimmy and that this had caused the overload fracture of the left MLG lower torsion link. Information from the aircraft manufacturer indicated that a substantial number of similar failures had occurred, over a period exceeding 10 years. Almost all the cases had been attributed to MLG shimmy, resulting from reduced damper effectiveness caused by excessive play in the torsion link apex joint. The play was considered likely to have been due to excessive wear in the joint, apparently because of inadequate maintenance.

Evidence of wear on G-BVKC's components was found and, in the absence of evidence of problems with the damper unit or its hydraulic supply, it was concluded that this had led to the shimmying. It appeared that the link had probably been damaged by the initial episode of violent shimmying that started shortly after a normal touchdown and which ceased when wheelbraking was reduced. Extremely violent shimmying then began at lower speed, when heavier braking was applied, which almost immediately caused the torsion link to fracture. This then allowed a higher amplitude shimmy to develop, resulting in damage to the wheels, tyres and brakes.

The MLG free play and apex joint checks had apparently been carried out at the recommended intervals. However, it appeared that the relevant AMM procedures, presented in five sections of the manual, were not easy to follow, were not fully consistent in some areas and could possibly be misunderstood. Ensuring that the thrust washer/apex nut gap was not excessive was apparently crucial but the procedures did not illustrate the measurement required or suggest a method of manipulating the heavy robust components to enable a small gap between them to be measured reliably.

Additionally, the procedures did not specify that the bushings and/or thrust washers should necessarily be replaced if the thrust washer/nut gap were found to exceed 0.005 inches, but only required them to be inspected. One of the procedures required replacement of worn, fractured or cracked apex bushings or apex thrust washers *'if necessary'*. The other procedure simply specified an inspection for wear. Neither specified a re-check of the gap after re-assembly and both allowed the interpretation that the washer/nut gap could exceed 0.005 inches if the components had been inspected. While the importance of not exceeding the gap limit was strongly emphasised in the Service Letter, Maintenance Tip and Messages to Operators, this was not fully reflected in the AMM. The gap limit was not included, for example, in the table of torsion link assembly wear limits.

Safety Recommendations

There have apparently been a substantial number of MLG torsion link fracture cases brought about by severe shimmying over a period of years. While none of the previous cases resulted in injury, it is clear that such events are likely to have a significant effect on the aircraft's steering capability, could inhibit use of the wheelbrakes in the event of shimmying and are likely to result in wheel, tyre and brake damage. A runway departure could possibly be the eventual result of such an event. Additionally, it appears that the substantial oscillatory loads associated with MLG shimmy, both before and after torsion link fracture, could potentially cause undetected damage to the aircraft structure.

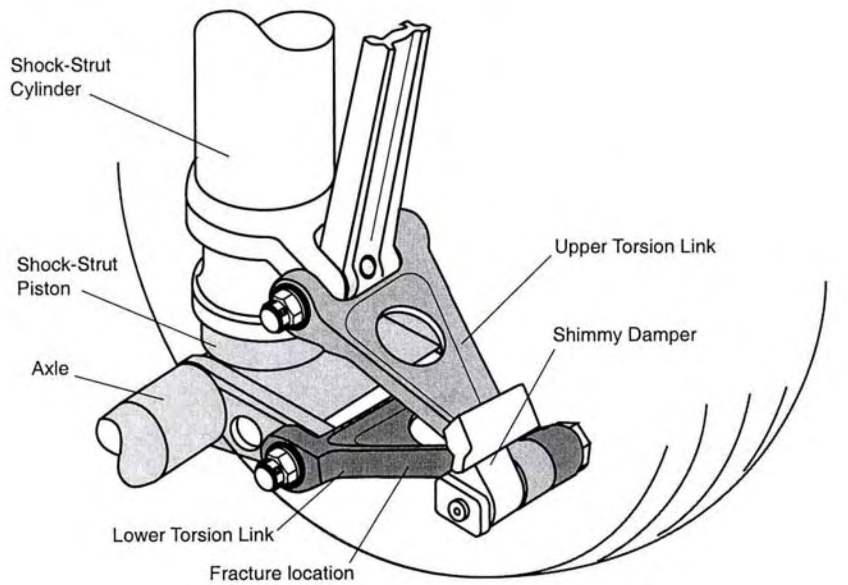
Changes to relevant sections of the AMM and MPD, together with a number of messages from the manufacturer emphasising the recommended maintenance, have apparently failed to prevent recurrence. It is considered that further measures, including an assessment of the need for improved methods of checking for excessive play in the torsion link apex joint and an increased check frequency, improvement to relevant sections of the AMM and assessment of the need for modification of the joint, need to be implemented. It has therefore been recommended that:

Safety Recommendation 2004-103

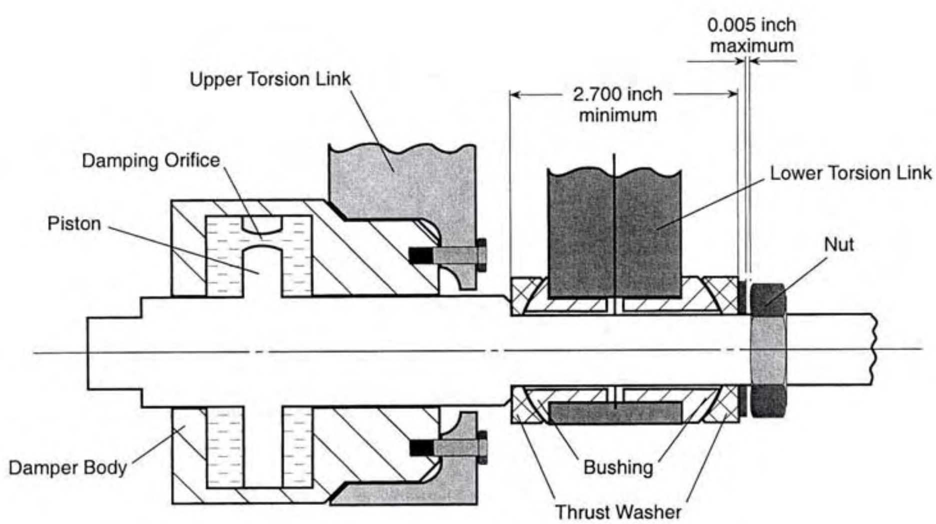
The Federal Aviation Authority and the Boeing Commercial Airplane Group should take effective measures aimed at preventing further cases of Boeing 737 main landing gear shimmy and resultant torsion link fracturing brought about by excessive play in the anti-torque links apex joint.

Figure 1

Main Landing Gear

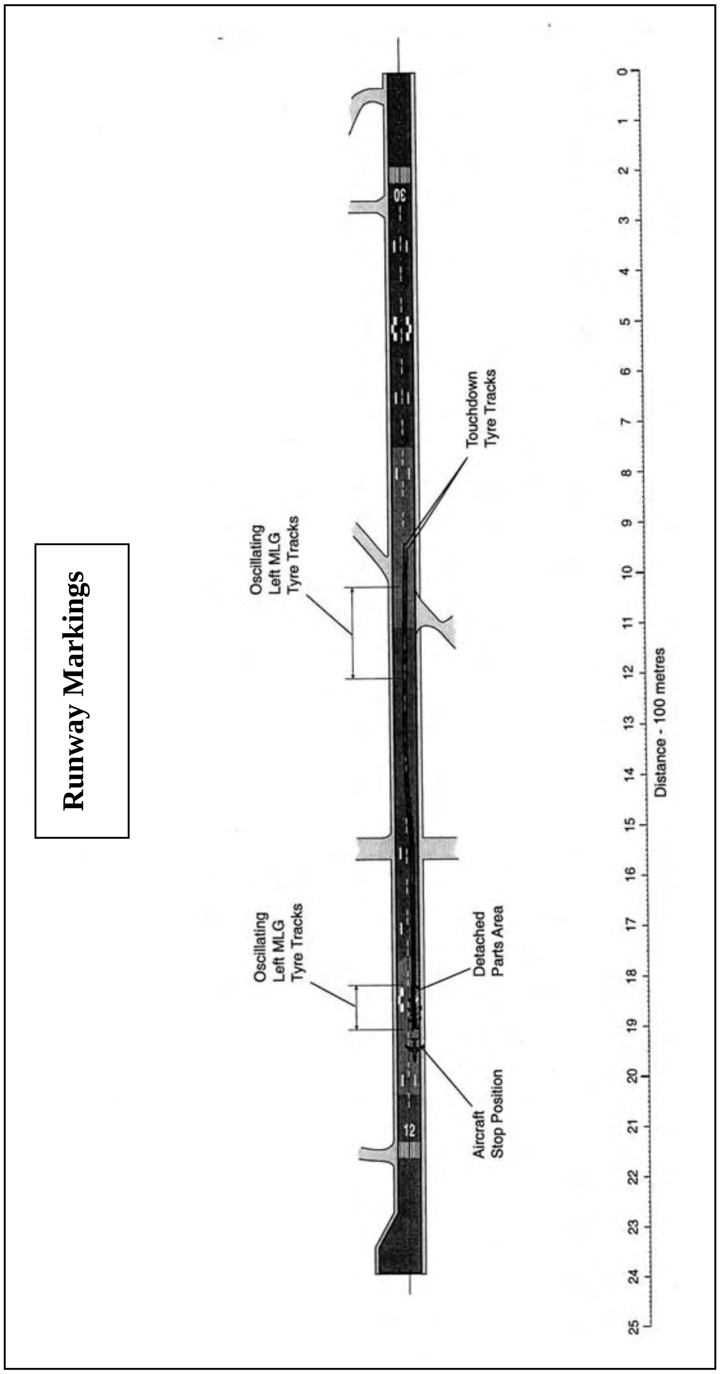


Torsion Links



Shimmy Damper Schematic

Figure 2


Runway Markings
Oscillating Left MLG Tyre Tracks
Touchdown Tyre Tracks
Oscillating Left MLG Tyre Tracks
Detached Parts Area
Aircraft Stop Position
30
12
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
Distance - 100 metres

INCIDENT

Aircraft Type and Registration:	Saab-Scania AB SF340B, G-LGNH
No & Type of Engines:	2 General Electric CT7-9B turboprop engines
Year of Manufacture:	1993
Date & Time (UTC):	2 January 2005 at 1405 hrs
Location:	Sumburgh Airport, Shetland Isles, Scotland
Type of Flight:	Public Transport (Passenger)
Persons on Board:	Crew - 3 Passengers - 29
Injuries:	Crew - None Passengers - None
Nature of Damage:	minor damage to bracket requiring a minor repair
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	26 years
Commander's Flying Experience:	2,134 hours (of which 1,754 were on type) Last 90 days - 90 hours Last 28 days - 32 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and information provided by the operator.

Synopsis

After an uneventful flight from Aberdeen to Sumburgh, the aircraft was preparing for the return journey, and was parked beside the terminal building, facing into a wind gusting up to 52 kt. After start, as the propeller condition levers were pushed forward, the aircraft pitched backwards and the tail struck the ground. Both engines were shut down and the aircraft settled back to a normal attitude. There were no injuries to the crew or passengers and an engineering inspection revealed only minor damage to a bracket on the bottom of the fuselage used for attaching a tail stand during loading. The likely cause of the accident was an extreme aft centre of gravity caused by incorrect loading of the baggage and the unauthorised relocation of some passengers.

Previous incident

Following a previous incident in which one of its SF340s was found to have been loaded with a baggage mass well in excess of that stated on the loadsheet, the operator decided to use actual baggage weights for all subsequent SF340 operations. ATP aircraft, also operated by the company, continued to use standard, or notional, weights for both passengers and baggage. Handling agents at all scheduled destinations were aware of this procedure. However, as this route was usually operated by an ATP, the handling agent presented the captain with passenger, baggage and cargo weights based on standard weights.

Centre of gravity determination

The captain completed a manual load sheet using the passenger seating positions allocated at check-in. From this he determined a baggage distribution that would enable the aircraft to operate within the company weight and balance envelope. This information was passed to the handling agent, who in turn passed instructions to the loaders. Subsequent inspection of the manual loadsheet revealed an arithmetic error, overestimating the weight of the aircraft by 100 kg, but this had no bearing on the occurrence.

Passenger and cabin crew reports after the event stated that three of the passengers were in fact sitting in Row 13, a row of three seats that is not available in other company SF340s, located in what is usually part of the cargo hold. It was not possible to determine if the passengers had moved with the consent of the cabin crew.

The manufacturer's normal operating aft Centre of Gravity (CG) limit corresponds to 37.7% of the mean aerodynamic cord (MAC). The operator's limit is more restrictive at 35.8% MAC. At its extreme, the CG must remain forward of a position corresponding to 47% MAC to avoid the aircraft tipping onto its tail. Using data provided by the operator, the actual CG was estimated using standard passenger mass and actual baggage mass. With all passengers seated in their allocated seats the aircraft CG would have been located at 37.3% MAC; aft of the operator's CG envelope but within the manufacturer's limit. However, with three passengers seated in Row 13 instead of in their allocated seats, the CG moved to 44.3% MAC; aft of the manufacturer's limit. Furthermore, the cargo net in the forward of the two cargo compartments was found to have been fastened incorrectly, allowing baggage to rest unrestrained against the rear bulkhead. Consequently, it is likely that the actual CG was aft of that determined above, and significantly aft of that calculated at the time. The use of standard passenger weights would probably have introduced additional errors in the estimation of aircraft CG, and it is therefore possible that the aircraft was loaded in such a way that the CG fell aft of 47% MAC (tipping limit). It is unclear what would have been the effects of the strong gusting headwind.

Operator's findings and recommendations

The principal findings of the operator's own investigation were that the handling agent had provided the captain with standard weights and not actual weights as required for SAAB SF340 operations; the loaders had not loaded the aircraft as instructed; and furthermore some passengers, without the commander's knowledge, were not seated in their allocated seats.

The operator has subsequently made the following recommendations:

1. The aircraft commander should receive written confirmation that the hold has been loaded in accordance with his instructions.

2. The Cabin Services manual should be updated to state clearly that passengers may not be moved without the captain's permission.

3. When reporting to the aircraft commander before departure, the cabin crew should confirm the passenger distribution.

Conclusion

The likely cause of the incident was an extreme aft CG caused by incorrect loading of the baggage and the unauthorised relocation of some of the passengers.

Aircraft Type and Registration:	Aero L-39C Albatros, G-OALB	
No & Type of Engines:	1 Ivchenko AI-25TL turbofan engine	
Year of Manufacture:	1979	
Date & Time (UTC):	10 December 2004 at 1444 hrs	
Location:	Manston Airfield, Kent	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	Rear canopy damaged	
Commander's Licence:	Commercial Pilot's Licence	
Commander's Age:	61 years	
Commander's Flying Experience:	11,600 hours (of which 7 were on type) Last 90 days - 18 hours Last 28 days - 12 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

Synopsis

The pilot shut both canopies before takeoff but the canopy "unlocked" light remained illuminated. Visual inspection confirmed that, the external locking handles appeared to be stowed correctly and the pilot believed that the micro switch that operated the "unlocked" light was incorrectly adjusted. During the takeoff, the rear canopy detached and came to rest beside the runway. The aircraft returned to the airfield safely, having sustained no further damage. An investigation revealed that the locking handle can be stowed without first locking the canopy, and that correct operation of the lever is the only means of ensuring that the canopy is secure.

History of flight

The aircraft was being delivered from Manston to North Weald for an engine change and annual servicing. The pilot carried out a thorough pre-flight inspection, which included checking that the rear cockpit canopy was closed and locked. He then attempted to start the aircraft auxiliary power unit (APU) but was unable to do so because the aircraft battery and external ground power unit

(GPU) provided insufficient power. The battery operated GPU was then charged for an hour, the pilot carried out a brief external inspection and then attempted another start. It is not known if the rear cockpit was opened during the intervening period. During this attempt, although the APU was started successfully, it ran down before the main engine could be started. The ground crew checked the GPU connection, and a further attempt resulted in successful APU and main engine start.

When the pilot closed the front canopy and attempted to lock it, the canopy 'unlocked' light remained illuminated. It remained illuminated despite subsequent attempts to lock the canopy, so the ground crew inspected the external handles to confirm that they were stowed. The pilot was satisfied that the 'unlocked' light was illuminated only because the micro switch which operated it was incorrectly adjusted; on a previous flight the light had been extinguished by twisting and pushing the internal front canopy lock vigorously. He therefore completed the engine run-up and before take-off checks and carried out an apparently normal departure.

At approximately 100 ft agl, as the landing gear was retracted, the pilot noticed an increase in the general noise level, which he likened to a pressurisation failure. Looking rearwards, he noticed that the rear canopy was missing. He throttled back to maintain between 120 kt and 130 kt and informed ATC that he intended to return and land. He passed the canopy on the runway during the subsequent uneventful landing. Fortunately, it appeared that the canopy had not come into contact with the aircraft after becoming detached and a post-flight inspection revealed no obvious damage or defects. A replacement canopy was fitted and the aircraft continued to North Weald as planned.

Aircraft description

The L-39C Albatros is a tandem two seat jet trainer of Czech origin. The front and rear cockpits are divided by an internal windshield and each has a separate canopy, hinged along its right hand edge as shown in Figure 1. The hinges are designed to disengage when the canopies are shut, to enable them to be jettisoned. The result is that, when closed, the canopy is not attached to the aircraft unless it is also locked. Accordingly, each canopy is locked by rotating a handle that engages two pairs of hooks with two pairs of corresponding pins recessed into the lower edges of the canopy.

Each canopy is locked independently, either using an internal handle on the left hand side of each cockpit, or using an external handle mounted below the shut line of each canopy again on the left hand side of the fuselage. If the rear cockpit is occupied, it is normal to secure the internal handle using a bungee cord which restrains it in the forward, locked position, and for the external handle to be stowed separately. However, the rear internal handle cannot be reached from the front cockpit due to the presence of the internal windshield. Therefore, if the rear cockpit is unoccupied, the rear canopy can only be locked from the outside.

When the canopy is unlocked, the external handle will appear as shown in Figure 2. In order to lock the canopy from outside, the handle must be rotated anti-clockwise, beyond the stowed position. When released it should appear as shown in Figure 3. However, the handle can be stowed, as shown in Figure 4, regardless of whether or not the canopy has been locked. Consequently, visual confirmation that the handle is stowed does not guarantee that the canopy is locked.

The pilot conceded that he may not have operated the handle correctly to ensure that the canopy was locked prior to takeoff.

Figure 1

Figure 2

Figure 3

Figure 4

Aircraft Type and Registration:	Cessna T310R, G-OGTX
No & Type of Engines:	2 Continental TSIO-520-B piston engines
Year of Manufacture:	1977
Date & Time (UTC):	13 March 2004 at 1155 hrs
Location:	Hotham, South Cave, Humberside
Type of Flight:	Training
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - 2 (Fatal) Passengers - N/A
Nature of Damage:	Aircraft destroyed
Commander's Licences:	UK Basic Commercial Pilot's Licence with Instructor rating and multi-engine examiner authorisation and FAA Airline Transport Pilot Licence with Flight Instructor Certificate
Commander's Age:	63 years
Commander's Flying Experience:	20,283 hours (of which 893 were on type) Last 90 days - 79 hours Last 28 days - 31 hours
Information Source:	AAIB Field Investigation

Synopsis

The aircraft departed from Humberside Airport on an instructional flight and was being flown in clear air at medium level when radar contact was lost. Shortly afterwards it impacted the ground in a steep nose-down attitude at high speed which killed both pilots on board.

Background

The pilot under instruction was employed to fly this particular aircraft by the company that owned it. He had a total of 710 hours flying time with approximately 400 hours flying this specific aircraft. He held a current Joint Aviation Authorities (JAA) Commercial Pilot's Licence and Instrument Rating (CPL/IR) but the company was also planning to operate a United States registered Beech 200 Kingair. In order to fly this aircraft commercially within Europe without placing it on the UK register, it was necessary for the pilot to obtain a Federal Aviation Authority (FAA) CPL/IR. Part of this licensing procedure involved a flying test with a FAA licensed examiner. Due to his experience, the pilot was required to undertake the minimum period of six hours mandatory instruction with an FAA licensed instructor prior to taking this test. It was during this period of instruction that the accident occurred.

History of flight

Three days before the accident, the company pilot flew the aircraft to Humberside Airport to undertake the instructional course. Over the next two days, he completed four flights with the FAA licensed instructor.

Immediately before the accident flight, the two pilots briefed together and 'booked out' with ATC by telephone. The instructor, who was also the commander, told the air traffic assistant that they intended *'to fly to the northwest for a while before returning to fly a couple of approaches'*. The aircraft had been refuelled the previous evening with 120 US gallons, which is almost full capacity.

They took off at 1139 hrs after requesting permission to practise an engine failure after takeoff. Although when airborne no radio call was made confirming the practise engine failure, the duty Air Traffic Control Officer noticed a reduction in the climb rate when the aircraft was at approximately 300 feet agl before the normal rate was restored about two miles later. At 1141 hrs, radio contact was established with Humberside Radar and the instructor stated that their intention was to fly to the northwest, climbing to 3,000 feet. Seven minutes later the instructor transmitted 'CLIMBING TO OPERATE BETWEEN THREE AND FIVE THOUSAND FEET'. Nothing further was heard from the aircraft and at 1157 hrs, the radar controller, having lost primary and secondary radar contact, attempted to make radio contact without success. At about the same time, eyewitnesses reported an aircraft crashing in the same area as radar contact was lost.

Radar recordings

Radar heads situated at Claxby and Great Dun Fell recorded much of the aircraft's flightpath. The recorded radar returns show the aircraft flying west from Humberside Airport for 7 nm before turning northwards to the Humber estuary. An orbit was carried out at approximately 3,000 feet altitude before the northerly track was resumed and the aircraft climbed to approximately 4,000 feet. The wind at altitude was westerly at 25 kt. Allowance for the wind was applied to the radar data to derive the equivalent 'still air' flight path, thus removing wind effect from the manoeuvres depicted by the radar plot. The entire 'still air' flight path is depicted at Figure 1 and the final three minutes of the flightpath is shown, together with associated altitudes and approximate airspeeds, at Figure 2.

The final leg began with the aircraft at an airspeed of approximately 100 kt TAS and its speed accelerated throughout the remainder of the leg to about 150 kt TAS when radar contact was lost. The last recorded altitude of the aircraft was 3,200 feet.

A test flight was flown over the same area in order to establish the base of the radar cover. This figure will vary from day to day depending on the atmospheric pressure setting and the aircraft's aspect to the radar head. However, 700 feet altitude was established as an approximate base. Although the precise elapsed time from the last radar contact to ground impact is not known, the aircraft was not detected by the next radar sweep, which was eight seconds later. If the aircraft had already descended below the base of the radar cover, it would have averaged a rate of descent during that time of over 18,000 feet per minute.

Witness information

Several people witnessed this accident at relatively close range. Due to a low cloud base, the engine noise was generally heard first and described as 'normal' with little variation in power setting. A subsequent increase in the noise level prompted several witnesses to look up and the aircraft was seen exiting the cloud base in an approximately 45° nose-down attitude, wings-level and travelling "extremely quickly". Approximately 5 seconds elapsed until the impact and during this period, only one witness reported any sign of attempted recovery from the dive. Nothing was seen to fall from the aircraft and no pre-impact smoke or fire was observed.

During the evening before the accident, the company pilot held a telephone conversation with his partner during which he discussed that day's training flights. He told her that "*he was learning a lot more about the aircraft and enjoying the whole experience"* and that his instructor had said he would have *"no problem in passing his flying tests"*. He also described how the instructor had demonstrated a stall that was *"almost nose up"* during which they entered cloud. Generally she described his manner as cheerful and enthusiastic.

Meteorology

An aftercast from the Meteorological Office showed a light to moderate, rather moist westerly airflow covering eastern England. The reported weather at Humberside Airport for 1150 hrs was a wind of 220°/10 kt, a visibility of 3,000 metres in light rain and a broken cloud base at 1,000 feet. An airborne message from another aircraft stated that the cloud tops were at 2,400 feet. The commander also called his company operations to advise them that the cloud tops were at 2,000 feet.

Pathology

Although it was not physically possible to determine the presence of any pre-existing disease, it was established that there was no evidence of any toxicological factors in either pilot that may have contributed to the cause of this accident.

FAA CPL/IR training

The instructor operated a flying school that trained students for Joint Aviation Regulations (JAR) Private Pilot Licences and FAA Commercial Pilot's Licences and Instrument Ratings. The instructor last renewed his JAR examiner authorisation, which included a flight test, on 14 January 2004.

The school was registered with the JAA for the purpose of private pilot licence training. However, because it did not offer JAR commercial pilot training it neither required nor held Flying Training Organisation (FTO) status. This meant that an annual physical inspection from a JAR inspector was not required. Moreover, under Federal Aviation Regulations (FARs), FAA commercial licence training can be conducted in the UK without requiring the school to be approved provided that the instructor has a current FAA Flight Instructor Certificate and the school operates under FAR Part 61. FAR 61.197 entitled 'Renewal of Flight Instructor Certificates', states that a person who holds a flight instructor certificate may renew it without taking a practical test by presenting the following to an authorised FAA Flight Standards Inspector:

(i) 'a record of training students showing that, during the preceding 24 calendar months, the flight instructor has endorsed at least five students for a practical test for a certificate or rating and at least 80% of those students passed that test on the first attempt;

(ii) a record showing that, within the preceding 24 calendar months, the flight instructor has served as a company check pilot, chief flight instructor, company check airman or flight instructor in a Part 121 or Part 135 operation or in a position involving the regular evaluation of pilots; or

(iii) a graduation certificate showing that, within the preceding 3 calendar months, the person has successfully completed an approved flight instructor refresher course consisting of ground training or flight training or a combination of both.'

The instructor involved in this accident renewed his Flight Instructor Certificate on the previous two occasions by completing a ground-based Flight Instructor Refresher Course in the USA. Once issued, a certificate remains valid for 24 months.

The FAA published Advisory Circular No. 61-67C on 25 September 2000 which stated in para 200:

> *'Stall demonstrations and practice, including manoeuvres during slow flight and other manoeuvres with distractions that can lead to inadvertent stalls should be conducted at sufficient altitude to enable recovery by 3,000 feet agl in multi-engine aircraft'.*

Aircraft description

G-OGTX was a Cessna T310 with two turbocharged, fuel injected, direct drive, air cooled, horizontally opposed, six cylinder engines each with a hydraulically actuated three-bladed constant speed, fully feathering propeller. Fuel was stored in wing tip tanks and bag tanks fitted in the wings. The aircraft had six seats with the main cabin door located on the right hand side above the wing adjacent to the co-pilot's seat. The pilot's side window, which included an integrally mounted foul weather window (sometimes called a Direct Vision or DV window) was designed such that it could be removed in an emergency. Operation of a red emergency 'pull ring' retracted retainers located around the top of the window frame and allowed the complete window to be pushed out.

On-site wreckage examination

The aircraft had impacted the ground at high speed, in a nose-down attitude of approximately 45º, on a heading of around 110°M. The impact crater contained pieces from the left and right wing tip-tanks and further debris from the structure of both wings. There was a strong smell of fuel around the crater, and some liquid with the visual appearance of fuel was evident at the bottom of the crater, although the wreckage had not burnt. The aircraft had broken up on impact, with items of wreckage thrown forward, creating a large debris field. The furthest items, including some of the cockpit instruments, were some 130 metres from the impact crater.

Some sections from the main cabin door were identified, including the latch mechanism which was closed and locked. Pieces of transparency material from the emergency exit window were found to the left of the wreckage trail, between 40 and 190 metres from the initial impact crater. From their positions relative to the main wreckage it was apparent that these pieces, including the foul weather window, had detached prior to impact. The window surround, including the pins, which were still extended, was found in the main debris field. It is considered probable that the airflow entering via the periphery of the foul weather window during the final high-speed descent, had caused the foul weather window together with the transparency material from the remainder of the side window to blow out; however the structure of the window frame had been retained. Representative amounts of material from each of the other aircraft transparencies were also identified. There was no evidence of a bird strike.

Two propeller blades from each engine were found buried in the impact crater to a depth of around one metre; the remaining blade from each engine had been thrown forward at impact and they were found separately in the main debris field. The blade pitch mechanisms had broken and so no assessment could be made of propeller pitch angle. All the blades showed evidence of rotational scoring associated with high power and damage to the left and right sets of blades was symmetrical. The landing gear and flaps were retracted.

Detailed wreckage examination

The wreckage was recovered to the AAIB's facility at Farnborough for a detailed examination in conjunction with the aircraft manufacturer's representative. There was no evidence of any mechanical failure within the engines.

The aircraft was fitted with two vacuum driven instruments: one artificial horizon and one directional gyro, both fitted in the pilot's instrument panel. The aircraft type's vacuum system includes two engine driven vacuum pumps, one fitted to each engine and each providing vacuum to a common manifold; should either pump fail, a check valve will isolate the inoperative vacuum pump from the system. The gauge also provides failure indicators for the left and right vacuum pumps, these small red buttons are spring loaded to the extended (failed) position. When a normal vacuum is applied to the system from both pumps the failure buttons are pulled below flush with the gauge face. Should insufficient vacuum pressure be sensed at either pump the relevant button will extend. The suction gauge from G-OGTX was recovered; it had been crushed in the impact with the needle indicating a normal five inches vacuum pressure. The red failure buttons had been destroyed.

Neither of the vacuum driven instruments were recovered; however some internal components were identified. These included a gyro, which showed evidence of rotation at impact, consistent with a serviceable vacuum system.

Continuity of the elevator and rudder control systems was confirmed and there was no evidence of any pre-impact disconnection. It was not possible to check the aileron system due to the extensive breakup of the airframe, which also precluded an assessment of the possibility of a flying control restriction due, for example, to a loose article.

Aircraft history

G-OGTX was constructed in 1977 since when it had accumulated around 5,280 hours; it had been placed on the UK register in December 2001. The last maintenance activity was a 50 hour inspection which had been completed on 9 March 2004. There were no outstanding maintenance issues and the pilot had not reported any recent problems with the aircraft.

Analysis

Not withstanding the extensive disruption to the aircraft, there was no evidence of any pre-existing aircraft defects. The aircraft's engines were also delivering symmetrical power at impact suggesting that neither power loss nor power asymmetry were causal factors in this accident. Moreover, the aircraft's final, wings-level dive reported by witnesses was inconsistent with a loss of roll control. Loss of pitch control was more likely but, with the exception of an elevator jam, there was adequate evidence within the wreckage to suggest that loss of elevator or pitch trim control were unlikely explanations. Had the control columns jammed, two experienced pilots should have been able to retain some degree of pitch control using the elevator trim unless the jam occurred during a dive at altitude. Therefore, whilst firm conclusions cannot be drawn, it appears likely that the primary causal factors for the accident were operational rather than technical.

Both pilots were qualified and in current practice on this aircraft type; the instructor in particular had vast experience of this type of aircraft and training operation. There was no record of the intended exercises for the forthcoming flight (and no FAA requirement for a record). Moreover, there was no annotation of their flights on the flying school's authorisation sheets, probably because they were not using a flying school aircraft and there was nothing in the briefing room to indicate the specific composition of the accident flight. Consequently, it was not possible to determine from the radar data where the actual flight profile diverged from the intended flight profile.

There appears to be nothing abnormal regarding the first phase of the accident flight with what seems to be a sensible decision to climb above the low-level cloud layer to operate in clear air. In this area, the pilot is likely to have been practising the stalls, steep turns and 'unusual attitude' elements of the FAA CPL/IR test. Analysis of the recorded radar data shows a region where the speed may have been slow enough to stall the aircraft but it is followed by speed increase in level flight suggesting full recovery from slow flight. There are periods of change of direction in level flight which may be attributable to steep turns. Unusual attitude entry and recovery generally involve significant speed change with manoeuvring in the vertical plane and it is a requirement to complete the recovery using 'limited panel' instruments, ie without reference to the artificial horizon. There does appear to be some vertical manoeuvring during the last few radar contacts that may possibly have arisen from unusual attitude entry or recovery. However it is also possible that the recorded height may be incorrect due to static pressure errors induced by an aircraft that was already out of control.

The general handling content of the FAA CPL/IR is very similar to that of the UK CPL/IR which the company pilot had recently renewed and it seems unlikely that he would have required much additional general handling training or practice. If the aircraft was being flown within the syllabus requirements there is no reason to suspect that two such experienced pilots would lose control. In light of the conversation that the company pilot held with his long-term partner, it may be that they were manoeuvring at more extreme attitudes and either lost control or allowed such a nose-low attitude to develop that they had insufficient height to recover. In either case it is likely that the cloud layer beneath them hindered rapid recognition of the problem and/or recovery from a loss of control. The difficulty in recognising the aircraft's predicament would have been exacerbated if the artificial horizon had toppled and an extreme attitude had developed.

Recommended minimum altitude for abnormal manoeuvres

The FAA advice to complete certain manoeuvres at sufficient altitude to enable recovery by 3,000 feet agl does not take account of the additional risks encountered by inadvertently entering cloud during a manoeuvre and thereby losing potentially vital spatial orientation references during recovery. Whatever the reason for the loss of control during this flight, it would have been prudent to have conducted these exercises with a greater margin than 2,000 feet from the cloud tops. Also, from an entry altitude of 4,400 feet, the FAA's advice to **complete** manoeuvring tasks involving slow flight or distractions by 3,000 feet agl could be compromised if a nose-low attitude was allowed to develop.

The minimum suitable height for abnormal manoeuvres depends on many factors, not least the manoeuvre intended and the risks of that manoeuvre developing into an unintended and more extreme manoeuvre. Consequently, the minimum entry height for abnormal manoeuvres is best determined by 'airmanship'. Therefore, no formal safety recommendation on this aspect has been made.

Flying training in the UK for FAA licences

Although there was no connection between this accident and the conduct of flight training to FAA standards in the UK, during this investigation it was established that flying schools conducting FAA professional pilots' licence training in the UK under FAR Part 61, do not require FAA approval. This is inconsistent with the JAA requirement for all flying schools in the USA conducting training towards JAR licences to be approved.

The AAIB is concerned that any flying school may conduct training towards an FAA CPL/IR with no regulatory oversight other than issue of the individual instructor's certificate; that certificate may be renewed legally without a practical test of instructor proficiency. A pilot issued with an FAA CPL/IR may then operate USA registered aircraft commercially within UK airspace.

Under new USA rules, in place as of 20 October 2004, all foreign nationals taking any flight training in the USA, on any size of aircraft, now have to submit to a security clearance procedure in advance and pay additional fees for security clearance. These rules include foreign nationals seeking *'ab initio'* training, glider and balloon training, and even factory courses on new aircraft types as part of an aircraft purchase. Consequently, the demand for flight training and testing for FAA licences within the UK is likely to increase. Therefore, it is recommended that:

Safety Recommendation 2005-001

The Federal Aviation Administration (FAA) of the USA should require all flying training performed in the United Kingdom for the award of FAA professional pilots' licences to be conducted by flying training organisations that have been evaluated and approved by the FAA.

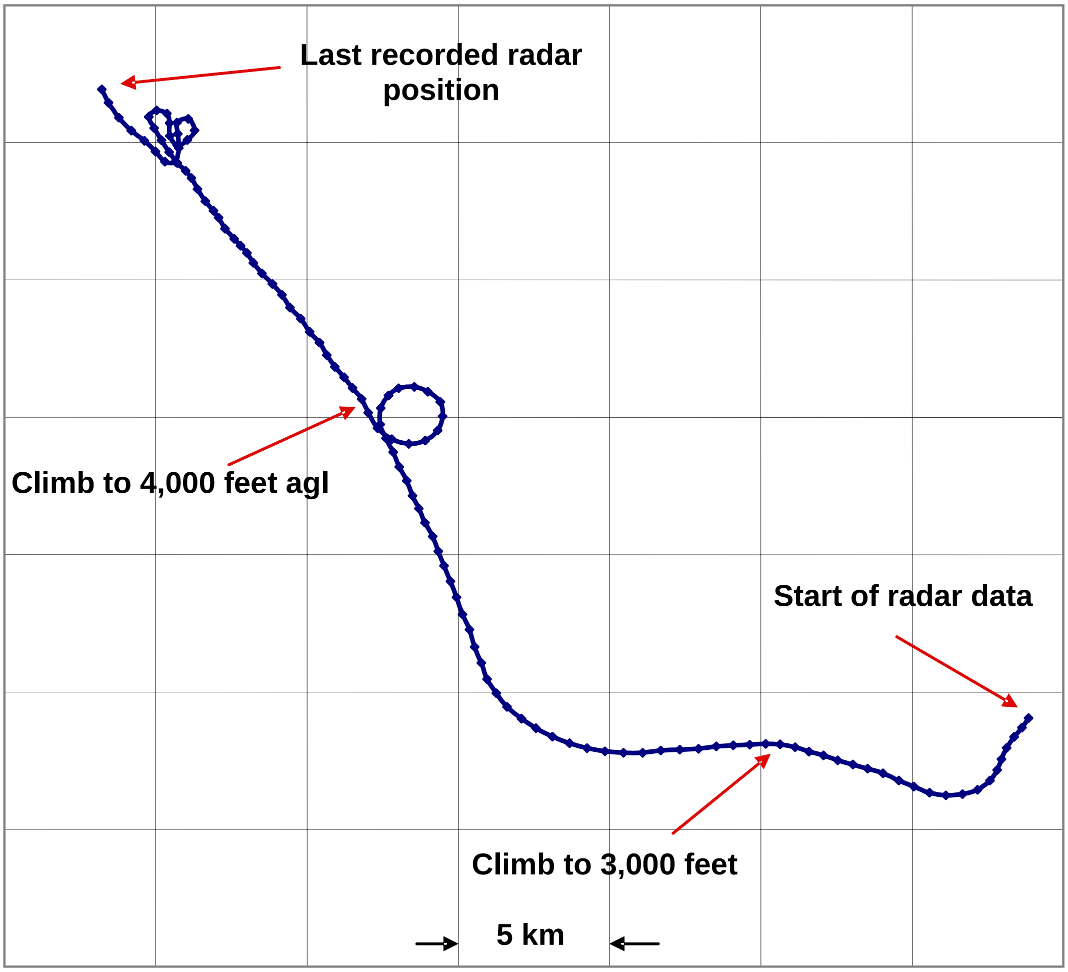


Figure 1 - Still Air Plot of Complete Flight

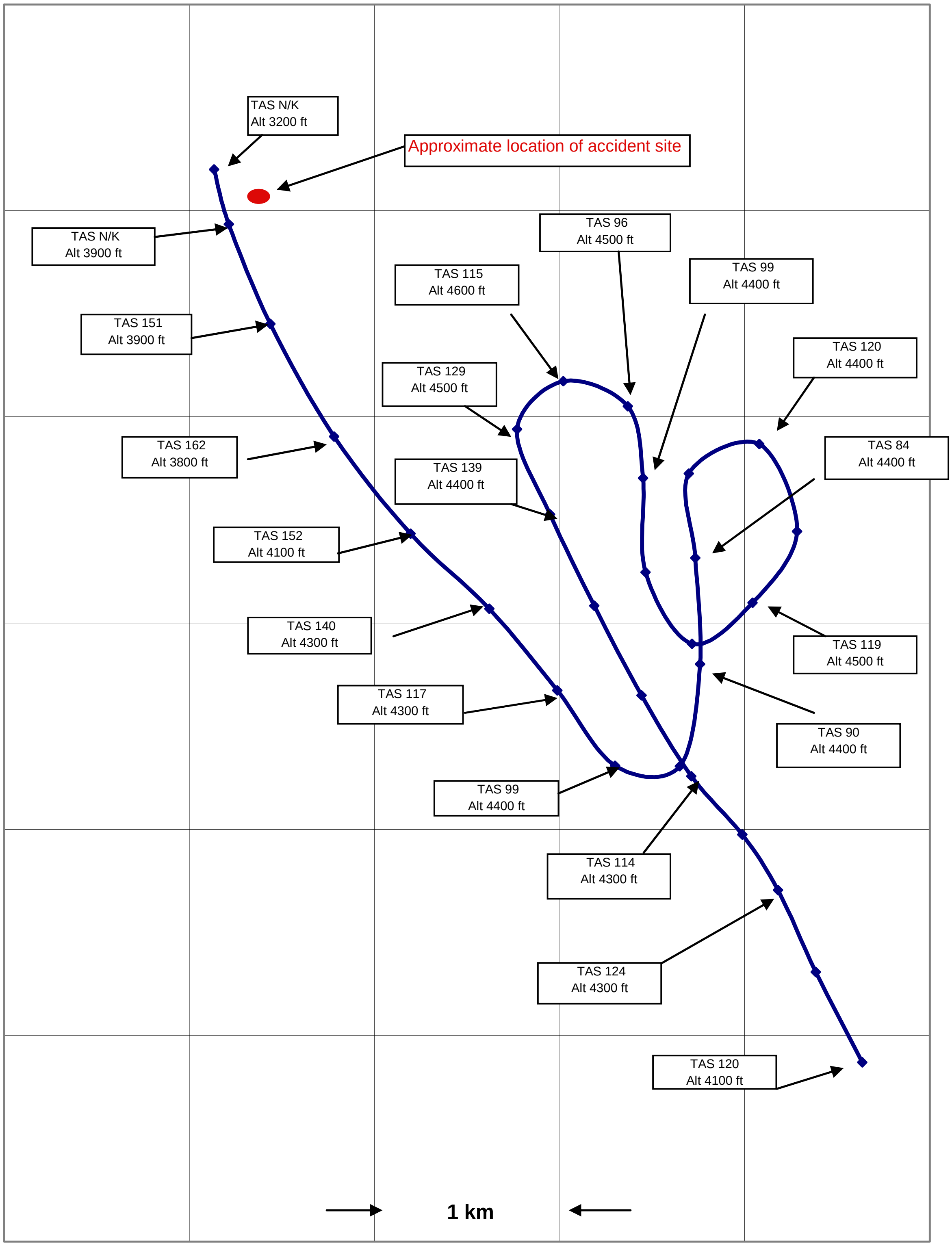


Figure 2 - Final Still Air Manoeuvring

INCIDENT

Aircraft Type and Registration:	North American P-51D-20, G-BIXL
No & Type of Engines:	1 Packard Merlin V1650-7 piston engine
Year of Manufacture:	1944
Date & Time (UTC):	17 July 2004 at 1908 hrs
Location:	East Garston, Near Hungerford, Berkshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Propeller and fuselage belly panels
Commander's Licence:	Private Pilot's Licence
Commander's Age:	63 years
Commander's Flying Experience:	2,000 hours (of which 200 were on type) Last 90 days - 26 hours Last 28 days - 7 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft had just completed some low altitude aerobatics and was climbing away when the engine lost power. Despite switching fuel tanks the pilot was unable to regain power and so he carried out a forced landing in a field.

History of the flight

Having just conducted a flying display at a nearby air show, the pilot was returning the aircraft to its home airstrip, located on a farm at the edge of a village. The weather was fine, with good visibility, little if any cloud and a westerly wind of about 10 to 15 kt. When overhead the airstrip the pilot flew a short series of aerobatic manoeuvres, culminating in a roll to the right. Whilst climbing away in a moderately steep climb, and at an altitude stated by the pilot to be below 1,000 feet agl, the aircraft's engine suddenly lost power.

The pilot estimated that at this point the aircraft had a 20º to 30º degree nose up attitude, a 20º to 30º right bank and a speed of about 200 kt. He maintained the climbing attitude whilst increasing the angle of bank in order to remain in the vicinity of the airstrip. The pilot stated the propeller was windmilling at 2,650 RPM and that he switched the fuel selector from the left tank to the right tank.

Surprised that the engine did not restart, the pilot put the propeller into full coarse pitch and prepared to carry out a forced landing. The aircraft stopped climbing and the pilot was alarmed at the subsequent rate of descent, which made him think he was unlikely to make it back to the airstrip. He also noted that the airspeed had decayed to 135 kt. He therefore decided to abandon his attempt to make the forced landing on the airstrip, and continued in a gentle right-hand turn, with the aircraft at a height of 700 to 800 feet agl over the bottom of a small valley.

The pilot lowered the aircraft's nose significantly in order to recover the airspeed and he banked steeply to avoid a hill and power lines. With the speed increased to 150 kt at about 200 feet agl, the pilot levelled the aircraft and headed north along the left-hand side of the valley. As he did so, he checked again for a response from the engine and saw the manifold pressure fluctuating in the region of 40 inches Hg (mercury). However, despite opening the throttle, the engine RPM failed to increase. At this point the engine emitted a series of "bangs", similar to a car backfiring, described by the pilot as the "over-boost death rattle".

Due to the terrain ahead the pilot then turned left, into wind, passing over the crest of a small hill. He then identified two large fields in which he could land. The airspeed had by that time decayed again to about 120 kt and the pilot selected full flaps, heading for the farther of the two fields. Deliberately keeping the landing gear retracted and with the airspeed at about 80 to 85 kt, the pilot rounded out gently, whilst maintaining the wings parallel to the sloping field surface. The aircraft touched down in a tall crop of broad beans, coming to rest upright, and the pilot was then able to vacate the cockpit as normal.

He had not been in contact with ATC at the time of the accident but was able to use his mobile telephone to contact members of his family who had been watching the aircraft from the airstrip. He also contacted his colleagues with whom he had been flying in the display and who were still at the air show. They took it upon themselves to summon the air show's emergency response helicopter to come to the pilot's aid. The helicopter arrived at the aircraft about 35 minutes after it had forced landed in the field, followed shortly afterwards by the local police who arrived by road vehicle.

Aircraft examination

An examination of the aircraft by the owner's own maintenance organisation has, at the time of this report, failed to reveal the cause of the power loss, although the description given by the pilot indicates it was most likely to be due to fuel starvation.

After the forced landing it was noted that the throttle was about half open, the fuel selector was to RIGHT TANK, the mixture was still at RUN and the fuel booster pump was ON. The pilot had not found time to switch off the fuel supply, electrical master and magneto switches before touch down, nor had he jettisoned the canopy. The engine exhaust port deposits were white in colour and all four propeller blades were bent rearwards.

The aircraft has two fuel tanks, one in each wing, each with a capacity of 95 US gallons. When the aircraft was still in the bean field the fuel gauges indicated 17 US gallons in the left tank and 55 US gallons in the right tank. After the aircraft had been recovered to its hangar the tanks were drained; 12 US gallons were found in the left tank and 50 US gallons in the right tank.

Various fuel system components were tested, but no faults were identified and no water was found in either the fuel filters or the fuel. The pilot did, however, comment that he had had considerable difficulty starting the aircraft prior to the flight, although at no time during the flight did he recall seeing any of the fuel pressure warning lights illuminate.

Analysis

Fuel starvation can be caused by a number of phenomena such as a vapour lock or collapse in a fuel line. The pilot was concerned by the ageing rubber of the fuel tank walls and although a blockage caused by debris from a tank, or elsewhere, cannot be ruled out, no blockages were found. Another possible cause was fuel 'sloshing', whereby the fuel remaining in a partially empty tank moves as a result of the aircraft being subject to longitudinal acceleration or an out of balance force during a turn. In some instances this can lead to the fuel uncovering the outlet from the tank and starving the engine.

In this case the flight had been conducted solely on the left tank until the engine lost power. During the aerobatic manoeuvres the fuel level in this tank was relatively low and it is possible that forces applied during the manoeuvres led to the fuel moving away from the tank outlet momentarily. With a break in the fuel flow, the engine would have cut out, although this would not have occurred until some seconds after the outlet had been uncovered. With the propeller still turning at speed, once the fuel flow was restored the engine should have regained power.

The pilot states that he expected the engine to have regained power within seconds, especially as he had switched to the right tank which he knew to be full. He also stated that it was hard to see the fuel tank selector due to its position behind the control column, and that he moved the selector a few times to ensure it was correctly located. His perception of time may also have been distorted by the fact that he was at low altitude and so concentrating more on flying the aircraft than on trying to resolve the engine problem. It is possible, therefore, that in switching tanks and moving the tank selector to ensure it was properly engaged, the pilot did not allow sufficient time for the engine to restart.

It is advisable to set the propeller pitch to COARSE after an unexplained engine failure to reduce propeller windmilling drag but if the propeller still rotates, it drives the engine and its geared supercharger. This explains why the engine manifold pressure, at about 40 inches was some 10 inches above ambient air pressure. However, if an apparent engine failure is due to a temporary fuel starvation, when the fuel supply is restored, with the throttle partially or fully open and the propeller RPM low, the internal combustion conditions may be conducive to detonation or backfiring. This probably explains the series of repetitive loud reports from the engine described by the pilot as the "over-boost death rattle".

Conclusion

Circumstantial evidence suggests the engine power loss was caused by a short period of fuel starvation. The temporary fuel starvation was probably caused by aerobatic manoeuvring, momentarily uncovering the outlet in the left fuel tank, which was selected at the time. Insufficient time was then allowed for the fuel flow to be restored from either the left tank or the right tank before the propeller was put into coarse pitch. Once the fuel flow was restored, when the throttle was opened, the engine was unable to respond as the pilot had hoped, due to the relatively low RPM effect of the propeller in coarse pitch. Had the pilot selected FINE pitch when he heard the engine misfiring, it might have recovered power.

The situation was aggravated by the fact that the aircraft was at low altitude when the incident occurred. Had it been at a higher altitude it is possible that the pilot would have allowed more time to try and restore engine power before selecting coarse pitch. Similarly, he might have had sufficient altitude remaining to allow him to select fine pitch when subsequently checking for engine response during the aircraft's descent.

A further causal factor was the relatively low fuel quantity in the tank selected. The pilot is not aware of any minimum fuel requirement for conducting aerobatics but it would seem prudent to select the fuller tank before engaging in aerobatic manoeuvres, especially at low altitude.

Finally, it is to the pilot's credit that, faced with the situation described, he managed to carry out a successful forced landing with minimal damage to the aircraft. The successful outcome was positively influenced by the pilot's top priority of flying the aircraft and only troubleshooting the problem when he could. Although he had considerable experience in flying low level aerobatics, this accident highlights the safety benefit afforded by increasing the altitude at which aerobatics are performed.

Aircraft Type and Registration:	Beech F33 Bonanza, G-BGSW	
No & Type of Engines:	1 Continental Motors Corp IO-470K piston engine	
Year of Manufacture:	1970	
Date & Time (UTC):	19 October 2004 at 1045 hrs	
Location:	Abingdon, Oxford	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 1
Injuries:	Crew - None	Passengers - None
Nature of Damage:	Damage to propeller and underside of aircraft	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	40 years	
Commander's Flying Experience:	248 hours (of which 148 were on type) Last 90 days - 4 hours Last 28 days - 1 hour	
Information Source:	Aircraft Accident Report	

History of the flight

The following information was provided by the accompanying pilot. The aircraft took off from Blackbushe Airport at 1108 hrs, with a planned destination of Bournemouth. An easterly heading was established after takeoff and contact made with Farnborough Radar. Soon after this, the aircraft lost all electrical power. The aircraft was turned onto a northerly heading to avoid controlled airspace and the aircraft systems were checked. No signs of electrical power were evident, other than a partial carrier wave on the 'COM 2' channel. Blackbushe Airport was contacted via mobile telephone and advised of the pilot's intention to continue North to Wellesbourne Mountford, an airport with which he was familiar. The weather conditions then deteriorated, with rain and visual conditions below VFR limits. Abingdon Airfield was visually identified and Farnborough ATC was contacted by mobile telephone to advise them of the intention to land there. The landing gear was lowered manually, with 50 to 60 turns of the hand crank but, being unable to assess if the gear was fully down, the pilot opted to perform an engine-off landing. The engine was shut down and the fuel selected off when over the runway threshold. Although the aircraft landed very gently, the landing gear collapsed. The aircraft maintained the runway centreline and came to a safe halt with no fuel spillage and no injuries to the pilot or passenger. The battery was subsequently disconnected as a precaution.

The following information was provided by Farnborough ATC. G-BGSW was routing from Blackbushe to Bournemouth in receipt of a limited Radar Information Service when, about 3 nm north-west of Blackbushe, communications and radar contact was lost. Enquiries with Blackbushe eventually established that the pilot had contacted them using his mobile telephone, to advise them that his aircraft's electrics had failed and that he was intending to fly to Wellesbourne Mountford. Blackbushe then called back to report that the pilot was now in IMC and requesting help. The pilot was given the Farnborough ATC telephone number and requested to phone the unit. The pilot made contact with them and after initially reporting IMC, he then advised that he had visual contact with an airfield below him. The Farnborough controller taking the call was able to identify the airfield as Abingdon and a request to RAF Benson (the adjacent airfield) confirmed a primary radar return orbiting over Abingdon. The pilot reported that he would be making an emergency landing and subsequently phoned to advise that the aircraft had made a wheels-up landing, but that all the occupants were uninjured.

Aircraft examination

The AAIB contacted the engineering organisation that recovered the aircraft from Abingdon. The aircraft's electrical system, normal landing gear system (which is electrically operated) and manual gear extension all operated satisfactorily when tested prior to recovering the aircraft. No further examination of the aircraft has been performed to date but should further relevant information become available, it will be reported upon in an update to this Bulletin.

Aircraft Type and Registration:	DHC-1 Chipmunk 22, G-AOSU	
No & Type of Engines:	1 Lycoming O-360-A4A piston engine	
Year of Manufacture:	1950	
Date & Time (UTC):	19 December 2004 at 1245 hrs	
Location:	Easterton Airfield, near Elgin, Scotland	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - None
Injuries:	Crew - 1 (Serious)	Passengers - N/A
Nature of Damage:	Aircraft extensively damaged	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	62 years	
Commander's Flying Experience:	2,576 hours (of which 596 were on type) Last 90 days - 8 hours Last 28 days - 4 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

The aircraft was returning to the airfield after a short flight in the local area, the airfield was covered in a light layer of snow. The aircraft joined the right base leg for Runway 27 at a height of 1,000 feet above airfield level (aal) and the pilot then closed the throttle and selected full flap before turning onto final approach in preparation for a glide landing. On this occasion the pilot was particularly keen to land on the first third of the grass runway because the upwind end was wet and soft. It was apparent that the aircraft was very high and, in order to lose height, he executed a tight S turn, initially banking to the left. As the aircraft rolled out of the second left turn the pilot suddenly realised that he was now too low on the approach, as well as being to the right of the nominal runway centre line. He decided to continue although he would be landing diagonally to the runway direction, which was not an unusual practice at this airfield. In doing so the landing would be more into the surface wind, which was from 190º at 10 kt. Having made his decision, the pilot was conscious that he was flying into the low winter sun, which was sitting just above the horizon. The pilot remembered nothing else before becoming conscious of being placed in an ambulance.

He reported that witnesses had seen the aircraft drop its left wing and descend from about 100 feet aal into the field immediately short of the airfield. The left wing struck the ground first and the aircraft came to rest upright. It was estimated that there were 10 gallons of fuel on board prior to the impact and this spilled on to the surface; however, there was no fire. The pilot, who was unconscious, was lifted out of the aircraft by observers of the accident and taken to hospital, where he was treated for a laceration to his head and back injuries.

In a fulsome and frank report the pilot concluded that he had stalled the aircraft in the final turn. He explained that he often closed the throttle at some point on the approach to the runway in order to maintain his skills for the future possibility of an engine failure. On this occasion he was confident that he would be able to land from the approach. However, having lost more height in the S turn than he expected he later believed that he had become "locked" into the task of landing without power, although he could have opened the throttle and gone around. He also considered that the angle and direction of the sun might have been a factor in distracting him from maintaining his scan of the air speed indicator.

The pilot surmised that the unexpected height loss in the S turn might have been the result of wind shear, which is a feature at that location with southerly winds. Of note, for a period of time during the S turn the aircraft would have been on a northerly heading and consequently flying downwind. The pilot also considered that his back injuries could have been worse but for the dynafoam cushion which was fitted to his seat.

Aircraft Type and Registration:	Grob G115E Tutor, G-BYXJ
No & Type of Engines:	1 Lycoming AEIO-360-B1F piston engine
Year of Manufacture:	2001
Date & Time (UTC):	29 June 2004 at 1650 hrs
Location:	4.5 nm Southwest of Salisbury, Wiltshire
Type of Flight:	Training
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - Nil Passengers - N/A
Nature of Damage:	One propeller blade, part of propeller hub and canopy detached; substantial damage to engine and airframe
Commander's Licence:	Royal Air Force Qualified Flying Instructor
Commander's Age:	28 years
Commander's Flying Experience:	1,450 hours (of which 215 were on type) Last 90 days - 60 hours Last 28 days - 20 hours
Information Source:	AAIB Field Investigation

Synopsis

The aircraft was completing an aerobatic manoeuvre when one of the propeller blades separated from the hub. Despite severe vibration, the pilot was able to shut down the engine quickly and perform a successful forced landing in a field. There were no injuries to either crew member.

The investigation determined that the No 1 propeller blade had detached due to a high-cycle fatigue failure of the blade socket in the aluminium alloy hub. The pattern of cracking suggested that the failure may have been vibration related. It was also established that the propeller blade-retaining nut preload decreases rapidly in the first few hours of propeller operation, raising concerns that the reduction in blade retention stiffness could increase the blade's propensity to vibrate, thereby increasing the stresses in the hub. A safety recommendation concerning the need for further vibration testing to be carried out in order to fully understand the mechanism of the failure was made on 1 December 2004. Two further safety recommendations have also been made concerned with the continued airworthiness of the propeller and focusing on propeller blade retaining nut maintenance procedures and the non-destructive testing of propeller blade sockets to detect fatigue cracks.

Background information

The aircraft was operated by the RAF University Air Squadron (UAS) based at RAF Boscombe Down, Wiltshire, England. The aircraft commander was a military flying instructor and the student was a member of the UAS undertaking a navigation training course. All of the Grob G115E Tutor aircraft operated by the UAS are on the UK civil aircraft register and were supplied by a civilian organisation which also holds a JAR-145 approval for maintenance. Crews flying the aircraft are subject to the UK Air Navigation Order.

History of flight

The aircraft was carrying out a short sequence of aerobatic manoeuvres at the end of an uneventful navigation training exercise. The weather was fine with a surface wind of 210°/12 kt, visibility of 35 km with a few clouds at 2,300 feet and broken cloud at 25,000 feet.

After a climb to FL50, using high RPM and full power, the instructor completed the 'HASELL' checks, selected 2,500 RPM and confirmed that the auxiliary fuel pump was OFF and that the fuel was balanced between the two wing tanks. After a clearing 'Wing Over' to the right the aircraft completed a loop at 130 kt, flew level briefly and then entered a '1/2 Cuban', climbing with a 60º nose-up attitude. When the airspeed reduced below 100 kt, full back control column and full left rudder was applied. The aircraft entered a snap roll (dynamic spin) to the left through 180° and was stabilised inverted in the climb before being 'pulled through' to the horizon.

As the aircraft levelled, at approximately 120 kt with full power still set, there was a loud bang accompanied by extreme vibration. The instructor saw debris passing the canopy and could feel airflow entering the cockpit. His immediate thought was that his aircraft had been involved in a mid-air collision. As he transmitted a 'MAYDAY' call he was aware of the canopy moving backwards and then detaching; neither occupant had touched the canopy latching system. The instructor could see that the propeller blades were damaged but the resultant vibration was such that he could not read the cockpit instruments. As the engine was shut down, the vibration increased but then stopped. When the propeller blades were stationary, it was possible to see that one appeared to be missing and one was badly damaged. Oil was also visible on the right windscreen.

The instructor had initially considered abandoning the aircraft but with the vibration stopped he now elected to carry out a forced landing. He was familiar with the area and able quickly to identify a suitable field that he had used previously in practice exercises. Passing through his planned 'High

Key' position, he completed his 'Forced Landing' checks and informed ATC of his present position and intention to land. The aircraft touched down, in a field in standing crop, at approximately 60 kt. On the ground, the nose started yawing to the right and the aircraft began sliding to the left. The nose landing gear was damaged, the left gear collapsed and the aircraft came to rest after a ground roll of about 50 metres. The crew were uninjured and able to vacate the aircraft without difficulty.

Subsequently, a coastguard helicopter transported the crew to Salisbury Hospital for medical checks.

Prior to flight the instructor had checked the Technical Log and signed for the aircraft. He noted that there were no outstanding defects in the Log and that the aircraft was fully refuelled. During his pre-flight exterior check, the instructor recalled visually checking the propeller and associated area and noted nothing unusual.

Aircraft examination

The aircraft had landed in a cornfield and was intact, except for the canopy, the No 1 propeller blade and a section of the propeller hub, which were missing. It was evident that the No 1 propeller blade had detached due to a fracture of the blade socket of the aluminium alloy hub (Figure 1). The fracture, which appeared to originate in the threads inside the blade socket, allowed the outer part of the blade socket and the blade retaining nut to separate from the hub, thus releasing the propeller blade. The departing blade was struck by the following (No 3) blade, causing the detachment of a large portion of the latter (Figure 2).

The canopy, the No 1 propeller blade and the detached section of the hub blade socket were located approximately 3.5 km from where the aircraft had landed. The latching mechanism of the canopy was still in the locked position and it was apparent that the severe vibration from the propeller imbalance had caused the canopy to detach from the aircraft.

The vibration had also caused significant damage to the engine and its mountings. The left-hand upper mounting lug had severed from the engine crankcase and the engine support frame was cracked and distorted, causing the engine assembly to rotate downwards through an angle of about 10°. The left-hand magneto had come away from its mounting and both exhaust mufflers had severed from the exhaust down pipes at the welded joints. The fuel flow gauge had also detached from the instrument panel.

There was no evidence of the aircraft having suffered a bird strike or collision with any other object.

Immediate safety actions

The maintenance organisation responsible for supplying and maintaining the aircraft withdrew the Grob G115E Tutor from operation immediately after the accident.

In July 2004 the propeller manufacturer issued Service Bulletin 61-10-03 SB E 15. This required propeller disassembly for eddy current non-destructive testing (NDT) to check for cracks in the threads of the propeller blade sockets prior to further flight. The Service Bulletin was mandated by the German Luftfahrt Bundesamt (German Civil Aviation Authority) under EASA-approved Airworthiness Directive LTA D-2004-352R2.

Aircraft with propellers that passed inspection were returned to service, but were subject to a regime of checking the propeller blade retaining nut torque values at intervals of 5, 25, 50, and 100 flying hours. In addition, an eddy current crack check of the blade socket threads was required every 100 flying hours. This also required the propellers to be disassembled.

A total of 26 hubs were rejected following the initial eddy current inspection. These were returned to the propeller manufacturer for examination, the results of which are still awaited. Hub, serial number G23, exhibited a particularly large amplitude eddy current defect indication in the bottom thread of the No1 blade socket and was initially examined by the AAIB, prior to being returned to the manufacturer. The serial number of the hub on G-BYXJ was G22.

Propeller information

The Grob G115E is fitted with a Hoffmann HO-V343K-V/183GY three-bladed constant-speed propeller (Figures 3 & 4). The hub is manufactured from forged aluminium alloy and the Type 183GY propeller blades are manufactured from compressed hardwood and spruce, with an outer sheath of carbon fibre. Each blade is mounted in a duralumin carrier, or ferrule. The blade is attached to the ferrule by large screws, that screw into the compressed hardwood blade root. The ferrule locates into a socket in the propeller hub. Needle roller bearings transmit blade centrifugal loads to the hub and allow the blade to rotate in pitch. The propeller blade is secured in the hub by a blade retaining nut, which screws into the threaded blade socket and is torque-tightened to between 30 and 40 Newton-Metres (Nm). A 'T-shaped' locking plate prevents the nut from rotating.

The maximum approved operating speed of the propeller is 2,700 RPM. Typical propeller speed during takeoff is 2,700 RPM and the speed in cruising flight is typically between 2,300 and 2,500 RPM. In February 2004, however, the aircraft manufacturer issued Service Letter No SIL115-50 recommending that the engine should be operated at 2,400 RPM or below whenever possible; the high vibration levels found to be present above 2,400 RPM having a detrimental effect on engine ancillary components.

Propeller design

The design requirements for aircraft propellers, specified in JAR-P Section 190, state that:

> *'A test shall be conducted on prototype propellers with detachable wooden blades to determine that the vibration characteristics are not such as to cause resonance detrimental to airworthiness throughout the whole range of speeds up to the Maximum Permissible Rotational Speed'.*

Design certification tests performed by the propeller manufacturer on the G115E propeller, in isolation, did not identify any vibration or resonance problems. It is understood that the aircraft manufacturer chose not to perform vibration testing on the engine-airframe-propeller combination as it was not considered necessary. A vibration survey had previously been completed on the Grob G115D variant, which has the same engine as the G115E and a Hoffmann HO-V 343K( )-V/180FP three-bladed constant speed propeller, which is similar to the propeller of the G115E. Both shared the same hub, but the propeller blades differed in airfoil design and span. A natural frequency analysis performed on both propeller blades showed the resonant frequencies to be largely the same. The vibration survey on the G115D and the comparable blade natural frequency analysis results were used to demonstrate compliance with the design requirements on the G115E, thus precluding the need for separate tests. (A vibration survey involves flight testing the aircraft with strain gauges installed on the airframe and propeller, to enable the magnitude of vibratory stresses to be measured.) One notable difference between the two aircraft is that the G115D has a glass fibre reinforced plastic airframe, whereas the G115E airframe is constructed of carbon fibre.

Following the G-BYXJ accident, the propeller manufacturer re-evaluated the stresses on the blade socket of the hub during the particularly high propeller loading conditions present in a snap roll manoeuvre. These calculations suggested that the stress levels induced in the propeller hub during such a manoeuvre were not critical.

The HO-V343K-V/183GY propeller is of a generally similar design to other propellers produced by this manufacturer and this is the first occurrence of a hub failure on this propeller type.

In-service experience

The G115E has been in service for approximately five years and the highest time propeller has achieved approximately 2,400 flying hours to date.

According to the maintenance organisation, service experience on the G115E has shown that engine components including the left-hand magneto, starter motor, timing and idler gears and exhaust mufflers exhibit an unusually high failure rate. The failures are believed to be attributed to the high vibration levels experienced on the aircraft. Measurements taken by the propeller manufacturer on a G115E aircraft using an HO-V343-K-V/183GY propeller, and a propeller from another manufacturer with a similar polar moment of inertia, showed that the levels of torsional vibration increase significantly at engine speeds above 2,500 RPM. This has the effect of inducing high oscillatory torque loadings which are transmitted to the propeller. This is thought to be associated with a crankshaft torsional resonance condition that occurs at around 2,600 RPM. An independent study conducted by the engine manufacturer showed that the left-hand magneto also experienced increased levels of torque vibration at engine speeds above 2,500 RPM. The vibration issues prompted the aircraft manufacturer to issue Service Letter No SL115-50 recommending that the engine be operated at 2,400 RPM or below, whenever possible.

According to the maintenance organisation, the removal rate of the G115E propeller is high compared to other propellers, with nearly 400 unscheduled removals on a fleet of 99 aircraft since the G115E entered service with the RAF in late 1999. The reasons for the unscheduled removals included foreign object damage to the blades, cracking of the blade ferrules and blade tip play.

A review of overhaul records for these propellers showed that a significant number were found to have blade retaining nut torque values below the propeller Component Maintenance Manual lower limit of 30 Nm on disassembly.

Propeller maintenance requirements

The aircraft was maintained by the JAR-145 approved maintenance organisation in accordance with Approved Maintenance Schedule 'VTAE/Grob 115 Series', that was compiled by the maintenance organisation based on the manufacturer's recommendations and approved by the UK CAA. The propeller is inspected daily during each Check 'A' and at each '50 Hour' aircraft inspection. The Check 'A' inspection requirements include an inspection of the propeller and spinner for damage. This includes a check for blade tip play, referred to as 'tip rock' or 'blade shake'. The method, as demonstrated by an engineer from the maintenance organisation, is to apply force at the blade tip in the fore/aft and sideways directions in turn, whilst feeling for any detectable movement at the blade root.

The manufacturers 'HO-V343-( ) Propeller Operation and Maintenance Manual (E492)' requires the propeller to be inspected daily, in accordance with the following instructions:

> *'7.1 Daily Inspection*
>
> *Check blade installation.* ***No*** *blade shake is allowed. Blade angle play up to 1° is permitted. Check the propeller for loose screws and safety wires, the blades and the propeller spinner for damage. Turn blades by hand to check for smooth pitch change. Check the correct position of counterweights, if installed.'*

It was noted that these instructions do not include any illustrations depicting blade shake or how it should be detected. Blade 'angle play' denotes blade rotational movement in the pitch change sense.

The aircraft manufacturer's Maintenance Manual for the Grob G115E requires that the propeller be inspected every 50 flying hours with the spinner removed. This includes a visual inspection of the propeller for oil leaks and damage to the blades and spinner. It also includes a requirement to refer to the propeller manufacturer's operating and maintenance instructions.

Service experience has shown that cracking of the blade ferrules can occur and the blade counterweights can rotate away from their set position. Consequently, in April/May 2004 the maintenance organisation issued 'Maintenance Instruction No 49/04' to inspect the blade ferrules every 25 flying hours with the spinner removed, and 'Maintenance Instruction No 45/04' to check for counterweight rotation at each spinner removal.

The Technical Log showed the next scheduled inspection on G-BYXJ as being due at 1,284:35 flying hours, which included an inspection of the blade ferrules. This was overlooked by the engineers from the maintenance organisation, by the aircraft commander on the accident flight and by the aircraft commander on the previous flight. The aircraft had completed 1,284:50 flying hours immediately prior to the accident flight. The inspection had actually been due at 1,284:55 flying hours, but a minor slip made when transposing the figures from one Technical Log sheet to another showed it being due at 1,284:35 hours.

Propeller overhaul requirements

The manufacturer's specified overhaul life of the propeller is 1,600 flying hours or 7 years, whichever occurs soonest.

The Component Maintenance Manual (CMM) E661, for the HO-V343-( ) series of propellers contains a general requirement that all steel and aluminium parts of the propeller be inspected for cracks when the propeller is overhauled. Aluminium parts, such as the hub, are required to be NDT inspected either by a fluorescent or a non-fluorescent dye penetrant method. There are no detailed instructions for inspecting any of the individual propeller components.

The JAR-145 approved UK overhaul agency inspects the threads in the blade sockets for cracks at propeller overhaul using the fluorescent dye penetrant method, which is approved by the propeller manufacturer. According to NDT experts consulted, this is not the most reliable technique for detecting cracks in threads, because of the tendency of the dye penetrant to pool in the roots of the threads, potentially masking any crack that might be present. Furthermore, given the relatively small diameter of the blade socket, a mirror is required to inspect the threads, making this a labour intensive inspection.

Examination of G-BYXJ's propeller

The damaged propeller from G-BYXJ (serial No G22) was initially examined by the AAIB, prior to being submitted for expert detailed metallurgical examination. During disassembly it was noted that the breakaway torque required to undo the No 2 blade retaining nut was only 16.7 Nm; well below the lower limit of 30 Nm quoted in the propeller Component Maintenance Manual.

Dimensional measurements of the No 1 blade components, including the pitch change bearings and thrust washers and the pitch change bush, which is pressed into the hub, showed that the levels of wear were not excessive. A red/brown residue was found on the pitch change roller bearings which appeared to be indicative of fretting between the rollers and the races.

Metallographic examination, chemical analysis and mechanical tests of the hub revealed a fine-grained forged microstructure and both the material composition and strength were within specification.

Examination of the fracture surface on the No 1 blade socket showed that it had fractured due to the initiation and growth of high-cycle fatigue cracks, on opposite sides of the blade socket (Figure 5). The centres of the primary crack initiation zones were displaced about 20 degrees clockwise (looking down on the blade socket) from the fore/aft axis of the hub. The cracks originated in the first or second threads from the bottom of the threaded portion of the socket, corresponding to the most highly loaded threads. A notable feature was that the initial direction of propagation, near the crack origins, was in an axial direction upwards, with the cracks undercutting the tooth of the thread. This appeared to be the result of bending loads applied to the blade socket threads by the blade retaining nut (see Figure 7 showing a similar crack in No 2 blade socket). The fatigue cracks then turned outwards in a predominantly radial direction, before propagating circumferentially around the blade socket until failure, with relatively small regions of overload.

When the threads in the No 2 and No 3 blade sockets were inspected using the 2 MHz eddy current procedure specified in Service Bulletin 61-10-03 SB E 15, a large defect indication was found in the No 2 blade socket. Visual inspection using an optical microscope at low power confirmed the presence of an approximately 8 mm long crack at the base of the thrust flank of the first full thread in the bottom of the socket. This was in a similar circumferential location to one of the secondary fatigue crack origins in the No 1 blade socket (Figure 6). A section taken through the crack revealed that the direction of propagation was axial, undercutting the tooth of the thread (Figure 7). The depth of the crack into the material was approximately 2 mm. When the crack was opened up to allow the surface to be viewed, evidence of fatigue propagation was seen.

Fretting damage was evident on the flanks of the threads in all three blade sockets, with the most severe fretting seen in the area closest to the primary crack initiation positions on the No 1 blade socket. This was indicative of relative movement having occurred between the blade retaining nut and the socket.

Measurements of the fatigue striation spacing on the fracture surface of the No 1 blade socket with the aid of a scanning electron microscope gave an estimate of 225,000 cycles from crack initiation to failure of the blade socket. This figure is considered to be conservative and does not in any case include the number of stress cycles required to initiate the cracking. It was not possible to estimate the length of time taken to form crack initiation to failure without a better understanding of the mode and frequency of the blade vibration, but this could not be determined from the available evidence.

History of propeller Hub serial No G22

At the time of the accident, the propeller hub had completed approximately 1,710 operating hours since manufacture in May 1999 and approximately 249 hours since previous overhaul in August 2003. The most recent workshop visit was in October 2003 when it was removed from G-BYUJ for repairs to superficial damage to the No 3 blade. After repair it was installed onto G-BYXJ on 8 January 2004.

At the previous overhaul in August 2003, the hub was inspected for cracks by a JAR-145-approved UK overhaul agency approved to carry out such inspections. The inspection included the threads in the blade sockets of the hub. Records show that the hub was reported to be free of cracks.

The most recent in-service inspection of the propeller was during a scheduled '50-hour' airframe inspection performed on 13 June 2004, at 1,259:55 airframe hours. Maintenance Instruction 49/04, which required removal of the propeller spinner to allow the blade ferrules to be inspected for cracks, was accomplished at the same time.

The next scheduled inspection of the propeller was due at 1,284:55 airframe hours (erroneously shown as 1,284:35 on the Technical Log page) for a repeat inspection of the blade ferrules per MI 49/04, coincident with an engine oil filter change. Due to oversights by the pilot and the maintenance organisation, the aircraft was offered and accepted for flight with 1,284:50 airframe hours and the inspection overran.

The removal history for hub serial number G22 shows that the No 1 and No 2 blade retaining nuts were found to have low torque values on two of the workshop visits and that the blade sets had been replaced a total of five times during the life of the propeller.

Examination of propeller Hub serial No G23

Hub G23, that had failed the initial eddy current crack check on the fleet, was sent to the AAIB for initial examination before being returned to the propeller manufacturer for further investigation. Examination, under a low power microscope, revealed a crack indication in the bottom thread in the region of the eddy current defect indication in the No 1 socket. The crack indication was located towards the rear of the blade socket and near the base of the thrust-bearing flank of the bottom thread (Figures 8 & 9). The external appearance and general location of the crack indication were similar to that of the crack found in the No 2 socket of hub G22.

Hub G23 had completed a total of 1,539 flying hours since new and 151 hours since previous overhaul.

Blade retaining nut torque values

The Service Bulletin inspection findings showed that a significant reduction in the blade retaining nut torque occurs in the first few hours of propeller operation, that may be associated with a bedding in process. The magnitude of this reduction is typically around 20 Nm. Breakaway torque values as low as 8 Nm were recorded at the initial 5 hour inspection and blade nut torque values of around 10-12 Nm were not uncommon. A test conducted by the AAIB on a newly assembled propeller showed that the blade retaining nut torque could be reduced to 10 Nm before blade shake could be detected.

Based on the inspection findings, the manufacturer increased the torque values for the blade retaining nuts from 30-40 Nm to 70 Nm. Subsequent checks showed that this provided a significant improvement in the residual preload on the nut, even given the average decrease of torque of around 20 Nm which occurs in first few hours of propeller operation.

The maintenance organisation subsequently introduced a requirement on newly installed propellers for a check of the blade retaining nut torques to be performed after the propeller balancing engine runs. It was established that re-torqueing the nuts to 70 Nm after the initial engine runs helped to maintain the blade retaining nut torque settings at acceptable levels over a longer period in service.

Control of maintenance and acceptance for flight

The function of maintenance planning is performed by the JAR-145 approved maintenance organisation with the aid of a computer-based maintenance planning tool. To assist in the day-to-day work planning, the next maintenance checks due are recorded against each aircraft tail number on a wall-mounted maintenance planning board. The number of flying hours remaining until the next scheduled maintenance (eg '50-Hour', '100-Hour' check, etc) are displayed for each aircraft and regularly updated. This is referred to on a daily basis by the company's base maintenance and line support engineers, who plan the day's operation accordingly. If an inspection should fall due during the day's operation, it is the responsibility of the line support engineer to withdraw the aircraft from service so that the inspection can be completed in time.

It was noted that the 25 hour requirement to replace the engine oil filter (at which time the propeller ferrule inspection in accordance with MI 49/04 was also due) which was also tracked on the maintenance board, did not display the flying hours remaining until the task was due, but rather the total airframe flying hours at which the task fell due. This made it more difficult to tell, at a glance, whether the task was likely to fall due during the day's flying operation.

The Aircraft Technical Log is also clearly annotated to show when the next maintenance is due, and it is the aircraft commander's responsibility under the requirements of the UK Air Navigation Order (ANO) to ensure that any necessary maintenance has been completed when signing the acceptance for flight. Notwithstanding this, enquiries revealed that the pilots did not always check the hours remaining until next inspection, thinking that this was the responsibility of the engineers. The operator has since amended their operational procedures to ensure that their aircrew comply with the ANO requirements for acceptance for flight.

Analysis

No evidence of was found of the aircraft having suffered a bird strike or in-flight impact with any other object therefore this possibility was discounted as a causal factor.

Given that the material properties of the hub G22 were acceptable and that the No 1 blade components did not exhibit excessive wear, there is no evidence to suggest that the failure was caused by any deficiency in the propeller hub, the blade or any of its components.

The lead propeller on the fleet had achieved approximately 2,400 flying hours to date, hub G22 had completed 1,700 flying hours when it failed and hub G23, which appears to be cracked, had completed 1,539 flying hours. This is the first failure on a fleet of 99 G115E aircraft. Whilst there appears to be no basic deficiency in the propeller design, there is clearly a long-term reliability issue with this propeller/aircraft combination. According to the manufacturer's estimates, even high loading cases such as snap roll manoeuvres are not likely to induce critical stresses in the propeller hub.

The high cycle fatigue failure observed in hub G22, with primary crack origins located on opposite sides of the blade socket and with similar rates of crack propagation in each location (Figure 5), is indicative of the blade socket having been subjected to cyclic stresses. The direction of the applied forces on the blade to produce such stresses is predominantly in the fore and aft direction.

The fact that the crack in the No 2 blade socket of hub G22 exhibited similar characteristics to the cracks in the failed No 1 socket, in that it was located at the base of the thrust flank of the bottom thread and was propagating in fatigue, suggests that a similar failure mechanism may have been at play in the No 2 socket.

The presence of cyclic stresses on the blade socket, leading to fatigue propagation at similar rates on opposite sides of the socket, opens up the possibility that the failure mechanism may be related to vibration. It is noteworthy that high torsional vibration levels, detrimental to engine ancillary components, are known to be present at engine speeds above 2,500 RPM.

The possibility of the causal factor being a discrete event, such as a propeller ground strike was considered, and whilst this remains a possibility, it is difficult to see how this would have induced fatigue cracks on opposite sides of the blade socket and it is likely that other witness marks associated with such an event would also have been evident. Furthermore, a single event could not explain the presence of the fatigue crack in the No 2 blade socket. The presence of a crack indication in hub G23 further suggests that the problem may be more widespread.

The initial direction of crack propagation in the No 1 socket was predominantly in the fore-aft direction. The close spacing of the fatigue striations and the small areas of final overload failure show that magnitudes of the cyclic stresses were relatively low and that the stresses on the blade socket due to the centrifugal loading are not particularly high. There was insufficient evidence to enable the mode and frequency of the blade vibration to be determined. It was therefore, not possible to estimate the elapsed time from crack initiation to hub failure. Further testing, involving flight trials with a strain-gauged propeller, would be required to establish the levels of vibration experienced by the propeller and the resultant stresses in the blades and hub.

The presence of severe fretting on the flanks of the threads in the No 1 blade socket and to a lesser degree on the threads in the other blade sockets, is evidence that the blade retaining nuts had moved within the hub. If the blade is not rigidly retained in the socket, due to insufficient preload on the blade retaining nut, relative movement may occur during propeller operation. The loss of preload on the blade retaining nut would change the loading/stress characteristics within the hub, to the point where fatigue cracks could be initiated. Low blade retaining nut torque may therefore be a significant contributory factor, reducing the rigidity of the blade in the hub and allowing the blade more freedom to move in response to normal in-service loads or any vibration that may be present.

The fact that the blade retaining nut preload drops off very quickly in the first few hours of propeller operation may be indicative of a bedding in process occurring, due to initial wearing in of surfaces in contact, or redistribution of grease within the hub, or a combination of both. The introduction of a requirement to check-tighten the blade retaining nuts after an initial period of running has proved to be beneficial. The breakaway torque of 16.7 Nm of the No 2 blade retaining nut and the results of the fleet inspection, which highlighted torque values less than 10 Nm in some cases, shows that low blade nut torque is not an uncommon condition. Given that the blade retaining nut torque can fall as low as 10 Nm before any blade shake becomes detectable, it must be questioned as to whether blade shake is a satisfactory method for ensuring adequate preload on the blade nuts. Regular checks of the nut torques would provide greater certainty of ensuring the correct preload in the long term.

The surveys conducted by both the propeller and engine manufacturers showed a dramatic rise in the level of torque vibration at engine speeds above 2,500 RPM, believed to be associated with a crankshaft torsional resonance condition. This or any other source of vibration, could exploit any lack of rigidity of the blades in the hub and induce them to vibrate. This in turn would cause dynamic amplification of the stresses on the blade retaining nut and the blade socket to the point where fatigue cracking could be initiated. The higher than normal failure rates of various engine components, compared with similar general aviation aircraft, are further evidence of the high vibration environment on the G115E.

It cannot be said for certain whether the cracks in hub G22 were present at the previous overhaul in August 2003. If they had been however, they may have been overlooked given the difficulty of detecting cracks in threads using dye-penetrant inspection methods. It is likely that the use of an eddy current or other suitably reliable technique would increase the probably of detecting a crack in the early stages of development. The effectiveness of the 2 MHz eddy current test, contained in Service Bulletin 61-10-03 SB E 15, has been demonstrated in that the relatively small crack in the No 2 blade socket of hub G22 was easily detected long before the crack had reached a critical length. The disadvantage however, is that this method of inspection requires removal of the propeller blades, an operation which is undesirable on a frequent basis, given the cost implications and the possibility of inadvertent damage or increased wear occurring on the threads.

It is not possible to say whether the cracks in the hub would have been externally visible or if they may have been found had the 25-hour visual inspection of the propeller ferrules been performed when it fell due prior to the accident flight. Given these uncertainties, the fact that the inspection was not completed is not considered to be a contributory factor to the accident. It was apparent that there was a lack of appreciation amongst some pilots of their responsibility for ensuring that the necessary maintenance has been completed on the aircraft prior to accepting it for flight. The fact that the inspection was also overlooked by the engineers was a human factor error, in that by recording on the maintenance planning board the total airframe hours at which the inspection fell due rather than hours remaining, it was not obvious at a glance that the inspection would fall due during that day's flying operation. Both issues have now been resolved to the satisfaction of the operator and the maintenance organisation through procedural changes.

Conclusions

The cause of the propeller failure was a fracture of the No 1 blade socket due to extensive fatigue crack propagation culminating in an overload failure that allowed the No 1 blade to detach from the hub. The presence of fatigue origins on opposite sides of the blade socket, with similar crack propagation rates on either side, suggests that the propeller blade had been subjected to cyclic stresses possibly related to vibration. The presence of a small fatigue crack in the No 2 blade socket, in a similar location to one of the crack origins of the No 1 socket, suggests that the No 2 blade may have been similarly affected.

There is a tendency for the blade retaining nut torque to decrease rapidly in the first few hours of operation of a newly installed propeller. This leads to a reduction in the preload on the nut, reduces the rigidity of the blade retention in the hub and has the potential to increase the stresses in the hub.

Studies and in-service experience show that the Grob G115E experiences high levels of vibration that appear to be related to the torsional vibration behaviour of the engine crankshaft. Further testing is necessary to confirm the source of the vibration and its effect on the propeller and other parts of the aircraft.

Safety Recommendations

It was not possible, without further testing, to determine the precise nature of the vibration that caused the fatigue cracking in the No 1 and No 2 blade sockets. Given that no in-flight vibration testing has yet been performed on the Grob G115E airframe/engine/propeller combination, the following safety recommendation was made by the AAIB:

Safety Recommendation 2004-102 (made on 1 December 2004)

The aircraft manufacturer, GROB-WERKE Aerospace Division, should perform testing of the HO-V343K-V/183GY propeller on the engine/airframe combination of the Grob G115E, in order to establish the vibration characteristics of the propeller and the resultant stresses in the propeller blades and hub. This testing should also examine the effects of a loss in preload of the blade retaining nut.

In order to ensure the continued airworthiness of the type HO-V343K-V/183GY propeller on the Grob G115E aircraft, the following safety recommendations are made:

Safety Recommendation 2005-02

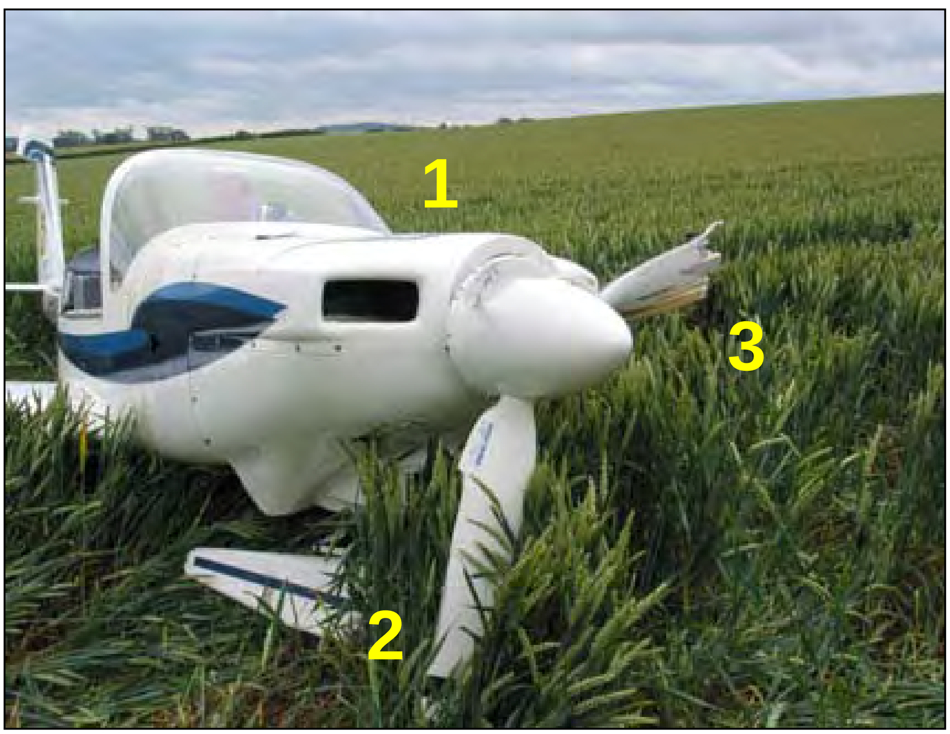
It is recommended that Hoffmann Propeller GmbH & Co KG introduce suitable maintenance procedures, or a suitable technical solution, for the type HO-V343K-V/183GY propeller on the Grob G115E, to ensure that the preload of the propeller blade retaining nut is maintained at an acceptable level.

Safety Recommendation 2005-03

It is recommended that Hoffmann Propeller GmbH & Co KG introduce adequate, high confidence level, non-destructive test (NDT) procedures, that will detect cracks in the threads of the type HO-V343K-V/183GY propeller blade sockets during overhaul and whilst in operational service on Grob G 115E aircraft.

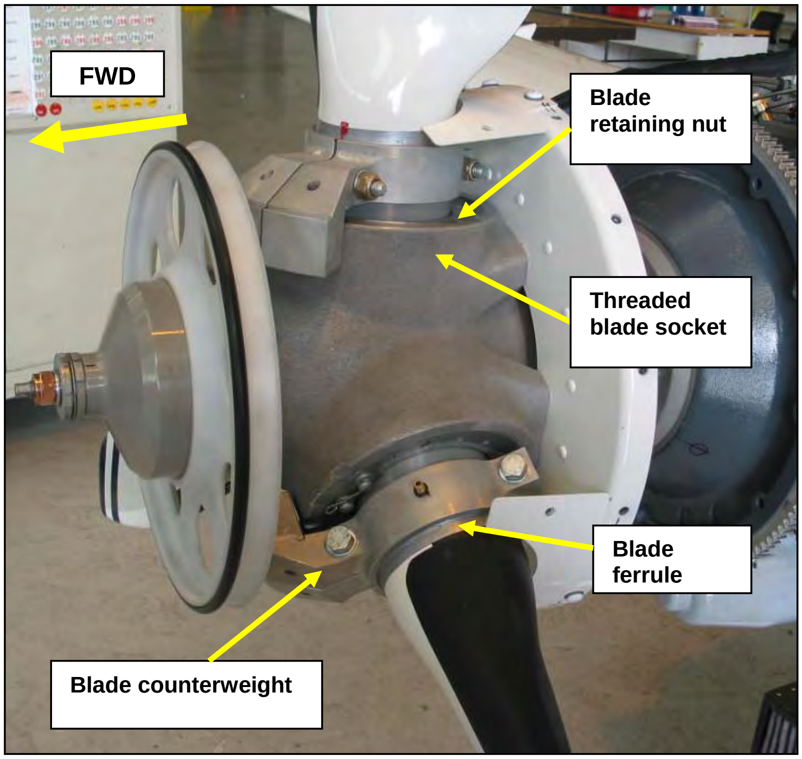
Propeller hub showing fractured No 1 blade socket

Figure 1



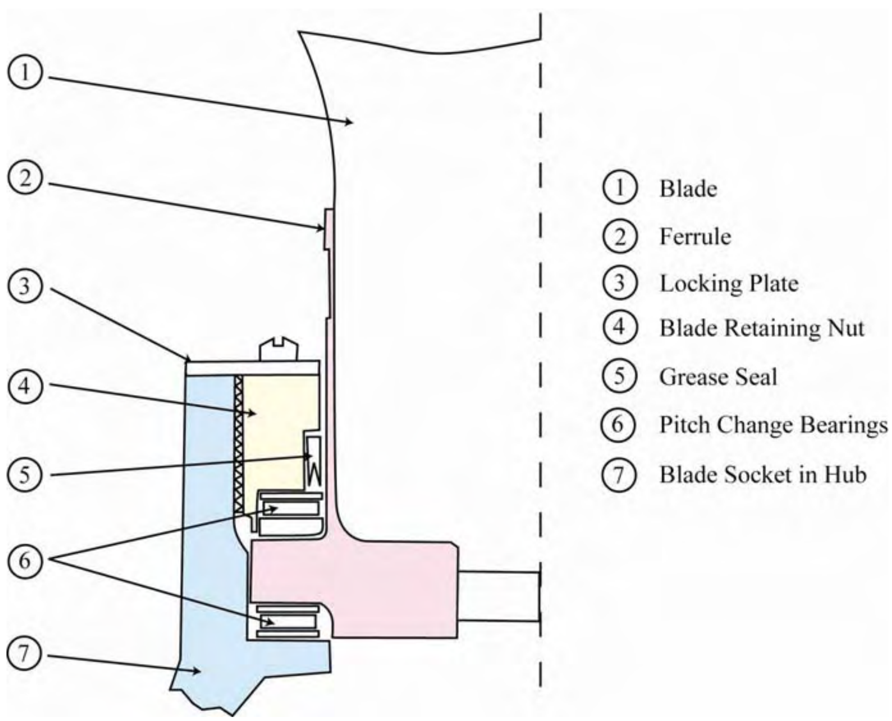
General view of propeller damage (blade locations numbered)

Figure 2



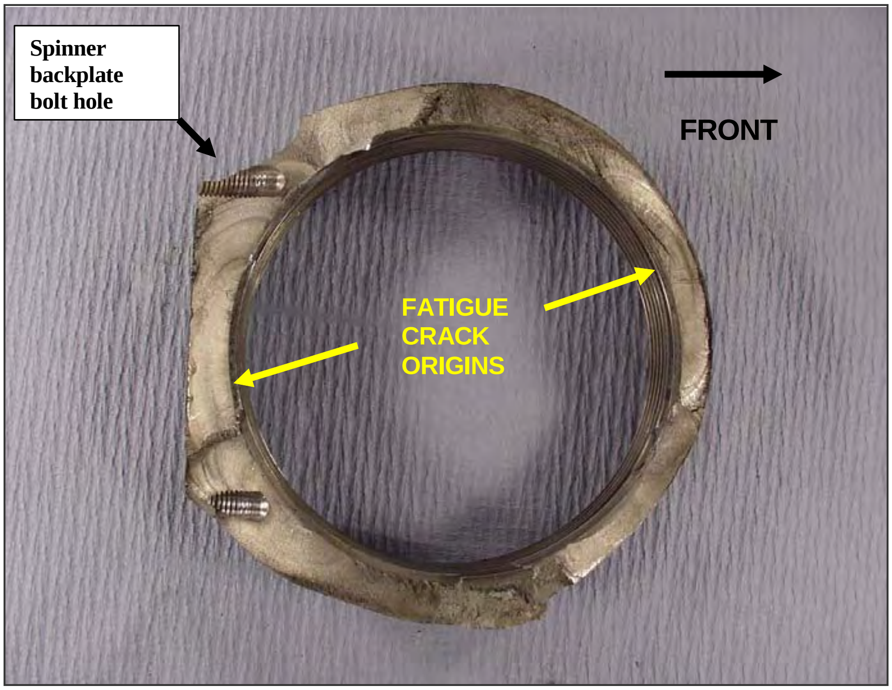
Grob G115E propeller assembly

Figure 3



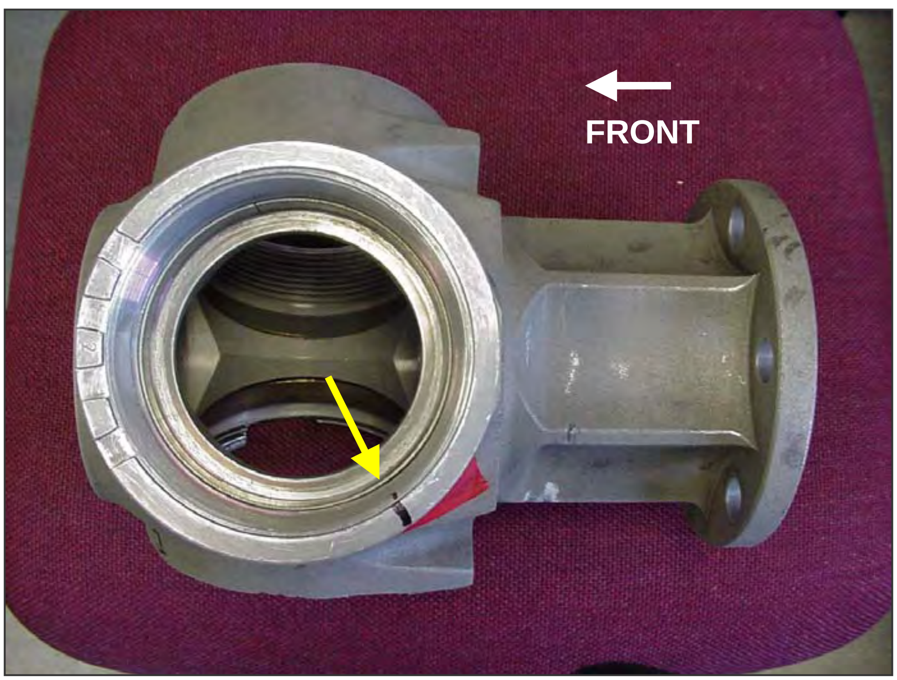
Part section through blade socket components

Figure 4



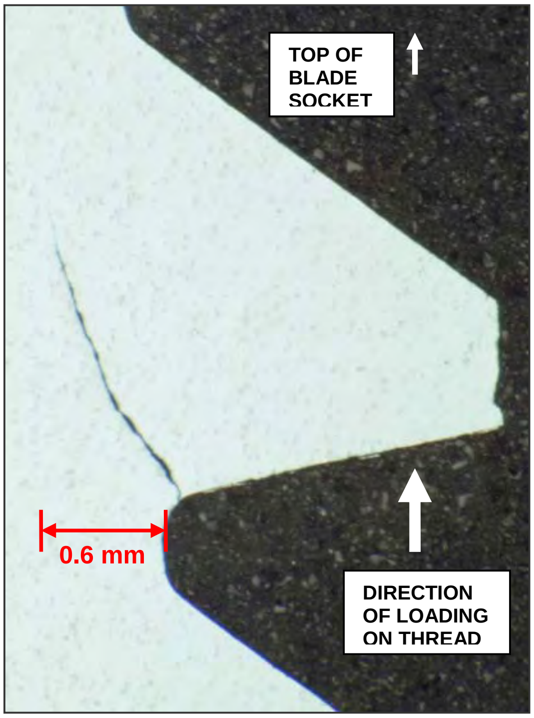
View on underside of separated portion of No 1 blade socket of Hub G22 showing locations of fatigue crack origins

Figure 5



Circumferential location of crack in bottom thread of Hub G22 No 2 blade socket

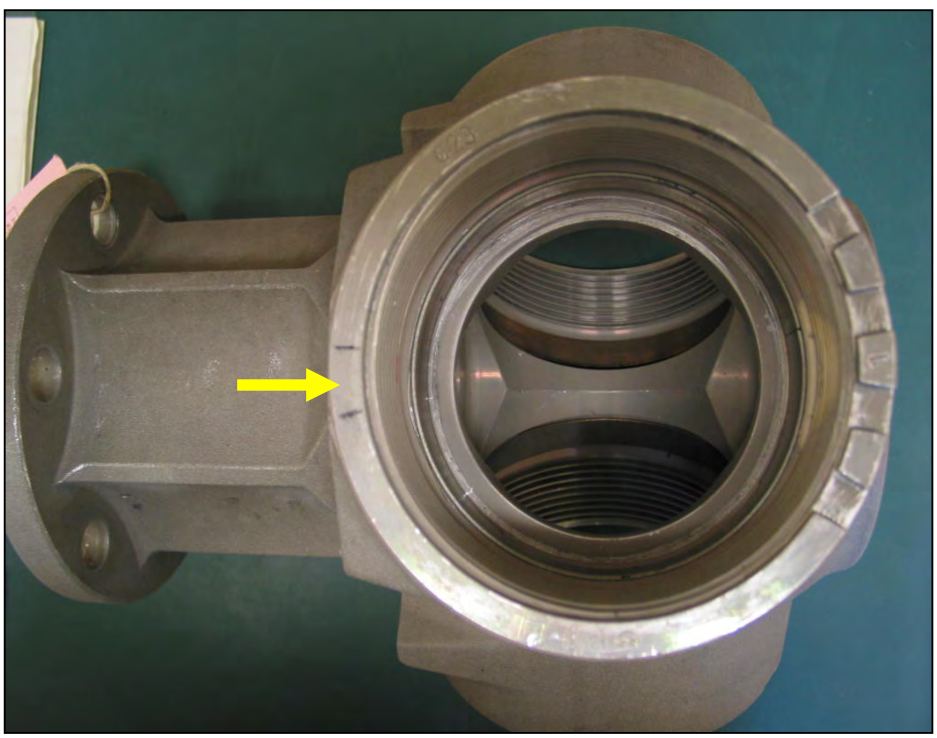
Figure 6



Fatigue crack in bottom thread of Hub G22 No 2 blade socket

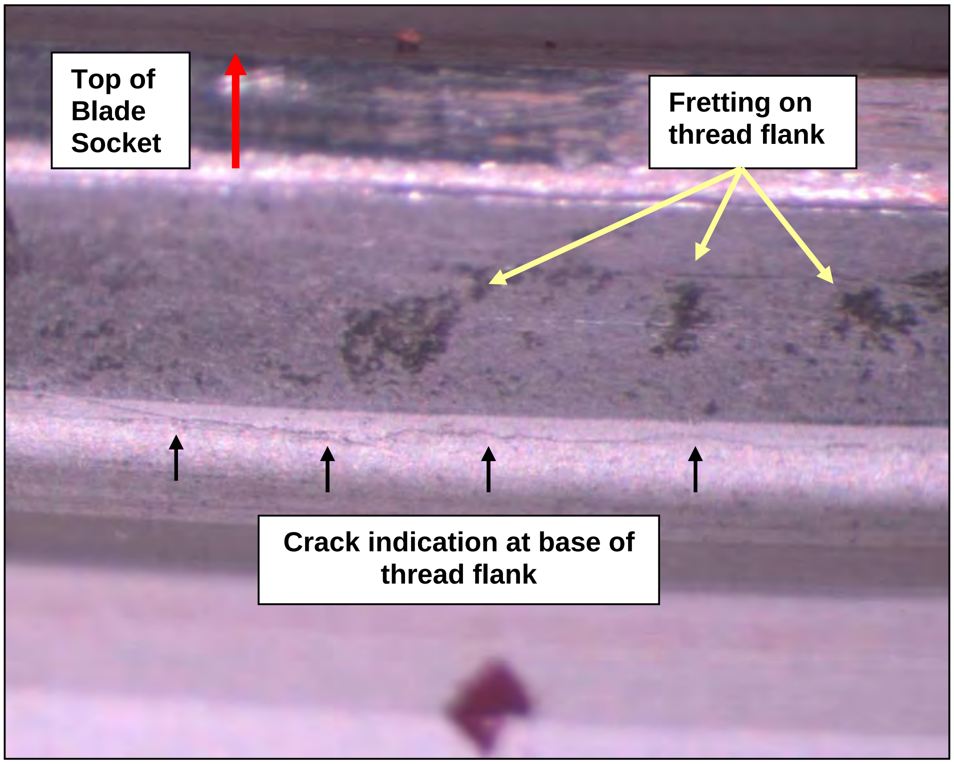
(Crack penetration depth approximately 2mm; crack detected using 2 MHz eddy current procedure)

Figure 7



Circumferential location of crack indication in bottom thread of No1 blade socket - Hub G23

Figure 8



Visual appearance of crack indication - Hub G23

Figure 9

Aircraft Type and Registration:	Jodel DR1050 Ambassadeur, G-AWWO	
No & Type of Engines:	1 Continental Motors Corp O-200-A piston engine	
Year of Manufacture:	1964	
Date & Time (UTC):	13 November 2004 at 1030 hrs	
Location:	Huddersfield (Crosland Moor) Aerodrome, West Yorkshire	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 1
Injuries:	Crew - None	Passengers - None
Nature of Damage:	Significant damage to rear fuselage	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	47 years	
Commander's Flying Experience:	263 hours (of which 124 were on type) Last 90 days - 3 hours Last 28 days - 1 hour	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

History of the flight

The aircraft was based at Manchester (Barton) Aerodrome and prior to a 50 hour check, the pilot and a friend decided to fly to Crosland Moor and then return to Barton. The weather was CAVOK with a calm surface wind at Barton. The flight was uneventful and the pilot made a blind transmission of his intention to land on Runway 25 at Crosland Moor. The windsock indicated a crosswind from the right but not of any significant strength. Runway 25 is 800 metres long and 22 metres wide with the first 550 metres asphalt and the remaining 250 metres grass. There is a significant upslope on Runway 25 which is listed in a well known Flight Guide as '*2.6% down on Rwy 07, from start of asphalt*'. There are quarry workings in the undershoot of Runway 25 that are adjacent to the threshold.

On base leg of the circuit to land, the pilot set 1,500 RPM and reduced the airspeed. On final approach he extended the airbrakes which are located below the wing and he lined up with the runway centreline, maintaining the normal approach angle by adjusting the power. He flared the aircraft over the threshold, on the centreline of the runway and increased power to compensate for the upslope. However, the aircraft drifted to the left and the tail wheel contacted the grass area on the left side of the asphalt runway.

The pilot decided to 'go-around' and so he applied take-off power but he did not retract the airbrake. Two large grass mounds are located approximately 10 metres to the left of Runway 25; the aircraft passed clear to the right of the first mound but as the second mound approached, the pilot applied right rudder in an attempt to avoid it. The aircraft yawed to the right and its tail struck the grass mound which slowed the aircraft and caused it to touch down in a level attitude whereupon the pilot closed the throttle. The landing gear absorbed the touchdown forces as the aircraft slid and the propeller remained clear of the ground. The aircraft came to a stop after a short distance and the pilot shut down the engine before he and his passenger vacated the aircraft by the normal exit. Other people at the aerodrome who had seen the accident promptly attended the scene.

Conclusions

Inspection of the tail revealed that it had suffered serious damage, probably when it impacted the grass mound. The pilot did not know if the drift to the left in the flare was as a result of the crosswind or the application of power or a combination of both. He considered that he had not corrected the drift in the flare and he should have executed a go around at that point. The strength of the crosswind only became apparent when the pilot was outside the aircraft. It was probably between 10 and 15 kt which was much stronger than he had interpreted from the wind sock.

Aircraft Type and Registration:	Mooney M20J, G-DESS
No & Type of Engines:	1 Lycoming IO-360-A3B6D piston engine
Year of Manufacture:	1982
Date & Time (UTC):	14 October 2004 at approximately 1427 hrs
Location:	Wadswick Airstrip, near Corsham, Wiltshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - 1 (Serious) Passengers - 1 (Serious)
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Private Pilot's Licence with IMC Rating
Commander's Age:	60 years
Commander's Flying Experience:	Approximately 1,250 hours (of which 1,000 were on gliders and 160 were on type) Last 90 days - 19 hours Last 28 days - 5 hours
Information Source:	AAIB Field Investigation

Synopsis

The aircraft crashed following a go-around during an approach to a private airstrip. The aircraft was in the landing configuration when the pilot suddenly realised that he was too low on approach and applied full power to go-around. On the go-around, the aircraft stalled accompanied by a left wing drop. The pilot was unable to recover from the subsequent incipient spin before ground impact.

History of flight

The owner of G-DESS had planned to move his aircraft from Old Sarum Aerodrome to a private airstrip at Wadswick. He had spoken to the airstrip operator and agreed that he would fly to Wadswick on the afternoon of 14 October to review the facilities. He was aware of the advice contained within '*LASORS Safety Sense 12 Strip Sense*' and the need to adhere to Rule 5 of the *Rules of the Air* (often referred to as the 500 foot rule). As he had not flown there before, he arranged that a friend would accompany him on the flight. The friend was not a pilot but was familiar with the local area.

Accordingly, on the morning of 14 October the owner and his friend went to Old Sarum for the flight. The plan was that they would fly to Wadswick where the pilot would make a couple of fly-pasts to familiarise himself with the airstrip, and then return to Old Sarum. The friend would disembark and drive the owner's car to Wadswick, while the owner would fly back and land at Wadswick. The weather was good with a forecast westerly surface wind of 10 to 15 kt at Wadswick. On arrival at Old Sarum, the pilot completed his normal checks and started the aircraft. He then taxied to the fuel area, where he filled his aircraft to full fuel. The subsequent takeoff from Runway 24 was uneventful as was the transit towards the north. The pilot was seated in the left cockpit seat and his friend was seated to his right. The pilot subsequently confirmed that the aircraft appeared fully serviceable and both occupants confirmed that the passenger made no control inputs during the flight.

After takeoff, the pilot made contact with Lyneham Radar at 1411 hrs on frequency 123.40 MHz and agreed a Flight Information Service (FIS). As Wadswick Airstrip was within the Lyneham Control Zone (CTR), the pilot advised Lyneham of his intention to make a pass over the airstrip before returning to Old Sarum. At 1421 hrs, Lyneham Radar advised the pilot of G-DESS that the surface wind at Lyneham was 290°/5 to 10 kt. In the area, the pilot had some trouble locating the airstrip but, at 1424 hrs informed Lyneham that he was on "*Finals for Wadswick Runway 27*". Following the subsequent acknowledgement, there was no further communication between G-DESS and Lyneham. Shortly after, with the gear down and full flap selected, at an indicated airspeed of 70 kt and with the aircraft trimmed, the pilot suddenly realised that he was much lower on the approach than he intended. He immediately applied full power. He could not subsequently recall any details between that point and then being aware of the aircraft in a nose down attitude. By then, G-DESS was banked to the left with full power set and with control inputs applied in accordance with an attempted recovery. It appeared obvious to the pilot that the situation was not recoverable. He called to his passenger that they were going to crash and was then aware of the aircraft striking the ground. When the aircraft came to rest the pilot, although badly injured, used his mobile telephone to alert the emergency services.

The passenger had previously flown with the pilot and considered him safe and conscientious. On the approach to the airstrip, the passenger was aware of power being applied and the nose of the aircraft rising quickly. He also confirmed hearing the sound of a warning horn. He subsequently stated that he had heard the same noise on a previous flight with the pilot when the pilot had been practising stalling.

Emergency Services

A police helicopter had been operating in the local area with Lyneham Radar and had landed to the south of Melksham, some 4 km from the crash scene, at 1427 hrs. Following the initial call to the emergency services the police helicopter crew lifted off and contacted Lyneham Radar. They arrived at the crash site at 1434 hrs. By then, the passenger had managed to extricate himself from the wreckage but the pilot was still trapped and badly injured.

With the serious injuries to the pilot and difficulties in extricating him from the wreckage, it was considered necessary to airlift a medical team to the scene. At 1607 hrs, the police helicopter reported that the pilot was being airlifted to hospital.

Weather information

The Meteorological Office at Exeter provided an aftercast for the crash location. This indicated that the surface wind was 270°/ 10 kt and the wind at 2,000 feet amsl was 300°/ 15 to 20 kt. The surface visibility was generally 20 to 30 km. Cloud was scattered to broken Cumulus base 2,000 to 2,500 feet amsl and scattered to broken Stratocumulus base 3,000 to 5,000 feet amsl. There was occasional broken Cumulonimbus over the area with a base of 1,500 to 2,000 feet amsl. Rain showers had been noted in the area.

Airstrip information

The airstrip has an elevation of 400 feet amsl and is just within the Lyneham CTR. It has a grass runway orientated 280°/ 100°M; the grass was short and dry at the time of the accident. The runway is approximately 700 metres long and 25 metres wide with a hedge at the eastern perimeter. There is also a power line crossing the runway near the eastern threshold but one span of the electric cable is buried below the runway. The airstrip has a windsock.

Recorded data

A Bendix/King Skymap model IIIC Global Positioning System (GPS) was recovered from the aircraft. The unit was successfully downloaded by the AAIB and a track log for the accident flight was recovered. The track log contained the following data points: date, GPS time, GPS position, GPS altitude, groundspeed and track. The unit was configured to record data points at twenty-second intervals.

Secondary radar was also available for the accident with position and altitude data recorded at eight second intervals. Ground speed was calculated using radar data and then compared with the GPS ground speed. The speeds did not typically differ by more than 6 kt at coincident data points.

The final secondary radar point was recorded at approximately 1423:40 hrs, groundspeed was approximately 90 kt and Mode C altitude was 1,700 feet. GPS data continued to be recorded after the final radar point. At 1424:07 hrs, GPS groundspeed was 68 kt and the track was 281°. The aircraft remained on a track of approximately 280° and groundspeed gradually reduced until the final data point, which was recorded at 1425:07 hrs, when the ground speed was approximately 47 kt. With the reported aftercast wind, the airspeed would be some 10 to 15 kt above the calculated groundspeed.

Examination of the wreckage

The aircraft and the accident site were examined the next day. The aircraft had come to rest in a newly-sown field some 80 metres to the south of the airstrip and about 50 metres west of the threshold. The right wing was completely detached, with the main landing gear in the extended position. The left wing was still attached and the left gear appeared to be retracted.

There had been some disturbance of the wreckage due to the activities of the emergency services but it was clear that there had been major impacts on the wingtips and the nose. This corresponded to the initial ground impact marks which indicated that first contact had been with the left wingtip, followed by the nose/propeller and then the right wingtip, with the aircraft in a steep nose-down attitude; a manoeuvre commonly called a 'cartwheel'. After this, the aircraft had slewed sideways and come to rest approximately on the heading of the runway.

The disruption to the nose and instrument panel was severe but it could be seen that the nose landing gear had been DOWN. There was considerable chordwise scratching of the propeller, suggesting that it had been turning at speed at impact. The right wing fuel tank had ruptured and the fuel had drained away but the left tank remained full of fuel. There had been no fire. The 'as found' condition of the controls suggested that full power, fully rich mixture and fully fine propeller pitch had been selected.

After removal to a hangar at the AAIB examination of the flap, landing gear and pitch trim actuators showed that the flaps were fully extended, the landing gear was down and locked and the pitch trim was slightly more nose-up than the normal take-off range. A subsequent flight in the same aircraft type by an investigator indicated that this 'as found' trim position may have resulted in a slight push force being required during an approach at 70 kt. The apparently retracted condition of the left main gear was due to sideways loading during impact, which had caused partial failure of the mounting trunnions.

In the cabin, both occupants' seats and lap-and-diagonal restraints had remained secure and it was evident that their injuries had been caused by rearward movement of the instrument panel/control columns and severe crushing of the floor structure.

Pilot's Operating Handbook (POH)

The POH contained the following relevant information:

1. Spin warning:

   'Up to 2,000 feet of altitude may be lost in a one turn spin and recovery; therefore stalls at low altitude are extremely critical.' Note: Aerobatic manoeuvres, including spins are not approved.

2. Caution during approach:

   'From a flaps retracted trimmed condition, the force required for nose up pitch control will rapidly increase when power is reduced to idle and as flaps are fully extended. Timely trimming action should be accomplished to minimize forces.'

3. Caution during a go-around:

   'From a flaps extended and power at idle trimmed condition, the force required for nose down pitch control will rapidly increase when Maximum Continuous Power (MCP) is applied and as flaps are fully retracted.'

4. The indicated airspeed on finals with full flap is 71 kt.

5. Initial airspeed on a go-around is 65 kt and flaps should be retracted once the climb is established.

6. The indicated stall speed with gear down, full flap and zero bank angle would be about 52 kt at the assessed aircraft weight of 2,500 lb. Note: The assessed weight and CG position were within normal flight limitations.

7. The electrical stall warning system uses a vane-actuated switch, installed in the left wing leading edge, to energise a stall warning horn located in the cabin. The stall warning provides an aural warning some 4 to 8 kt before the actual stall is reached and will remain on until the aircraft flight attitude is changed.

Analysis

In preparation for a possible move of location for his aircraft, the pilot had made reasonable plans for the move. He had reviewed the advice within LASORS '*Safety Sense 12 Strip Sense*' and arranged for a friend to accompany him on an initial flight to locate and survey the new site. The weather was suitable and the pilot had received permission from the airstrip operator. Prior to, and during the flight, there was no indication of any technical problem with G-DESS. Fortunately, both occupants survived the serious impact and both were very honest and open in their recollection of the events leading up to the accident.

The pilot had identified the airstrip and was established on his approach in the normal landing configuration. He was not aware of the elevation of the airstrip and so was relying on visual cues to determine his approach path. His recollection was that the aircraft was correctly trimmed at approximately 70 kt. Post-crash investigation confirmed that the aircraft had gear down and full flap extended at ground impact. The impact marks were also indicative of an incipient spin. It was apparent that control of the aircraft had been lost close to the point of the go-around. This was confirmed by the occupants' recollection of hearing the stall warning activate during the go-around and by the pilot's recollection of the aircraft rolling to the left. Following the loss of control, there was insufficient altitude to recover from the developing spin.

On approach, the pilot suddenly had the impression that he was too low and had immediately applied full power for a go-around. In that perceived situation, he made the correct decision but the manoeuvre resulted in a loss of control. Without exact information on the airspeed, pitch trim setting and the control input at the time, it was not possible to determine precisely the reason for the loss of control. However, GPS evaluation indicated that the airspeed may have been slowly decreasing over the last period of flight from approximately 80 kt to about 60 kt. Any reduction of airspeed below the normal approach speed of 71 kt would have resulted in a reduced margin from the stall speed of 52 kt.

Additionally, for any go-around, a pitch control input is required to stop the descent and start a climb. The force input required can be dependent on the existing pitch trim position. Post-crash analysis revealed a trim position, which would have resulted in a slight push force being required to keep the aircraft on the required flight path prior to the go-around. It is possible for this trim position to have been changed between the loss of control and impact. However, any such out of trim position could have resulted in a gradual speed reduction on approach and an increased tendency for the aircraft to pitch up during a go-around.

Finally, any change in engine power would require the use of rudder to keep the aircraft balanced. A rapid change of power would require a positive rudder input in the correct sense. Any imbalance would result in an unplanned roll / yaw and have an adverse effect on the stall speed.

In summary, it is likely that a go-around, initiated earlier and lower than planned, resulted in a stall and loss of control from which the pilot could not recover in the height available. It is possible that the airspeed had reduced below the target speed and, if the aircraft had been slightly mistrimmed, then the rapid application of power, together with any control input by the pilot, would have resulted in a rapid nose-up pitch change. The accident highlights the need for appropriate and detailed planning for all flights, using all available information and to consider possible problems. The information contained within *LASORS Safety Sense 12* is comprehensive and sensible.

Aircraft Type and Registration:	MW5D Sorcerer, G-MZEI	
No & Type of Engines:	1 Rotax 503 piston engine	
Year of Manufacture:	1997	
Date & Time (UTC):	2 September 2004 at 1648 hrs	
Location:	Belle Vue Farm, Great Torrington, Devon	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - None
Injuries:	Crew - 1 (Serious)	Passengers - N/A
Nature of Damage:	Aircraft destroyed	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	63 years	
Commander's Flying Experience:	420 hours (of which 10 were on microlights) Last 90 days - 5 hours Last 28 days - 3 hours	
Information Source:	AAIB Field Investigation	

Synopsis

The pilot had recently purchased the aircraft and on the day before the accident, he had assembled it and carried out some taxiing trials to familiarise himself with it. On the day of the accident the pilot once again confirmed that the aircraft was properly assembled and following further taxi practice, he elected to carry out his first flight on the type. The aircraft accelerated quickly and became airborne after what seemed like a short take-off run following which, the pilot experienced difficulty in controlling the aircraft, mainly in pitch but also in roll. Despite having inadvertently applied substantial nose-down trim before takeoff and having applied full forward control column after becoming airborne, the pilot was unable to lower the nose of the aircraft. After a short distance, the right wing dropped and the aircraft impacted the grass area to the north of the runway in an inverted attitude, seriously injuring the pilot.

History of the Flight

The pilot purchased the aircraft in January 2004 and kept it in his garage in a dismantled state whilst preparing an operating site adjacent to his home. On 1 September 2004 the pilot moved the aircraft to Belle Vue Airstrip and assembled it in the main hangar. Having re-checked his work and confirmed that all the flight controls operated in the correct sense and were full and free, he took the aircraft for some taxiing checks and to gain some experience of the feel of the aircraft without becoming airborne. Satisfied that the aircraft was functioning correctly, he placed the aircraft in the hangar intending to fly it for the first time the following day.

The next day the pilot arrived at the airfield at about 1445 hrs and made a thorough inspection of the aircraft. He once again confirmed that the flight controls were correctly rigged, full and free but this did not include the mechanical full-flying tail trimmer. He calculated that the aircraft's weight and centre of gravity were within the operating limits before carrying out some further taxiing practice along the runway in preparation for his first flight.

Belle Vue Airstrip has a single grass runway orientated 26/08; it is 625 metres long and 15 metres wide. The surface is smooth and well maintained with no significant undulations or bumps. The grass areas to the north and south are large, level and open with no obstructions and the wind sock to the north was clearly visible from the point at which the pilot commenced his take-off roll.

After the taxiing practise, the pilot refuelled the aircraft and made a final external check before moving out to the runway. He decided to carry out a take-off run, raising the nosewheel to the point of lift off before closing the throttle and stopping on the runway. His intention was to gain a feel for the effects of the flight controls, in particular the amount of aft stick movement required to get the aircraft airborne. Having completed two such runs the pilot was satisfied that he was ready to get airborne and carry out some general handling before returning to the circuit for landing.

The aircraft was lined up on Runway 26 abeam the hangar with the surface wind from approximately 310° at a speed estimated to be about 5 kt. The pilot advanced the throttle to maximum power and the aircraft accelerated rapidly. He held the control stick aft and the nose landing gear lifted off, followed almost immediately by the aircraft becoming airborne with the nose continuing to pitch up. The pilot applied full forward nose down elevator control but the aircraft did not appear to respond and it began to roll left and right, which he was unable to correct, even with large aileron control inputs. The pilot's last recollection of the accident was the right wing low with full left aileron applied and the ground rushing up from the right. A witness driving along the road to the north of the airfield from the west did not see the take-off run but saw the aircraft rise up from behind a hedge and then make what he described as a cartwheel manoeuvre to the right.

The aircraft impacted the ground in a nose-down attitude almost inverted, seriously injuring the pilot, who lost consciousness. The witness drove to the scene of the accident and with the assistance of those at the airstrip, removed some of the wreckage from the pilot and cut his four-point seat harness in an attempt to remove the pilot because petrol was leaking from the fuel tank onto him. As it was not possible to extract the entangled pilot, initially they tore off a transparency and placed this across him to protect him from the leaking fuel. Eventually they were able to cut the fuel tank securing strap, close the fuel shut off valve and then remove the tank. The emergency services attended the scene and the fire service extracted the pilot who was then removed to hospital by an air ambulance.

Pilot experience

The pilot commenced flying on 27 April 1981 on a Piper PA-28 aircraft type gaining his Private Pilot's Licence on 27 July 1983. He continued to fly the PA-28 with occasional flights in other types until April 1992, accumulating 91 flight hours. In that year he procured a Pulsar aircraft which he flew until 24 March 2002, logging 317 flight hours on the type. Having sold the Pulsar, he did not fly again until 30 September 2004 when he carried out differences training on an X'Air (a kit-built 3-axis microlight) and completed a general flying test on that date. From then until the date of the accident he flew 10.7 hours in the X'Air microlight at the rate of one hour, every other month until August when he flew 3.3 hours.

Accident site details

The aircraft crashed approximately 55 metres off the right hand side of Runway 26 and about halfway along its length. It had come to rest essentially inverted, but with the right wing reportedly pointing into the air. (Note: some dismantling of the aircraft had occurred during the operation to recover the pilot.) Only three impact marks were apparent on the ground and they were found to have been made by the engine/propeller assembly, a wing tip and the nose. It was determined that the aircraft had struck the ground in a steep, inverted dive, on a track of 315° magnetic, with the lack of ground-slide indicating a low forward speed. The aircraft had come to rest less than 2 metres from the impact marks. It was apparent that a significant amount of fuel had been leaking from the tank (which was located behind the pilot's seat), although nearly 10 litres remained.

Following the on-site examination, the wreckage was removed to the AAIB's facility at Farnborough for a detailed analysis.

Detailed examination of the aircraft

A photograph of G-MZEI shown above. The main structural member of this type of aircraft is a longitudinal alloy boom running from the tail, through the wing centre section and then beyond the leading edge. The fuselage is located below the wing such that the boom runs along the cockpit roof. The engine is mounted on the front of the boom and so is positioned above and forward of the pilot. This arrangement had served to protect the pilot to an extent, as the main force of the impact had been borne by the engine and mounting structure. However, additional bracing was provided in the form of struts located between the engine mount and the cockpit sides, and the compressive failure of one of these during the impact had resulted in a broken end penetrating the pilot's right thigh, causing a serious injury.

There was no evidence of a pre-impact structural failure, or of any pre-impact failure or disconnection of the flying controls. However, the tailplane trim system was the focus of some attention. The aircraft featured an 'all flying' tail, which is usually more powerful than the tailplane and elevator combination that was a feature of the X'Air aircraft on which the pilot had conducted some training. This had necessitated the fitting of an anti-balance tab on the trailing edge of the left side, which also functioned as the trim tab. The trim adjustment wheel in the cockpit had been fabricated from the hollow cap of a plastic 'Jerrycan' container and was mounted on a pair of brackets with a threaded insert in its centre. Rotation of the wheel caused a longitudinally orientated threaded shaft to move either fore or aft, depending on the direction of rotation. The rear end of the shaft was connected to the trim cable, which moved the tab against the tension of a spring mounted between the tab operating horn and the underside of the tailplane. The design was such that normal operation of the tailplane resulted in relative movement between it and the fixed trim cable, which in turn caused deflection of the tab, thereby achieving the anti-balance function.

The trim operating cable had remained intact, although the boom along which it was clipped had broken at its join with the fuselage. Some stretch had inevitably occurred during the accident and subsequent recovery, but after allowing for this, the as-found position was considered to be excessively trailing edge up (ie aircraft nose down). This corresponded with the as-found position of the trim adjuster, which was set with 24 mm of exposed thread ahead of the wheel and only 7 mm to the rear. Rotating the adjuster until the threaded shaft was in its mid position produced a tab position that was only slightly nose down. It thus appeared that the trim had been set to a markedly nose-down position prior to the accident flight. However, it was noted that a casual glance at the adjuster, which was located under the pilot's right elbow, gave the impression of an approximate mid position, due to the length of threaded shaft that was "hidden" under the rim of the hollow Jerrycan cap.

Aircraft history

Following its construction in 1997, the aircraft was withdrawn from service in June 2002, after accumulating around 63 flying hours, in order to exchange its Rotax 447 engine for its current Rotax 503 model, which has approximately 10% more power. The new engine was heavier than the unit it replaced, which necessitated a modification that moved its mounting point rearwards. This was accomplished by the end of August 2003 and the aircraft flew a further 8 hours in September. The last flight entered in the log book was an air test on 19 September 2003. The aircraft was subsequently acquired by its current owner, who conducted no additional work other than rigging it prior to his first flight.

Analysis

The owner was both an experienced private pilot and a trained engineer who had re-assembled the aircraft and thoroughly checked it for the correctness of his work before flying it. There was no operating manual and he relied on the differences training and the experience he had accumulated on the X'Air to provide the basic level of skill he would need to fly the MW5D Sorcerer. This was added to his experience on the Pulsar, which was a responsive aircraft similar in handling qualities to the Sorcerer.

His taxiing trials and abandoned takeoff exercises had been an incremental approach to carrying out a first flight and apart from the rapid acceleration, he had detected no major differences from what he was used to. The weather was good for his first flight, which was to be general handling, stalls to confirm the calibration of the ASI and a landing. He followed information he had researched from articles that the control column should be held aft for half to two thirds of its travel and the aircraft allowed to accelerate until the nose landing gear could be lifted off. The researched information then advised that the control column should then be moved forward to check the nose-up rotation and the aircraft allowed to maintain that pitch attitude and climb away.

From the interviews held with the pilot, it was clear that he believed that the rapid acceleration may have led him to raise the nose too early and continue the rotation to a higher pitch attitude than intended (despite the inadvertent nose-down pitch trim setting). The aircraft became airborne in a partially stalled condition and the low airspeed, and hence low airflow over the tailplane, contributed to a lack of aircraft response to the pilot's full-forward control column movement.

The aircraft's designer stated that although the ailerons are still effective at the stall, the rolling motion to left and right reported by the pilot, coupled with his difficulty in controlling the rolling motion, were consistent with the aircraft type's stalling behaviour.

Conclusion

The accident occurred when the aircraft became airborne in an attitude and at an airspeed, which did not permit the pilot to control it properly. The aircraft stalled and the right wing dropped, rolling the aircraft to a nose down inverted attitude from which insufficient height remained in which to recover. There was no aircraft operating manual or supervisor present to warn the pilot of the specific hazard he encountered.

Advice to microlight pilots

Generally, the privileges of a fixed-wing Private Pilot's Licence are applicable to classes of aircraft and there is no regulatory requirement for type conversion training before flying unfamiliar microlight aircraft types. However, when transitioning to a new type or variant of microlight, where only a single seat version is available, the pilot should have authoritative documentation available containing all the necessary information and handling advice to operate the aircraft safely. If appropriate documentation is not available, a suitably qualified and experienced person should be present to advise the converting pilot on what to expect during the first flight on type.

Aircraft Type and Registration:	Piper PA-28-181 Cherokee Archer II, G-BPAY	
No & Type of Engines:	1 Lycoming O-360-A4M piston engine	
Year of Manufacture:	1980	
Date & Time (UTC):	27 December 2004 at 1245 hrs	
Location:	Leicester Airport, Leicestershire	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 1
Injuries:	Crew - None	Passengers - None
Nature of Damage:	Nosewheel and starboard undercarriage severely damaged; propeller and engine cowlings damaged	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	60 years	
Commander's Flying Experience:	165 hours (of which 10 were on type) Last 90 days - 6 hours Last 28 days - 2 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

History of the flight

The pilot and a colleague had returned from Wellsbourne Airfield to Leicester Airport where the pilot had expected to land on Runway 28, which was the runway in use when he departed but the duty runway had been changed to Runway 22. Runway 28 is 940 metres long by 30 metres wide whereas Runway 22 is 490 metres long by 30 metres wide. Both runways have an asphalt surface.

The pilot joined overhead for a left hand circuit. On the downwind leg he lowered one stage of flap with the second stage lowered on the base leg. The surface wind was from 220º at 5 to 10 kt with 15 km visibility and scattered cloud at 3,000 feet. At about half a mile from the runway threshold, the pilot realised he was too low and corrected his approach by increasing power which also raised his approach speed from 65 kt to 75 kt. The aircraft touched down near the threshold and the pilot applied the wheel brakes which felt as though the tyres were skidding on a slippery surface. He released the brakes and then reapplied them several times to try and improve the braking. The aircraft overran the end of the runway into a ploughed field which caused the landing gear to collapse and the propeller struck the ground stopping the engine.

The pilot carried out the emergency drills and he and his passenger vacated the aircraft by the normal exit. The airport Rescue and Fire Fighting Service promptly attended the scene.

Conclusion

The pilot had only used two of the three stages of flap available and the aircraft's speed was abnormally fast on touchdown. He thought the main reason for the accident was that he had a mental picture of landing on Runway 28 as he had not used any runway other than 28/10 at Leicester for over a year. Runway 22 is 450 metres shorter than Runway 28 and he considered that the accident might have been avoided if he had used runways other than 28/10 to vary his experience.

Remarks

This aircraft previously over-ran the available length of Leicester's Runway 22 on 23 July 2001 at the conclusion of an abnormally fast approach, having touched down half way along the runway.

Aircraft Type and Registration:	Piper PA-28-181 Cherokee Archer III, G-CCHL
No & Type of Engines:	1 Lycoming O-360-A4M piston engine
Year of Manufacture:	1998
Date & Time (UTC):	12 September 2004 at 1515 hrs
Location:	Lydd Airport, Kent
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 2
Injuries:	Crew - None Passengers - None
Nature of Damage:	Skin panel damage on the underside of the fuselage and port wing
Commander's Licence:	Private Pilot's Licence
Commander's Age:	44 years
Commander's Flying Experience:	300 hours (of which 245 were on type) Last 90 days - 57 hours Last 28 days - 20 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

History of the flight

The pilot and two friends had flown to France from Lydd Airport in order to visit two rural landing sites before returning via Le Touquet to Lydd. The flights had been uneventful and the aircraft was positioned on long finals for Runway 22. The surface wind at Lydd was 240º/21 kt with some gusting and an element of crosswind from the right. The conditions were typical of the two previous landings made by the pilot that day.

Re-surfacing was being carried out on Runway 22 and the displaced threshold was marked by a barrier board across the runway, a short distance beyond which, were a row of cones also across the runway. The cones were the large type used in motorway maintenance. There were no PAPIs due to the resurfacing work and at about 2 nm from touchdown, the gusting wind was producing significant turbulence.

The pilot selected two stages of flap instead of the three normally used for landing and increased his approach speed from 75 kt to 80 kt in order to compensate for the gusts. He chose an aiming point on the runway sufficiently beyond the cones to allow for their obstruction but ensuring adequate landing distance remained. Once over the barrier board the pilot flared the aircraft and reduced power as normal but the wind speed seemed to drop and the aircraft sank rapidly, earlier than the pilot wanted. The aircraft appeared to become unstable and the pilot applied power which stabilised it and the aircraft touched down normally. After landing the pilot taxied the aircraft to its parking place.

Aircraft examination

The underside of the aircraft had struck the cones but the pilot and passengers were not aware of the impact and they did not see any signs of damage to the aircraft during the post-flight inspection. A person in the tower who had seen the incident reported it to the flying group and the damage was discovered on further examination of the aircraft.

Conclusion

The pilot considered that the sudden drop in wind had contributed to the rapid sink which caused the aircraft to undershoot the intended touch down point and contact the cones.

Aircraft Type and Registration:	Reims Cessna F152, G-BHZH	
No & Type of Engines:	1 Lycoming O-235-L2C piston engine	
Year of Manufacture:	1980	
Date & Time (UTC):	16 February 2005 at 1635 hrs	
Location:	Exeter Airport, Devon	
Type of Flight:	Training	
Persons on Board:	Crew - 1	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	Left wing and nose wheel damaged	
Commander's Licence:	Student pilot	
Commander's Age:	50 years	
Commander's Flying Experience:	19 hours (all on type) Last 90 days - 10 hours Last 28 days - 3 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

The student pilot had completed three successful circuits with an instructor and was performing a solo circuit with a flapless 'touch and go' landing. The landing on Runway 08 was smooth and on the centreline but, when he applied full power to take off again, the aircraft suddenly yawed to the left. He immediately applied right rudder to correct the yaw, which caused a violent change of direction to the right and he attempted to correct with left rudder. Realising that he had now lost control of the aircraft, he fully closed the throttle. The aircraft departed the left side of the runway, but he did not apply the brakes at first to avoid upsetting the balance of the aircraft. When it failed to slow down on the grass as expected, he applied gentle braking. The aircraft then bounced and the left wing dropped, causing the wingtip to strike the ground. It then continued forward, crossing an area of hard standing before finally coming to rest on the grass beyond. The nosewheel was damaged on striking a ridge at the edge of the hard standing.

Immediately after the accident, a second flying instructor took the student for a flight in another aircraft. He noted that whilst the student was very competent, on two occasions whilst taxiing, he applied left rudder when he intended to turn right. The student accepted that he may have reacted incorrectly during the touch and go by applying left rudder as he applied full power.

Given the aircraft's natural tendency to yaw to the left when power is applied, inadvertently applying left rudder at a relatively high airspeed during a touch and go would produce a sudden yaw to the left. Excessively large corrective rudder inputs at such an airspeed can lead to over-controlling and a loss of directional control.

Aircraft Type and Registration:	Reims Cessna FA152, G-BHEN
No & Type of Engines:	1 Lycoming O-235-N2C piston engine
Year of Manufacture:	1980
Date & Time (UTC):	26 December 2004 at 1619 hrs
Location:	Leicester Airport, Leicester
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Severe damage to nose landing gear, engine, propeller, wing and fin
Commander's Licence:	Private Pilot's Licence
Commander's Age:	75 years
Commander's Flying Experience:	540 hours (of which 533 were on type) Last 90 days - 5 hours Last 28 days - 3 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The pilot and his passenger were the last competitors scheduled to take part in the local Aero Club's flour bombing and spot landing competitions. Following delays earlier in the day, the competitions were running behind schedule.

Having completed three runs to drop flour bombs on a target, the pilot made a normal left-hand circuit and approach for the asphalt Runway 28, aiming to touch down on a line provided as a spot landing target. Agricultural activity immediately to the north of the runway had left that area with ruts running parallel to the runway edge, and these ruts were now filled with ice. The pilot reported that in the limited light from the setting sun, these ruts appeared very similar to the runway area, and although he had lined up correctly on the extended runway centreline at first, the aircraft drifted, and he did not recognise that he was no longer aligned correctly with the runway.

The aircraft touched down some 60 metres north of the runway and rolled out on its landing gear for approximately 25 metres with the main wheels running in the parallel ruts. The nose wheel assembly then failed and the aircraft very slowly pitched over, coming to rest inverted. Both occupants, who were wearing lap and diagonal harnesses, were able to vacate the aircraft uninjured.

The local time of sunset was 1555 hrs, and official night began at 1625 hrs, six minutes after the accident. The decision to continue the competition in deteriorating light conditions played a significant part in the accident.

Aircraft Type and Registration:	Reins Cessna F152, G-TAYS	
No & Type of Engines:	1 Lycoming O-235-L2C piston engine	
Year of Manufacture:	1980	
Date & Time (UTC):	22 January 2005 at 1020 hrs	
Location:	Fife Airport, Scotland	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	Nosegear collapse, propeller damage and engine shock loaded	
Commander's Licence:	Student Pilot	
Commander's Age:	34 years	
Commander's Flying Experience:	43 hours (all on type) Last 90 days - 12 hours Last 28 days - 2 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

The intention was to carry out a 'touch and go' landing on Runway 07 at Fife Airport. The approach and landing, into the reported 5 kt northerly wind, appeared normal. However, during the ground roll the pilot felt the aircraft yaw to the left and so he delayed the retraction of the flaps and applied right rudder in an attempt to maintain the runway centreline. Shortly afterward the flaps were retracted and full engine power was applied; immediately the aircraft yawed more violently to the left.

Full right rudder was applied, but this caused the aircraft to lurch and in fear of the right wing dropping and losing control of the aircraft, the pilot aborted the takeoff. He slightly released pressure on the right rudder pedal and closed the throttle. The yaw continued and the aircraft departed the paved surface onto the grass to the left of the runway. After travelling a short distance, the aircraft nose landing gear struck a ridge, causing the aircraft's nose to rise in the air, before pitching downwards and damaging the nose gear. This allowed the propeller to contact the ground. After coming to a halt, the uninjured pilot shutdown the aircraft and made his exit unaided.

The pilot later commented that the yaw was more than he would have expected from the usual engine torque and propeller wash during a 'touch and go'. However, a subsequent examination of the aircraft did not reveal any defects which could have accounted for the left yaw.

Aircraft Type and Registration:	Reims Cessna FRA150M, G-BFGX	
No & Type of Engines:	1 Continental Motors O-240-E piston engine	
Year of Manufacture:	1977	
Date & Time (UTC):	27 January 2005 at 1202 hrs	
Location:	Prestwick International Airport, Glasgow, Scotland	
Type of Flight:	Training	
Persons on Board:	Crew - 1	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	Damage to both wingtips and propeller	
Commander's Licence:	Student pilot	
Commander's Age:	19 years	
Commander's Flying Experience:	25 hours (all on type) Last 90 days - 10 hours Last 28 days - 2 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot and subsequent enquiries by the AAIB	

The student pilot had initially been cleared by ATC to taxi to holding point 'S1' from Apron 'E'; Figure 1 shows the runways and holding positions. The student was also advised that a B747 was taxiing to 'R1'. After about 10 minutes at the holding point, the student watched as the B747 approached and then stopped at 'R1'. After a further five minutes, ATC cleared G-BFGX to taxi to holding point 'Q'. The student's impression was that the B747 was sitting with engines at idle as G-BFGX passed directly behind. He then felt his aircraft start to shake violently. Almost immediately, it was blown up onto its left wing and then clockwise through about 180° before the right wing and propeller struck the ground. The aircraft was then blown onto the grass where the student shut down the engine. The surface wind was light and variable.

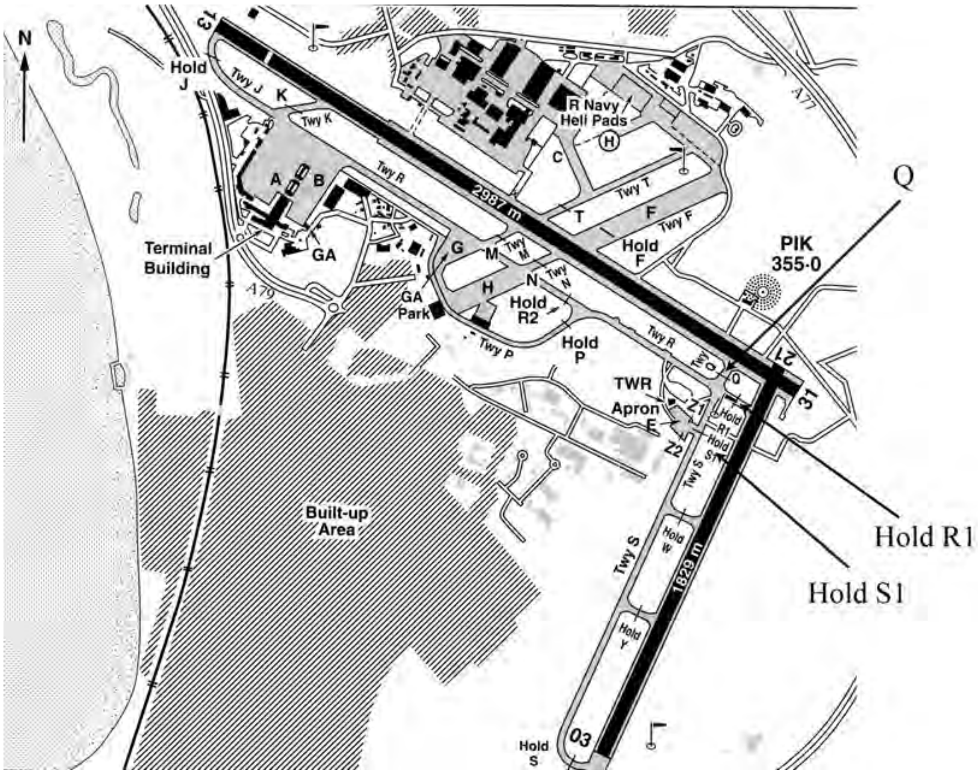


Figure 1: Airfield Map

ATC had cleared the B747 to line up on Runway 31 and had then cleared G-BFGX to taxi to 'Q'. However, the B747 advised ATC that he was still awaiting oceanic clearance and would hold his position at 'R1'. The controller then informed him of the light aircraft taxiing behind him and advised him that he should maintain idle engine power; this was acknowledged by the B747.

Subsequent enquiries by the AAIB confirmed that the flying club involved regularly briefs all club pilots on the hazards involved in operating on airfields with large aircraft. ATC personnel are also aware of the hazards involved. However, no written guidance was found in UK aeronautical publications dealing with the hazards of engine efflux on the ground. Reference to the subject was found in a Transport Canada Aeronautical Information Publication (AIP), dated 15 March 1984 and this indicated that the danger area of a 'Jumbo Jet' size aircraft at ground idle extended to 600 feet behind the tail of the aircraft. For the accident involving G-BFGX, ATC estimated that the tail of the B747 was at the edge of Taxiway 'S'.

The AAIB has also investigated a similar accident to a Cessna 172, registration G-BNKE on 3 March 2001 at Manchester Airport (reported in AAIB Bulletin No 6/2001). In that accident, it was estimated that G-BNKE was 102.5 metres behind the engines of a B777.

It is apparent that the hazards of engine efflux on the ground are not fully appreciated by aircraft crew or ATC personnel. Following this latest accident, discussions with the CAA have resulted in the following action:

1. The CAA intends to publish an article on the hazards of engine efflux on the ground in a future edition of General Aviation Safety Information Leaflet (GASIL) and to include guidance in an appropriate Safety Sense Leaflet.

2. The CAA intends to provide guidance on the hazards of engine efflux on the ground with an appropriate amendment to the Manual of Air Traffic Services Part 1.

Aircraft Type and Registration:	Scheibe SF25C, G-FLKS
No & Type of Engines:	1 Rotax 912-S piston engine
Year of Manufacture:	2000
Date & Time (UTC):	19 February 2005 at 1225 hrs
Location:	London Gliding Club, Dunstable, Bedfordshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Propeller destroyed
Commander's Licence:	Private Pilot's Licence
Commander's Age:	Over 18 years
Commander's Flying Experience:	3,120 hours (of which 52 were on type and approximately 3,000 were gliding experience) Last 90 days - 15 hours Last 28 days - 3 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The SF25C is a motorglider of tail wheel configuration. On completion of a short flight of 30 minutes duration in conditions that were clear and sunny, the aircraft was landed directly into a northerly wind of some 20 kt. After rolling to a stop, the pilot operated the tail wheel lever to disengage the tail wheel and allow it to freely castor. The pilot began to taxi the aircraft with the stick held in the fully back position, turning to the right, with the intention of returning downwind to the launch point. After the glider had turned through approximately 80 degrees, it stopped. The pilot applied more power, with the stick still held fully back. At this point, the tail rapidly lifted and the propeller struck the ground and shattered. It took the pilot two or three seconds to react and to switch off the engine, which was still running with the remains of the propeller were still turning. On exiting the aircraft, the pilot noted that the tail wheel lever was in the locked position, but this may have been disturbed when the pilot and passenger exited the aircraft.

Ground manoeuvring of tail wheel aircraft in strong and gusting winds requires caution particularly as, when crosswind, there is a strong tendency for such aircraft to weathercock into wind. Under such circumstances, if rudder and power are applied in an attempt to continue the turn, particularly if differential wheel braking is applied with rudder, then a nose down pitching moment is generated and the tail may lift. Also, when crosswind in a strong wind, the propeller slipstream may be deflected to some extent from the tail surfaces, reducing the down force on the tail normally expected when the stick is held back. In this situation, a tailwind component of the wind may additionally be present and contribute to the de-stabilisation of the aircraft.

Aircraft Type and Registration:	Yak-50, G-OJDR
No & Type of Engines:	1 Ivchenko Vedeneyev M-14P radial piston engine
Year of Manufacture:	1979
Date & Time (UTC):	30 October 2004 at 1438 hrs
Location:	Wellesbourne Mountford Airfield, Warwickshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to aircraft underside and propeller, oil cooler torn off and engine shockloaded
Commander's Licence:	Private Pilot's Licence
Commander's Age:	36 years
Commander's Flying Experience:	464 hours (of which 114 were on type) Last 90 days - 30 hours Last 28 days - 21 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and further enquiries by the AAIB

Synopsis

After takeoff the pilot selected the landing gear to UP but only the left main gear locked up while the right main gear remained unlocked. The pilot left the circuit and made numerous attempts to extend both main gear legs using the normal and emergency pneumatic systems. After conducting two low 'fly-bys' at the airfield to confirm the state of the landing gear, he decided to land on the grass surface alongside the paved runway. During the landing roll both main gears collapsed. Examination of the landing gear system revealed that the O-ring seals on the right main gear actuator piston were 'rolled'. The rolled seals caused a leak that prevented the actuating air pressure from fully extending both main landing gears.

Aircraft description

The Yak 50 is a low-wing, single-seat aircraft of Russian design and manufacture with a tailwheel landing gear configuration (see Figure 1). It is constructed primarily of aluminium alloy and it is powered by a 360 HP radial piston engine which drives a variable-pitch propeller. The aircraft does not have an Airworthiness Type Certificate recognised by the UK Civil Aviation Authority (CAA) but the CAA had issued G-OJDR with a Permit to Fly, authorising its operation on the UK Register.

History of the flight

The pilot was intending to carry out a local flight of approximately 15 minutes duration to practice landings and then he was going to refuel the aircraft and repeat the exercise. He carried out a normal pre-flight inspection of the aircraft and checked that the landing gear uplocks operated freely and checked that the pneumatic system water drain valve was closed. Before engine start the pneumatic system contained 30 kg/cm^2 (427 psi) of air pressure which recharged to 45 kg/cm^2 (640 psi) after the engine had been started and warmed. After carrying out taxi and power checks the pilot performed a normal takeoff. When he selected the gear lever to UP he heard a noise which sounded like air venting from behind the gear selector lever. The gear indication lights showed that only the left gear had locked up and that the right gear was unlocked. The pneumatic gauge showed very little remaining air pressure so the pilot selected the gear lever to NEUTRAL which stopped the venting noise.

The pilot departed the airfield circuit to the south and climbed to 2,000 feet to try and diagnose the problem. After approximately eight minutes the engine-driven compressor had recharged the pneumatic system to 45 kg/cm^2. He selected the gear lever to DOWN at which point the same venting noise was heard. The left gear indicated down and locked while the right gear remained unlocked. Once again the pilot selected the gear lever to NEUTRAL to preserve the air pressure, and then repeated the exercise once the pneumatic system had recharged. Again this was unsuccessful so he tried various aircraft manoeuvres involving pitching, yawing and pulling 'g' but still the right gear would not lock down. With the gear lever in the NEUTRAL position the pilot opened the emergency air valve to allow the emergency air supply to extend the gear. Despite unwinding the valve quickly (the recommended procedure) the pressure rapidly reduced to zero and the right gear remained unlocked.

With only approximately 10 minutes of fuel remaining the pilot decided to return to Wellesbourne so he contacted Wellesbourne Radio to advise them of his predicament and to request a low fly-by. Witnesses to the fly-by observed that one gear leg appeared to be down while the other leg appeared to be semi-retracted. The pilot rejoined the circuit and attempted to recycle the gear one last time using both the normal and emergency air systems sequentially but these actions were unsuccessful. The pilot requested a further fly-by and again one gear appeared to be down while the other was semi-retracted, but this time it was reported to be the other leg that was down. With only an estimated 5 minutes of fuel remaining the pilot decided to carry out a landing on the grass surface alongside the paved Runway 36. After carrying out a go-around to establish in the pilot's words "the correct descent profile", he carried out a low-level circuit followed by an approach to the grass surface.

At between 15 and 20 feet agl the pilot switched off the magnetos. The aircraft touched down tailwheel first and rolled on all three wheels for approximately 20 metres before both main gears collapsed almost simultaneously. As the aircraft dropped, the windmilling propeller struck the ground breaking its tips. When the aircraft's underside hit the ground the oil cooler housing and oil cooler on the aircraft's belly were torn off. The aircraft finally came to rest after travelling approximately 100 metres on its belly. The pilot switched off all the electrical systems and was able to vacate the aircraft unassisted in the normal manner. The airfield's fire service arrived on the scene soon afterwards but there was no fire.

Description of the landing gear system

The aircraft has retractable main landing gear and a non-retractable tailwheel. The main landing gear legs are unconventional in that they retract aft into the wing rather than sideways. Half of each wheel retracts into the wing leaving the other half and the landing gear leg exposed to the airstream (see Figure 2). The design makes wheels-up landings (on hard surface runways) practicable while minimising damage to the aircraft's underside. The left and right main gear actuators are pneumatically powered. When the gear is selected DOWN pneumatic pressure causes each actuator arm to pull on the top of the respective main gear leg, rotating the leg forwards into the air stream. The leg needs to rotate approximately 10 degrees forward of the vertical before it will lock down. Two spring loaded hooks on the main gear leg engage a fixed stop within the wing as the leg is forced forwards against it until the hooks lock the gear in place. The hooks also press against a microswitch which triggers the 'green' down and locked light in the cockpit. If not properly rigged it is possible for the 'green' down and locked light to illuminate before the gear has fully locked into position.

The landing gear selector has three positions, UP, NEUTRAL and DOWN. For emergency operation of the landing gear, the selector must be set to NEUTRAL and the emergency valve on the right side of the cockpit opened rapidly to allow the emergency air supply to extend the gear. The maintenance organisation stated that the reason for opening the valve rapidly is to overcome any minor leaks within the system and to ensure there is sufficient pressure to close the spring-loaded bleed-off valve.

Description of the pneumatic system

The aircraft's pneumatic system is provided for engine starting and for operating the wheelbrakes and retractable main landing gear. The nominal operating pressure of the system is 50 kg/cm^2 (711 psi). The main air pressure reservoir, located on the left side of the firewall has a 6.4 litre capacity and an emergency reservoir, located on the right side of the firewall has a 3.2 litre capacity. Both reservoirs are recharged by an engine-driven compressor. A pneumatic system water drain, located on the forward lower side of the firewall, should be operated before and after flight to drain any water in the system. If the drain is left open the air system will not charge.

Aircraft examination

When the aircraft was raised during the recovery operation both main landing gear were extended by hand and they both locked into place. The aircraft was then transported, with the gear retracted and the wings removed, to a maintenance organisation that specialised in maintaining Yak aircraft. At the maintenance facility a stand-alone compressed air tank was attached to the aircraft's pneumatic system. Although this tank was not full, it had sufficient pressure to extend both main landing gear and lock them into place. However, it is important to note that on the ground, the actuators did not need to overcome the drag force on the landing gear that was encountered in flight. The maintenance organisation carried out a detailed examination of the landing gear system and discovered a problem with the seals in the right main landing gear actuator.

The two O-ring seals on the piston of the right main landing gear actuator are shown in Figure 3. The seal on the left (used for extension) had a rolled lip and the seal on the right (used for retraction) had a side that was severely rolled. The condition of both seals would have resulted in air leakage during both retraction and extension.

No anomalies with the operation of the main gear downlock mechanism were found.

Discussion

The maintenance organisation reported that a pressure of at least 30 kg/cm^2 was required to lock the gear in the DOWN position at the maximum gear extension speed of 200 km/hr (108 kt). According to the pilot the pneumatic system pressure was depleting at approximately 10 kg/cm^2 each second when the gear was selected down. Since gear extension takes at least four seconds there was never sufficient pressure in the system to lock down both gear legs in flight. The cause of the leak was attributed to the rolled seals in the right main gear actuator. The plumbing of the pneumatics is such that as air leaked past the piston to the other side of the actuator, it would have vented at the valve behind the gear selector lever. This explains the venting noise heard by the pilot.

Both main gear actuators had been installed on 13 January 2004 following an overhaul which involved replacing the seals. According to the maintenance organisation the grooves in the actuator piston make it easy to install the seals correctly. However, it is possible that inadequate or improper lubrication could have contributed to the rolled state of the seal.

Because the air leak was within the actuator, the effectiveness of the emergency reservoir would also have been reduced. The pilot reported that on a previous occasion in 2003 he had suffered a partial pressure loss due to the water drain valve working loose in flight. On that occasion he had been able to persuade the gear to lock down by yawing and pitching the aircraft without recourse to the emergency system. The Yak-50 Pilot's Operating Handbook only mentions the use of the emergency valve in the event of a gear extension problem. The maintenance organisation stated that it was important to open the emergency valve rapidly, in the event of a problem with the gear locking down.

It appeared to the pilot that one of the main gear legs was locking down each time he attempted to extend the gear, and yet both main gear legs collapsed on landing. It is probable that neither main gear leg was locked down prior to the landing. The design of the down lock microswitch and locking mechanism makes it possible to obtain a 'green' down and locked indication when the downlock hook is not fully engaged.

Conclusions

Both main gears collapsed on landing because they were not locked down. The gear did not lock down because there was insufficient pneumatic pressure to extend fully the main gear actuators in flight. The loss of pneumatic pressure was attributed to a leak in the right main gear actuator which was caused by a rolled O-ring seal on the actuator piston.

Figure 1 Accident aircraft

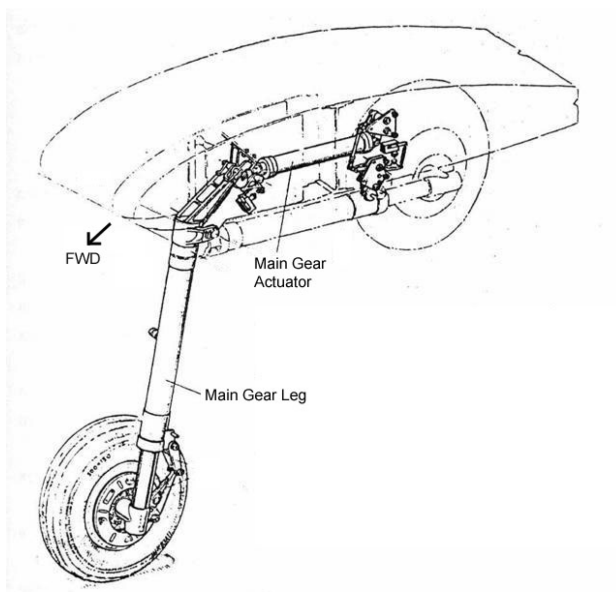


Figure 2 Yak-50 main landing gear

Figure 3 Rolled O-ring seals found on right main gear actuator piston

INCIDENT

Aircraft Type and Registration:	Piper PA-24-260 Comanche, G-BRXW	
No & Type of Engines:	1 Lycoming O-540-E4A5 piston engine	
Year of Manufacture:	1964	
Date & Time (UTC):	13 January 2005 at 1623 hrs	
Location:	Coventry Airport, West Midlands	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 1
Injuries:	Crew - None	Passengers - None
Nature of Damage:	Damage to underside of fuselage, landing gear and propeller; possibly beyond economic repair	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	72 years	
Commander's Flying Experience:	181 hours (all on type) Last 90 days - 4 hours Last 28 days - 0 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot and telephone enquiries by AAIB	

Having flown to Leicester earlier in the day without problems, the pilot was returning to Coventry. However, when he selected the landing gear DOWN on the approach the gear appeared to stop when only about half-extended. He noticed that the landing gear motor circuit breaker had tripped but each time he tried to reset it, it tripped again. A fly-by of the control tower resulted in the information being passed to him that "The nose gear appears to be not in the locked-down condition".

The pilot then flew to the nearby Visual Reference Point (VRP) at Draycot Water with the intention of deploying the manual 'free-fall' mechanism but this was also unsuccessful. He then spoke with his usual engineer on the radio, but he was unable to offer any further advice. Having exhausted all his options he orbited the VRP for about 50 minutes to burn-off fuel and to allow the glare from the low sun to reduce. He then positioned the aircraft for an approach to Coventry Airport, where ATC had suggested that he land on the grass section of the northern taxiway. The pilot made an approach with full flap selected and with some power applied, upon touchdown all three landing gears collapsed and the aircraft slid to a halt. He and his passenger evacuated the aircraft normally without injury, there was no fire and no apparent fuel leaks.

Examination of the Aircraft

The PA-24 aircraft uses a single electric motor to drive all three landing gears. This is connected to a transmission which converts the rotary motion into a linear movement which acts upon two large push-pull 'Bowden' type cables to move the main landing gears, and a rod which moves the nose landing gear. In the event of electrical malfunction of the landing gear, a manual release lever is provided which should disconnect the transmission from the motor, allowing the landing gear to drop under gravity.

It was found that the landing gear motor relay had developed an internal short-circuit and that this was the reason why the circuit breaker had tripped and the electric motor had stopped. There had been considerable damage to the actuating system due to the landing loads being fed-back into the operating system and it was not possible to operate the manual release mechanism. However, the maintenance company is of the opinion that, given the unusual semi-extended condition of the landing gear, it may have resulted in forces which rendered it difficult, if not impossible, to achieve the mechanical release necessary for free-fall.

The circumstances of this accident are similar to those which occurred to another PA-24 aircraft, G-BUTL on 15 October 1998, and which are reported in AAIB Bulletin 5/99. As in the case of G-BRXW, the pilot selected landing gear DOWN normally, but the motor circuit-breaker tripped, leaving the gear partially extended. Subsequent operation of the free-fall lever was also unsuccessful in completely lowering the gear.

The investigation of that accident suggested that a restriction in one of the main landing gear operating cables may have been responsible for high forces which stalled the motor and also prevented the gear from free-falling. However, it is not known whether the motor relay was checked at the time, although the motor itself was found to be serviceable.

Aircraft Type and Registration:	Quad City Challenger II, G-MYDS
No & Type of Engines:	1 Rotax 503 piston engine
Year of Manufacture:	1990
Date & Time (UTC):	19 January 2005 at 1515 hrs
Location:	½ mile from Runway 24 at Southend Airport, Essex
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Nose landing gear pushed into the fuselage, left main landing gear extension sheared and slight fabric damage on the fuselage
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	34 years
Commander's Flying Experience:	40 hours (of which 31 minutes were on type) Last 28 days - 2 hours Last 90 days - 31 minutes
Information Source:	Aircraft Accident Report Form submitted by the pilot

At approximately 300 feet during the climb following takeoff the pilot heard the engine speed suddenly increase. The pilot quickly became aware that the belt drive from the engine to the propeller had failed. He informed his passenger that the engine had failed and that they would be landing. The pilot selected a suitable field and carried out a soft field landing but unfortunately the aircraft encountered a rut during the landing roll which caused the nose landing gear to collapse.

Examination of the belt drive between the engine and the propeller revealed that the belt's teeth had torn away from the belt. The pilot assessed that this had been caused by incorrect belt tension.

Aircraft Type and Registration:	1) Robinson R22 Beta, G-LIDS 2) Hybred 44XLR, G-MTJP
No & Type of Engines:	1) 1 Lycoming O-360-J2A piston engine 2) 1 Rotax 447 piston engine
Year of Manufacture:	1) 1998 2) 1987
Date & Time (UTC):	6 July 2004 at 1154 hrs
Location:	Overhead Welham Green, Hertfordshire
Type of Flight:	1) Training 2) Private
Persons on Board:	1) Crew - 2 Passengers - 0 2) Crew - 1 Passengers - 1
Injuries:	1) Crew - 1 (Serious) Passengers - N/A 2) Crew - 1 (Fatal) Passengers - 1 (Fatal)
Nature of Damage:	1) Damage to cabin, transparencies and main rotor blades 2) Aircraft destroyed
Commander's Licence:	1) Airline Transport Pilot's Licence 2) Private Pilot's Licence
Commander's Age:	1) 45 years 2) 45 years
Commander's Flying Experience:	1) 13,940 hours (of which 580 were on type) Last 90 days - 233 hours (6 on type) Last 28 days - 72 hours (5 on type) 2) 77 hours (all on type) Last 90 days - 4 hours Last 28 days - 1 hour
Information Source:	AAIB Field Investigation

Synopsis

A Robinson R22 helicopter departed Elstree Aerodrome with an instructor who was the aircraft commander and a student who was receiving a trial lesson. A microlight aircraft with a pilot and his friend were carrying out a local private flight returning from Hunsdon to Plaistow Farm near St Albans. Both aircraft were operating under VFR in good VMC when they collided at about

1,200 feet above Welham Green. The microlight suffered severe structural damage and descended out of control into a wooded area, fatally injuring both persons on board. The helicopter instructor received a serious injury to his left foot and despite some structural damage to the helicopter, he was able to perform a successful emergency landing in a crop field. Both occupants of the helicopter survived the accident.

History of the Flight

Background

The microlight pilot and his passenger had met at Plaistow Farm, a private grass operating site, to carry out a flight to Hunsdon, a disused airfield to the north of Harlow. Following a short stop for coffee they would then return to Plaistow. Both persons were suitably dressed for the flight with one piece flying suits, gloves and protective helmets equipped with communications headsets. The aircraft, of which the pilot owned a half share, was already rigged and following some pre-flight activity they departed for Hunsdon.

There was no requirement to 'book in or out' at either location and therefore no accurate record of the departure or arrival times was available. Witnesses recalled that the aircraft departed Plaistow Farm at about 1000 hrs arriving at Hunsdon at about 1100 hrs.

The pilot of the Robinson R22 was an experienced helicopter instructor and professional helicopter pilot whose full-time occupation was flying large transport aircraft as a co-pilot for an airline. It was his second full day of instructing in recent weeks, following a two year period during which he had given occasional flying instruction but had focussed mainly on his professional flying activities.

The instructor arrived at Elstree at about 0930 hrs and met his student at 1015 hrs to conduct the trial lesson, which comprised one hour of ground briefing and a one-hour flight. Because the weather was good the instructor decided to conduct the briefing at the helicopter rather than in the classroom and he fully involved the student in all aspects of the pre-flight checks of weather, NOTAMS and refuelling. Having explained the use and effects of the flight controls, the instructor carried out a comprehensive safety briefing covering the seat harness, normal and emergency procedures, positive hand-over of control and the need for 'lookout' with the clock code method of indicating the position of other aircraft. The flight was to be conducted with the student occupying the right seat.

Following engine start the pilot booked out with the aerodrome information service and departed Elstree at 1114 hrs to the north-west climbing to 1,000 feet. The anti collision light was switched on but the navigation lights and landing light were switched off. During the next 40 minutes, the instructor carried out a series of exercises which involved turning, increasing and reducing speed, climbing and descending with the student handling the controls when appropriate.

Having completed their break, the pilot and passenger of the microlight departed Hunsdon at about 1130 hrs from Runway 03 climbing through circuit height of 500 feet before departing to the south.

The collision

Both aircraft were being operated VFR in good VMC at about 1,200 feet on the QNH. The radar data recorded from the Stansted radar head, showed the microlight was generally tracking 245°T at a ground speed of 65 kt. This was confirmed by a number of witnesses just prior to the collision who saw the aircraft holding a constant heading in a level attitude and maintaining what appeared to be a constant height. The radar tracks are overlaid on the map included at Figure 1. The slightly oscillatory nature of the aircraft tracks, particularly the microlight track, results from the limitations of the radar recording.

The instructor of the R22 had just completed a high hover at about 1,800-2,000 feet and had transitioned into forward flight. In order to demonstrate the effect of increasing airspeed on rotor RPM, the aircraft was turned to the right halfway between Hatfield and Potters Bar onto a track of 100°T. The engine governor was switched 'OFF' in order to permit the rotor RPM to rise ungoverned as airspeed increased. The instructor made a visual scan of the area ahead and below before gently descending the aircraft and increasing airspeed from 55 to 85 KIAS. The rotor RPM began to rise as expected and he pointed this out to the student before levelling the aircraft at about 1,200 feet. The student was looking to his left across the cabin with his attention on the RPM gauge and the instructor, when out of his right peripheral vision he detected the microlight. At the same instant the instructor noticed the microlight through the left front transparency, slightly below and filling approximately 60% of his windscreen. Having perceived that the microlight was moving from left to right, he immediately applied full left cyclic in an attempt to avoid it but as he did so the two aircraft collided.

The helicopter pitched nose down and the instructor felt an impact to his left foot; the noise level increased markedly as the windshield disintegrated and the left door was torn off. Realising he still had control, the instructor transmitted a 'MAYDAY' call to Elstree and reversed his left turn whilst entering autorotation. Ahead was a large crop field into which he commenced an emergency descent. Having confirmed the student was not injured he continued the approach for an engine-off landing. As he flared to reduce airspeed he realised that the engine was still driving the rotors and so he closed the throttle before cushioning the touch-down with the collective pitch lever, making a safe, short, run-on landing. On the ground he confirmed on his radio that Elstree had received his transmissions and he tried to shut down the engine using the mixture control but this still allowed the engine to idle. Consequently the ignition key was used to stop the engine.

The student was sent to a nearby farm to ensure that the helicopter's location passed by radio was accurate and another company helicopter landed near the damaged aircraft to render assistance. The emergency services were quickly on the scene and the instructor was evacuated to hospital.

Engineering information

Accident site details

The microlight aircraft had come down in a small area of dense woodland that lay between the back gardens of a row of houses and a road. It was evident that the collision had occurred approximately 250 metres to the east because this was where much of the debris that had been released in the air was centred. Debris was scattered in the woods, on the road and at the uncultivated edge of an oilseed rape field to the south of the road. This mostly consisted of fragments of transparency from the helicopter cabin and door, together with pieces of the left-hand door frame. The only microlight wreckage found in this area consisted of three pieces of aluminium tubing that were subsequently found to be from the outboard right wing leading edge; these had been struck by the helicopter's main rotor. Approximately 100 metres to the east of the microlight main wreckage, the outermost portion of the right wing, some 1 metre in length, was found lodged in tree branches. Pieces of wooden propeller blade were found at the western extremity of the wreckage trail. One of these had fibres embedded in it that came from the sailcloth-covered wing of the microlight.

The microlight had struck the ground nose-first at the base of some trees, having brought down a number of light branches on top of itself. The 'trike' was lying on its left side and was separated from the wing due to the failure of the 'mono-pole' structural member.

The helicopter had landed approximately 1 km to the east of the collision area. The entire left side of the cockpit transparency was missing, together with the left door apart from a small section of the door frame that included the hinge.

After an on-site examination the microlight wreckage and the helicopter's main rotor blades were recovered to the AAIB's facility at Farnborough for a more detailed examination. The helicopter was released to the operator to await repair assessment, but was also examined in detail. It is likely that not all the scattered debris was recovered due to the difficulty of searching the standing rape crop and the undergrowth within the wooded area.

Detailed examination of the wreckage

Helicopter

The cabin windshield of an R22 helicopter extends downwards to a few inches above the floor. Below this level, the 'chin' area of the fuselage structure is covered with a glassfibre skin. This had been distorted as a result of the aerial collision, and the surface was imprinted with a dark purple dye that was the colour of the microlight sailcloth. (The microlight manufacturer stated that the sailcloth colour was black, although a degree of fading had occurred over time.) The impact damage extended from the landing light bezel on the nose of the helicopter round to the left almost as far as the door cut-out, and was centred on the approximate 10 o'clock position. Higher up, the mid-section of the front of the doorframe had been deflected rearwards. The fuselage skin and its supporting structure had been pushed rearwards to the extent that it limited the travel of the left seat pilot's left yaw pedal. This damage also accounted for the injury to the instructor's left foot.

The main rotor blades had sustained minor damage close to the tips, with associated distortion on the leading edge of one of them. One blade also had a chord-wise smear approximately 1 metre inboard, and a few fibres from the microlight wing fabric covering were found on a blade tip.

There was no obvious evidence of collision damage on any other part of the helicopter.

Microlight

All the damage to the 'trike' had occurred during the impacts with the trees and the ground. The mid-air collision had involved only the wing upper surface, although evidence of the aerial contact had become confused with marks subsequently made by the trees.

A section of inboard left wing leading-edge tube approximately 1.4 metres long had broken off and was found lying within the wing. The tubing had suffered bending overload failures at each end, with the inboard failure located 0.15 metres from the nose. There was an indentation in the tube approximately 0.5 metres from the nose which was probably made whilst airborne by one of the helicopter skids. Although this would have affected the aerodynamic characteristics of the wing, its basic structural integrity had been maintained by the cross-tube which had remained intact. A chordwise tear was apparent in the wing upper surface, which could have been made by one end of the broken leading edge tube, or perhaps by the helicopter skid. It was clear that the tear had occurred in the air however, as the individual fibres of the fabric around the tear had become teased out due to the effect of the airflow during the descent. Similar tears were apparent around the right wing tip and on the underside of the inner right wing where it had been contacted by the propeller. Although a number of additional tears were noted, their clean edges suggested they had occurred as a result of ground impact forces. The series of tears on the right tip area had been made by the helicopter's main rotor blades; these blade strikes progressed in a forward direction before severing the leading edge tube in two places. The fractures in the tube were tears rather than clean cuts, and it was not possible to derive a relative angle of the rotor disc to the wing. At least four blade strikes were evident. (Note: at 100% rotor RPM, there would be around 17 blade passes per second.)

The only obvious signs of contact with the helicopter on the wing fabric were a faint chordwise smear on the left wing upper surface, approximately 1.5 metres left of the centreline and another mark some 0.7 metres to the right of the centreline. None of the wires attached between the top of the king post and various locations on the wing upper surface had been broken. However the wire attached to the outboard left leading edge had suffered abrasion damage to its protective plastic sheath at a point approximately 1.7 metres from the king post. This had probably been caused by the same helicopter skid that broke the leading edge tube. None of the battens (which are inserted into chordwise pockets in the wing fabric, and which give the wing its aerodynamic profile) had been broken.

Collision parameters

The sum total of the evidence led to a 'best fit' of the parts of each aircraft that came into contact in the air, which in turn suggested that the R22 was banked approximately 30° to the left, relative to the microlight, on a relative heading of around 135°. This is represented graphically in Figure 2 where it can be seen that the helicopter's left skid would contact the left inboard leading edge of the microlight wing, with the right skid remaining clear of the left wing rigging wires. From this position, the helicopter's nose would go on to brush the wing upper surface, with the main rotor cutting into the right tip. It was not clear how all but one of the upper surface wing wires escaped being damaged, although the effect of the impact on the leading edge may have resulted in an instantaneous loss of tension, causing them to droop out of the way.

It must be stressed however that the illustration is a 'best fit' approximation and the relative attitude of the ensemble to the horizon is not known.

Meteorological information

The synoptic situation at 1200 hrs on the day of the accident showed a slack area of high pressure over Southern and Eastern England. The high was centred over the southern North Sea, with a central pressure of 1,024 mb. There were small amounts of cloud over the area with 3/8 to 4/8 of cumulus reported at Stansted, London City and Northolt Airports. Visibility was 30 km with 3/8 to 4/8 cumulus at 4,800 feet. The wind at 2,000 feet was variable in direction at 5 kt and the air temperature at that height was +14°C.

The METAR for Stansted at the time of the accident was: EGSS 061150Z VRB03KT 9999 SCT045 21/08 Q1022. Witnesses described bright sunshine being present at the time of the collision; from records for that time of day the sunlight was from an azimuth of 180° at an elevation of 61°.

Communications

The R22 instructor was using the aerodrome frequency at Elstree to maintain his flight watch. The microlight had been using a dedicated frequency of 129.825 MHz at both Plaistow Farm and Hunsdon.

Other information

The colour schemes for both aircraft were relevant to the accident in addition to their small size, speed and profiles.

The CAA's General Aviation Safety Sense leaflet 13A, '*Collision Avoidance*', provides comprehensive guidance on maintaining an effective visual scan in the visual flight environment, sometimes referred to as the 'see and avoid' method. There are distinct limitations with the human eye which, although it can accept light rays through an arc of nearly 200°, only through approximately 10-15° can it focus on and classify an object. Although movement can be detected on the periphery of vision, the brain cannot identify what is happening there. In addition, glare from the sun makes aircraft hard to see and looking into the sun is uncomfortable.

Motion or contrast is needed to attract the eyes' attention but with slow moving aircraft on a collision course there is little or no relative movement. An aircraft on an unwavering collision course will remain in a seemingly stationary position without appearing to move or grow in size for a relatively long time and then suddenly, it will bloom into a huge mass almost filling up one of the windows. This is known as the 'blossom effect'. Contrast of aircraft colour against background will also allow the object to be seen. High contrast such as a black object against a white background would have high conspicuity whereas a dark object against a dark background would have poor contrast and would be difficult to see. It would be said to have low conspicuity. Seeing an aircraft against a background cluttered with buildings, woods, shadows and a patchwork of fields could be difficult if it tended to blend into the background. The use of landing lights and strobe lights can improve the conspicuity of an aircraft.

Size and profile of the aircraft also affect conspicuity, particularly the distance at which an aircraft is first detected. Given the aggregate of times required for a pilot to perceive an aircraft, realise that it is on a collision course, make a control input, for the input to take effect, and for the aircraft to manoeuvre, it is vital that the aircraft is seen some distance away. This distance is also a function of closing speed.

Medical information

A post mortem examination of the microlight pilot and passenger revealed that they had both died from multiple injuries as a result of the ground impact. No evidence was found of any disease, alcohol, drugs or any toxic substance which could have caused or contributed to the accident. The commander and student of the R22 helicopter provided blood samples to the police. These were analysed for alcohol and drugs but no trace of either was found. Neither pilot had any medical limitations in their licence nor any requirement for corrective lenses for their vision.

Analysis

When the R22 rolled out of its gentle right turn at about 1,500 feet the aircraft were approximately 1 nm apart and some 30 seconds from the collision. From that moment onwards they were heading towards each other with nearly constant relative bearings of 085°/265° creating virtually a 'head-on' collision. There was no obstruction of any significance between the two aircraft to prevent them seeing each other.

According to eye witness evidence, the sun was shining at the time of the accident with the scattered cloud well above the two aircraft. On the ground, the rural patchwork of fields and woods was supplemented by deep shadows cast by ground structures, buildings and clouds. This visual scene tends to 'camouflage' any dark coloured aircraft when viewed from above, particularly if the aircraft's apparent movement relative to the ground is slow.

The R22 instructor had visually cleared the area ahead and below the helicopter prior to descending for the acceleration exercise and he did not see the microlight. During the descent he continued to look out ahead and below the helicopter with an occasional scan of the rotor RPM gauge to confirm that the rotor speed was increasing, which it was. Having levelled off, the instructor began to review the exercise with the student discussing the behaviour of the rotor whilst pointing to the instrument. The sudden appearance of the microlight was consistent with the 'blossom effect' described earlier. The dark coloured wing and fuselage of the microlight with its small profile would effectively have been a stationary object to the occupants of the R22. When set against the background of shadows and dark areas of woodland as the helicopter descended, the microlight would have had no discernible contrast or movement for the helicopter instructor or his student to detect.

Equally, the white colour of the R22 against the cloud combined with the small size and profile of the helicopter in bright sunshine would also have meant that it too had low conspicuity. The anti-collision beacon would not have been easily visible in the bright light. Moreover, because the helicopter was ahead and mainly above the microlight, the beacon, mounted on the upper surface midway aft along the tail boom, was probably obscured from the view of the microlight occupants by the helicopter's cabin. It is not known where the pilot and passenger of the microlight were looking shortly before the collision but the helicopter was not approaching directly out of the sun. The microlight pilot was wearing sun-glasses which would have assisted in reducing glare.

The two pilots were using different radio frequencies and neither was receiving a radar or information service that could warn them of the proximity of the other aircraft.

Conclusions

The collision occurred because those onboard the two aircraft did not see each other and take timely avoiding action. Contributory factors were the small size and profile of the two aircraft and the lack of movement or conspicuity against their respective backgrounds. Detection in these visual conditions was challenging for the human eye. The aircraft were also on different radio frequencies and so had no common service to alert either of the pilots to the presence of the other aircraft.

Safety Recommendation 2005-006

It is recommended that the Civil Aviation Authority should initiate further studies into ways of improving the conspicuity of gliders and light aircraft, to include visual and electronic surveillance means, and require the adoption of measures that are likely to be cost-effective in improving conspicuity.

Safety Recommendation 2005-008

It is recommended that the Civil Aviation Authority should promote international co-operation and action to improve the conspicuity of gliders and light aircraft through visual and electronic methods.

The same safety recommendations will be made in the report on the mid-air collision between two gliders on the 26 April 2004 approximately 2 km west of Lasham airfield, (EW/C2004/04/03) which is likely to be published in Bulletin 5/2005.

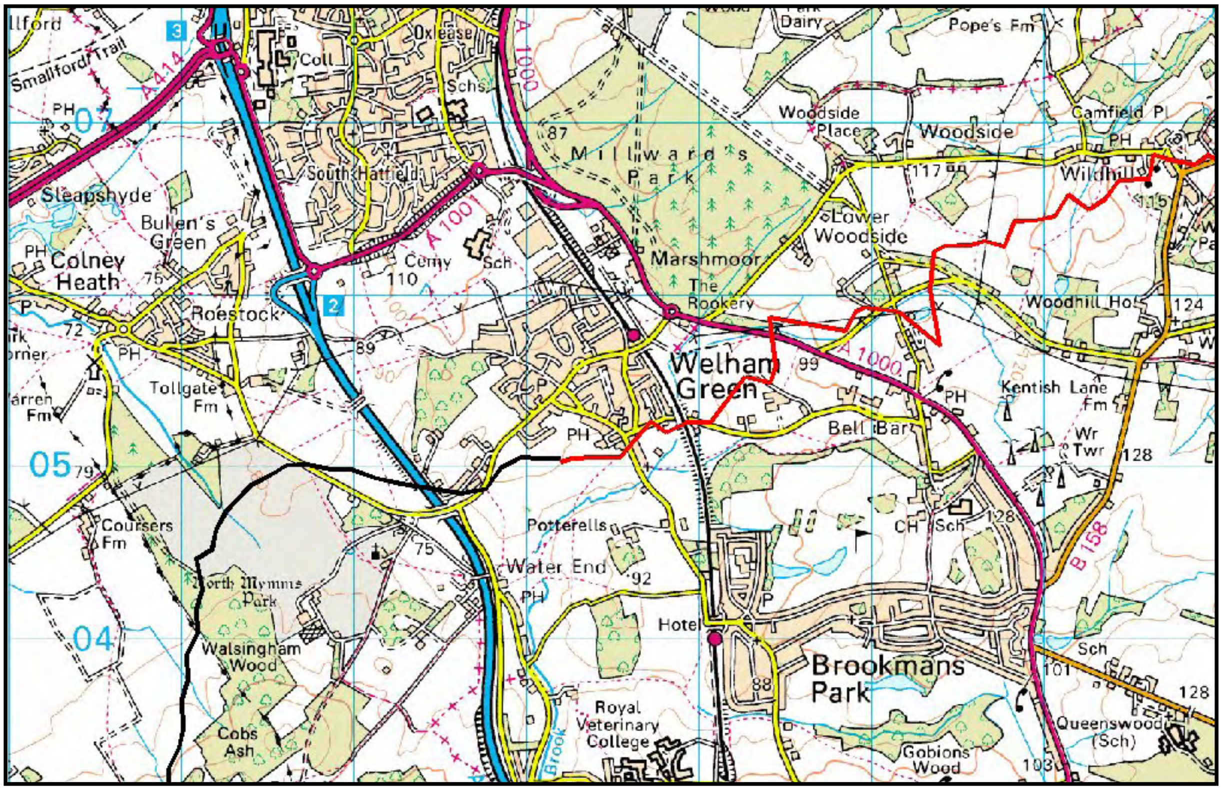


Figure 1 - Radar tracks of microlight G-MTJP (in red) and helicopter G-LIDS (in black)

Note: Microlight trike omitted for clarity.

Figure 2 - Representation of the two aircraft immediately prior to impact

Aircraft Type and Registration:	Cameron A-250, G-BWKX	
No & Type of Engines:	None	
Year of Manufacture:	1996	
Date & Time (UTC):	5 September 2004 at 1815 hrs	
Location:	Near South Stoke, Arundel, West Sussex	
Type of Flight:	Public Transport (Passenger)	
Persons on Board:	Crew - 1	Passengers - 9
Injuries:	Crew - None	Passengers - 1 (Serious)
Nature of Damage:	None	
Commander's Licence:	Commercial Pilot's Licence	
Commander's Age:	55 years	
Commander's Flying Experience:	981 hours (of which 594 were on type) Last 90 days - 44 hours Last 28 days - 21 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

Synopsis

At the conclusion of a commercial pleasure flight the balloon landed at unexpectedly high ground speed, due probably to local wind effects. Despite being correctly positioned for the firm landing, one passenger sustained fractures in both legs.

Background information

The pilot had planned to take nine passengers on a one hour pleasure flight from Hickstead showground travelling to the southwest. He had obtained a weather forecast from the Met Office Internet web site which indicated good weather for the intended flight. The surface wind was forecast as varying between 050º and 100º at 6 to 9 kt, with the wind at 1,000 feet from 070º at 15 kt. Visibility was 8,000 metres with no significant weather, scattered cloud at 6,500 feet and surface temperature 18ºC.

The balloon operator's instruction to its experienced pilots regarding wind speeds were that they were not to fly if the surface wind speed was expected to exceed 15 kt.

Balloon description

The Cameron A250 balloon envelope has a cubic capacity of some 250,000 cubic feet and can lift a basket holding up to 15 persons. The balloon's basket is of wicker construction measuring 1.6 metres wide by 3.0 metres long and 1.2 metres deep; it is divided into five compartments. A central compartment runs the full width of the basket in which the pilot and gas cylinders are located. The two compartments either side of the pilot's compartment are each sub-divided into two which provides a compartment at each corner in which three passengers can stand. The centre compartment provides the pilot with full-length movement across the basket with control of the gas cylinders and central burner. Passenger protection is provided by a suede-covered cushion along the tops of the wicker surfaces and shock absorbent pads on the floor and walls of each compartment.

Two rotation vents on the balloon envelope allow the basket to be turned but do not control the direction in which the balloon travels. The top of the balloon envelope has a large hole into which a parachute-shaped inner envelope sits forming an air tight seal. On this balloon a 'Smart Vent' is fitted where the parachute has ropes attached to it at multiple points. When the control rope is operated, the parachute vent collapses and the hot air in the balloon envelope is released causing swift collapse of the main balloon envelope.

History of the flight

The passengers gathered at the showground and received a briefing on the balloon assembly and inflation procedures, followed by the anticipated sequence of events. A safety briefing on the position to be adopted for landing was given. This required each passenger to place their back against the wicker basket ensuring that they had their back towards the direction of landing with their knees bent. The procedure was briefed again and rehearsed when the passengers had boarded.

Ground crew and passengers assisted with the assembly and inflation of the balloon. During the early part of the inflation, a Chad balloon was seen launching from a site approximately 1 km to the north-east of the showground. The pilot noted its speed and direction which appeared consistent with the forecast wind.

Having completed the inflation of the balloon, the pilot and passengers boarded the basket and received a further briefing including the passenger landing position and stowage of personal items such as cameras. The balloon envelope was vertical with only the light wind forecast and an uneventful departure was made climbing to 1,300 feet agl. The wind direction and speed were derived from a GPS receiver and indicated 050º to 060º at 12 kt. The wind speed increased during the flight to between 17 kt and 19 kt at 1,000 feet with little decrease below that level.

The pilot of the Chad balloon, which was observed departing earlier, was on a similar flight approximately 15 minutes ahead and, following some discussion between them, he relayed to the Cameron pilot that the surface wind at Goodwood was calm. Colleagues of the Cameron balloon pilot flying in the Petworth area some 15 nm west of his position were reporting winds of 6 to 7 kt.

As normal, after approximately 45 minutes, the pilot began to look for a suitable landing site. At about that time the Chad balloon pilot landed and reported that the wind speed during his landing had decreased to 9 kt. Having identified a landing field, the Cameron balloon pilot commenced his approach to land but the wind speed was indicating 14 to 16 kt. The selected field had obstacles of trees and hedges on the far side and so, in view of the likely landing speed, the pilot abandoned that approach and continued the flight at low height, crossing the River Arun at South Stoke. The pilot could see an area of open fields on the downwind side of a farm and, having ensured that the passengers were in the correct landing position, he made an approach to a suitable field with the wind speed still at about 12 to 14 kt.

The landing technique adopted when groundspeed is high is to make a shallow approach and when positively on the ground, operate the 'Smart Vent' to collapse the envelope and prevent the basket being dragged along the ground. The balloon touched down positively and rose back into the air, clearing a boundary fence before touching down again and coming to a stop in the adjoining field, with the basket tipped on its side due to the touch down speed. All the passengers remained in their landing positions in the basket whilst the pilot made safe the balloon. One passenger in the top right compartment (when viewed from above the basket) had sustained leg injuries on the first touch down, despite appearing to be in the correct landing position. She was made comfortable in the basket and an ambulance was called. It arrived within five to ten minutes and conveyed the injured passenger to hospital where fractures in both legs were diagnosed.

Conclusion

The pilot concluded that whilst the landing was firm and the surface wind had increased above that forecast, he was surprised that the passenger had injured her legs because, as far as he could see, she had been correctly positioned. The wind was much as forecast with some local gusting which was also experienced by some of the other balloons.

A video recording provided by the injured passenger covered the early part of the balloon assembly, the briefing and some of the flight. The recording confirmed the report submitted by the pilot.