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CONTENTS (Continued)

(ALL TIMES IN THIS BULLETIN ARE UTC)

ACCIDENT

Wing:	Paramania Revolution 23	
Serial Number:	N/A	
Paramotor:	H & E Paramotores R120 series (modified)	
Year of Manufacture:	2005	
Date & Time (UTC):	8 July 2007 at 1950 hrs	
Location:	Middle Barn Farm, Bexhill, Sussex	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - None
Injuries:	Crew - 1 (Fatal)	Passengers - N/A
Nature of Damage:	Substantial	
Commander's Licence:	N/A	
Commander's Age:	42 years	
Commander's Flying Experience:	5 years (paramotors)	
Information Source:	AAIB Field Investigation	

History of the flight

Several instructors, students and other pilots of the paramotor school had spent the day at the site discussing paramotor flying, conducting ground instruction and waiting for conditions to become suitable for flying. At around 1930 hrs, in conditions described as a light west-south westerly wind and good visibility, three of the more experienced pilots took off.

The pilot involved in the accident was flying a harness and wing combination belonging to the school, at which he was an instructor. He had aborted his first three attempts to launch because on each occasion the wing made an uncommanded left turn on takeoff. With the assistance of another paramotor pilot he found that the left riser had become jammed in the maillon (similar to a small 'D' ring) at the base of the left B-line. This resulted in the B-line being shorter than the other flying lines to the extent that it induced an uncommanded left turn. Together they were able to free the riser and the subsequent launch was successful.

After he had been airborne for several minutes, conducting what witnesses considered to be normal flight manoeuvres, the pilot was seen to climb to a height of approximately 1,000 ft. This indicated to the more experienced pilots that he was about to carry out some more extreme manoeuvres, such as wingovers or a "spiral". During a subsequent turn the wing was seen to collapse partially over approximately 40% of its span. Shortly afterwards the wing re-inflated.

The pilot then climbed once more and appeared to attempt a wingover to the right. This was followed almost immediately by a wingover to the left which developed into a left hand spiral. The first three turns of this spiral appeared "normal" to the witnesses, in the sense that the speed of rotation was similar to other spiral manoeuvres they had observed. However, the fourth and subsequent turns appeared to develop into a "SAT", a fast rotational manoeuvre in which the vertical axis of the wing/harness combination was horizontal and the axis of rotation appeared to be between the wing and the harness. Some witnesses considered that the paramotor had recovered partially into a spiral manoeuvre at approximately the height at which they expected the pilot to return to level flight.

At a height of approximately 150 ft several witnesses heard the engine note increase, indicating that the pilot may have applied full power. The spiral appeared to become less severe, suggesting to the witnesses that the paramotor was beginning to recover to normal flight but, almost immediately afterwards, it was clear that it had hit the ground (although approximately the last 30 ft of its descent were obscured by low hedges and trees).

The school's other instructor directed another pilot, who was airborne at the time, to fly over to the site of the impact, some distance from the main gathering. Several other witnesses made their way on foot or by car but were hampered by numerous ditches which separated the fields. Others alerted the emergency services, the first of which arrived in vehicles which were also unable to reach the site. Another pilot was able to identify the location using a hand held GPS and directed the air ambulance to within a short distance of the injured pilot.

The pilot was attended at the scene by paramedics then flown to hospital. He remained unconscious throughout and succumbed to his injuries two days later.

Integrity of Paramotor Structures

The initial investigation of this fatal accident has revealed that at least one in-flight component failure occurred to the metal structure of the paramotor.

Examination of components from several other paramotors has revealed distortion or damage to the horizontal arms, parts of the arms, or fittings attached to and applying loading to the arms. Such distortion indicates that these components have been loaded close to their failure stress levels.

The arms examined so far vary considerably in design and incorporate a range of different fittings. The AAIB is concerned that no design criteria appear to exist to determine the strength of these items and that there is no overall control of the design and geometry of fittings. Given that each harness may be used with a variety of wings, each with different lift capabilities, and that the mass of the pilot and machine is variable, many arms and fittings in use may not be sufficiently strong to sustain the loads experienced in certain manoeuvres. Without further information, the AAIB regards this as a potential flight safety hazard.

Accordingly, all pilots are advised to refrain from extreme manoeuvres until the structural integrity of these machines is ascertained. Owners and representative bodies are strongly advised to establish the level of testing carried out by individual manufacturers of the structures of their machines. Load levels must be related to the lift capabilities of the particular wings in use and the maximum suspended weight of the harness, power unit and pilot. Reliable estimates of the maximum normal acceleration experienced in particular manoeuvres must be established to enable these loadings to be properly factored. In addition, the effects on strength of any fittings which alter the loading (either directly or by creating offset geometry) of the structure to which they are attached must be established.

Only when precise reserve factors have been established for individual harness/wing combinations carrying realistic suspended masses, at load factors appropriate to the manoeuvres to be carried out, can these aircraft be considered to be structurally safe.

Published August 2007

INCIDENT

Aircraft Type and Registration:	Airbus A319-131, G-DBCI
Serial No:	2720
No & Type of Engines:	2 International Aero Engine V2522-A5 turbofan engines
Year of Manufacture:	2006
Date & Time (UTC):	24 January 2007 at 1208 hrs
Location:	Leeds Bradford Airport
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 5 Passengers - 53
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to all main landing gear tyres
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	49 years
Commander's Flying Experience:	9,500 hours (of which 950 were on type) Last 90 days - 147 hours Last 28 days - 41 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot, investigation reports produced by the operator and AAIB follow-up enquiries

Synopsis

On approach to Leeds Bradford Airport (LBA), the commander inadvertently selected the parking brake to ON after the first officer had called for full flap. As a result of a previous landing by the commander at LBA, in difficult weather conditions, his attention was focused upon the numerous ATC wind advisory messages transmitted during the approach. One of these messages coincided with the first officer request for full flap. When the first officer realised that the flaps had not been deployed to full, he called again for their selection, to which the commander responded correctly. The application of the parking brake was not detected prior to touchdown. All four main landing gear tyres deflated on landing.

History of the flight

The aircraft was inbound to LBA from London Heathrow Airport and broke cloud at a height of approximately 3,000 ft in a snow shower. During the approach, ATC transmitted five advisory wind reports and, at approximately 1,300 ft, the first officer, who was the Pilot Flying (PF), requested full flap.

Coincidentally, ATC transmitted a further wind check and this was acknowledged by the commander[1]. A few seconds later, the first officer noticed that the ECAM (Electronic Aircraft Central Monitoring) still indicated FLAP 3 and repeated his request. The commander then selected full flap and the landing checklist was completed. Immediately after touchdown, the flight crew noted that the brakes appeared to take effect immediately with a greater deceleration than normal. The commander noticed that the AUTOBRAKE blue caption remained illuminated, but with no DECEL indication. The first officer then 'dabbed' the brakes in an attempt to disengage the autobrake, but this had no effect. The aircraft came to a halt on the runway, slightly left of the centreline. After coming to a halt the commander requested the first officer to apply the parking brake but the first officer found it already set. Initially, the flight crew had believed that only one tyre had deflated but, when the AFS attended the aircraft, they were informed that all four main wheel tyres had, in fact, deflated. Neither pilot reported any abnormal noises during the landing.

After assessing the situation, the passengers were disembarked through the normal exits and taken by coach to the terminal.

Investigation

The parking brake handle and flap selection lever are located on the aft section of the centre pedestal between the pilots' seats, Figure 1, and are of different shapes. The flap lever is moved fore and aft through the various flap position 'gates' whilst the parking brake is selected by grasping the parking brake handle and rotating it clockwise. Despite these controls being of different shapes, requiring different methods of activation, their shapes allow both to be grasped in a similar manner prior to selection. An inspection of the aircraft's flight deck showed that the identifying placard was missing from the parking brake selector.

The operator's Standard Operating Procedures (SOPs) state that:

> *'when the configuration of an aircraft is changed, positions of the surfaces should be monitored to confirm that the change has been accomplished.'*

The SOP for the pre-landing checks require the flight crew to confirm that no checklist items remain outstanding; any such items appear in the lower left quadrant of the ECAM display. There is no requirement to check the lower right quadrant of the display for caution or advisory messages. Should the parking brake be selected in-flight, an amber PARK

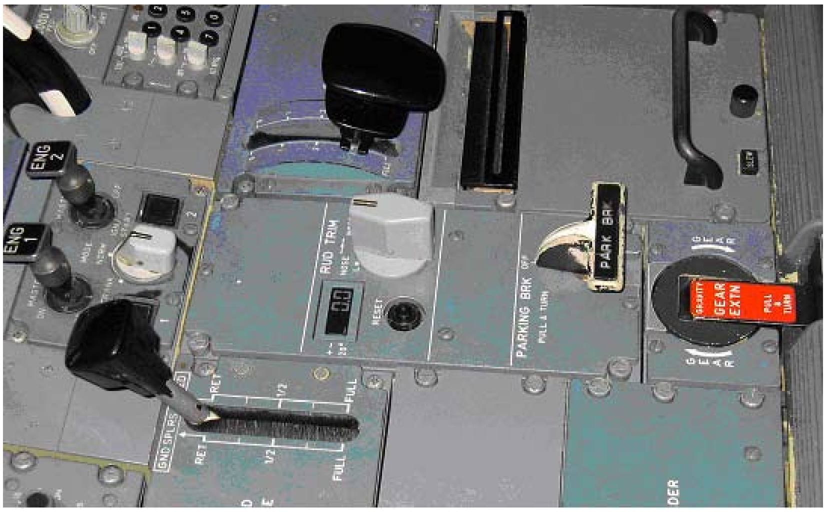


Figure 1

Parking brake and flap selectors on an A320

Footnote

[1] The ATIS for LBA at the time was recorded as: Info. 'F', Runway 32, 01014KT 340V050 9999 FEW007 SCT013 03/01 Q1014.

BRK caption is generated in the lower right quadrant of the ECAM display, Figure 2.

This caution is classified by the manufacturer as a 'Level 1' caution and, therefore, the master caution light does not illuminate and the audible 'attention getter' tone does not sound. The aircraft was fitted with a pre-'H2F3' standard Flight Warning Computer (FWC). In these circumstances, in an aircraft fitted with the 'H2F3' standard FWC, the master caution light will illuminate and the 'attention getter' tone is generated; in addition, the following landing checklist item appears on the ECAM screen:

'BRAKES PRK BRK ON
-PARK BRK……………………………………OFF'

During an investigation carried out by the operator into this event, the commander stated that he had been involved in a previous landing at Leeds Bradford in difficult wind conditions, which resulted in the use of a significant proportion of the runway length, due to a tailwind. He also acknowledged that he had no recollection of his action taken in response to the first officer's first request for full flap. The aircraft manufacturer has confirmed that there have been five similar events worldwide.

Additional information

During the operator's investigation into this event, they were advised on the issues of Crew Resource Management (CRM) and Human Factors, by a Psychologist. The following is an extract from that report, reproduced with the agreement of the operator.

'It is possible that the commander was temporarily fixated on the environmental conditions exacerbated by the perception that these could lead to the repetition of a previously experienced unpleasant event.

This fixation and the requirement to complete simultaneous tasks could have resulted in a narrowing his focus of attention and an inability to complete both using conscious thought processes.

Hence the task of flap selection may have been relegated to a sub-conscious and thus un-monitored motor action.

In this case a regularly used, but inappropriate motor action was transposed with the correct one.

Although it may appear that the SOP for configuration change and the subsequent check following surface travel was not followed correctly, the commander was unaware that he had commenced the process and so would not have consciously checked for process completion.

It was therefore extremely unlikely to have been a case of conscious failure to follow SOPs.

Figure 2

ECAM Display with parking brake selected

The above would explain the incorrect action taken, the inability to remember task completion and omitting to trap the error at the selection stage or thereafter.

As humans are generally susceptible to this type of fallibility, it is important to have robust procedures in place that trail the error after it has been made, but before it leads to an incident, thus breaking the error chain.'

Analysis

The large number of wind advisory reports transmitted by ATC, coupled with the commander's experience of landing with a tailwind at LBA, may have led him to become temporarily fixated on the changing environmental conditions during the later stages of the approach. The transmission, and acknowledgement, of the final wind advisory report, at the same moment as the first officer requested full flap, probably caused the commander to make a subconscious control selection. This is supported by his lack of recollection of the event. The ability to grasp the parking brake handle in a similar manner to the flap selector may also have prevented the commander from obtaining initial tactile feedback that the wrong control had been selected. The fact that these actions appeared to have been made subconsciously would most likely have prevented the triggering of the requirement to confirm that the correct configuration had been achieved after selection. Given the nature of the control selection, the lack of a placard on the parking brake handle is not thought to have contributed to the incident.

The standard of FWC fitted to the aircraft did not trigger the illumination of the master caution light and an aural alert, which could have drawn the crew's attention to the inadvertent selection. The SOP's in force at the time of the incident did not direct the flight crew to check for messages in the lower right quadrant of the ECAM screen and, given the high cockpit workload during the later stages of the approach, it is possible that any such messages could be easily overlooked.

Conclusions

In the later stages of the approach, the commander inadvertently set the parking brake, instead of the flaps to FULL. He was probably focused on changing weather conditions, because of a previous difficult landing at LBA as well as the numerous wind advisory calls from ATC, the last of which was coincident with the co-pilot's initial request for full flap.

The FWC fitted to the aircraft generated an advisory message on the ECAM display but did not produce any additional 'attention getters'. Had the later standard been fitted, both aural and visual cues would have been produced by the selection of the parking brake, together with the generation of an open checklist item on the ECAM screen. The pre-landing checks in use at the time of the incident required that the crew confirm that there were no open checklist items; it did not require crews to check for advisory messages.

Safety action

As a result of this event, the operator has made changes to its SOP's to incorporate a pre-landing check of the lower right quadrant of the ECAM screen for advisory and caution messages.

INCIDENT

Aircraft Type and Registration:	Airbus A321-231, G-MIDC
No & Type of Engines:	2 IAE V2533-A5 turbofan engines
Year of Manufacture:	1998
Date & Time (UTC):	13 November 2006 at 1647 hrs
Location:	Dublin Airport
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 7 Passengers - 129
Injuries:	Crew - None Passengers - None
Nature of Damage:	Loss of hrust reverser blocker door
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	54 years
Commander's Flying Experience:	15,000 hours (of which 1,800 were on type) Last 90 days - 240 hours Last 28 days - 80 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and follow-up AAIB investigation

Synopsis

During a post-landing walk-around check at London Heathrow Airport (LHR), the flight crew noticed a blocker door missing from the left engine by-pass duct; the acoustic panels lining the duct itself had also been damaged. The loss of the blocker door was found to have been caused by failure of the door mounting lugs, due to corrosion cracking and the seizure of a blocker door hinge bearing. The manufacturer is investigating several similar failures and will take action to minimise the possibility of additional failures of this nature when their investigations are complete.

History of the flight

The aircraft had completed a flight from Dublin to LHR when, during a post-flight walk-around inspection, the flight crew observed that the acoustic panels lining the interior of the left engine by-pass duct had been damaged and that a thrust reverser blocker door was missing, Figure 1. No defects had been observed during the pre-flight inspection at Dublin, no unusual vibrations or noises were noticed during the flight and the aircraft had not recorded any defects in its fault monitoring systems. The remains of the blocker door were found adjacent taxiway E7 at Dublin Airport.

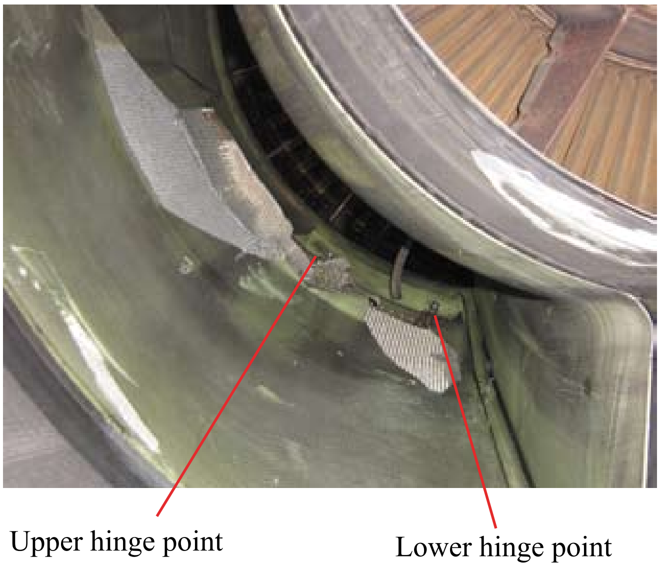


Figure 1

Damage to by-pass duct (view looking forward)

Investigation

In response to a request from the Irish Accident Investigation Unit, the AAIB conducted an investigation into this incident and the blocker door, together with its mounting hardware from the thrust reverser, were dispatched to the AAIB for examination.

Blocker door description

The blocker door consists of a rolled and machined aluminium alloy 'plate', secured to the translating sleeve of the thrust reverser by two hinges located towards the forward edge of the door. Each hinge consists of a stainless steel spherical plain bearing pressed into a lug in the door structure. Each lug sits within a bracket on the thrust reverser sleeve and is held in place by a bolt which passes through the bracket and the bearing. A hinged arm located towards the rear of the door is secured to the inner fixed section of the thrust reverser. When the reverser operates and the translating sleeve moves aft, the blocker door is pulled across the bypass duct by the hinged arm.

Detailed examination

Examination of recovered material showed that the door actuation arm had failed due to an overload condition, and that the lugs on the forward edge of the door, into which the bearings had been located, had both failed, Figure 2.

The bearings had remained in their respective mounting brackets on the reverser translating sleeve. Laboratory examination of the fracture surfaces of both lugs showed areas of inter-laminar and inter-granular corrosion cracks, at the lug holes, suggesting stress corrosion. Overload failure areas towards the rear of each lug were also observed. The lower lug had also been distorted due to the application of a torsional load prior to failure.

Examination of the bearings showed that the upper bearing had seized in its race. Some evidence of corrosion staining was present between the bearing roller and race and it was noticed that evidence of primer residue was present between the inner surface of the lug holes and the spherical bearings.

Figure 2

Blocker door, showing failed hinge lugs

Blocker door maintenance history

The records for the blocker door indicated that it had been inspected and repaired by a Maintenance Repair Organisation (MRO) in December 2002, and was subsequently fitted to G-MIDC in February 2005 during a 'C' check. Discussion with various operators and MROs confirmed that previous cases of cracked bearing lugs were attributed to stresses introduced during the bearing installation process. However, tests carried out on the door whilst at the MRO established that no cracks were present in the lugs at that time.

A review of the maintenance program for the aircraft showed that there is no requirement to carry out routine lubrication of the blocker door bearings.

Analysis

Deformation of the lower lug indicated that the upper lug failed first, which resulted in the failure of the lower lug and the actuation arm, which allowed the blocker door to be released.

The use of a stainless steel bearing in the aluminium lug would have provided a source of galvanic corrosion and, therefore, an initiator for the corrosion cracking observed. In order to minimise this possibility, blocker doors are primed prior to the installation of the bearings; residue found in the lug holes confirmed that primer had been present. However, clear evidence of corrosion cracking in both lugs was present. This was probably as a result of galvanic corrosion between the steel bearing and aluminium alloy blocker door, and it is possible that the primer was of insufficient thickness to prevent this happening, or had become damaged during the installation of the bearings. The seized upper bearing would have introduced additional torsional loads in the door lugs, accelerating the rate of crack propagation.

Safety action

The manufacturer is currently investigating several similar events and will, based on the results of these investigations, take action to minimise the possibility of additional failures of this nature. In view of this, no Safety Recommendations are considered necessary to be made at this time.

INCIDENT

Aircraft Type and Registration:	BAE Systems Jetstream 4100, G-MAJI
No & Type of Engines:	2 Garrett Airesearch turboprop engines
Year of Manufacture:	1993
Date & Time (UTC):	12 January 2007 at 0723 hrs
Location:	After takeoff at Durham Tees Valley Airport, County Durham
Type of Flight:	Commercial Air Transport
Persons on Board:	Crew - 3 Passengers - 3
Injuries:	Crew - None Passengers - None
Nature of Damage:	None
Commander's Licence:	Air Transport Pilot's Licence
Commander's Age:	44 years
Commander's Flying Experience:	4,330 hours (of which 577 were on type) Last 90 days - 206 hours Last 28 days - 49 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and subsequent inquiries by the AAIB

Synopsis

Immediately after takeoff from Durham Tees Valley Airport, the crew found difficulty in controlling the aircraft in pitch using the control yoke. They found that the pitch trim wheel and engine condition lever friction wheel had locked together, jamming both controls. The aircraft returned to the airport with the crew using engine power to assist in controlling pitch and an uneventful landing was made.

History of the flight

The aircraft was taking off from Durham Tees Valley Airport. The crew had performed all the pre-flight checks including those for full and free movement of the flying controls and trim wheels and, as they were cleared to take off, the crew advanced the engine condition levers to FLIGHT and applied takeoff power. The engine condition lever friction lock was tightened as a precaution against 'creep-back', which could cause a configuration warning and a rejected takeoff.

The commander passed control to the co-pilot at 80 kt, the aircraft was rotated normally into the climb and the landing gear was retracted. At about 400 feet, and before the acceleration altitude of 620 feet, the co-pilot stated that he was having control difficulties and could not push the aircraft's nose down using the control column.

The commander took control and he, too, found it was difficult to control the pitch attitude, resorting to power reduction to reduce the rate of climb. A message was passed to the approach controller, advising him of their control difficulties and requesting vectors for a return to the airport. Meanwhile, the crew attempted to diagnose the problem, having climbed to 7,000 ft and returned to the overhead.

It was soon found that both the elevator manual trim wheel (see Figure 1) and the condition lever friction wheel had jammed and were immovable. The elevator electrical trim also did not work. Vectors were provided for a 10-mile final approach to the airport for an ILS landing on Runway 23 in order for the crew to assess handling. The decision was made to keep the flaps at their takeoff setting of 9º in case further flap extension exacerbated the problem. The crew found that it was possible to control the pitch attitude satisfactorily using power variations and a safe landing was made. The aircraft taxied back to the stand and the engines were shut down with the condition levers still at the flight selection.

Investigation by the company's engineers found that the condition lever friction wheel, which rotates about a common shaft with the elevator manual trim wheel (Figure 1), had made contact with the trim wheel such that application of nose-down elevator trim also caused rotation of the friction wheel in the 'tighten' sense until the two had jammed together. When the two wheels were freed, both mechanisms worked correctly. The aircraft manufacturer provided the information below

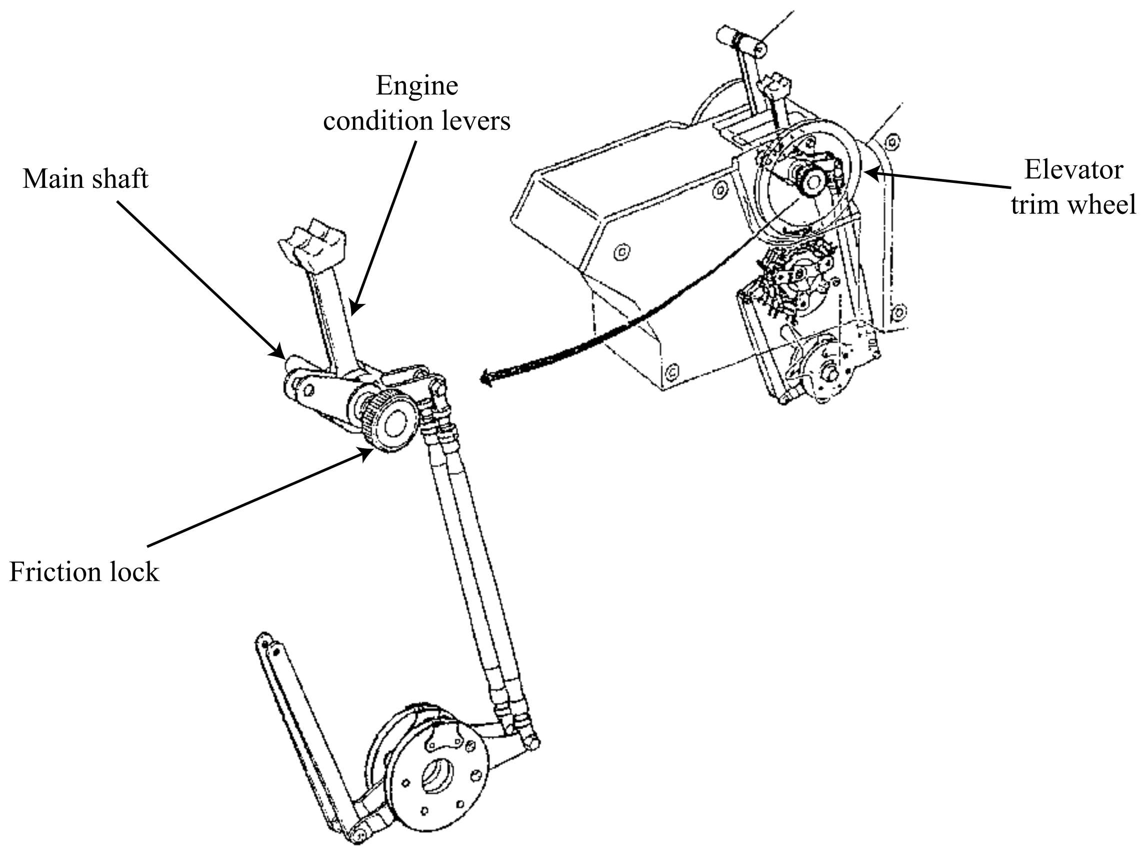


Figure 1

Jetstream 41 centre console, showing relationship between engine condition lever friction lock and elevator trim wheel to assist the airline's investigation, but the 'displaced circlip' condition (below) described by the manufacturer was not found.

Previous incidents of a similar nature

The aircraft manufacturer supplied details of their All Operators Message (AOM) number 99/006J – issue 1 dated 9 February 1999. The AOM was issued in response to a number of reports from a particular operator in the United States of abnormally stiff elevator trim. Investigation had shown that a circlip, designed to prevent axial movement of the trim wheel along the shaft it shares with the condition levers, had become displaced from its groove (the friction wheel travels down a thread towards the trim wheel when rotated in the 'tighten' direction). As the pilots applied condition lever friction, the wheel had moved along the shaft and contacted the displaced trim wheel. The AOM recommended a 'once-off' inspection to ensure that the circlip was correctly seated and the operator of G-MAJI had introduced an additional requirement to check the circlip at 600-hour intervals.

In their response to these incidents, the FAA recommended that BAe and the CAA conduct an investigation into the causes and take action to prevent recurrence. The resulting investigation identified the cause as being the displaced circlips which, it was concluded, had been incorrectly fitted or moved during maintenance, as opposed to becoming dislodged through a design deficiency. On the basis of this, the manufacturer reasoned that no physical changes needed to be made to the assembly, as the AOM had alerted operators to the problem. The manufacturer also added a caution in the Aircraft Maintenance Manual (AMM) to ensure that the circlip was correctly seated, in response to a second FAA recommendation.

There do not appear to have been recurrences of this problem between the AOM and the incident to G-MAJI.

Discussion

In this incident, what the crew initially believed to be an abnormality in the primary pitch controls appears, in fact, to have been an out-of-trim condition. This belief led to the crew largely dismissing elevator inputs in favour of controlling pitch with power adjustments.

The commander also commented that, in hindsight, in view of the difficulties the crew were having, he should have declared a 'MAYDAY'. He also noted that ATC, while being aware of the general nature of their problems, did not ask him if he was declaring an emergency and, due to the stress and workload, he had not thought of it himself.

It is of concern that this incident, apparently a rather more extreme variation of incidents that had occurred (and which had appeared to have been resolved) about eight years ago, should not have the same root cause. The AOM described how the friction wheel is fitted with a boss which 'bottoms' on the main shaft before it can interfere with a correctly-fitted trim wheel, and therefore only a displaced trim wheel can cause contact. Despite a thorough check against the maintenance manual, no abnormalities were found in G-MAJI, and the aircraft has operated without further incident since then. The conclusion drawn by the operator is that the condition lever friction wheel had been tightened with greater than normal force to cause this incident.

However, the aircraft manufacturer has advised that, as an added precaution, it is revisiting the design review of the mechanism, carried out in response to the earlier occurrences.

INCIDENT

Aircraft Type and Registration:	BAE Systems Jetstream 4100, G-MAJI
No & Type of Engines:	2 Garrett Airesearch turboprop engines
Year of Manufacture:	1993
Date & Time (UTC):	26 February 2007 at 0705 hrs
Location:	Durham Tees Valley Airport, County Durham
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 3 Passengers - 29
Injuries:	Crew - None Passengers - None
Nature of Damage:	None
Commander's Licence:	Air Transport Pilot's Licence
Commander's Age:	59 years
Commander's Flying Experience:	11,300 hours (of which 278 were on type) Last 90 days - 94 hours Last 28 days - 46 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and additional AAIB enquiries

Synopsis

Prior to taking off, when conducting the 'full and free' flight control checks, a restriction was felt in the elevator circuit. Examination revealed that there was a lack of appropriate lubrication of the gust lock mechanism associated with an elevator circuit. As a result of this finding, the operator now applies lubrication on an annual basis, instead of once every four years, and the manufacturer is amending the Maintenance Schedule to increase the frequency of lubrication of the flight controls gust lock system.

History of the flight

Whilst waiting to enter Runway 23 for takeoff at Durham Tees Valley Airport, the manually operated flight controls were unlocked by the co-pilot by means of moving the gust lock lever on the flight deck pedestal. He then checked for free movement of the ailerons and elevator, while the commander checked the rudder. The co-pilot reported that there was a restriction in the control column movement aft of neutral. He checked that the gust lock lever was fully down, but the restriction remained. The commander then checked the controls a number of times and confirmed that the control column always came up against an apparent obstruction, approximately three inches aft of neutral.

The aircraft was taxied back to the stand where it was handed over to the operator's engineering department.

Examination of the aircraft

Operation of the gust lock control lever, with respect to the elevator circuit, causes a lock pin to engage in a slot cut into a cable quadrant located in the rear fuselage, Figure 1.

In this case, an apparent lack of lubrication was causing the pin to 'hang up' in the slot, thus keeping the elevators in a locked condition. When the operating lever on the flight deck was moved to the unlocked position, the 'lost motion' was taken up by the compression of a spring within the locking mechanism. The operator, who has a fleet of 25 Jetstream 41 aircraft, has stated that they have experienced 19 similar occurrences involving the gust lock system, although many of these were the result of the locks failing to engage and, therefore, were not the subject of any mandatory reporting action. The operator also stated that all their pilot reports are routinely sent to the manufacturer for reliability analysis.

The Maintenance Schedule required that the gust lock system components be lubricated every 6,000 flight hours which, with this operator, occurred approximately every four years. Since this incident the operator has adopted a policy of applying lubrication every year. Also, the aircraft manufacturer is in the process of changing the Maintenance Schedule to increase the frequency of gust lock system lubrication. Since this will take some time, they are considering raising the matter in an All Operators Message (AOM) to be published in the shorter term.

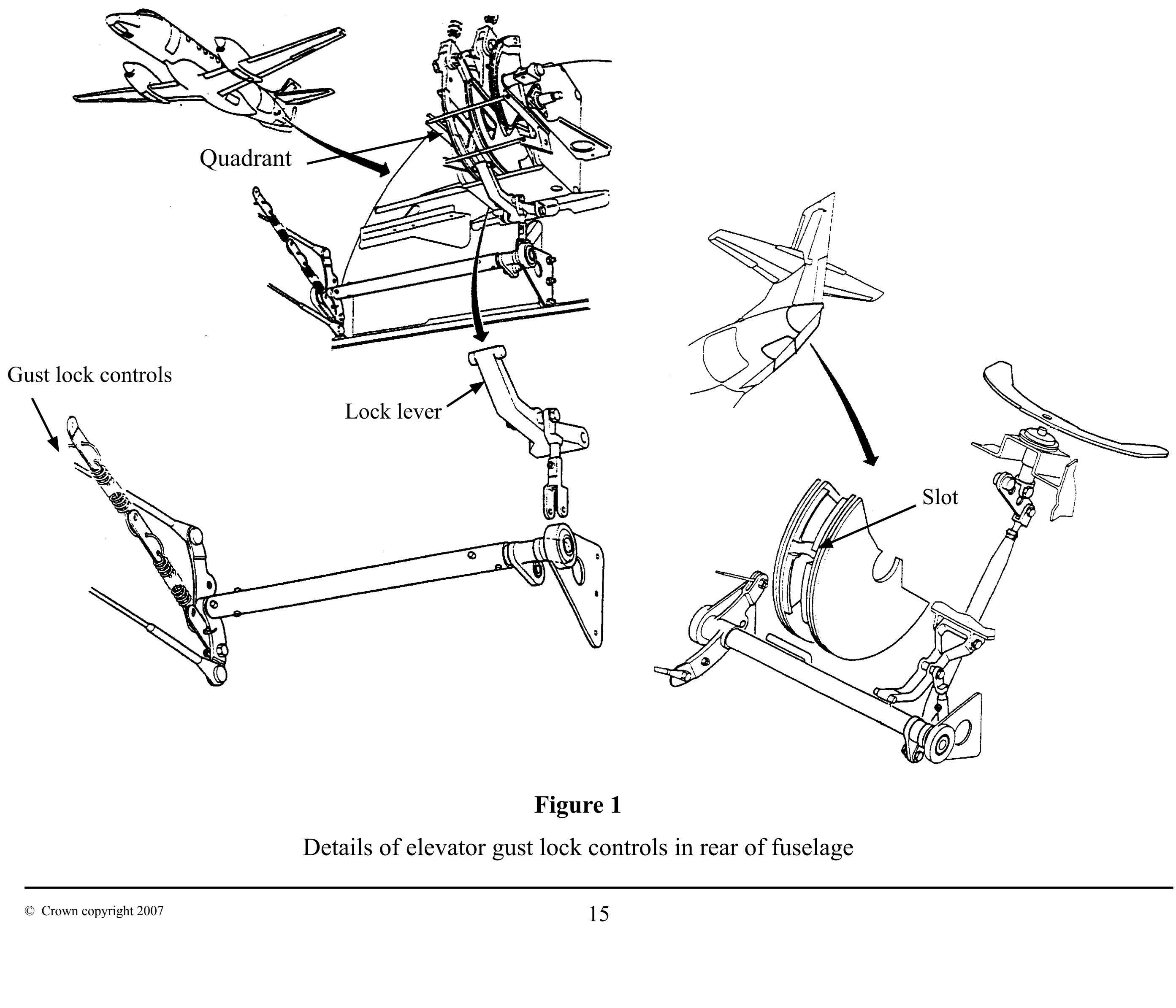


Figure 1

Details of elevator gust lock controls in rear of fuselage

ACCIDENT

Aircraft Type and Registration:	MD Helicopters MD 900, G-EHMS
No & Type of Engines:	2 Pratt & Whitney Canada PW206E turboshaft engines
Year of Manufacture:	2000
Date & Time (UTC):	4 June 2006 at 1548 hrs
Location:	Walworth Road, London Borough of Southwark
Type of Flight:	Commercial Air Transport
Persons on Board:	Crew - 2 Passengers - 2
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to main rotor blades, main rotor head, main rotor gearbox and left vertical stabiliser
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	50 years
Commander's Flying Experience:	4,000 hours (of which 300 were on type) Last 90 days - 60 hours Last 28 days - 20 hours
Information Source:	AAIB Field Investigation

Synopsis

The helicopter was attending a road traffic accident (RTA) in which a pedestrian had suffered potentially life-threatening injuries. While landing on a garage forecourt, close to the RTA, a metal sign became detached from the wall of the garage and was blown into the main rotor disc. The commander was able to make a controlled landing on the forecourt and no-one within or outside the helicopter was injured by the flying metal debris from the sign.

History of the flight

G-EHMS had been tasked by the London Ambulance Service to attend a road traffic accident (RTA) on Walworth Road in the London Borough of Southwark, in which a pedestrian had received potentially life-threatening injuries. The crew received the call at their offices, adjacent to the helicopter landing platform on the roof of the Royal London Hospital, Whitechapel, at 1541 hrs and G-EHMS took off from there at 1543 hrs. The weather conditions were good, partly sunny, with visibility in excess of 10 km and a light wind from the north-west. On board the helicopter were a crew of two pilots, a doctor and a paramedic.

The straight line distance to the site of the RTA was 2.15 nm, in a south-westerly direction, and G-EHMS arrived overhead its location at 1546 hrs. The commander, who was the pilot flying (PF) in the right seat, commenced an orbit at a height of between 500 ft and 1,000 ft agl while he and the co-pilot identified potential landing sites. The commander recalled seeing three possible sites and the co-pilot identified four. Between them they concluded that a nearby garage forecourt on the west side of the Walworth Road was the most suitable because of its size, proximity to the RTA (125 metres away) and freedom from obstacles. They also assessed that it was over and above the minimum dimensions required for a landing site when the helicopter is operating in its primary life-saving role. This demands a space whose dimensions in any direction are at least twice the length of the helicopter from the front of the main rotor disc, when rotating, to the end of the tail ('2D'). The co-pilot later stated that he had landed at this site some five or six years before.

The commander flew two or three orbits before making an approach to the forecourt, into wind. Before and during the approach the crew checked the forecourt for overhead wires, pedestrians, vehicles, loose articles and its slope, size, shape, surrounds and surface conditions. They also checked for the presence of high walls (which might affect the helicopter's handling if they encountered recirculated air from the helicopter's downdraft), fixed obstacles and vegetation, and a potential go-around flight path in case of an engine failure.

The garage forecourt, which was rectangular in shape, with its longest dimension orientated north-south, was adjacent to a petrol station but the commander observed, that there were no vehicles at the petrol pumps before committing himself to landing. However, one car was seen on the access driveway from the main road, which led to both the forecourt and petrol station. G-EHMS descended through the committal height of 100 ft agl and was established in a hover about four feet above the middle of the forecourt. During the final stages of the approach the co-pilot opened his door and looked out for any obstacles on the left of the helicopter, closing it again before they had reached the hover. In the hover, the commander manoeuvred the helicopter slightly to the left and rearwards, with lookout assistance from the co-pilot, to leave the access road clear once they had landed. Also, the co-pilot recalled advising the commander to manoeuvre the tail of G-EHMS to the left, and its nose to the right, in order to give adequate clearance from the vehicle which he had seen on the access driveway, to the right of the helicopter.

G-EHMS had been in the hover for 5-10 seconds when all the occupants of the helicopter heard a loud bang. The helicopter remained in a stable hover but the commander felt substantial vibration through the flying controls and immediately manoeuvred the helicopter forward 5-10 feet and down for a zero speed landing, facing north. He suspected that something had entered the main rotor disc and, without delay, shut the engines down and stopped the rotors. No-one was injured and the doctor and paramedic departed to attend the casualty at the RTA.

After exiting the helicopter, the crew found metal debris scattered on the forecourt and damage to the helicopter's main rotor blades. One of the helicopter's VHF aerials had detached and they found a puncture hole in the left vertical stabiliser. The metal debris was identified as being from one of the signs located above the garage doors.

A number of police officers had attended the scene of the RTA before the arrival of the helicopter. On seeing the helicopter making an approach to the garage forecourt, two of them ran towards the forecourt to prevent members of the public approaching too close to the helicopter and its landing site. While doing this, one of these police officers saw a metal sign above one of the garage doors being "pulled off" the wall into the path of G-EHMS's main rotor blades as it was landing. There was a loud "crashing" sound and some pieces of the metal sign were thrown towards the people being held back by the other police officer on the pavement, three to four yards from the access driveway to the forecourt. One piece of metal, which measured about one foot by 10 inches, landed within a few feet of them. However, no-one was struck by any of the debris.

Aircraft description

The MD 900 helicopter is fitted with a five-bladed, fully articulated, hingeless flexbeam main rotor driven by a PW206E turboshaft engine. Anti-torque, directional control and yaw stability are provided respectively by the NOTAR fan driven directly from the main transmission, the circulation control tailboom, the thruster and the horizontal and vertical stabilizers. The rotor diameter is 10.83 metres and at its nominal 100% rotor speed, the rotor runs at 392 rpm, which equates to a tip speed of 695 ft/s. The distance 'D' from the front of the main rotor disc to the rear of the tail boom is 11.83 metres. G-EHMS was used being as the London Air Ambulance and was fitted with special cabin equipment for the role.

Accident site and wreckage examination

Figure 1 shows a plan of the garage and the petrol station forecourt on the Walworth Road. The garage has a clear area in front for vehicle manoeuvring and over which cars access the petrol station. There are kerbs and bollards within this area to direct entry and create parking areas. The total extent of the clear area is approximately 42 metres (from boundary wall to the petrol station canopy) by 25 metres (from the front of the garage to the pavement kerb). However, a car was parked within this clear area at the time of the accident (see Figure 1), approximately 13 metres from the front of the building.

The garage is constructed with brick side walls and brick pillars linked across the front of the building by a corrugated metal fascia board. The latter is attached via metal brackets cemented into the brick wall. Metal advertising signs are attached to the fascia board. One of these had detached in the helicopter downwash and been drawn into the rotor disc.

The helicopter had come to rest on a northerly heading with the rotor disc approximately 5m from the front of the garage building. Numerous impacts with the rotor blades had shredded the metal sign, pieces from which had been flung to the edge of the garage forecourt. The remains of fixings on the fascia board indicated that the sign had been attached prior to the helicopter landing. The metal bracket connecting the fascia to the end brick wall had been dislodged so that the fascia was no longer attached to the wall. There was also damage to the brickwork at the base of the side wall. The garage manager stated that the base of the wall had been hit by a Heavy Goods Vehicle (HGV) at some time prior to the accident. It was not possible to determine whether the detachment of the fascia board had occurred in the HGV impact, or was part of the damage caused by the helicopter downwash.

All the main rotor blades, which were of fibreglass/epoxy construction, had suffered damage to their outer sections. The leading edge abrasion strips were smeared with blue paint from the sign and the blades had suffered multiple impacts. An aerial from the top left side of the helicopter had detached and the left vertical stabiliser had suffered impact damage from the sign fragments.

Further examination of the helicopter revealed no pre-impact faults with could have contributed to the accident. A download of the non-volatile memory (NVM) from the Integrated Instrumentation Display System (IIDS) showed no faults or exceedances had been recorded.

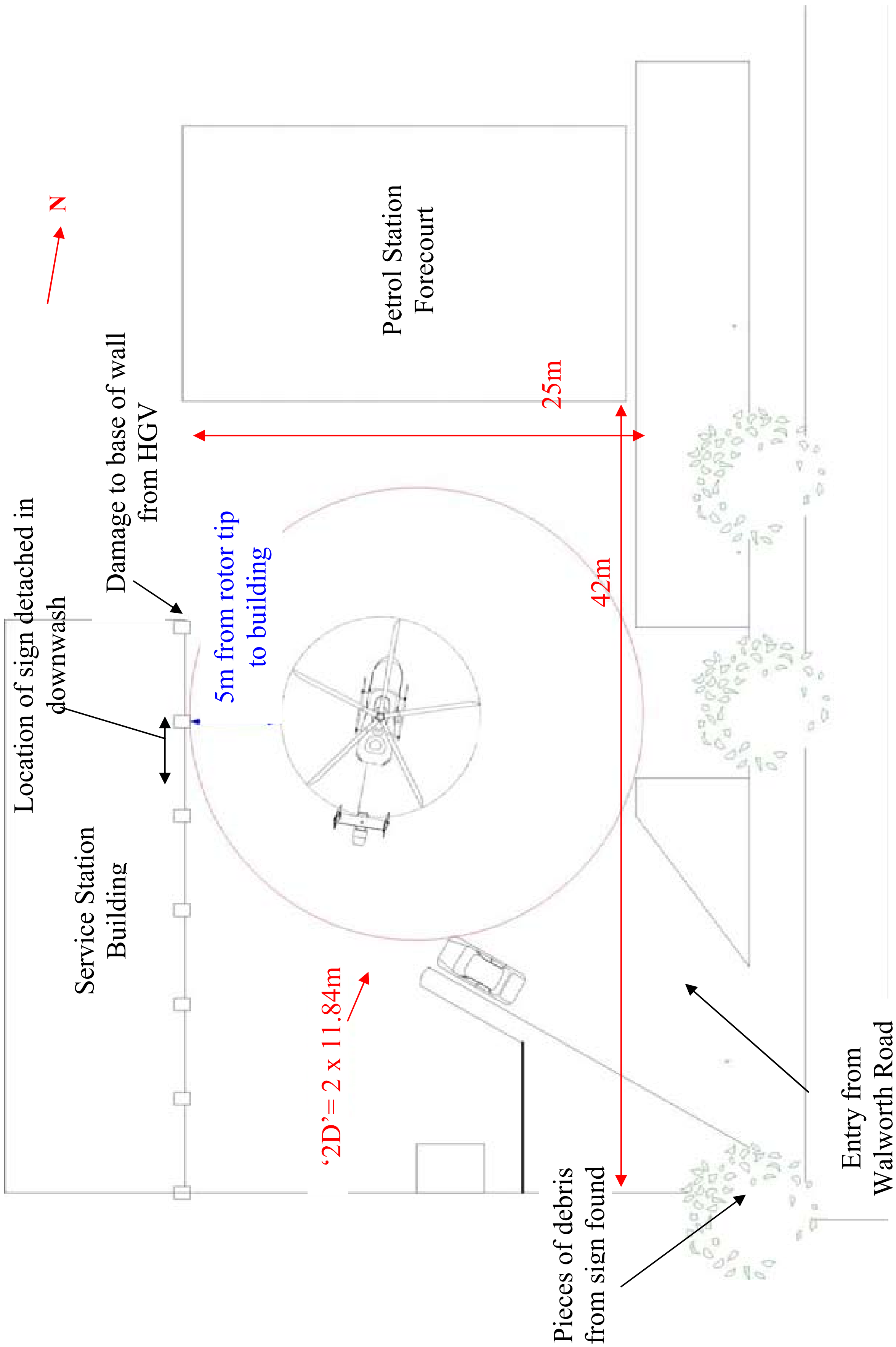


Figure 1
G-EHMS at Walworth Road, 4 June 2006

Procedures

Selection of Landing Sites

For operations in its Primary Helicopter Emergency Medical Services (HEMS) role, when tasked by the London Ambulance Service and where human life is in immediate danger, the operator's operations manual states that a landing site is to be at least 2D in size, where D is the overall length of the helicopter, with rotors running. The operations manual specifies that 2D for G-EHMS is 77.6 feet, which equates to 23.66 metres. This reflects the requirements in JAR-OPS 3 for HEMS daylight operations.

The operator's operations manual also states that:

> *'When landing and taking off from congested sites which exercise the Rule 5 (1) (b) dispensation it is essential that both pilots are checking their respective sides of the aircraft throughout the manoeuvre for adequate clearance from surrounding obstructions.'*

'Adequate clearance' was not defined but the inference was that the helicopter should land in the centre of a landing site of limited size to give maximum clearance in all directions. It is worth noting that G-EHMS is a type of helicopter which has no tail rotor and uses vectored air emitted from the tail boom for yaw control. This design removes the hazards associated with tail rotor blades and the potential danger from nearby obstacles.

Training

The operator's training on the assessment of landing sites is included in the ground training syllabus for newly appointed pilots. This includes instruction on the exemptions granted to HEMS operations as well as the performance, operational and physical factors to consider when selecting a landing site. Initial Line Training is conducted on non passenger carrying flights. Following a satisfactory Line Check, the pilot is then '*cleared for line flying under the supervision of a Line Training Captain'* on all types of missions. Practical flying training in Confined Area Techniques is carried out during the latter period of Line Training, and this builds on the subjects covered during ground training.

Since the accident, the operator has introduced a new requirement for all their pilots:

> *'to undertake site selection refresher training by auditing one randomly chosen, previously used landing site per week.'*

The results of the audits are recorded and all comments arising are reviewed by the Chief Pilot and discussed on a monthly basis by all the operator's pilots.

Other accidents

The helicopter was involved in a similar event in October 2005. G-EHMS had been attending an RTA in London and was touching down in an area which had been secured and was of adequate size for a HEMS operation. Part of a metal shutter from a nearby shop window became dislodged, due to the downdraft from the main rotor blades, and passed through the rotor disc damaging one main rotor blade. No one was injured.

Discussion

Both pilots assessed the garage forecourt, in which one of them had landed before, as being in excess of the minimum size required for a landing site when operating in their primary HEMS role. Subsequent measurement of the landing site showed that its external dimensions were greater than 2D but that the presence of a vehicle reduced the clearance around the helicopter; although it was still possible for G-EHMS to land in an area of the minimum required size. In the event, the helicopter landed with its main rotor disc less than 0.5D from the garage wall and it may have been closer than that during the hover manoeuvres. These manoeuvres were carried out to ensure that the access road to the petrol station remained clear. Had G-EHMS landed in the centre of the clear area and equidistant from all the obstacles, it would have been at least 0.5D from any obstruction. Also, landing without manoeuvring would have reduced the time in which the helicopter's downdraft had an effect on the surrounding structures. The inference in the operator's procedures is that, when landing in a site of limited size, the helicopter should maintain the maximum clearance from all the surrounding obstacles.

The evidence indicates that the sign which detached and struck the main rotors may have been loose before the arrival of G-EHMS, possibly loosened when the garage wall was struck by a lorry at an earlier date. It seems that the sign became detached from the garage wall as a result of the helicopter's downdraft, and then struck the main rotor blades.

The operator's pilots receive instruction on the assessment of landing sites during their initial training with the operator. By the very nature of the operation, the assessment of the dimensions of an unsurveyed landing site for a primary HEMS task is, of necessity, a visual exercise. Since the accident, the integrity of landing site assessments has been enhanced by the addition of weekly landing site audits in which the operator's pilots are required to select, at random, one previously used landing site and critically assess it.

The operator, like many others carrying out missions of a similar nature, successfully completes many landings and takeoffs during the course of a year. However, in these two cases, although the crew correctly assessed the size of the landing site as being greater than the minimum required dimensions, they could not assess the security of the surrounding structures and the effect the helicopter's downdraft would have on them. In this accident, members of the public who were observing the landing missed being struck by flying debris by a few metres.

The operator began operating in August 1990. Before being authorised to do so, the regulatory authority (the CAA) carried out a comprehensive risk assessment. In the light of these two events, it is recommended that new risk assessments are carried out to establish that the current policies and procedures address the potential risks of HEMS operations into improvised confined areas, while enabling the operators to achieve their tasks.

The following two Safety Recommendations are made:

Safety Recommendation 2007-057

It is recommended that the European Aviation Safety Agency perform a risk assessment of the policies and procedures in JAR-OPS 3 associated with Helicopter Emergency Medical Services (HEMS) operating into improvised confined areas.

Safety Recommendation 2007-058

It is recommended that the Civil Aviation Authority ensure that a risk assessment is performed of the current agreed operating standards associated with Helicopter Emergency Medical Services (HEMS) operating into improvised confined areas.

ACCIDENT

Aircraft Type and Registration:	Diamond DA 40 D, G-ZANY
No & Type of Engines:	1 Thielert TAE 125-01 diesel piston engine
Year of Manufacture:	2003
Date & Time (UTC):	30 December 2006 at 1215 hrs
Location:	Near Southwoodham Ferrers (approximately 8 miles NW of Southend)
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to front of aircraft, nose gear and left wing
Commander's Licence:	Private Pilot's Licence
Commander's Age:	61 years
Commander's Flying Experience:	14,455 hours (of which 232 were on type) Last 90 days - 12 hours Last 28 days - 2 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and subsequent enquiries by the AAIB

Synopsis

Whilst conducting steep turns, the engine lost power, forcing the pilot to make an emergency landing in a field. The aircraft landed long and the pilot was unable to prevent it colliding with a boundary hedge. Despite damage to the aircraft the occupants were uninjured. Evidence suggested that the engine had been starved of fuel, possibly by air entering the fuel system, but the cause of this could not be determined with any degree of certainty.

History of the flight

The accident occurred whilst performing a handling exercise on the return leg of a trip from Stapleford Aerodrome, Essex, where the aircraft was based, to Lydd Airport, in Kent.

The passenger, a current PPL holder with over 2,200 flying hours, was the handling pilot for the exercise which was conducted in the vicinity of Hanningfield Reservoir, to the north-west of Southend Airport. All indications were normal until the general handling exercise was performed. Fuel had been transferred from the right to the left tank five minutes previously. The left tank quantity indicated slightly less than half full and the right approximately one third full. The pilot first performed a clean stall and recovery, followed by a steep turn to the right.

He then made a steep turn to the left up to a load factor of approximately 2g, advancing the power lever from around 80% to 100% in one to two seconds. During this manoeuvre the engine momentarily shuddered. He performed a second steep turn to the left, and the engine shuddered once more and, again, momentarily, during subsequent operation of the engine power lever. The commander briefly observed propeller overspeed and engine power exceedance cautions and announced this to the pilot. The pilot lowered the nose of the aircraft to gain airspeed to perform a wingover-type manoeuvre, at which point both occupants became aware that the engine had suffered a significant loss of power.

The Engine Control Unit (ECU) switch was selected to 'ECU 'B[1] in an attempt to resolve the problem, but this proved ineffective. Shortly thereafter, 'ECU A' and 'ECU B' caution annunciations appeared, the engine power indication fell to 7% and the engine ceased to respond to power lever changes. Neither pilot reported seeing or hearing any low fuel annunciations prior to the loss of engine power.

An emergency was declared to Southend Airport and preparations were made for a forced landing in a field. The approach speed was high and the aircraft touched down well into the field; there was insufficient distance available to stop and the aircraft struck a hedge and a small ditch. This caused the nose gear to collapse rearward, damaging the propeller, lower front fuselage and left wing. The aircraft remained upright, there was no fire and the occupants, who were uninjured, exited the aircraft normally. The emergency services attended the scene promptly.

Footnote

[1] The ECU electronically controls the manifold pressure, fuel rail pressure (which determines the quantity of fuel injected) and propeller speed, according to the power lever position. It has two independent channels, designated 'ECU A' and 'ECU B'.

Aircraft information

General

The Diamond DA 40 D is a diesel engine powered, composite construction, four-seat low-wing monoplane aircraft. It is certificated in the JAR-23 'Normal' and 'Utility' airworthiness categories, with bank angles of up to 90 degrees being permitted.

Powerplant

The TAE 125-01 engine is a liquid-cooled, four-cylinder, four-stroke, turbocharged common-rail direct injection diesel engine, designed to run on Jet A-1 fuel. It is rated at 99 kW (135 DIN HP) at 2,300 rpm at sea level, ISA conditions. The engine drives the propeller via a 1:1.69 reduction gearbox; the maximum allowable continuous propeller speed is 2,300 rpm, corresponding to an engine speed of 3,900 rpm. The three-bladed, variable-pitch, wood-composite propeller is hydraulically regulated and the propeller governor system has its own independent oil supply. The engine and propeller are controlled electronically by a digital ECU.

The ECU has two independent channels, designated ECU A and ECU B. The engine is normally controlled and regulated by ECU A, with ECU B provided for redundancy. An ECU 'swap' switch allows the pilot to select between automatic and manual ECU control. The switch is normally set to AUTOMATIC, in which case ECU A assumes control. If a failure is detected, ECU B will automatically take control. If the automatic switch-over should fail, the pilot must manually select ECU B. The ECU has fault recording and data-logging capabilities, to aid in troubleshooting engine faults, and the data can be downloaded for post-flight analysis. The ECU does not monitor or record fuel quantity data.

Engine parameters are presented on two display panels in the cockpit: the Compact Engine Display (CED) and the Auxiliary Engine Display (AED). The CED displays engine parameters, including engine speed and engine load as a percentage (derived from the manifold pressure) and the AED displays fuel system and electrical system information.

Fuel system (Figure 1)

The fuel is contained within aluminium tanks located in each wing. The tanks are mounted between the front and rear wing spars and are relatively long in the spanwise direction, narrow in the chordwise direction and fairly shallow. G-ZANY was equipped with the optional long range tanks and thus has two tanks in each wing. The inner and outer tanks are interconnected by a large diameter hose. Each inboard tank has a capacity of 56.8 litres, of which 53 litres is useable and each outboard tank has a capacity of 20.8 litres. The total usable fuel available with long range tanks is 147.6 litres. The fuel quantities in the main and auxiliary tanks are sensed by capacitance probes and the quantities are indicated on circular LED bar-type gauges. The gauges indicate up to a maximum of 15 USG (57 litres); there is no indication for the fuel quantity in the outer tanks. If the useable fuel in the main tank drops below 3 USG (11.5 litres) +2/-1 USG (+7.6/-3.8 litres), an amber LOW FUEL message will illuminate on the central annunciator panel, accompanied by a momentary aural alert via the intercom. According to the Airplane Flight Manual, the indication is calibrated for straight and level flight and may be triggered in unbalanced turns with fuel levels greater than this threshold. When the main tank is empty, a red warning message will appear, accompanied by a continuous aural tone. The low level caution and warnings are driven by independent sensors.

The engine is supplied with fuel from the left wing inboard tank only, which is designated the main tank. The right inboard 'auxiliary' tank feeds the main tank

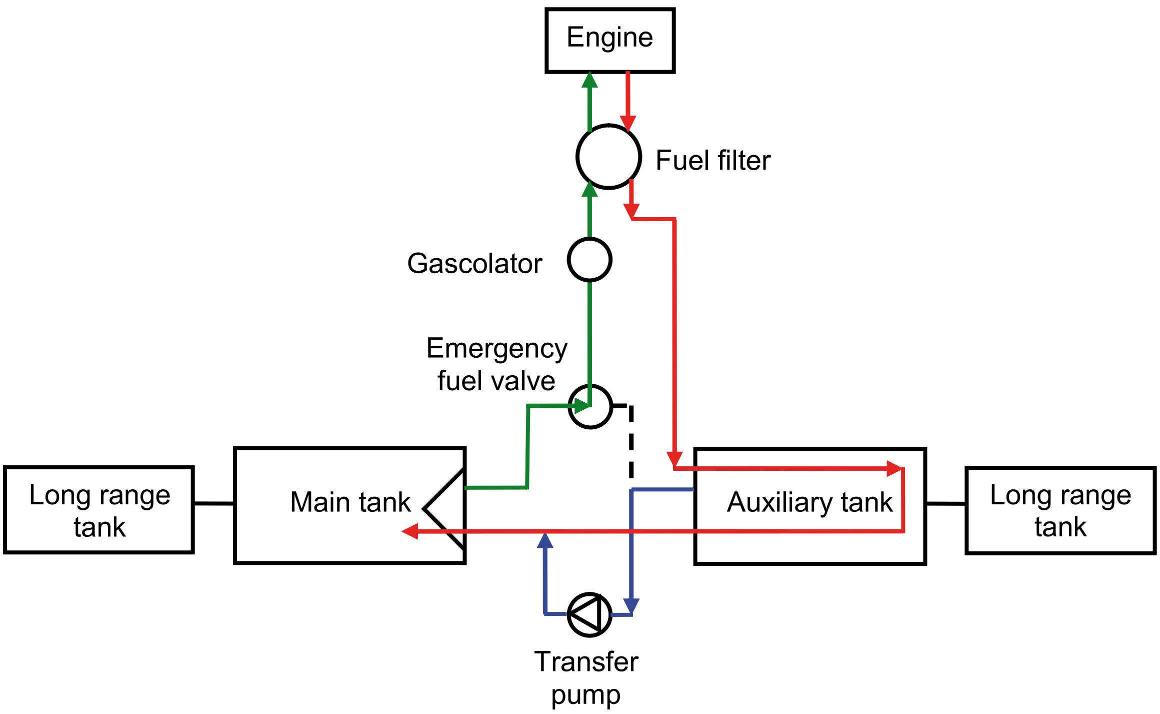


Figure 1

Fuel System Schematic

and the pilot must periodically transfer fuel from the auxiliary tank to the main tank as the engine consumes fuel. The fuel is transferred via an electrically driven transfer pump, operated by a switch in the cockpit. Any unused fuel from the engine fuel rail is returned to the main tank and, as the fuel may be hot, it is cooled by routing it through the auxiliary tank.

The fuel system is not equipped with a boost pump, but the engine is fitted with two engine-driven pumps which draw fuel from the left wing tank. A low pressure pump feeds a high pressure pump, which provides the high pressure fuel to the common rail for the injectors; these inject fuel directly into the cylinders. The fuel pressure in the common rail typically ranges from 600 bar at idle, to 1,350 bar at maximum power. The ECU controls the rail pressure via an electronic valve. This varies the return fuel flow rate in accordance with the power lever position, by comparing the measured or actual common rail fuel pressure with the computed target value, based on the power lever setting. If the difference between the two exceeds a specific threshold, an ECU caution annunciation is triggered.

Prior to reaching the engine, the fuel passes through a gascolator and a filter module. The gascolator is located at the lowest point in the fuel system, under the fuselage, approximately 30 cm forward of the wing leading edge. The filter module is mounted high up in the engine compartment with the fuel inlet and outlet connections being made to the lid of the filter canister.

Each inboard tank incorporates a fuel trap, which comprises an open-topped, sheet aluminium container welded to the tank inboard rib. This is designed to ensure that the engine is always provided with a supply of fuel during transient manoeuvres.

Fault annunciation

The aircraft features a centralised fault annunciation system which presents the pilot with visual and aural cues when certain system failures or conditions are detected. A warning is visually indicated by a flashing red WARNING legend and a flashing red legend for the affected system; both are displayed on a central annunciator panel and are accompanied by a continuous aural tone on the intercom. A caution is annunciated by a yellow CAUTION legend, accompanied by a flashing yellow legend for the affected system, together with a momentary aural tone.

Aircraft fuelling history

A review of the aircraft fuelling records showed that, on 28 December 2006, the aircraft was filled to full (ie, 155 litres, of which 147.6 litres were useable). The commander of the aircraft and an independent witness observed the refuelling and confirmed that the tanks were filled to the brim. The aircraft completed four flights that day, with a total block time of 3.5 hours; it did not then fly again until the day of the accident when it flew the outbound leg to Lydd, with a recorded block time of 45 minutes. The duration of the subsequent accident flight was approximately one hour.

The total recorded block time since previous refuelling to full was therefore 5.25 hours. If an average fuel consumption of 19 litres per hour is assumed, for a cruise power setting of 75% engine load (as quoted in the DA 40 D Airplane Flight Manual), the aircraft should have had an endurance of approximately 7.75 hours with a full useable fuel load of 147.6 litres. Based on available information, at the time of the accident the aircraft should have had fuel remaining on board for approximately 2.5 hours of flight, amounting to approximately 50 litres.

Aircraft examination

General

Several days elapsed before the aircraft could be recovered, after which it was placed in a hangar where it was examined by the AAIB.

Fuel system examination

It was reported by the engineer who drained the fuel tanks prior to recovery that the main (left) tank was found to be almost empty and the auxiliary (right) tank contained an estimated 20 litres of fuel.

The fuel pipes between the main tank and the engine were blown through and found to be free from blockage. The fuel tank vent lines and the fuel transfer pipe between the auxiliary tank and the main tank were also confirmed to be free from blockage. The integrity of the fuel tanks in each wing was checked by sealing the tank openings and lightly pressurising the tanks; no leaks were found.

Borescope inspection of the main tank showed that it was free of debris and that the fuel trap appeared to conform to the manufacturer's drawings. The finger filter in the main tank fuel outlet was removed and found to be clean. The gascolator was also clean, and no evidence of water contamination was found. The drain valve was badly distorted and jammed open, having been struck by the nose landing gear as it collapsed rearwards on impact. A test showed that fuel leaked from the valve at a rate of approximately two litres per hour. The fuel filter element was also clean, but it was noted that the filter canister contained only a small amount of fuel, Figure 2. According to the aircraft manufacturer, it would normally contain between 250 to 300 millilitres of fuel. The fuel transfer pump operated satisfactorily when tested.

Figure 2

Fuel filter canister showing small amount of fuel present, as found

Engine and ECU testing

The engine and ECU were tested at the engine manufacturer's facility in Germany. This was overseen by the AAIB and representatives from the German Federal Bureau of Aircraft Accident Investigation (Bundestelle fuer Flugunfalluntersuchung, BFU). The engine was tested in accordance with the company's production acceptance test procedure and, after purging the fuel lines of air by cranking the engine with the starter motor, it started and ran normally. It produced the nominal rated power of 135 HP and no faults were recorded by the ECU. The engine responded satisfactorily to changes in power demand, even with rapid movements of the power lever.

Additional tests were performed to explore what effect air in the fuel might have on the behaviour of the engine. This was achieved by loosening one of the clamps on the fuel supply hose to the engine and manipulating it until air was drawn into the hose. Whilst it was not possible in the test cell to reproduce exactly the conditions in flight, it was thought to provide a general indication of what might be expected. The engine was found to be very tolerant to air in the fuel supply. Small air bubbles entrained in the fuel passed through the engine with little or no effect. Larger bubbles were also tolerated, although the engine was heard to hesitate, before recovering. It was only when larger 'slugs' of air were introduced into the fuel hose that the engine ran down and stopped.

ECU downloaded data

A copy of the ECU data log for the accident flight was provided to the engine manufacturer for processing and review. The data shows that, until the point of power loss, the measured fuel rail pressure closely matched the target fuel rail pressure, signifying that the engine was responding normally to power lever demands. However, at the point of power loss, the measured fuel rail pressure diverged from the target pressure and fell rapidly to, and remained at, around 130 bar. According to the engine manufacturer, this was indicative of the engine being starved of fuel.

Manufacturer's flight tests

On 26 June 2007, at the AAIB's request, the aircraft manufacturer conducted a flight test to investigate the effect of steep turns with a similar fuel load to that estimated to have been on board G-ZANY at the time of the incident. The test was performed on a new production aircraft with a fuel load of 5 USG (19 litres) in the main tank and 5 USG (19 litres) in the auxiliary tank. Although this aircraft was equipped with standard, rather than the long range tanks, it was considered to be acceptable for comparative purposes.

A series of steep 360º turns to the right and left were performed both with and without slip. In balanced turns of up to 70º bank angle in either direction, the engine ran normally and no abnormal fuel indications were observed. It was possible to perform five consecutive, balanced, steep turns to the left with no adverse effect on the fuel system or engine operation.

When performing 360º steep turns to the left, with slip induced to the outside of the turn by applying rudder, the left fuel indication dropped to 3 USG after 1½ turns; the amber fuel caution illuminated and the aural warning sounded. A profile was flown which included one steep 360º turn to the right, followed by two steep turns to the left, to simulate, as far as possible, the flight conditions leading up to the incident. These were flown firstly with no slip, then with rudder-induced slip to the outside of the left turns. No unusual behaviour was noted with the engine when this was performed without slip.

However, when slip was applied in the left turns, after one 360º orbit the left fuel tank quantity indication fell to 3 USG and the amber low fuel caution annunciation illuminated. After two orbits, the left tank quantity indication dropped to zero and the red low fuel warning annunciation also illuminated. The test was halted after 2½ orbits to the left. The engine performed normally throughout this test, with no speed fluctuations or signs of shudder.

Subsequent incident

On 7 June 2007, a Danish registered DA 40 D landed in a corn field, short of its intended destination at Copenhagen, when the engine failed to respond to throttle lever inputs, and produced only low power. The aircraft was not damaged. After the incident there was found to be 45 litres of fuel in the main tank and 52 litres in the auxilary tank.

Analysis of the ECU data by the engine manufacturer revealed that, about the time of the power loss, the fuel rail pressure had dropped to a minimum of 130 bar. Examination of the aircraft revealed no evidence of mechanical or electrical failures and, after removing and replacing the fuel filter bowl and bleeding the fuel system, the engine started and ran normally. It was concluded by the engine manufacturer that the total loss of power was caused by fuel starvation at the engine fuel pump, and that air may have been introduced into the system.

Analysis

The downloaded data from the ECU show that the engine was performing as expected up to the time that the actual fuel rail pressure dropped to 130 bar; this is consistent with the pilots' reports that the engine performed normally until the general handling manoeuvres were flown. The tests on the engine and ECU did not identify any faults and it is therefore reasonable to assume that the engine and ECU were not the cause of the loss of power.

If the fuelling record information and aircraft utilisation information are accurate, the aircraft should have had sufficient fuel on board for the flight. However, as most of the fuel in the main tank had leaked out via the damaged gascolator drain valve, it was not possible to determine the actual fuel quantity in the main tank at the time of the accident. It is therefore significant that the fuel filter canister was found to contain very little fuel. Given that the aircraft remained upright and that the fuel inlet and outlet are on the top of the filter module, it is unlikely that the fuel had leaked out after the accident. The small volume of fuel found in the module seems to indicate that the engine suffered fuel starvation. This possibility is supported by the ECU data, which shows a large and rapid drop in fuel pressure to 130 bar, well below the normal 600 bar rail pressure when the engine is at idle. This low pressure would be expected if air had been ingested into the fuel system. Detailed examination of the fuel system did not identify any blockages or obvious defects in any of the fuel delivery system components; these were therefore considered unlikely to have caused the loss of engine power.

The possibility that fuel starvation could have occurred due to fuel flowing away from the pickup in the main tank (if the steep turns were inadvertently performed with slip) must be considered. The results of the manufacturer's flight tests showed that unbalanced steep turns can if extreme cause the fuel to move away from the fuel pickup. This was, however, always accompanied by a change in the fuel quantity indication in the main tank and low fuel quantity caution and warning annunciations. Given that the low fuel level cautions and warnings are independently triggered, had the engine suffered fuel starvation due to lack of fuel in the tanks, it would be expected that the pilots would have observed or heard a low fuel annunciation. However, neither pilot could recall any such warnings.

Conclusions

The evidence of the lack of fuel in the fuel filter canister, and the sudden drop in the actual fuel rail pressure observed in the ECU downloaded data, strongly suggests that the engine had been starved of fuel. However, despite extensive investigation, insufficient evidence was available to allow the cause of the fuel starvation to be determined with any degree of certainty, although the possibility that air entered the fuel system could not be dismissed.

ACCIDENT

Aircraft Type and Registration:	Europa, G-BWIJ
No & Type of Engines:	1 Mid-West rotary engine
Year of Manufacture:	1996
Date & Time (UTC):	23 May 2007 at 1145 hrs
Location:	Near Kemble Airfield, Gloucestershire
Type of Flight:	Private
Persons on Board:	Crew -1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Main wheel pushed upwards into the wheel well, minor scrape to the left outrigger and lower fuselage and slight damage to the propeller blade tips
Commander's Licence:	Private Pilot's Licence
Commander's Age:	67 years
Commander's Flying Experience:	1,794 hours (of which 369 were on type) Last 90 days - 19 hours Last 28 days - 18 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and engineering examination by a PFA Inspector

Synopsis

The aircraft, whilst undergoing a test flight, suffered a seizure in the landing gear extension/retraction system which resulted in the landing gear becoming stuck in the almost fully retracted position. A landing was carried out which resulted in some damage to the aircraft. Examination revealed that the main landing gear pivot bearings had seized onto the shaft of the main gear mounting frame.

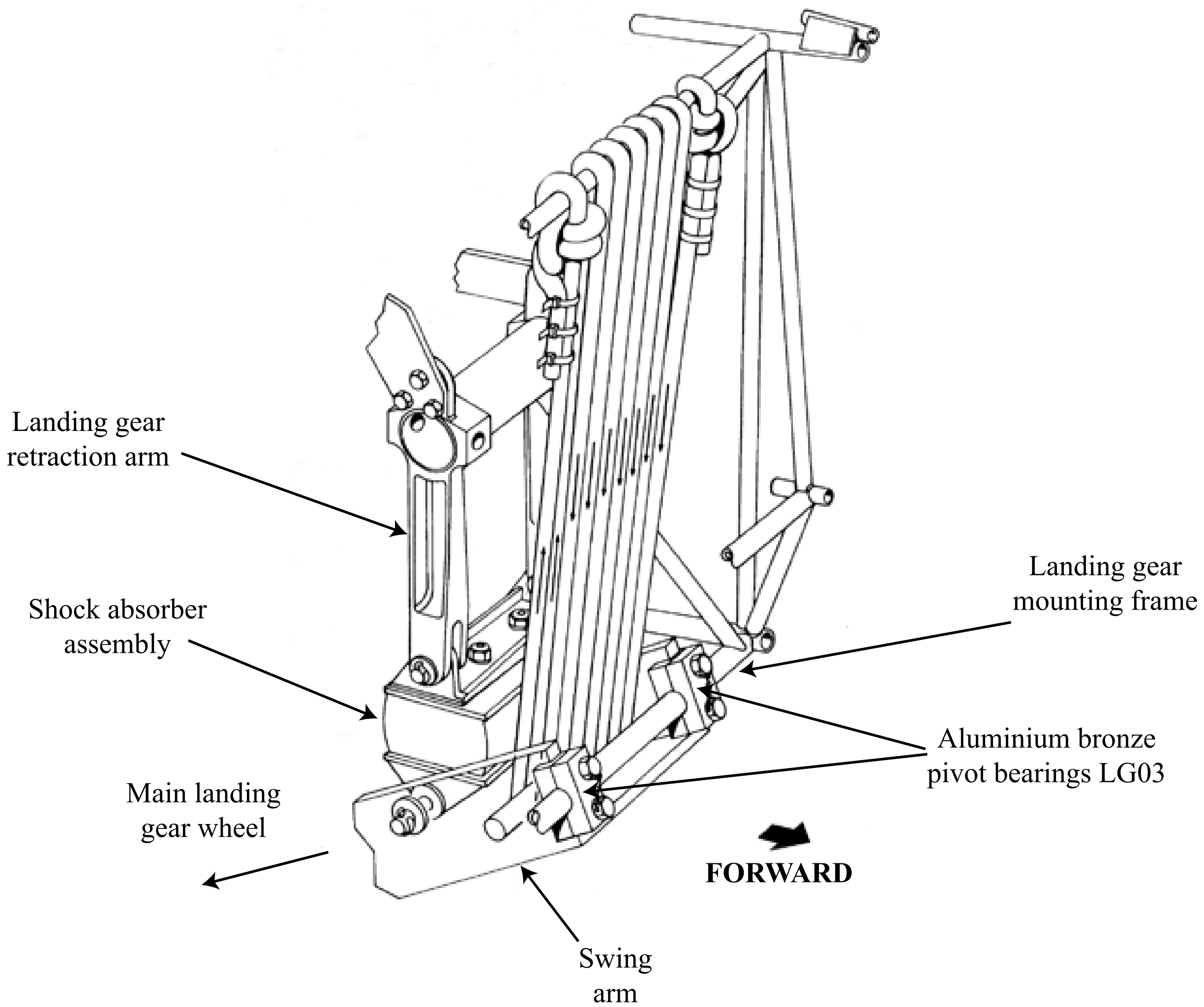
History of the flight

Following its construction by the owner, the aircraft was undergoing a series of test flights that were flown by a PFA Inspector with a view to recommending the issue of its first Permit to Fly. The accident flight was the fourth in this series of test flights.

After conducting a pre-flight inspection the pilot started the engine, taxied the aircraft to the runway and took off. Shortly after takeoff the pilot attempted to retract the landing gear but found that the landing gear lever became 'solid' as it was moved towards the retracted position. The pilot discontinued the test flight and returned to the airfield. When the aircraft entered the downwind leg of the circuit the pilot found that he could not move the landing gear lever to the extend position; it appeared to be seized. He flew the aircraft past the ATC tower and the controller reported that the landing gear was in what appeared to be its normal retracted position. Whilst keeping ATC informed, the pilot flew to the north and attempted to free the landing gear by conducting negative and positive 'g' manoeuvres, coupled with adverse yaw, but to no avail. After a number of attempts to lower the landing gear the pilot elected to carry out a flapless gear-retracted landing, using the up-slope high-friction section of the runway to his advantage. After stopping the engine the approach and touchdown were as planned and the aircraft quickly came to a halt. There was smoke in the cockpit from the almost retracted landing gear tyre rubbing within the wheel well. The pilot evacuated the aircraft without difficulty. The airfield fire service arrived quickly at the scene but there was no fire.

Engineering examination

The pilot, who was also a PFA Inspector, carried out a detailed examination of the landing gear system and found that the aluminium bronze pivot bearings, part number LG03 (Figure 1), that allow the main landing gear swinging arm to rotate around the landing gear mounting frame, had seized onto the steel shaft of



Adapted from manufacturer's drawing

Figure 1

Main landing gear pivot

the mounting frame. There was very good evidence of aluminium bronze pick-up on the steel shaft of the mounting frame and there was also evidence of corrosion on the steel shaft.

Inspection requirements

Following final assembly there is no requirement to dismantle the aluminium bronze pivot bearings to inspect their condition. There is an annual requirement to place the aircraft on trestles and retract and extend the landing gear. Providing that this function check is completed satisfactorily there is no requirement to examine, in detail, any part of the landing gear extension/retraction system.

Other information

The aircraft was complete towards the end of 2006 following a build lasting several years. Following the third test flight it was found that the engine coolant was well above the normal operating temperature. The aircraft was dismantled and transported uncovered by road, on an open trailer, to a facility where larger capacity radiators were fitted. During the road journey a very heavy rain storm was encountered. The aircraft was then stored for approximately two months in an unheated covered facility whilst awaiting the fitting of the larger radiators. It is possible that this could have contributed to the corrosion in the landing gear system.

ACCIDENT

Aircraft Type and Registration:	Grob G115E Tutor, G-BYWE
No & Type of Engines:	1 Lycoming AEIO-360-B1F piston engine
Year of Manufacture:	2000
Date & Time (UTC):	24 May 2007 at 1543 hrs
Location:	Colerne Airfield, Wiltshire
Type of Flight:	Training
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Nose leg collapsed, propeller damaged and engine shock-loaded
Commander's Licence:	RAF pilot's qualification
Commander's Age:	62 years
Commander's Flying Experience:	4,760 hours (of which 923 were on type) Last 90 days - 65 hours Last 28 days - 35 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

Following a landing at Colerne, the nose leg collapsed. The nose leg sliding tube had been incorrectly reassembled during maintenance. Procedures in place at the maintenance organisation to prevent this had not been carried out.

History of the flight

Following an uneventful training flight, the aircraft had just landed at Colerne, Wiltshire. As the nose was lowered to the ground a slight judder was felt through the airframe, along with a 'clunk' noise. The intention was to carry out a 'touch-and-go' but due to the juddering, this was aborted and the aircraft was slowed down. The handling pilot was then given clearance to backtrack along the runway. As he applied right rudder to turn the aircraft, the nose leg collapsed. The propeller then struck the runway, causing the engine to stop. The crew shut the aircraft down and exited normally.

Nose landing gear description

The nose leg of the Grob 115 consists of a steel housing secured to the airframe, into which fits a tubular shaft. A diagram of the nose leg is shown in Figure 1. Fitted within the tubular shaft is a gas spring strut shock-absorber. The upper end of the strut is attached to the tubular shaft; the lower end is screwed into the bottom fitting. A sliding tube surrounds the spring strut and the bottom fitting, and is secured at its

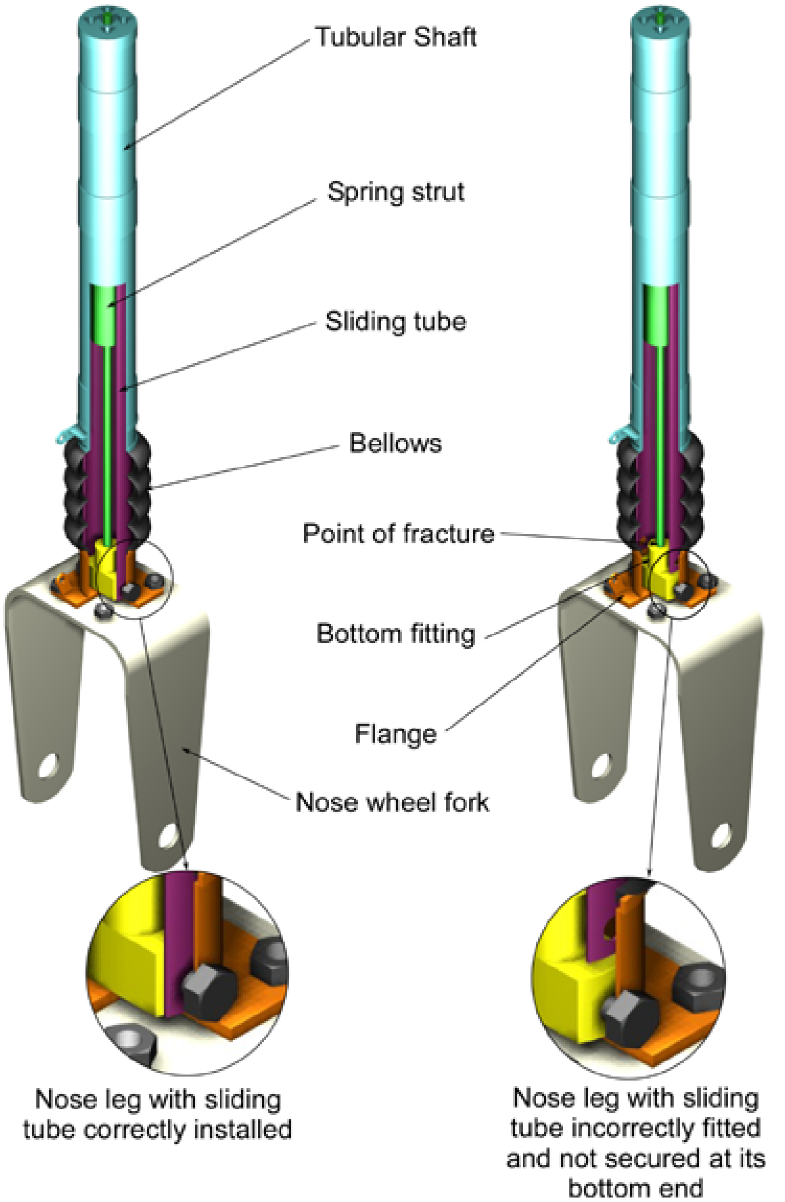


Figure 1

Simplified drawing of the nose leg, with the steel housing, wheel and torque links removed for clarity

bottom end by the same bolt that secures the bottom fitting to the flange.

Examination of the aircraft

An examination of the aircraft by the maintenance organisation found that the gas spring strut had failed at its lower end where it screws into the bottom fitting. The sliding tube was found to have been incorrectly assembled - it had not been secured to the flange, with the attaching bolt only passing though the flange and bottom fitting (see Figure 2). This failure to secure the sliding tube had allowed it to float freely. It had migrated upwards out of the lower flange and induced high bending loads on the lower end of the gas spring strut. Eventually this had led to its fracture, and the ultimate collapse of the nose leg.

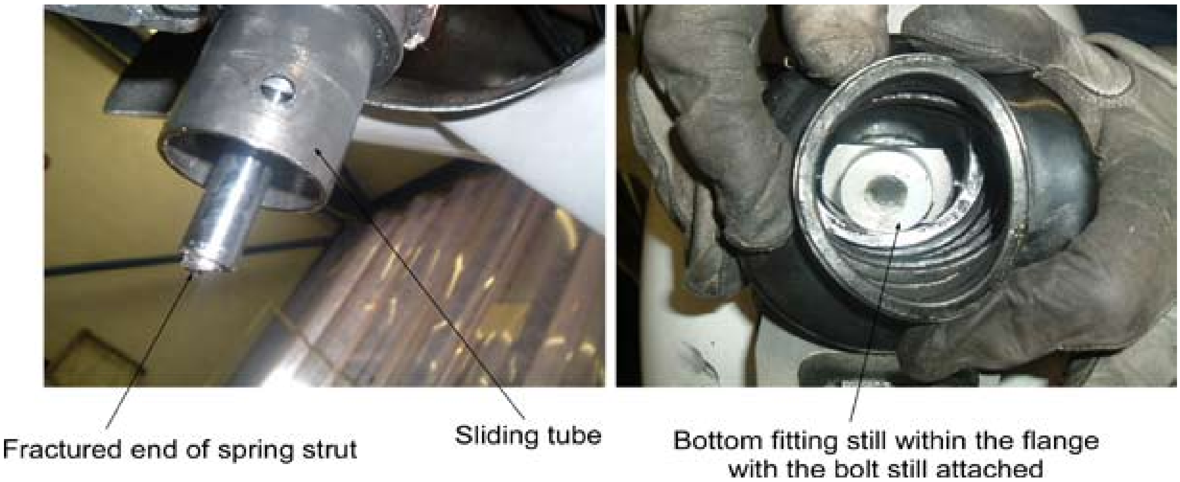


Figure 2

Fracture of the spring strut

Maintenance History

The last maintenance carried out on the aircraft was a 50 hr inspection on 12 May 2007. During this inspection the nosewheel bellows were replaced. Replacement of the bellows required the dismantling of the nose leg assembly, in particular the removal of the sliding tube from the lower flange. The maintenance documentation associated with the replacement of the bellows did not show the completion of a duplicate inspection.

Previous occurrences

The AAIB has investigated two previous occurrences of similar nose leg failures on the Grob 115. The first was in February 2003, (G-BVHG EW/G2003/02/07, Bulletin 9/2003). Following this accident the maintenance organisation added additional steps and warnings about the correct installation, in their procedures. The second accident occurred in November 2006 (G-BYVZ, EW/G2005/11/02, Bulletin 2/2006). After this, the maintenance organisation reclassified the nose leg as a critical task, and introduced a duplicate inspection requirement, to ensure that the flange and sliding tube are correctly assembled.

Discussion

The nose leg had failed due to incorrect reassembly of the nose leg sliding tube, following maintenance on the nose leg bellows. Due to similar failures in the past, procedures at the maintenance organisation, in particular the duplicate inspection of any work on the nose leg, had been put in place to prevent recurrence. However, in this instance, the required duplicate inspection had not been carried out on the leg assembly or sliding tube, following the replacement of the bellows. Once the nose leg was fully assembled and the bellows in place, it was not possible to see if the sliding tube had been correctly secured.

The maintenance organisation has promulgated the cause of this and the other accidents, and has restated the level of awareness required and the procedures to be followed when working on the nose leg. The aircraft manufacturer has been made aware of the issue and has been requested, by the maintenance organisation, to consider alternative nose leg bellows that do not require the dismantling of the leg.

ACCIDENT

Aircraft Type and Registration:	Kolb Twinstar Mk 3 Extra, G-CDFA
No & Type of Engines:	1 Jabiru 2200A piston engine
Year of Manufacture:	2004
Date & Time (UTC):	6 April 2007 at 1500 hrs
Location:	Trough of Bowland, near Clitheroe, Lancashire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Propeller missing
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	66 years
Commander's Flying Experience:	105 hours Last 90 days - 13 hours Last 28 days - 4 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and metallurgical examination by the AAIB

Synopsis

The aircraft was in the cruise when the propeller detached. The pilot made a successful forced landing without further damage. Examination showed that the bolts securing the crankshaft extension fitting to the crankshaft had fractured in long-term high-cycle fatigue.

History of the flight

The aircraft was on a flight from Rufforth to Rossall Field, Cockerham. Whilst flying straight and level on-track at 2,500 ft, the occupants noticed a rattling sound, but without any vibration. About two minutes later there was a new "mechanical" noise, followed a few seconds later by the abrupt stoppage of the engine. The pilot was convinced that the engine had seized, so he did not attempt a restart and instead concentrated on finding a field for a forced landing. This was successful and there was no further damage to the aircraft. On vacating the aircraft, the pilot and passenger were surprised to find that the two-bladed wooden propeller was missing, having departed without causing airframe damage.

The aircraft was collected from the field by fellow flying club members using a trailer and the propeller was found 11 days later by a local farmer and despatched to the AAIB for further examination.

Examination

Figure 1

Detached crankshaft extension showing fatigue fractures of five bolts with sixth missing. (Note surface corrosion)

On the Kolb Twinstar, the engine and propeller act in a 'pusher' configuration. The propeller is mounted on an extension fitting which in turn is bolted to the end of the crankshaft, using six bolts. The propeller does not require removal of the extension fitting when it is installed. The propeller had detached due to failure of the bolts holding the extension fitting to the crankshaft – one was missing completely (see Figure 1). Metallurgical examination showed that the five remaining bolts had fractured in long-term high-cycle bending fatigue. This was caused by progressive slackening of the bolts due to fretting of the holes in the fitting. The six bolts are normally wire locked in pairs and it was noted that the wire locking of two of the pairs had broken due to high-cycle fatigue. Also noted was that the bolts, which are threaded along their entire length, had cut ' threads' into the holes in the fitting. This was considered to have exacerbated the fretting, as may the presence of a relatively high level of surface corrosion on the crankshaft fitting.

The owner of G-CDFA had purchased the aircraft from its original owner in March 2007 and had flown some six hours since then. The original owner, who is also the UK importer of the kits, states that he had flown the aircraft for about 150 hours from new and the engine/propeller combination had performed faultlessly. The bolts securing the extension fitting to the crankshaft were as supplied and specified by the manufacturer and he was not aware of any similar incidents.

The AAIB consulted the Popular Flying Association (PFA) concerning the suitability of the bolts and they agreed that it is not good engineering practice to use bolts which are threaded along their entire length in an application such as this. However, the PFA pointed out that this unusual event may be linked to the use of the Jabiru engine in the Kolb Twinstar, as this is the only application employing a pusher installation. A propeller operating in the disturbed air behind a wing is subjected to varying airflow across the propeller disc at every revolution (compared with a tractor layout) with consequent higher stresses on the propeller and its attachments. Consequently, although the PFA advise that they will be requiring replacement of the bolts with items featuring a plain shank, this will initially be limited to Jabiru engines on the Kolb Twinstar unless service experience suggests that other applications experience similar problems. They will also investigate the corrosion protection on the extension fitting.

ACCIDENT

Aircraft Type and Registration:	Piper PA-28-161 Warrior, G-ELZN
No & Type of Engines:	1 Lycoming O-320-D3G piston engine
Year of Manufacture:	1984
Date & Time (UTC):	13 June 2007 at 2015 hrs
Location:	Near Fosdyke, Lincolnshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 3
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to propeller, right wing, right main landing gear and nose landing gear
Commander's Licence:	Private Pilot's Licence
Commander's Age:	32 years
Commander's Flying Experience:	80 hours (of which 8 were on type) Last 90 days - 14 hours Last 28 days - 3 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft flew into bad weather, and the pilot decided to land in a field. During the landing the aircraft hit a ditch and was extensively damaged.

History of the flight

The weather forecast for the day was good, with a risk of showers and thunderstorms during the afternoon. In the morning, the pilot flew from Peterborough (Sibson) to East Kirkby Airfield, Lincolnshire, with three passengers. At the planned time for departure for the return flight to Peterborough a thunderstorm was passing through the area of East Kirkby and the takeoff was delayed. The pilot telephoned the meteorological office of the nearby RAF station at Coningsby, who advised him that there was only a 50% chance of the weather improving sufficiently for the pilot to be able to fly back to Peterborough that evening. At around 1900 hrs, as the pilot was making preparations to remain at East Kirkby, the weather improved. The pilot telephoned Sibson Airfield, who confirmed that they considered the Peterborough weather was suitable for his return.

The aircraft was airborne at 1945 hrs and the pilot flew a circuit at 500 ft to check the weather. He assessed the conditions as suitable and set a course for Peterborough. On passing Boston, almost half-way along the planned track, the weather conditions started to deteriorate, with low cloud, heavy rain and poor visibility. In order to remain in VMC the pilot descended. He then attempted to turn back towards East Kirkby, but was having difficulties in maintaining VMC and became alarmed by several flashes of lightning.

The pilot made a radio call to the Distress and Diversion cell, using the distress frequency of 121.5 MHz, and requested vectors to Peterborough (Sibson). The heading for Peterborough took the pilot into worse weather, with lower cloud, and more lightning. The aircraft was now at 300 ft in poor visibility with heavy rain and lightening all around, so the pilot decided to make a forced landing. He declared a 'MAYDAY' and turned towards a field which appeared suitable.

The pilot landed in a field near Fosdyke. During the landing roll the aircraft hit a ditch and came to a standstill. The pilot and his passengers were uninjured and vacated the aircraft normally.

Comment

The pilot reported that "the lightning, heavy rain and low cloud gave me no choice but to land immediately". However, an early decision to turn back in the deteriorating weather may have prevented the accident.

ACCIDENT

Aircraft Type and Registration:	Piper PA-32-301 Saratoga, G-BIWL
No & Type of Engines:	1 Lycoming IO-540-K1G5 piston engine
Year of Manufacture:	1981
Date & Time (UTC):	24 March 2007 at 1158 hrs
Location:	Scilly Isles (St Mary's) Airport
Type of Flight:	Private
Persons on Board:	Crew - 2 Passengers - 2
Injuries:	Crew - None Passengers - 1 (Serious)
Nature of Damage:	Damaged beyond economic repair
Commander's Licence:	Private Pilot's Licence
Commander's Age:	64 years
Commander's Flying Experience:	150 hours (of which 21 were on type) Last 90 days - 4 hours Last 28 days - 3 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and further enquires by the AAIB

Synopsis

After landing long on Runway 09 at Scilly Isles Airport, G-BIWL bounced slightly. Due to insufficient runway remaining, a go-around was initiated. The aircraft subsequently failed to get airborne, veered left, departed the runway surface and hit a stone wall.

History of the flight

G-BIWL departed Exeter Airport for Scilly Isles Airport with two pilots and two passengers on board at approximately 1100 hrs. After an uneventful VFR cruise the pilot was cleared by ATC to descend to circuit height and join on right base for Runway 09. The weather at Scilly Isles Airport was CAVOK with a surface wind of 040º/9 kt.

The commander stated that he flew a normal final approach at approximately 80 kt with 40 degrees of flap selected. After crossing the perimeter fence he closed the throttle and crossed the threshold at approximately 70 kt. He estimated that the aircraft touched down 80 m from the threshold and then bounced slightly before drifting to the left edge of the runway. As the aircraft approached the asphalt section of the runway (see Figure 1), the commander elected to commence a go-around due to insufficient runway length remaining within which to stop. The co-pilot transmitted this to ATC. The commander selected full power and the engine sounded normal but the aircraft only briefly became airborne again before the left wing dropped. The aircraft veered to the left on landing before leaving the paved surface of the runway. It continued down a small grass slope, sliding to its right, before impacting a stone wall and stopping.

The co-pilot vacated the aircraft through his door on the right side. The passengers vacated the aircraft without assistance. At the same time the commander isolated the aircraft's electrics and fuel and vacated the aircraft. The ARFS, local police and ambulance were quickly on the scene and offered their assistance.

The passenger seated in the right rear seat suffered a broken left shoulder and a dislocated right shoulder in the impact when the left seat passenger's body crushed him against the cabin wall. Both passengers were wearing lap harnesses only.

Eyewitness information

Air traffic controller's comments

The ATCO in the control tower at the time of the accident witnessed the accident. He stated that having cleared G-BIWL to land he observed it high on the final approach, prior to a rapid descent. It landed firmly abeam the second set of runway side lights from the threshold of Runway 09. He saw the aircraft drift to the left edge of the runway but maintain runway heading. It then became airborne briefly in a nose-up attitude, with the tail almost touching the runway, before settling back onto the grass. As G-BIWL reached the intersection of Runways 15/33 it became airborne again, remaining "very low" in a pronounced nose-up attitude. The left wing dropped and the aircraft "started turning" rapidly

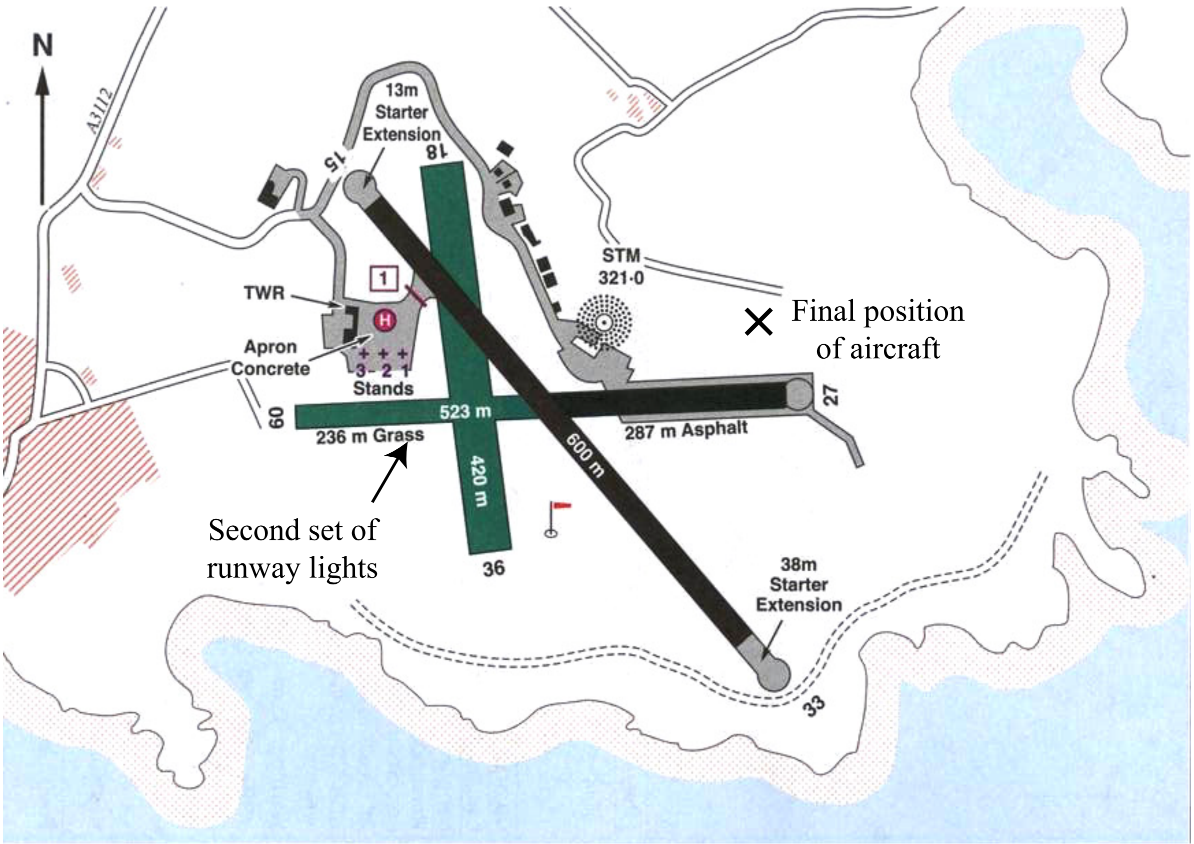


Chart courtesy of R Pooley

Figure 1

Scilly Isles Airport

to the left. The controller was then occupied with initiating the ATC emergency procedures and did not see G-BIWL impact the stone wall.

Passengers' comments

The rear cabin of the Saratoga has two pairs of seats facing each other. There were two passengers in the forward facing seats of the rear cabin, one of whom held a Private Pilot's Licence (PPL) and had landed there on several occasions. They reported that they did not notice anything untoward until the landing. Both recalled that the aircraft seemed to land long and firmly. They were aware of full power being applied and the aircraft briefly becoming airborne again in a nose-high attitude before the left wing dropped. The aircraft then veered left, landed in the field adjacent to the runway and skidded sideways into the wall.

The passenger who held the PPL reported that the co-pilot was advising the commander on the final approach, telling him at one point that it looked as if they were going to land long and that he needed to reduce power. He did not hear any verbal hand over of control during the go-around.

The passenger in the right rear seat thought that the co-pilot took control during the go-around.

Other eyewitnesses

Five eyewitnesses who were near the airport terminal, approximately 80 m north of the threshold of Runway 09, observed the initial part of the accident.

They described the approach as high and fast and the landing as hard. One described the touchdown point as half-way along the grass section of Runway 09. They saw G-BIWL get airborne again in a nose-high attitude, touchdown again and then become airborne for a second time, again in a nose-high attitude. The eyewitnesses saw the left wing drop just before the aircraft veered left but then lost sight of it as it descended towards a field adjacent to the runway.

Pilots' comments

G-BIWL was jointly owned by the commander, co-pilot and the passenger who was seated in the left rear seat.

Commander's comments

The commander reported that he had not landed at Scilly Isles Airport before and that he did not calculate a Landing Distance Required (LDR) prior to take off. He stated that "both the commander and co-pilot were aware that the shorter runway on the Scilly Isles was within the LDR of the aircraft. The co-pilot had landed there in a similar light aircraft on a previous occasion without incident." Before boarding the aircraft at Exeter, the commander discussed the Scilly Isles Airport runway profile and possible windshear/turbulence with the passenger who held a PPL.

When asked whether the co-pilot took control during the go-around the commander refused to comment, stating only: "I was Pilot in Command and was responsible for the aircraft."

Co-pilot's comments

The co-pilot had 586 hrs total flying of which 122 were on type. He reported that the final approach was flown with 40 degrees of flap and appeared normal. He added that the aircraft landed at approximately 75 kt, half way along the grass section of Runway 09. The aircraft then bounced slightly and drifted to the left edge of the runway but maintained runway heading. As the aircraft reached the top of the rise on the runway, the commander commenced a go-around and he transmitted this to ATC. Although the commander selected full power, the aircraft did not climb and the aircraft's left wing dropped before it landed back on the left edge of the runway. It then veered left and slid to the right and down a slope before hitting a stone wall. The co-pilot added that the engine sounded as if it was functioning correctly throughout the attempted go-around but at no time did he take control.

The co-pilot reported that "although I have flown similar aircraft onto similar runways in the Scillies, I had not flown this particular aircraft (G-BIWL) into the Scillies before." He also added that "at no time did I take control of the aircraft as I am more than confident in the pilot's ability."

Airfield information (see Figure 1)

Runway 09 at Scilly Isles Airport has a LDA of 523 m. The first 236 m is grass and the remaining 287 m is asphalt. The first 100 m of Runway 09 rises at a 1:20 gradient (5%) and the last 100 m descends at a 1:23 gradient (4.3%). There are no Precision Approach Path Indicators. There is a 100 feet high cliff approximately 400 m beyond the end of the runway, and four runway edge lights on the grass section. The second set of runway lights is half way along the grass which equates to 118 m from the threshold. Runway 15/33 (which the co-pilot had previously used) has a LDA of 600 m.

The UK Aeronautical Information Package (AIP) contains the following warnings for Scilly Isles Airport:

> *'Warnings*
>
> *a. Pilots should exercise extreme caution when landing or taking-off at this aerodrome, which is markedly hump-backed. The gradients increase to as much as 1 in 13 at runway ends.*
>
> *b. Pilots are warned of the different braking characteristics of the grass/asphalt sections of Runway 09/27.'*

The airport's website advises the following:

> *'Pilots should exercise extreme caution when landing or taking-off as the aerodrome is severely hump-backed. The gradients increase to as much as 1 in 13 at runway ends. Pilots who have not visited previously are advised to request a low fly past to observe and assess the runway's profile and possible wind shear/turbulence.'*

Pilot's operating handbook

The landing performance graph in the Pilot's Operating Handbook (POH) for G-BIWL, indicated that the LDR on a level dry runway, with 40º flap, at 3,300 lb and with 5 kt headwind, is 432 m. CAA Safety Sense Leaflet 7, '*Aeroplane Performance*', states the following:

> *'**Landing**: It is recommended that the Public Transport factor should be applied for all flights. For landing, this factor is x 1.43 (so that you should be able to land in 70% of the distance available).*
>
> *Again when several factors are relevant, they must be **multiplied**. As with take-off, the total distance required may seem surprisingly high.*
>
> *You should always ensure that after applying all the relevant factors, including the safety factor, the Landing Distance Required (LDR) from a height of 50 feet does not exceed Landing Distance Available.*
>
> *Dry grass add another 15%.'*

Multiplying the LDR by the Public Transport Factor (as recommended) would make the LDR 617 m.

Discussion

The LDR of 432 m obtained from the landing performance graphs in the POH suggests that with a LDA of 523 m on Runway 09, this landing was, at best, going to be marginal. If this figure was then factored, as recommended in the CAA's Safety Sense Leaflet 7, the LDR exceeds the LDA and the landing should not have been attempted. Landing 118 m in from the threshold would have left the aircraft with insufficient runway remaining to stop using either calculation.

On initial touchdown it should have been apparent that a go-around was necessary but the runway's humpback would have made it difficult to assess the length of runway remaining. Had the crew considered landing performance in more detail before departure and read the advice in the AIP and on the airport's website, they would have been aware how marginal the LDA was and the extra care required due to the runway profile.

The hump-backed nature of the runway can also create a visual illusion that may have caused the commander to misjudge the approach. This may explain the observed high and possibly fast approach and consequent long landing.

The eyewitnesses' description of the accident suggest that once the decision to go-around was made, the aircraft was rotated to a high-nose attitude leading to a large increase in the drag component. The power of the engine was probably insufficient to overcome this and the airspeed decreased. The aircraft then appears to have stalled, as indicated by the left wing drop, before landing back on the runway and sliding across the field into the stone wall. It is probable that the aircraft was over rotated when the commander or the co-pilot became alarmed by the lack of runway remaining and also by the cliff beyond the end of the runway. If the co-pilot did take control, without formally announcing the fact, it is also possible that both pilot's pulling back on the control column may have caused the aircraft to over-rotate.

If there is a need to take control from another pilot, use of the phrase 'I have control', as pilots are taught during their initial training, will reduce the likelihood of simultaneous control inputs.

Although the possibility of an engine problem can not be discounted, given the fact that the occupants of the aircraft and the eyewitnesses said they heard nothing unusual, it is reasonable to assume that the engine was functioning correctly at the time of the accident.

ACCIDENT

Aircraft Type and Registration:	Piper PA-38-112 Tomahawk, G-OLFC
No & Type of Engines:	1 Lycoming O-235-L2C piston engine
Year of Manufacture:	1979
Date & Time (UTC):	24 June 2007 at 1715 hrs
Location:	Ashcroft, a private airstrip approximately 5 miles east of Oulton Park, Cheshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Engine shock-loaded and displaced from its mountings. Moderate damage to rear fuselage
Commander's Licence:	Private Pilot's Licence
Commander's Age:	62 years
Commander's Flying Experience:	368 hours (of which 50 were on type) Last 90 days - 8 hours Last 28 days - 4 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and additional AAIB enquiries

Synopsis

During takeoff from a grass strip the tail of the aircraft struck a fence resulting in the aircraft landing heavily in a field and coming to rest inverted.

History of the flight

The pilot had flown into Ashcroft on the morning of the accident flight. He subsequently walked 50 m of Runway 27 and assessed the surface as dry and suitable for departure. At approximately 1700 hrs the pilot started G-OLFC, taxied to the undershoot of Runway 27 and carried out the power checks. He estimated the surface wind to be 300°/5-10 kt. Acceleration during the takeoff roll seemed normal with one stage of flap selected. In accordance with the Pilot's Operating Handbook soft field takeoff technique, the pilot rotated at minimum speed and then held the aircraft in ground effect to achieve a climb speed of 61 kt. Approaching the four foot high fence at the end of the runway, the pilot rotated further to the climb attitude. The rear fuselage underside struck the fence, pitching G-OLFC nose-down. This caused the nosewheel to strike the ground and collapse. The aircraft subsequently pitched down and came to rest inverted facing back towards the airfield. The pilot, who was wearing a full harness, switched off the fuel and battery master switch before being dragged from the wreckage by the airfield owner.

Eyewitness Report

An eyewitness observed the takeoff roll. He reported that the wind was light and variable and that during the takeoff run the acceleration appeared slow. He also reported that the aircraft adopted a high nose-up attitude shortly before the accident.

Performance

The pilot had carried out a calculation of the aircraft's takeoff performance incorporating both a factor for grass and the CAA recommended safety factor of 1.33. The pilot calculated that with a 10 kt headwind and at maximum takeoff weight, a distance of 537 m was required to clear a 50 ft obstacle. He estimated that his actual takeoff weight was 91 lbs less than the maximum allowed. CAA Change Sheet number 4 issue 1 to the Piper PA-38-112 Pilot's Operating Handbook '*Performance Writedown*', states that:

> *'Take-off field lengths – Add 5%'.*

This was not included in the pilot's calculation.

Runway

Runway 27 is declared in various flight guides as 550 m long. This length is based on information provided to the current owner by previous owners. The current owner has informed the AAIB of his intention to re-measure the runway to ensure the accuracy of the distance declared.

Pilot's Assessment

The pilot considered that several factors may have caused the accident. He suggests that the performance of G-OLFC was below that calculated. This may have been due to a lower headwind factor or possibly a dragging brake. He also suggested that the strip may be shorter than allowed for in his calculations. However, the pilot considered it likely that he was concentrating on the approaching fence and misjudged the pull up from level acceleration to climb away.

ACCIDENT

Aircraft Type and Registration:	Pitts S-2A, G-PTTS
No & Type of Engines:	1 Lycoming AEIO-360-A1A piston engine
Year of Manufacture:	1978
Date & Time (UTC):	14 May 2007 at 1900 hrs
Location:	Leicester Airport, Leicestershire
Type of Flight:	Private
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Both wheel spats destroyed, both brake calipers and tail wheel detached, damage to rudder, right lower mainplane and aileron
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	62 years
Commander's Flying Experience:	13,357 hours (of which 104 were on type) Last 90 days - 7 hours Last 28 days - 5 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and additional AAIB enquiries

Synopsis

Shortly after taking off from Leicester Airport, all thrust was lost from the propeller. A forced landing was made on to the disused section of the runway, where the aircraft sustained some damage. After coming to a halt, the engine continued to run, but at idle speed. It was established that a failure had occurred in the propeller control unit, leading to a loss of controlling oil pressure to the propeller hub. This resulted in the propeller blades moving to the coarse pitch angle stops. The pilot was unaware of this characteristic of the propeller, as this had not been covered in his training. Also, no reference to this was in the aircraft's Flight Manual. One Safety Recommendation is made.

History of the flight

The Pilot in Command (PIC) occupied the rear seat for the flight, the purpose of which was to be part of type conversion training on the Pitts S-2A for the front seat pilot, who held an Instructor's Rating. After two uneventful circuits from Runway 28, the aircraft was climbing away from its third 'touch-and-go' when, at a height of 50 ft to 100 ft and without any warning, it suffered a complete loss of thrust. The PIC immediately took control and executed a forced landing on the disused extension of the runway. This had a rough surface, was littered with debris and contained a number of tree saplings. The aircraft nevertheless remained upright and came to rest with relatively little damage and with the engine running at idle speed.

Examination of the aircraft

Subsequent investigation revealed that there had been no disconnect in any of the engine or propeller controls. Since the propeller had escaped damage in the accident, it was decided to run the engine. Whilst it started readily, it would not run above approximately 1,400 rpm: it was then realised that the propeller blades would not move away from the fully coarse setting. The propeller control unit (PCU) was removed from the engine and subsequently bench-tested. The licensed engineer who conducted the test reported that there had been a failure of the internal relief valve spring, resulting in a loss of controlling oil pressure to the propeller hub.

Discussion

In most single piston engine aircraft fitted with constant speed propellers, the propeller is designed such that in the event of a failure of the oil supply, the blades will move to the fully fine position. However, in aerobatic aircraft such as the Pitts, manoeuvres involving the use of full power and reduced or negative g, carry a risk of a temporary interruption of the oil supply to the PCU, even with engine oil systems modified for inverted flight. Such an occurrence would result in an instant engine overspeed with an attendant possibility of severe damage. Accordingly, many aerobatic aircraft have propeller systems that are designed so that the propeller blades will move to the coarse pitch stop in the event of a loss of controlling oil pressure.

In the case of G-PTTS, the pilot had little time in which to conduct any diagnosis of what appeared to be an engine problem, and thus had no option but to land ahead. He was unaware of the behaviour of the propeller following a PCU failure, as this had not been covered in his training; furthermore, there was no information on this subject in the FAA approved aircraft Flight Manual, which contained UK CAA Supplements.

This type of aircraft has a typical landing speed of 90 kt to 100 kt, rendering it particularly vulnerable to severe damage in the event of a forced landing away from an airfield. In the event of a PCU failure occurring in the cruise, an experienced pilot, even if he were unaware of the propeller characteristics, would have a chance of diagnosing the problem. Engine speed would not respond to movement of the propeller speed lever but would change with throttle movement, assuming the airspeed was sufficiently high. There would thus be a reasonable chance of flying to an airfield, as opposed to a forced landing elsewhere. However, it is considered that some knowledge of the characteristics of the propeller control system type fitted to G-PTTS would be of benefit, particularly to less experienced pilots. The following Safety Recommendation is therefore made:

Safety Recommendation 2007-054

It is recommended that the Civil Aviation Authority consider that information on the specific propeller behaviour following a propeller control unit failure, or other malfunctions, which result in a loss of control of the propeller blade angle on piston engine aerobatic aircraft, should be made readily available to all pilots of such aircraft on the UK register.

ACCIDENT

Aircraft Type and Registration:	Rand KR-2, G-BOUN
No & Type of Engines:	1 Volkswagen 1834 piston engine
Year of Manufacture:	1990
Date & Time (UTC):	28 March 2007 at 1730 hrs
Location:	Horse Leys Farm, Burton on the Wolds, Leicestershire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Private Pilot's Licence
Commander's Age:	48 years
Commander's Flying Experience:	1,522 hours (of which 400 were on type) Last 90 days - 14 hours Last 28 days - 3 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and AAIB enquiries

Synopsis

One of the propeller blades detached from the hub following a touch-and-go landing. During the subsequent forced landing the aircraft struck a hedge and was severely damaged.

History of the flight

The pilot stated that on the climb out, after a touch-and-go landing and at height of 100 ft to 150 ft, the engine developed what he described as "major" vibration and then stopped. He made a forced landing in a field, as a result of which the aircraft struck a hedge and turned over on to its back.

The pilot believed that the accident was caused by the failure of a propeller blade as a result of a bird strike, spinner failure, or foreign object damage. However, the pilot does not recall seeing any birds just prior to the accident or any evidence of bird remains on the aircraft.

Following the accident the pilot said that he was told by the police that he could move the aircraft and do whatever he wished with the wreckage. Based on this advice, and before the Aircraft Accident Report Form was returned to the AAIB, the pilot burnt and disposed of the damaged propeller blade and other damaged parts of the aircraft. He also informed the AAIB that the broken spinner had been stolen. The pilot did not take any photographs of the damaged parts before he disposed of them.

Police video

A video of the accident site, taken from a police helicopter, was provided to the AAIB.

The crash site was next to a hedge which separated two large fields that appeared to have been recently harrowed. The aircraft, which was badly damaged, was upside down with the left wing detached. The engine and structure forward of the cockpit had broken away from the aircraft and a number of large pieces of wreckage had been thrown some considerable distance from the aircraft. There was also wreckage, including a wheel spat, embedded in the hedge; a number of the thick branches of the hedge had been recently snapped and some of the hedge had been pulled out of the ground. From the video there was no evidence of any wheel tracks from the aircraft in the soil on either side of the hedge; however wheel tracks, made by two vehicles parked close to the aircraft, could be clearly seen in the soil.

The video also focused on two large pieces of structure approximately two fields before the crash site: these pieces of structure, coloured white, did not resemble parts of the propeller spinner. As the tail section and wings could be clearly identified in the video taken at the crash site, it is concluded that the two pieces of structure must have come from the cockpit or nose area of the aircraft.

Witness observation

A witness at the airfield observed the touch-and-go landing and remarked that the aircraft touched down more firmly than normal, but did not appear to be a heavy landing. As the aircraft reached a height of 150 ft to 200 ft the witness saw a black and roughly rectangular object, about the side of his forearm, detach from the aircraft and fall into a field of oilseed rape. The engine then stopped and the aircraft started a gentle turn to the left and disappeared from view.

Another witness who arrived at the crash site shortly after the accident reported that the aircraft had struck the hedge and the fuel tank and engine had been thrown forward by approximately 20 m and 40 m respectively. One of the propeller blades had broken off close to the blade root and the second was still connected to the hub. The rear face of the propeller blade was painted black.

AAIB comment

The Civil Aviation (Investigation of Air Accidents and Incidents) Regulations 1996 states:

> *'...neither the aircraft nor its contents shall, except under the authority of the Secretary of State, be removed or otherwise interfered with.'* (Regulation 7-1).

In General Aviation accidents where there are no fatalities, the AAIB, acting under the authority of the Secretary of State, normally gives permission to remove the wreckage to a secure location and requires the commander to preserve the evidence and to submit a written account of the accident on an Aircraft Accident Report Form (AARF). Based on this information the AAIB decide what, if any, follow up action to take. With the damaged parts destroyed, spinner stolen and no detailed photographs of the damaged propeller, the AAIB was unable to determine positively the cause of this accident or make Safety Recommendations to prevent a recurrence.

Nevertheless, from the information available it is likely that, following the touch-and-go landing, one of the propeller blades detached from the hub, damaging part of the forward structure, which then fell away from the aircraft. The engine stopped and as the aircraft approached the chosen landing site it hit a hedge that ran across the threshold of the field. The lack of bird remains makes it unlikely that the aircraft suffered a bird strike. The witness did not see the spinner fall from the aircraft, so it is unlikely that the failure of the spinner was the initiating factor. Therefore, either the propeller blade struck the ground during the touch-and-go landing, or it failed for some other reason which cannot be determined.

ACCIDENT

Aircraft Type and Registration:	Rans S10 Sakota, G-BWIA	
No & Type of Engines:	1 Rotax 582 piston engine	
Year of Manufacture:	1997	
Date & Time (UTC):	7 April 2007 at 1125 hrs	
Location:	Kingsnorth, Kent	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	Landing gear collapsed, lower cowling and fuselage belly damaged	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	53 years	
Commander's Flying Experience:	332 hours (of which 3 were on type) Last 90 days - 0 hours Last 28 days - 0 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot and subsequent AAIB enquiries	

Synopsis

During the climb following a touch-and-go landing, the aircraft's engine "spluttered" and then stopped. The pilot was unable to restart it, so he carried out a forced landing into a field. No definite cause for the engine failure has been identified.

History of the flight

The pilot reported that he flew two circuits without incident, and was climbing away from the airfield after the second touch-and-go when the engine started "spluttering". He adjusted the throttle setting, but the engine stopped. An attempt to restart the engine was unsuccessful, and the pilot carried out a forced landing into a field of knee-high rape seed. The landing gear collapsed and some damage occurred to the aircraft's underside. The pilot was uninjured, and exited the aircraft via the hatch.

The pilot did not know why the engine stopped, but believed that the possibilities included vapour locking in the fuel system or carburettor icing. Neither cause leaves symptoms readily identifiable for investigation.

The METARs for nearby Gatwick, Lydd, and Biggin Hill airports indicated that at the time of the accident, the temperature was +13ºC and the dewpoint between +3ºC and +5ºC. The CAA Safety Sense Leaflet 14, *'Piston Engine Icing'*, describes how piston engines may be affected by icing, and includes a graph illustrating the likelihood of carburettor icing at various power settings, temperatures, and dewpoints. With a temperature of +13ºC and dewpoint of +4ºC, moderate carburettor icing is likely to occur at cruise power. The aircraft owner reported that he intended to fit carburettor body heaters to the aircraft's engine in order to reduce the possibility of carburettor icing.

Engine information

The operating manual for the Rotax 582 engine includes the following warnings:

> *'WARNING*
>
> *'This engine, by its design, is subject to sudden stoppage. Engine stoppage can result in crash landings, forced landings or no power landings…'*

ACCIDENT

Aircraft Type and Registration:	AS355F2, Twin Squirrel, G-CAMB
No & Type of Engines:	2 Allison 250-C20F turboshaft engines
Year of Manufacture:	1989
Date & Time (UTC):	7 April 2007 at 1225 hrs
Location:	Shobdon Airfield, Herefordshire
Type of Flight:	Training
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - 1(Minor) Passengers - N/A
Nature of Damage:	Crease damage to forward end of tail boom
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	59 years
Commander's Flying Experience:	4,372 hours (of which 1,190 were on type) Last 90 days - 39 hours Last 28 days - 25 hours
Information Source:	Aircraft Accident Report Form submitted by the commander

Synopsis

During type conversion training, a rejected takeoff manoeuvre resulted in a hard landing.

History of the flight

The student was in the final stages of type conversion. A departure, with a simulated engine failure, was carried out with the intention of landing straight ahead. After simulating the engine failure, the helicopter was at approximately 8 ft agl when it lost forward speed and developed an increased rate of descent. The simulated failed engine was immediately restored by the instructor. A slight yaw developed and the helicopter landed on the right skid before bouncing from right to left to right and then settling onto both skids. The commander considered the landing not to have been unduly hard and the exercise was continued; a subsequent rejected takeoff being accomplished before the helicopter returned to its dispersal. The damage was discovered during the post flight inspection. The instructor suffered a minor injury from delayed whiplash.

Analysis

When this twin-engined helicopter takeoff was rejected, translational lift was used to offset some of the reduced performance capability. As the speed decayed, the reduction in translational lift resulted in the remaining engine being unable to provide sufficient torque to arrest the rate of descent. The slight yaw the crew reported was probably the additional torque effect of the simulated failed engine being restored.

ACCIDENT

Aircraft Type and Registration:	Hughes 500C-369HS, G-ORRR
No & Type of Engines:	1 Allison 250-C20 turboshaft engine
Year of Manufacture:	1975
Date & Time (UTC):	9 May 2006 at 1306 hrs
Location:	Hanover Hill, Lane End, near High Wycombe, Buckinghamshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Helicopter destroyed
Commander's Licence:	Private Pilot's Licence
Commander's Age:	47 years
Commander's Flying Experience:	118 hours (of which 18 were on type) Last 90 days - not known Last 28 days - not known
Information Source:	Field Investigation

Synopsis

The pilot reported that as he reduced speed to approach the airfield he experienced erratic power fluctuations. He therefore entered an autorotation and attempted to clear some trees on the approach to his chosen landing site. At about 40 to 50 feet above the ground, the helicopter descended rapidly and as a result landed heavily and rolled on to its side. The pilot was uninjured. The investigation could not identify the cause of the reported power fluctuations.

History of the flight

The pilot reported that he intended to fly from his private site at Checkendon on a short 5 minute flight to Wycombe Air Park where he planned to refuel prior to a further flight He reported that the weather and visibility were good, the wind was 225º/5 kt and the cloud base was 1,800 ft to 2,000 ft.

During the climb out from Checkendon the pilot contacted Benson radar and climbed to 1,200 ft amsl. Just north of Henley he reported that he was visual with Wycombe Air Park and was instructed, by Benson radar, to contact Wycombe. As the helicopter approached the airfield the pilot reduced the engine torque from 50% to 40% and the speed reduced from 95 ft to 80 kt. He made his initial radio call to Wycombe Tower, received the airfield information and set the aerodrome pressure setting on his altimeter subscale.

By this time the helicopter was at about 750 ft over woodlands located about 2.5 miles west of the airfield. The pilot acknowledged a message from Wycombe Tower regarding two other helicopters operating from the airfield, and shortly after this he reported that he was experiencing power fluctuations.

As the engine power started to fluctuate, the nose of the helicopter yawed to the right and then pitched up and yawed to the left. The pilot's perception was that, as he used the collective lever, the engine power reduced to "nothing" and therefore he lowered the collective lever and entered autorotation. He turned 180º back into wind and selected a landing site. At this stage he was at about 450 ft, 60 kt and clear of the woodlands. The pilot reported that as he started to transmit a 'MAYDAY' call the power kicked back in, or the engine reignited itself, and he thought he could salvage the situation. He therefore broke off the radio call and started to raise the collective, but the engine did not respond and both the rotor speed and airspeed started to reduce. By this time the airspeed had reduced to about 30 kt and the helicopter was approximately 100 ft above the ground, with a group of trees to the left of the direction of travel. The pilot said that he pushed forward on the cyclic control in an attempt to recover some airspeed. He raised the nose when the helicopter was 40 to 50 ft above the top of a hill, but at this point it suddenly dropped to the ground.

The helicopter struck the ground on the back of the skids and tail boom. It then pitched forwards and the main rotor blades hit the ground. The helicopter was then violently thrown on to its left side and the main rotor blades detached from the rotor head, which was still turning under engine power. The pilot pulled the fuel cock closed and turned the engine off before vacating the helicopter through the right door.

The pilot reported that all the fuel was in the main fuel tank and the fuel warning light did not illuminate during the flight. He also stated that the start fuel pump remained switched off throughout the flight and that during the power fluctuations his attention was focussed on controlling the aircraft and remaining clear of the trees on the approach to the landing site.

Report by Air Traffic Control

Shortly after the Wycombe controller gave G-ORRR the information for a standard helicopter join he heard the pilot broadcast a 'MAYDAY'. The controller attempted to elicit some more information from the pilot, but received no response. He passed the limited information to the Distress and Diversion Unit at the London Air Traffic Control Centre and at the same time two helicopters operating in the circuit commenced a search for the aircraft. Shortly afterwards the pilot contacted the controller, by telephone, to report that he was uninjured but the helicopter was badly damaged.

The controller reported the weather on the airfield at 1320 hrs as visibility 10 km, wind 350º/5 kt, cloud base 1,600 ft and temperature 17ºC.

Aircraft description

General

The Hughes 500C is a free turbine, turboshaft engine-powered helicopter with a four bladed fully-articulated main rotor and a two bladed semi-rigid tail rotor. The fuselage is a semi-monocoque construction of aluminium alloy. G-ORRR was equipped to carry two pilots in the front and three passengers in the rear. It was fitted with two non-retracting skids and an auto re-ignition system.

Fuel system

The basic fuel system consists of two flexible interconnected fuel cells, located beneath the passenger compartment. It is replenished through a filler neck mounted on the right side of the fuselage. A start fuel pump is mounted in the sump of the left cell and provides fuel through the tank shut-off valve to the engine for starting. Once the engine is started, fuel is drawn from the cells through the shut-off valve by the engine-driven pump. The fuel shut-off valve is located on top of the left fuel cell and is operated by a push-pull cable from a control mounted on the instrument panel. The valve operating lever is detented in the open and closed positions. Fuel tank contents are indicated by a gauge on the instrument panel with a float-operated sender unit located in the left cell. The fuel gauge is marked in 100 lb increments and there is a red dot on the gauge which corresponds to a fuel load of 35 lb. A FUEL LOW yellow caution light, mounted on the top of the instrument panel, illuminates when approximately 35 lb of fuel remains. There is also a warning in the Flight Manual which states that when the caption is illuminated the pilot should avoid large steady sideslip angles and uncoordinated manoeuvres.

G-ORRR was also equipped with a 21 US Gallon (USG) auxiliary fuel tank located behind the rear seat. The auxiliary fuel tank was replenished through its own fuel filler located on the side of the fuselage above the main fuel tank filler. The auxiliary fuel tank did not have a content indication system. It was fed via its own fuel shut-off valve directly into the right fuel cell, and the shut-off valve was located in the pilot's compartment on the floor next to the left door. The Flight Manual Supplement states:

'To initiate fuel transfer to the main aircraft fuel tank from the auxiliary fuel tank, push the auxiliary fuel system control knob full down' (Section IV para 4-2);

and 'Auxiliary fuel... should transfer in 25 minutes' (Para 4-4).'

Engine fuel system

The engine fuel control system which was fitted to G-ORRR was manufactured by CEKO, and was of a type which uses fuel as the controlling medium with which to schedule the fuel flow. The main components of the engine fuel system are a high-pressure fuel pump, fuel filter, a Fuel Control Unit (FCU) and a power turbine governor. The FCU controls the engine power by metering the fuel flow up to ground idle conditions; during flight conditions the governor meters the fuel flow so as to control the speed of the power turbine.

Automatic re-ignition system

The engine was equipped with an automatic re-ignition system, which provides an automatic engine restart capability in the event of a flame-out in flight. The system is activated when the gas generator speed (N_1) rpm drops below 50 to 55% or the rotor rpm (N_R) drops below approximately 98%.

The pilot arms the system by moving the selector switch, mounted below the instrument panel, to the ARMED position. An indicator light then illuminates to advise the pilot that the system is armed. If the system has detected that N_1 or N_R has dropped below the trigger limits, the re-ignition circuits are activated. At the same time the RE-IGN caption illuminates. The system does not activate the starter-generator and therefore can not start an engine that has stopped.

Flight Manual

Under the heading PARTIAL POWER LOSS the Flight Manual states:

> *'Under partial power conditions, the engine may operate smoothly with reduced power or it may operate erratically with intermittent surges of power' and 'Turning the start pump ON may smooth out an erratic operating engine and/or restore power enabling the pilot to fly to a favourable landing area. However, do NOT disregard the need to land.'*

The Flight Manual also states that a loss of torque will result in a yaw to the left and a drop in engine and rotor speed, and advises:

> *'.....If possible, fly at reduced power to the nearest safe landing area and land as soon as possible. Be prepared for a complete power loss as any time.'*

Recent maintenance

The helicopter had undergone a 100 hr annual servicing and a 300 hr engine inspection approximately 6 hours prior to the accident. During this maintenance the engine was removed and the compressor casings were replaced.

The pilot reported that there had been no recent faults on the aircraft and that the engine had operated satisfactorily prior to the incident.

Damage to the helicopter

The helicopter and its engine were examined at the AAIB Headquarters at Farnborough on 29 June 2006. The damage was consistent with the helicopter sustaining a heavy landing and then rolling on to its left side. All four main rotor blades were badly distorted and had broken away from the rotor head at approximately 30 cm from the blade attachment point. One blade damper had broken off and both the rotating and non-rotating scissors were fractured. All the damage to the rotor system was consistent with the main rotor turning under power when the blades struck the ground. Both magnetic plugs in the main gear box were clear of debris.

The tail pylon aft of the engine compartment was distorted and the skin was creased. The tail rotor and its drive assembly were relatively intact although distortion of the tail pylon had resulted in the drive shaft tearing through the drive shaft tunnel into the area of the engine air intake.

The glazing on the left side of the helicopter had cracked and there was distortion to the structure around the pilot's door and in the floor frame under the front seats. The skid dampers and main attachment bolts were intact and both skids had broken off near the bottom of the down struts.

Fuel system

During the examination of the fuel system it was noted that the Low Pressure (LP) fuel cock operating cable had pulled out of the fuel cock operating arm, which was still in the fully open position. It was also noted that the LP fuel cock lever mounted on the instrument panel had come out further than normal, which was a possible indication that the cable had pulled off the operating arm. However, in the open position the LP fuel cock sits in a detent and it is considered unlikely that it would have moved out of this position during the accident flight. The pilot subsequently confirmed that the cable had become disconnected after the accident and before the AAIB examination.

The fuel contents of the main fuel tank were established as 100 lb by levelling the aircraft with a plumb line against the aircraft datum point and reading the contents on the fuel gauge. The start pump was also tested and found to have a satisfactory flow rate of 0.125 ltr/sec. Fuel was pumped out of the tank with the start pump in order to check the calibration of the fuel gauge. A total of 85 lb of fuel was pumped out of the aircraft and the low warning light illuminated when the needle was aligned with a red spot corresponding to a fuel load of 35 lb. A sample of fuel was sent for analysis and found to be of a satisfactory standard.

The LP fuel cock was turned on and off several times whilst the fuel was being pumped out of the tank. The flow stopped on each occasion with no evidence of fuel seeping across the fuel valve. Both fuel cells were examined and there was no evidence of any foreign objects in the tank. No fuel was seen to enter the main tank when the valve on the auxiliary tank was opened, which indicated that the auxiliary fuel tank was empty.

A vacuum was applied between the engine inlet pipe and the start fuel pump. This test revealed no evidence of air leaking into the engine fuel system.

Engine

Rolls-Royce accident investigators assisted with the investigation into the possible power fluctuations.

The initial examination revealed that the right rear engine mounting strut had broken during the crash and that a crease in the exhaust duct was probably caused when the aircraft rolled over. The compressor and turbine were free to rotate and all the fuel pipes and control rods were undamaged, correctly fitted and locked. With electrical power switched on, all the engine instruments appeared to operate correctly and the igniter was heard to operate when the auto-ignition was tested. There was no evidence of a fuel leak from any of the pipes on the engine.

Rolls-Royce, under the supervision of the AAIB, undertook a fuel system rigging check and vacuum test in accordance with their procedures detailed in Model 250/T63 Checklist for Accident Investigations, Revised 30 January 2001. The fuel system rigging test established that, prior to the accident, the engine controls were probably correctly rigged and all the parameters were comfortably within the acceptable limits. The vacuum test was satisfactory.

The engine was removed from the aircraft and taken to an overhaul facility were it underwent extensive ground runs. During the pre-run checks it was established that the magnetic plugs, oil filter and fuel filter were clean. The igniter plug was removed and the combustion chamber and turbine were inspected using a borescope; nothing unusual was detected. There was also no evidence of any oil leak from the torque meter which might have given false indications of power fluctuations. The engine was run for just over two hours during the test with no repeat of the fault. Rolls-Royce and the overhaul agency both assessed the engine as being serviceable.

The fuel control unit, governor and High Pressure (HP) fuel pump were removed from the engine and tested independently in accordance with their respective test schedules. All the components were found to be serviceable and the test results were within the acceptable limits. The three components were then subject to a strip examination and their condition was assessed as being typical of components of their age.

It was noted that the governor was, unusually, a 500 series, which is used on the twin engine installation. There are minor differences between the governors used on the single and twin installations, which would not be noticeable to the operator, and the latter is set up to tighter tolerances. As the governor was tested to the twin installation test schedule and found to be satisfactory, it would also have passed the single engine installation test schedule. It is therefore concluded that the use of this governor played no part in this accident.

It was also noted that the speed set diaphragm in the FCU had a kink along its edge, which probably occurred when the unit was assembled. Rolls-Royce reported that any malfunction arising from this would not have been intermittent and would have been detected during initial rig testing.

Comment

Despite an extensive investigation by the AAIB and Rolls-Royce, no fault could be found that would have caused the symptoms described by the pilot. Moreover the fault could not be reproduced when the engine and major components were extensively tested using ground rigs. The helicopter had no recent fault history and no recent maintenance was brought into question.

Whilst the pilot reported that the "engine power reduced to nothing" the damage to the main rotor head indicated that the rotor was still turning under power when the aircraft rolled on to its side. This shows that whilst the engine power might have fluctuated in flight, the engine did not stop. The pilot stated that, during the incident, he concentrated on controlling the helicopter in order to land in a confined site surrounded by trees and did not have the time to select the start pump to ON. Although the Flight Manual states that this is an appropriate action in cases of power loss or fluctuation, with no evidence as to the cause of the reported power fluctuations it is not known if this would have had any effect on the engine performance.

ACCIDENT

Aircraft Type and Registration:	RAF 2000 GTX-SE, G-REBA
No & Type of Engines:	One Subaru EJ22 piston engine
Year of Manufacture:	2001
Date & Time (UTC):	1 June 2006 at 0927 hrs
Location:	West of Simon's Stone, Colliford Lake, Bodmin Moor, Cornwall
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Fatal) Passengers - N/A
Nature of Damage:	Gyroplane destroyed
Commander's Licence:	Private Pilot's Licence
Commander's Age:	69 years
Commander's Flying Experience:	242 hours (of which 191 were on type) Last 90 days - 5.4 hours Last 28 days - 1.5 hours
Information Source:	AAIB Field Investigation

Synopsis

The gyroplane was being flown to Bodmin Airfield in Cornwall by the pilot who was also the owner and builder. Approximately 2.8 nm north-east of Bodmin Airfield at a height of about 450 ft agl, the main rotor blades stopped. The gyroplane fell to the ground fatally injuring the pilot. The main rotor blades had contacted the vertical stabiliser, propeller and rudder.

Test flying was conducted by the UK CAA identified undesirable handling characteristics of the RAF 2000. As a result the CAA has published Mandatory Permit Directive MPD 2006-013, restricting operation of the type.

The investigation has identified an undiagnosed medical problem, pre-impact mechanical interference of the control runs and undesirable handing characteristics of the gyroplane, but has not identified the precise cause of the accident. However any combination of these factors could have caused the accident. Four Safety Recommendations have been made.

History of the flight

On the day of the accident a witness had also assisted the pilot with some maintenance of the gyroplane on the day before, he watched the pilot taxi his gyroplane on to the field and park it with the engine running. He could also see a golf bag and clubs in the right seat but could not tell if they were secured. He spoke to the pilot, who explained that he was going to Bodmin Airfield to meet some friends and then was going to play golf.

The pilot made a telephone call following which he boarded his gyroplane and taxied to Runway 04. He used the pre-rotator to increase the main rotor rpm and then departed normally from the runway making a left turn and climbing away to the south-west.

The weather was recorded at Exeter Airport at 0850 hrs as wind, 6 kt from 310º, visibility greater than 10 km with no cloud beneath 5,000 ft and no significant weather, temperature 15ºC, dew point 9ºC, sea level pressure 1030 mb. At the accident site, the police helicopter pilot recorded the 1,000 ft wind from a GPS navigation system as being 12 to 15 kt from 340º and the 2,000 ft wind as 20 kt from 360º. The weather was clear, the surface temperature was 20ºC and there was no significant turbulence.

Shortly after departure from Watchford Farm, the pilot contacted the Exeter Approach controller and informed her that he was at 1,500 ft. The pilot did not report any abnormalities and left the Exeter frequency at 0838 hrs.

The gyroplane tracked initially 260º passing to the north of Oakhampton before turning left on to a track of 240º for Bodmin Airfield. As far as could be established, and apart from two descents near local landmarks, the gyroplane maintained its altitude and heading until approaching Colliford Lake when it descended. It passed along the northern shore of the lake where witnesses estimated the height at between 100 ft and 200 ft, flying slowly. The pilot was clearly visible and returned the waves of some children. The witnesses saw the gyroplane make a gentle climb to the west towards Simon's Stone before losing sight of it. A number of witnesses working in the fields in the area of Deweymeads and Simon's Stone saw and heard the gyroplane pass overhead and estimated the height at approximately 300 ft to 500 ft. Descriptions of the engine noise varied; "normal at high power" was one description, and "intermittent, akin to an rpm limiter operating on a motorbike", was another.

About this time, the pilot contacted the AFISO at Bodmin Airfield. The RT was not recorded but the AFISO stated that the pilot reported that he was approaching from the east. The AFISO passed him the joining instructions for Runway 31 with a QFE of 1007 hPa which the pilot repeated back correctly. There was no indication of any difficulty or abnormality.

A witness walking her dog on Blacktor Downs some 1,100 metres from the accident site watched the gyroplane approaching from the east. It appeared to be maintaining height and heading and then "as if caught in a crosswind, the rotor blades came together above the gyroplane". The engine cut out at about the same time and the gyroplane dropped to the ground.

Medical and pathological information

Following a post-mortem examination, the pilot was found to be suffering from very severe coronary artery disease. The pathologist reported that:

> *'Coronary heart disease of this magnitude could potentially cause a number of symptoms ranging from chest pain and abnormalities in the heart rhythm through to collapse or even sudden death. The pilot had no past medical history of heart disease and had not complained of any symptoms which could be related to his heart; this however does not preclude the possibility of his having had a cardiac-related episode of*

medical incapacitation in flight. Pathological investigation was unable to provide any evidence as to whether this had indeed occurred. However, if other strands of the investigation suggest that incapacitation was likely, then the degree of coronary artery disease identified at the autopsy certainly provides a possible mechanism for such incapacitation.'

The toxicological analysis was negative; there was no evidence of drugs or alcohol in the pilot's body.

Gyroplane description

The RAF 2000 is a Canadian designed kit-built two-seat gyroplane of conventional layout with a pusher engine configuration. It is fitted with a two-bladed glass-fibre main rotor which turns in an anti-clockwise direction when viewed from above. The blades incorporate an aluminium spar. The rotor mast can be moved fore and aft in order to adjust the gyroplane Centre of Gravity (CG) to accommodate pilot weights of between 135 and 265 pounds.

The gyroplane was equipped with a Subaru EJ22 carburetted engine producing 130 horsepower, driving a three-bladed 'Warp Drive' carbon fibre propeller, which rotates, when looking forward, in an anti-clockwise direction. The engine operates on 91 to 93 Octane Mogas and the gyroplane is equipped with a fuel tank of 25 US Gallons capacity, giving an endurance of around four hours. The gyroplane has a maximum airspeed of 140 mph and a maximum cruise speed of 90 mph.

Wreckage and impact information

The gyroplane crashed on the edge of an area of marsh land to the West of Colliford Lake on Bodmin Moor (see Figure 1) and came to rest on its left side on a heading of 287º M. Ground marks indicated that the it struck the ground from a near vertical descent with some sideways movement to its left.

The left side of the gyroplane was extensively damaged, the fuel tank had ruptured and there was a strong smell of fuel in the area. There was localised damage to the leading edges of both main rotor blades. One blade was trapped under the engine and both blades were bent downwards along the majority of their length. All three of the propeller blades had broken off close to the hub.

Pieces of the canopy and items from the cockpit had been thrown forward by approximately 25 m on a heading of 211º M. A second wreckage trail consisting of the broken propeller blades and parts of the fin and rudder were found approximately 54 m to 150 m from the crash site. Most of the items were found between 90 m and 120 m on bearings of between 272º M and 316ºM to the gyroplane.

The pilot was sitting in the left seat and was secured by a four-point harness. The buckle of the harness had been forced open by mud penetrating the cockpit area; the position of the body indicates that this probably occurred after the gyroplane had lost most of its momentum. The right control column had been removed from the gyroplane and a set of golf clubs had been secured in the right hand seat by the lap strap. During the impact the golf bag had slipped through the belt and lodged in the area of the rudder pedals. A pair of golf shoes and a shoe horn were also discovered in the area of the right-hand rudder pedals.

Flight Recorders

There was no legislative requirement for a flight recorder to be installed.

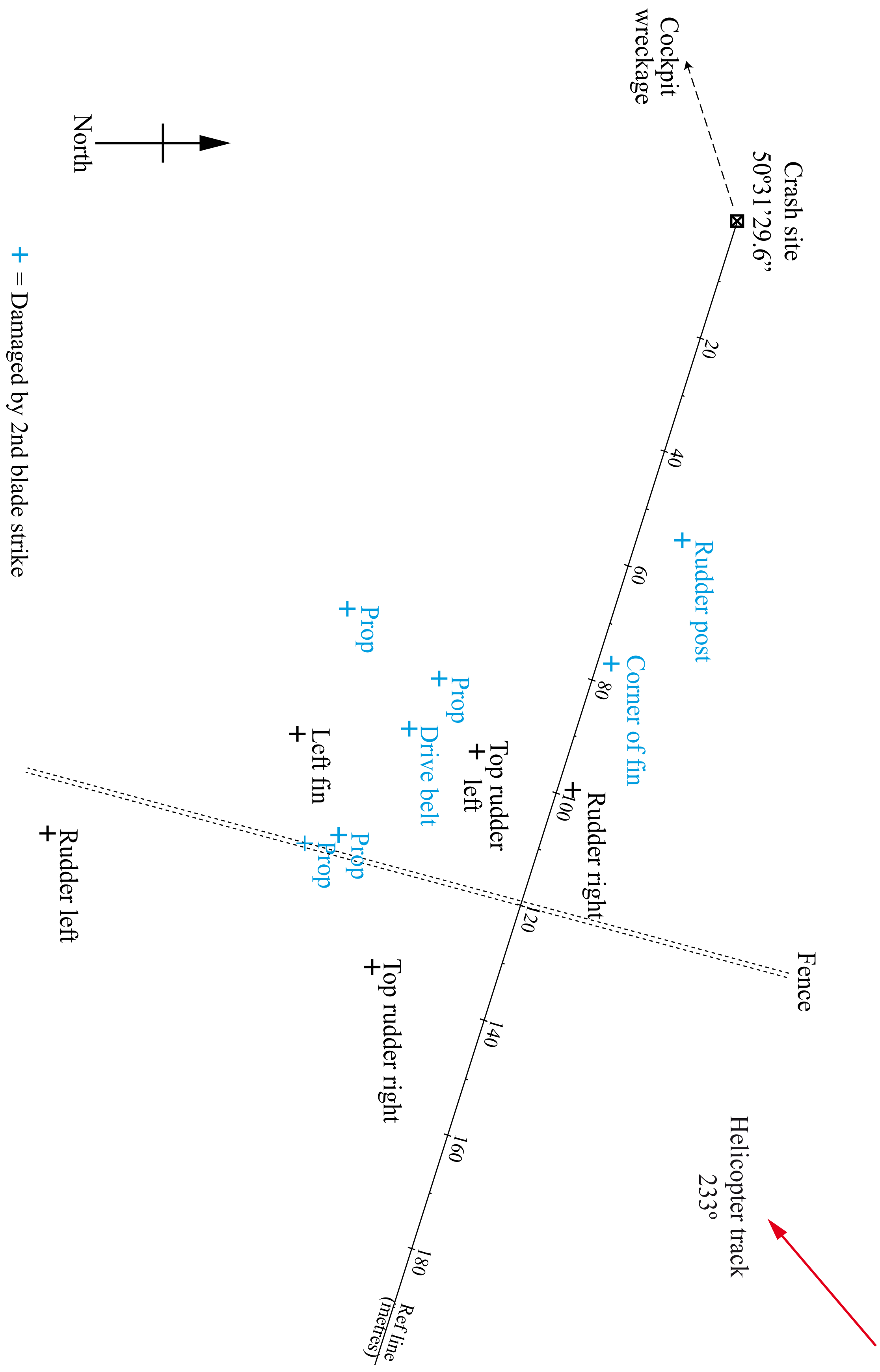


Figure 1
Wreckage distribution

(a) Global Positioning System

A Garmin International global positioning system (GPS), model GPSIII Pilot, was recovered from the accident site. Although the unit had sustained impact damage, (the display panel had been rendered inoperative by an impact to the bottom left corner) it was successfully downloaded at the AAIB. The download provided three track logs, the last of which was from the accident flight.

The accident track log consisted of 312 data points; a data point consisted of GPS time, GPS position and ground speed information[1].

The recording frequency of data points was dynamically controlled by the unit: if the aircraft speed and track remained near to constant the number of data points recorded per minute would reduce. Similarly if the rate of change of speed or track increased (outside preset limits which GARMIN advised are proprietary) the number of data points recorded per minute would increase.

(b) Portable Data Assistant (PDA) GPS

A PDA[2] with an in-built GPS receiver and a Secure Digital (SD) memory card were also recovered from the accident site. The PDA had suffered significant impact damage and could not be powered. The SD card contained a number of files, of which five were found to contain historical video footage of G-REBA and data files relating to a flight planning software utility[3] which was later confirmed as incorporating a track log recording function.

Footnote

1 Speeds were the average between two data points.
2 PDA with an integrated GPS. Manufactured by MiTAC, model number A201.
3 Pocket FMS.

With the assistance of the software manufacturer it was confirmed that the PDA had been operational during the accident flight and sections of a track log were eventually recovered[4]. The track log consisted of data points being recorded once per second, with each data point containing GPS time, GPS position, ground speed and GPS height[5].

(c) Radar data

Primary radar data was available from the Burrington Radar site. The system recorded time stamp and positional information every eight seconds. In the event that no primary return was available, a data point with time stamp only would be recorded. No altitude data was recorded as Mode C equipment was not installed on the aircraft. The last data point recorded was approximately 790 m from the accident site.

(d) GPS data

The data indicated that the aircraft had flown a distance of 62.6 nm and the GPS calculated average speed was 55.3[6] kt. Data points were on average recorded every 13 seconds with the aircraft travelling about 360 m between each data point. Table 1 details the final 12 data points recorded by the GPS. During the final three data points rapid changes in groundspeed can be observed.

Footnote

4 The complete track log could not be recovered as some sections of the data had been overwritten by data from other software applications running on the PDA at the time of the accident flight. The Pocket FMS software manufacturer believed this may have been as a result of a problem in the operating system, but this could not be confirmed.
5 The track log also contained part of a vehicle journey to the airfield, prior to the flight. Through testing of the same model of PDA and verification of track log GPS height against Ordanance Survey spot heights along the car journey it was confirmed that GPS height data was referenced to mean sea level and at the points checked the difference was no greater than +/- 50ft.
6 Based on all data points so does not represent the average cruise speed.

Date / time	Altitude	Distance between points	Time between data points (seconds)	Ground Speed (kts)	Track
01/06/2006 9:10:37	NONE RECORDED	0.2 nm	00:00:11	65.9 kt	241º mag
01/06/2006 9:10:48	NONE RECORDED	0.2 nm	00:00:11	65.0 kt	240º mag
01/06/2006 9:11:01	NONE RECORDED	0.2 nm	00:00:13	64.2 kt	243º mag
01/06/2006 9:11:14	NONE RECORDED	0.2 nm	00:00:13	65.8 kt	244º mag
01/06/2006 9:11:29	NONE RECORDED	0.3 nm	00:00:15	66.8 kt	246º mag
01/06/2006 9:11:43	NONE RECORDED	0.3 nm	00:00:14	67.9 kt	247º mag
01/06/2006 9:11:55	NONE RECORDED	0.2 nm	00:00:12	65.8 kt	245º mag
01/06/2006 9:12:06	NONE RECORDED	0.2 nm	00:00:11	70.6 kt	240º mag
01/06/2006 9:12:22	NONE RECORDED	0.3 nm	00:00:16	72.2 kt	238º mag
01/06/2006 9:12:26	NONE RECORDED	427 ft	00:00:04	63.2 kt	234º mag
01/06/2006 9:12:27	NONE RECORDED	119 ft	00:00:01	70.7 kt	233º mag
01/06/2006 9:12:30	NONE RECORDED	157 ft	00:00:03	31.0 kt	224º mag

Table 1

(e) Data from Portable Data Assistant (PDA) GPS

The data contained in the PDA shows that the aircraft took off at about 0813 hrs on a heading of 060º. Shortly after takeoff, the aircraft made a left turn onto a heading of about 220º and climbed progressively to about 1,300 ft amsl. Figure 1 provides height, speed and terrain elevation below the track. The last data point was recorded at 0912:17 hrs, at which time the aircraft was about 370 m (0.2 nm) from the crash site. The ground speed was 73 kt and GPS height amsl was about 1,250 ft (about 450 ft agl). The average speed during the cruise phase was calculated at 63 kt.

The elapsed time between the last recorded GPS data point and PDA GPS data point was about 13 seconds. Figure 2 provides the two tracks overlaid on an OS map.

(f) Track and topography

If the aircraft track had been maintained, the aircraft would have passed almost overhead of Bodmin Aerodrome. Had the aircraft been maintaining the last recorded GPS height amsl, which was about 1,250 ft, the height agl would have been no less than about 500 ft before reaching Bodmin Aerodrome.

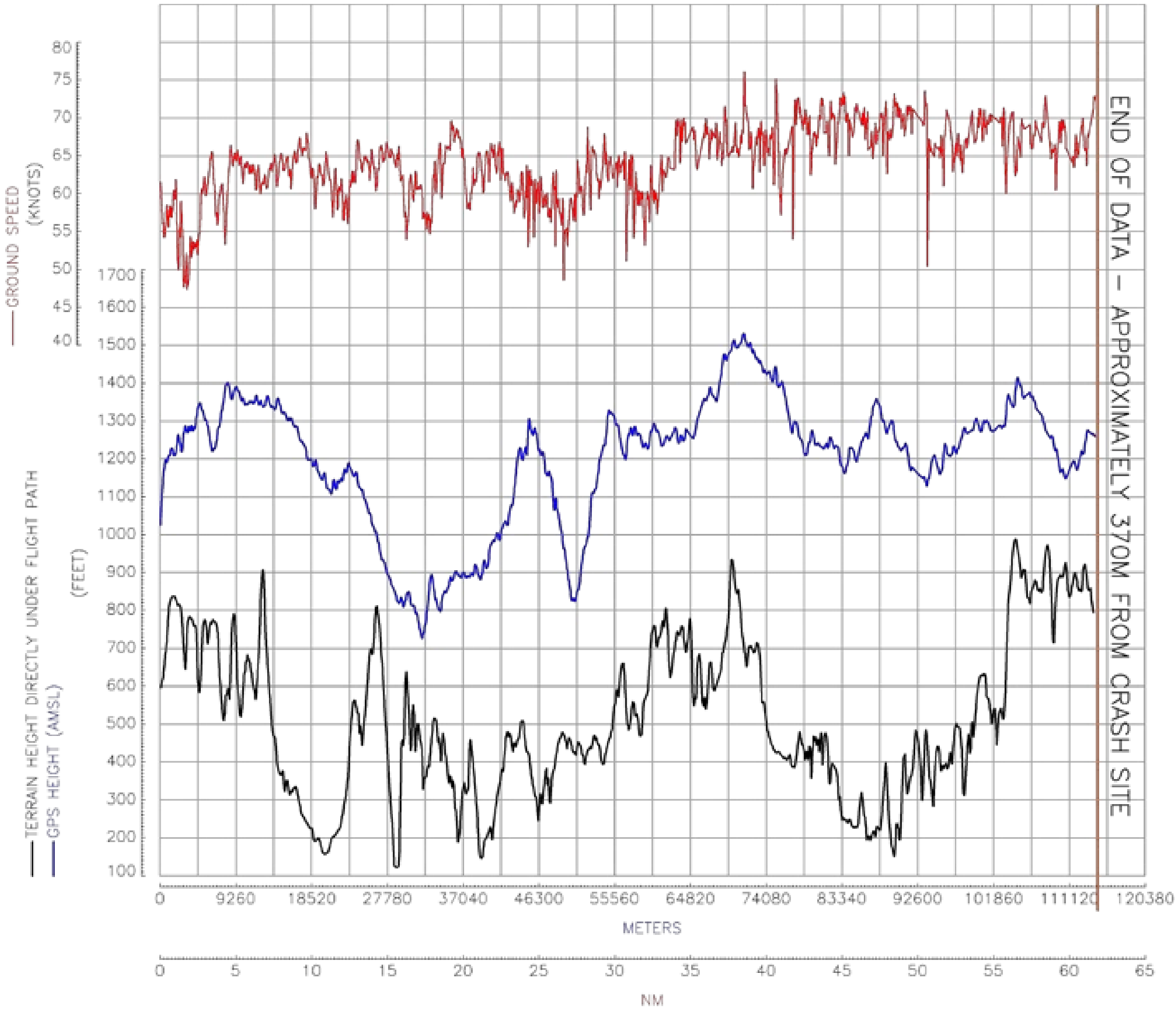


Figure 1

PDA GPS Data

Detailed examination of the wreckage

1) General

The cockpit area, fuel tank and fuel system were extensively damaged. The keel had failed 44 cm aft of the mast and the direction of the damage indicates that this occurred when the gyroplane crashed. The mast, which was bent and distorted to the right, had partially fractured 40 cm above the keel. With the exception of the pilot's right-hand lap strap securing bracket, which failed in overload, the remainder of the harness assembly remained intact. During the crash much of the structure was scratched and distorted. Deep abrasion marks were discovered on the engine frame, adjacent to the battery bay, but these might have occurred prior to the crash.

2) Engine

Fractures in the engine casing and distortion of the mounting brackets were all consistent with the engine

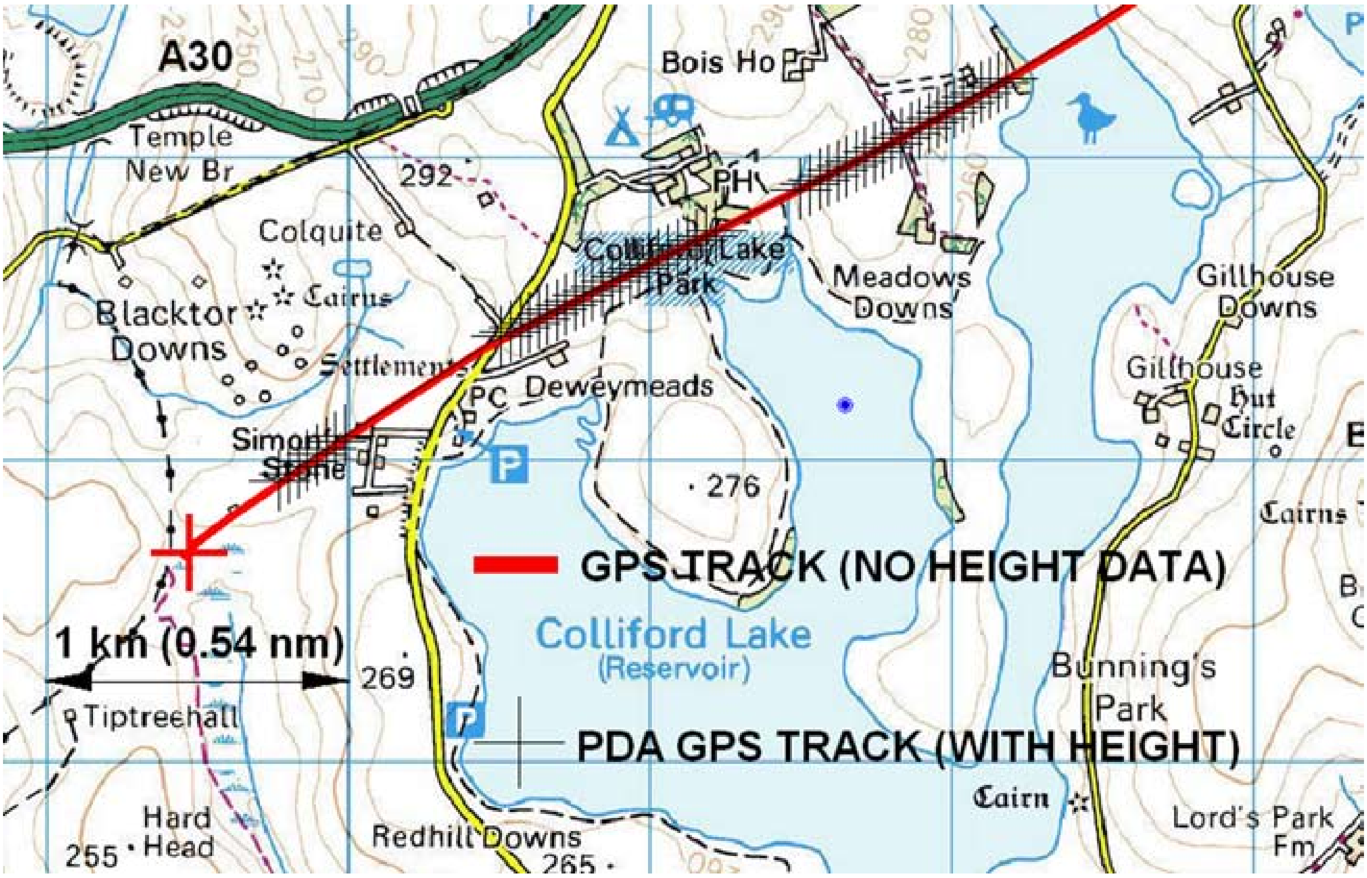


Figure 2

GPS and PDA GPS tracks

striking the ground. Whilst it was not possible to run the engine, it was possible to rotate the crankshaft and observe the movement of the internal components. Both cylinder heads were removed and the pistons were found to be connected and in good condition. The spark plugs were a light grey colour which indicated that the engine had been operating normally. The engine valves and pistons all operated normally and there was no evidence of seizing or overheating. The exhaust and induction systems appeared to be intact and the throttle control was still connected to the carburettor. The timing belt, which was still routed around the engine pulleys, had failed in overload. The overall assessment was that the engine had been in good condition and had been operating normally prior to the accident.

3) Propeller blades and drive

The drive belt from the engine to the propeller reduction gear had failed in overload but was assessed as being in otherwise good condition. All three blades had broken away from the hub and sections 50 cm, 52 cm and 30 cm long were found in the wreckage trail.

Reddish brown streaks were discovered along the leading edges of all three blades. These streaks glowed when exposed to ultraviolet light indicating that they were probably organic in nature and were most probably made by insects or vegetation.

4) Flying controls

The pilot's left rudder pedal had broken off and the right rudder pedal layshaft had popped out of the right mounting bracket, which had distorted during the impact. The rudder hinge rod, which was still connected to the cables, was distorted and had a dent similar to the profile of the leading edge of a main rotor blade at a position just above the upper hinge point. Continuity of the rudder cables was established between the rudder pedals and the rudder attachment point.

With the exception of the torque levers, continuity of the cyclic control was confirmed between the control column and the gimble activation arm. Both torque levers, which are mounted at the base of the mast, had failed at the point where the bolts secure the levers to the cross shaft (see Figure 4). The left lower control rod was badly bent during the impact and broke during the recovery of the gyroplane. At 34 cm from the bottom of the rod there were deep abrasion marks along the rod for approximately 40 mm. The lock nut on the lower fitting on the left upper control rod had been

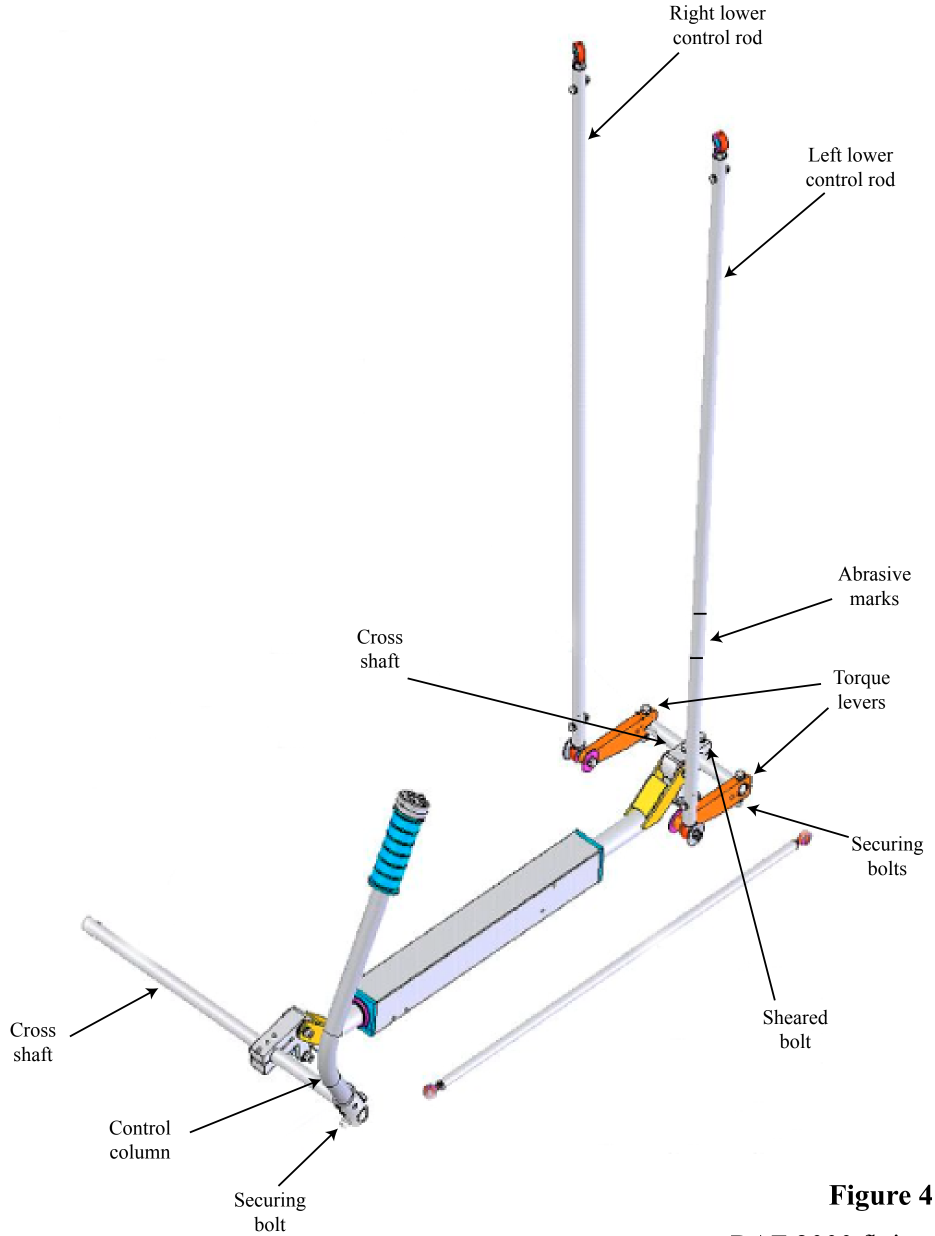


Figure 4

RAF 2000 flying controls

fully wound off and the fitting was loose. Abrasion marks were also discovered at 80 mm and 35 cm from the bottom of the right lower control rod. The lock nut on the fitting on the right upper control rod was found to be loose. The bolt used to secure the pilot's control column to the cross shaft had four washers between the column and the nut. The bolt which secured the torque lever to the cross shaft had failed in shear. Both trim springs were still connected to the control rods. The trim indicators were in the fully down position and the trim cables were unwound from the barrels inside the trim mechanism, so that there was no tension in the trim springs and no trim force applied to the control system.

5) Rotor

The rotor mast had been set at CG position No 3 and the upper portion of the mast was tilted backwards by approximately 4º in relation to the lower portion of the mast. The lower adjustable mast bolt was covered in a heavy layer of surface corrosion along its shank and it was difficult to remove the bolt. The mast and rotor assembly appeared to have been correctly assembled in accordance with the gyroplane build manual.

The rotor head was distorted and the main rotor securing bolt and pre-engage disc were bent. However, all the damage to the rotor system indicated that it occurred when the gyroplane crashed.

The blade pitch, as measured between the blade root and hub bar, was 5º for the black blade and 4.5º for the white blade. The hub bar was also found to be set equidistant between the teeter towers. A black indelible pen had been used to write '*6.34*' on the teeter tower, '*5.58*' on the hub bar adjacent to the white blade and '*5.54*' on the hub bar adjacent to the black blade.

6) Rotor blades

The metal spars on both blades were intact and there was localised damage to the leading edge of the blades. The position of damage to the rotor blades, designated white and black, was referenced to the distance along the blade from the rotor pivot point.

The white blade had bent upwards at a position 94 cm spanwise, and then bent downwards at 1.4 m. On the lower surface there were black carbon smears at 96 cm to 1.1 m and gold paint smears at 2.1 m to 2.7 m. There was also a single black rubber mark at 2.5 m. A small area of leading edge adjacent to the carbon smears had sustained some impact damage. A 30 cm length of the leading edge at 2.6 m was also damaged.

The inboard 1.7 m of the black blade had been extensively damaged as a result of the engine crushing it in the impact. At 2.16 m the blade started to bend downwards and on the lower surface there were black carbon smear marks at 82 cm to 93 cm and gold paint marks at 2 m to 2.3 m. There was evidence of some impact damage to the leading edge adjacent to the carbon smears and a small area of impact damage at 2.3 m.

7) Rudder and fin

The rudder, which had broken into four main pieces, and the upper third of the fin, were found in the wreckage trail. When the rudder and fin were reconstructed there was evidence that the tail section had been struck three times by the main rotor blades. The evidence consisted of a clean cut at the trailing edge of the top part of the fin; a shadow along the left side of the fin and an indentation along the rear wheel trailing arm.

8) Golf bag

The golf bag and shoes found in G-REBA were loaded into the right seat position on another gyroplane, which also had the control column removed, to establish if either the golf clubs or shoes could have fouled the flying controls. With the golf bag secured by the lap strap, and forced as close to the controls as possible, it was still possible to obtain the full range of movement of the controls. From the layout of the cabin it is likely that the shoes would have been placed on the floor behind the golf bag. In this position it is highly unlikely that in normal flight they would have been able to move to a position where they could have restricted the movement of the rudder pedals. The AAIB was later advised by an experienced RAF 2000 instructor that the fuel tank, which forms the base of the seats, was slightly different on G-REBA from the gyroplane on which the trial was undertaken. However, in his opinion the design of the tank on G-REBA would have meant that there would have been a greater clearance and, therefore, a lower probability that the golf bag would have restricted the movement of the controls.

Previous accident

On 24 April 2004, shortly after taking off, the same pilot and gyroplane clipped the top of a six foot hedge and, as a precautionary measure the pilot landed in the field immediately beyond the hedge. However the gyroplane landed heavily, the main rotor blades struck the ground and the gyroplane rolled over on to its side. An entry in both the engine and aircraft log book dated 18/9/04, and 134:45 airframe hours, stated *'Airtest of a/c. See aircraft worksheet 18/9/04. Permit maint release'*. Two worksheets with this date, both referenced 1 of 1, were provided to the AAIB with the gyroplane documentation.

One worksheet recorded the work required as *'EJ22 engine shock loaded during roll over. Crankshaft required to be replaced as per RAF manual.* The rectification block recorded that this work had been carried out and both the 'Eng' and 'Insp' signature blocks were signed by a PFA Inspector.

The second worksheet recorded the remaining work carried out to recover the gyroplane from the accident. On this worksheet the owner signed the 'Eng' and a PFA inspector the 'Insp' signature blocks for the following work:

'Nose wheel replaced

Windscreen, right door and back panel replaced

Main mast & cheek plates replaced and assembled as per build manual

Control rods & gimble head replaced with new parts from RAF

All axel struts replaced with new from RAF

Main rotor & hub bar obtained from Newton Air Ltd

3 new warp drive blades installed'

It is possible that in the accident, the load in the control rods and torque levers might have exceeded the design loads. Therefore the manufacturer stated that after being informed of the roll-over he provided the owner with a copy of Product Notice 37, which specifies the inspections and components to be replaced following an accident. The notice states that the *control system must be dismantled, the components inspected and all hardware must be replaced.* Whilst the owner subsequently ordered a number of parts, the investigation was unable to establish if he fitted new torque levers to the gyroplane. Whilst the Product Notice 37 is not specific, the manufacturer has advised that the torque levers are amongst the parts which should be replaced.

Mandatory Permit Directive (MPD) 2006-003

MPD 2006-03 was issued by the CAA on 24 March 2004 and required a number of components in the control system to be replaced in order to meet the requirements of British Civil Airworthiness Requirement (BCAR) Section T. Whilst there is no entry in the aircraft logbook to indicate that the modification had been embodied the manufacturer stated that they had supplied the owner with the modification kit in the month before the accident. A PFA inspector, who assisted the AAIB with the examination of the gyroplane, confirmed that the modified components were fitted on the gyroplane. Two days before the accident a witness was asked to assist the pilot by holding the control column whilst he replaced a part in the control system. The part was later identified as the torque lever cross tube, which was provided in the modification kit. A second witness stated that he spoke to the pilot the day before the accident when he briefly mentioned that he had recently completed a major modification, but the gyroplane was now flying slightly sideways and so he was going to make further adjustments to it. The second witness subsequently saw the owner taxi around the field and take off. The gyroplane had been put back in the hanger and the owner had left the airfield before the witness had the chance to talk to him again. On the day of the accident, the first witness spoke with the pilot before he departed for Bodmin and no mention was made of the modification or handling qualities of the gyroplane.

There was no documentation to indicate that the modification had been embodied, nor was the owner's usual PFA Inspector aware that the work had been carried out. Therefore there was also no evidence that a duplicate inspection had been carried out following embodiment of the modification. Moreover, it became apparent during the investigation that some other RAF 2000 owners did not realise that a duplicate inspection was required following embodiment of MPD 2006-03. Therefore, on the 14 July 2006, in AAIB Special Bulletin S6/2006, the following Safety Recommendation was made to the Popular Flying Association.

Safety Recommendation 2006-087

It is recommended that the Popular Flying Association takes the immediate steps to ensure that a Duplicate Inspection is carried out following the embodiment of MPD 2006-03 on the RAF 2000.

In response to this Safety Recommendation the PFA wrote to all RAF 2000 owners on 10 July 2006 reminding them that embodiment of MPD 2006-03 required a duplicate inspection. The letter also advised owners as to how duplicate inspections should be recorded and carried out.

Tests and research

Gyroplane stability research by Glasgow University

The stability of gyroplanes has been under investigation by Glasgow University, supported by the UK CAA, for at least 10 years. In a published paper (Houston, 1996) Professor S S Houston concluded:

> *'The vertical position of the centre-of-mass in relation to the propeller thrust line is of significant consideration in gyroplane longitudinal stability; …the rotorspeed degree of freedom is strongly coupled with the 'classical' rigid-body modes of motion, in particular the phugoid; …changes in phugoid stability, and therefore rotorspeed behaviour, may occur for configurations with main rotor thrust line passing close to the centre-of-mass….'*

Power pushover

Whilst the numerical analysis of gyroplane pitch stability is relatively recent, the gyroplane community has long been aware of what it has termed the 'Power pushover'. This is commonly described as being due to the propeller thrust acting above the vertical CG of the gyroplane and tending to pitch the gyroplane nose down. In normal flight the lift or rotor thrust developed by the main rotor blades opposes the propeller thrust and balances the nose-down pitching moment. If the gyroplane is disturbed in pitch, either by turbulence or control input, this may result in a 'pushover' or 'bunt' manoeuvre. As the normal 'g' reduces, the rotor thrust also reduces proportionately allowing propeller thrust to become the dominant force. If the onset of the bunt manoeuvre is rapid, loss of rotor thrust is also rapid and, with a high propeller thrust setting, the propeller thrust causes the fuselage to pitch nose-down and the tail to rise. If this situation occurs, the main rotor blades may flap back or if the pilot makes a large aft cyclic input to correct the situation, the blades are able to strike the tail surface and the propeller. It is notable that the Glasgow University research has found a strong coupling between pitching motion and rotorspeed, since reduced rotor speed adversely affects rotor disc stability.

Flight tests

Following a previous accident involving an RAF 2000 autogyro, G-CBAG on 17 May 2002, the AAIB made several Safety Recommendations aimed at evaluating the handling characteristics of the UK gyroplane fleet. Safety Recommendation 2003-03 recommended that the CAA should assess the RAF 2000 for compliance with BCAR Section T and if necessary recommend appropriate modification to achieve compliance. The CAA accepted this Safety Recommendation and, having evaluated the other types on the UK register, was about to conduct flight tests on the RAF 2000. Therefore the proposed evaluation was combined with an effort to identify possible cause(s) of the accident involving G-REBA.

A series of test flights were carried out in the UK using an RAF 2000, registration G-ONON, which was of similar specification to G-REBA. Following the flight tests in the UK, a test flight was made in Medicine Hat, Canada with the manufacturer's recommended instructor pilot accompanying the CAA test pilot. The gyroplane was an RAF 2000, C-FLDE. This differed from G-REBA in that it was equipped with a more powerful 2.5 litre Suburu engine fitted with fuel injection driving a four-bladed propeller. It was also fitted with a 'Stabilator' designed to improve the longitudinal handling qualities of the gyroplane and an electric pitch and roll trim system. Unlike G-ONON, this gyroplane was equipped with instrumentation to record specific parameters. Throughout all the tests flown, the gyroplane operation remained entirely within the manufacturer's (Rotary Air Force) published envelope. The purpose of the UK test flights was to undertake a handling qualities assessment of the RAF 2000 autogyro and assess the test gyroplane against the latest issue of BCAR Section T. The test flight conducted in Canada investigated the handling qualities of the gyroplane fitted with the 'Stabilator'. The onboard instrumentation was also used to document the relevant results.

During the flights carried out in the UK, the CAA test pilot gained experience of flying the gyroplane and during the tests identified a number of deficiencies when trying to establish compliance with BCAR Section T. Both gyroplanes tested exhibited marked longitudinal dynamic instability when flown above 70 mph and directional instability with cabin doors fitted. The conclusion of the UK flight tests was:

> *'The gyroplane had unacceptable longitudinal dynamic stability above 70 mph and unacceptable directional stability with the doors fitted.'*

Following the test flight of the RAF 2000 in Canada, the CAA test pilot concluded that:

> *'The Stabilator dramatically improved the gyroplane's trim system however the gyroplane tested exhibited similar static and dynamic stability characteristics to a similar gyroplane tested without a Stabilator.'*

In essence, the test flying identified significant instability of the gyroplane as speed was increased above 70 mph. With the thrust line above the CG an inherent nose-down pitching moment existed which increased with an increase in power. Although dynamically unstable above 70 mph, the gyroplane exhibited relatively strong longitudinal static stability. When the gyroplane was trimmed for the higher speed cruise, typically above 70 mph, a noticeable aft force was required on the cyclic control in order to slow the gyroplane down. Releasing the cyclic control when flying more slowly than the trimmed cruising airspeed, resulted in a nose down pitch. Pitch trimming is achieved by a trim wheel on the centre console. Approximately 60 rotations of the wheel are required to trim the gyroplane from speeds between 50 mph to 80 mph. This lengthy process does not make re-trimming simple and also requires the pilot to fly the gyroplane with his left hand whilst using his right to perform the trim adjustments. This requires the pilot to be equally competent at flying the gyroplane with either hand, which does not come naturally to some pilots.

During flight testing, G-ONON appeared to have a well damped convergent phugoid long term response (LTR) at slow speeds and the gyroplane was comfortable being flown at speeds up to 65 mph. At 60 mph the LTR was damped and convergent. Maintaining pitch attitude ± 2º was easy and could for periods of three to six seconds be accomplished with no inputs to the cyclic control. At 65 mph a 'release-to-trim' input of the cyclic control excited a lightly damped phugoid with a period of around eight seconds. Maintaining pitch attitude ± 2º at 65 mph was more difficult requiring constant small (2 mm) inputs to the cyclic control. At 70 mph natural turbulence excited a divergent phugoid which had a period of approximately five seconds and a time to double amplitude of approximately 10 seconds. Testing was curtailed after eight seconds to prevent excessive pitch attitudes being reached. Maintaining pitch attitude ± 4º at 70 mph was very difficult requiring continual small (2 mm) inputs to the cyclic. Flying at speeds between 70 mph and 100 mph required increasing attention and required good visual cues, that is to say, a clearly defined horizon.

It was also noted during flight testing that with the doors fitted, the gyroplane had no inherent directional stability and would not naturally yaw into the prevailing sideslip. Additionally, if feet were taken off the rudder pedals, the rudder would not centre but would pay off into the prevailing sideslip, reducing directional stability further. In flight, constant small rudder inputs were required to maintain heading accurately (± 2º).

Throttle chops were conducted in level flight at 70 mph. In each case the gyroplane rolled to the left and yawed noticeably to the right. A slight pitch-up was followed by a tendency for the nose to drop as airspeed reduced. Maintaining heading initially required moderate pilot attention due to the poor directional stability.

With regard to the gyroplane's behaviour in the pitching plane, the test pilot concluded that although stable at lower speeds, it was clear that the dynamic instability of the gyroplane occurred at higher airspeeds with a corresponding increase in workload, noticeable above an indicated 70 mph.

Following these evaluations, the UK CAA issued Mandatory Permit Directive MPD 2006-013 which imposed flight limitations on the type. In particular, the 'never exceed' speed V_{NE} was reduced to 70 mph, the doors were required to be removed for flight, and flight when the surface wind exceeds 15 kt was prohibited.

Metallurgy

A metallurgist inspected a number of components using visual and low level optical techniques and made the following observations:

General

The failure of the rotor mast, gimbal arm and various bolts occurred due to overload, with no evidence of any pre-existing condition that would have contributed to the failure.

Left lower control rod

The left lower control rod failed as a result of bending overload separation. The deep abrasion marks 34 cm from the bottom of the control rod were identified as longitudinal frettage corrosion damage which had resulted from high contact pressures and large sliding movements. The metallurgist considered that the restriction resulting from this contact could have been sufficient to overload the torque levers.

Engine frame

The frettage damage on the engine frame adjacent to the battery bay was also caused by a sliding action and was similar to the frettage damage on the left lower control rod.

Torque levers

The torque levers exhibited signs of plastic deformation and had failed as a result of having being overloaded. There was no evidence of progressive separation of the metal by either fatigue or stress corrosion. However, the properties of the metal used in the torque levers makes it difficult to differentiate between a failure caused by very low cycle fatigue (up to 200 cycles) or by the levers having been subjected to an excessively high load. Therefore low cycle fatigue of the torque levers could not be ruled out.

An electrical conductivity check of the metal used in the torque levers gave average values of 45% IACS[7] and a Vickers Hardness test gave values of 111 HV for the left torque lever and 112 HV for the right torque lever. These tests indicate that the tensile strength of the material was approximately 430 N/mm^2 and that the material had probably been solution treated and artificially aged.

The PFA, using the material strength estimated by the metallurgist and the dimensions of the torque levers fitted to G-REBA, established that both levers met the requirements of BCAR Section T, which states:

> *'The parts of each control system from the pilot's control stops must be designed to withstand pilot forces of not less than (for stick controls) 445N fore and aft, and 300N laterally.*
>
> *The parts of each control system from the control stops to the attachment to the rotor hub (or control areas) must be designed to at least*

Footnote

7 International Annealed Copper Standard.

withstand the maximum pilot forces obtainable in normal operation; and if operational loads may be exceeded through jamming, ground gusts, control inertia, or friction, support without yielding 0.60 times the limit pilot force (for stick controls) 445N fore and aft, and 300N laterally.'

Comparison with other gyroplanes

A comparison was made of the control and rotor system on G-REBA with four other RAF 2000 gyroplanes. The comparison established that the rotor blade pitch (5º) was similar to the other gyroplanes. The manufacturer confirmed that the rotor blade pitch was within the acceptable range. The length of the left control rods on G-REBA was slightly greater than for the other gyroplanes, whereas the right control rods were of a similar length. This difference was due to the build tolerances and the positioning of the torque levers and control columns on their respective layshafts.

The comparison also established that the abrasion marks at the base of the right lower control rod were probably caused by the trim springs rubbing against the control rod. It was noted that a number of other owners of RAF 2000 gyroplanes had identified this problem and introduced their own modifications using plastic sheaths and blade tape to protect the control rods from the trim springs. Whilst it is unlikely that the rubbing of the trim springs against the control rod played any part in this accident, on the 14 July 2006, in AAIB Special Bulletin S6/2006, the following Safety Recommendation was made to the Popular Flying Association.

Safety Recommendation 2006-090

It is recommended that the Popular Flying Association considers introducing a modification to the lower control rods of the RAF 2000 to protect them from being damaged by the trim springs.

The left lower control rod from G-REBA, which had the deep abrasion marks 34 cm from the bottom of the control rod, was compared with the equivalent control rod on another gyroplane where it was noted that the marks were in line with the battery tray. It is, therefore, probable that the marks on the engine frame adjacent to the battery tray and the control rod were caused by these two items rubbing against each other.

Whilst operating the controls on one of the gyroplanes used in the comparison, it was noted that the excess safety chain, fitted to one of the trim springs, jammed between the lower control rod and undercarriage strut thereby restricting the roll control of the gyroplane. The chain on G-REBA had been set up such that there was no free hanging excess chain and, therefore, it is unlikely that it would have caused the control to jam. However, on the 14 July 2006, in AAIB Special Bulletin S6/2006, the following Safety Recommendation was made to the Popular Flying Association.

Safety Recommendation 2006-088

It is recommended that the Popular Flying Association takes the necessary immediate steps to ensure that the safety chain connected to the trim springs on the RAF 2000 does not jam the moving parts in the control system.

In response to these two Safety Recommendations, the PFA has amended the Type Acceptance Data Sheet (TADS) for the RAF 2000 at issue 4 dated 14 December 2006 and at issue 5 dated 2 July 2007 to include special inspection points dealing with the trim spring and pushrod abrasion issues.

Discussion

There was no evidence that the pilot had experienced difficulties handling the gyroplane, or expressed concerns about flying it. The weather was good and he was properly licensed to conduct the flight. At the time of the flight he had no history of medical problems.

The flight, from Watchford Farm up until immediately before the accident, appears to have been normal. The pilot, on contacting Bodmin Radio made no mention of any abnormal situation or difficulties. As he passed along the north shore of Colliford Lake, the pilot returned the waves made by two children before climbing away to the west. The estimated heights provided by the majority of the witnesses of between 300 ft to 500 ft appear to have been accurate. They also saw the gyroplane in steady flight, not executing any violent manoeuvres. The witness on the bridge at Blacktor Downs was quite specific that the gyroplane appeared in steady flight. It then appeared to be caught in a crosswind, the rotor blades came together above the gyroplane and the engine cut out at about the same time.

Evidence from witnesses and the pilot's GPS indicates that the gyroplane was flying at cruise speed on a heading of 233º when the rotor blades struck the tail assembly, causing the rotor to stop. The gyroplane then continued through the air for approximately 120 m on a heading of approximately 300º before striking the ground.

Missing tips on two of the propeller blades, marks on the rudder and paint marks on the rotor blade indicate that the white blade was the first to strike the tail assembly when the rotor was tilted back by approximately 37º. Damage to the fin and rudder, rudder hinge post, propeller blades, and paint marks and damage to the leading edge of the rotor blades indicate that a second high energy strike involving the black blade occurred when the rotor was tilted back by 45º. It is probable that it was this strike that broke all the propeller blades and drive belt. Marks on the fin and tail wheel assembly, and paint marks and leading edge damage to the white blade indicate that a third strike occurred when the rotor was tilted back by approximately 52º.

The propeller drive belt failed in overload when the propeller blades were struck by the main rotor blade and then fell, under gravity, to the ground. Whilst the distribution of the broken parts of the rudder and fin had been affected by their size, shape and local air currents, this would not have been the case for the relatively heavy rudder hinge post which was knocked to the right of the gyroplane. The drive belt and rudder post are believed to have failed as a result of the second main rotor blade strike. From the wreckage distribution it is assessed from the relative position of the gyroplane track, drive belt and rudder post that the gyroplane was probably flying forwards on a heading of about 233º when the accident occurred.

Whilst there was no entry in the aircraft logbook or any associated worksheets, there was evidence that the owner had recently embodied MPD 2006-03, which required the replacement of a number of components in the control system. It would also appear that the day before the accident the owner was still making adjustments to the control system following the modification.

The investigation discovered that two of the lock nuts on the control rod end fittings were loose. It is possible that one might have come loose in the crash when the control rods were subject to high bending forces. However, the other lock nut had been backed fully off the thread and must have been in this position before the impact. There was also evidence of the trim springs rubbing against the lower control rod and a high pressure moving contact between the left lower control rod and the engine frame.

The loads that the control system must be cable of withstanding are specified in BCAR Section T, which is based on the force that a pilot would be able to exert to clear a control restriction. The PFA confirmed that the control system met the strength requirement of BCAR Section T and it is considered unlikely that the pilot would have flown the gyroplane, following a major modification to the control system, if it required an unusually high force to move the stick. It is also considered unlikely that rubbing contact of the lower control rods against the trim springs and engine frame would have been sufficient to cause a control restriction which could not be overcome.

Consideration was given to the torque levers having been damaged in the previous accident and then failing during the final flight. Whilst it was not possible to establish if the torque levers had been replaced, the gyroplane had flown for a further 50 hours and there was no evidence of fatigue or any pre-existing damage to the levers. It is, therefore, considered unlikely that damage sustained to the gyroplane during the previous roll-over contributed to this accident.

The metallurgist was of the opinion that frettage damage to the left lower control rod and the engine frame would have required a high contact pressure that would have increased the load in the control system. This increased load might have been sufficient to cause the low cycle fatigue failure of the left torque lever. With the modification having been carried out just prior to the accident flight, it is possible that the number of cycles of the lower control rod at the higher loading would have been less than 200; this would make detection of a fatigue failure difficult. Had the left torque lever failed then the pilot would have been unable to control the rotor and the right torque lever would have either failed in overload in the air, or when the gyroplane struck the ground. In summary, with the evidence available, it was not possible to determine if the left torque lever failed when the gyroplane struck the ground, or whether it failed as a consequence of the left lower control rod rubbing against the engine frame.

The layout of the control system is such that there are a number of different ways for it to be set up. Moreover, the lower control rods move up and down in a semi-elliptical path and, consequently, contact between the control rod and the engine frame may only occur part way through the range of movement. Therefore it is essential that the control system is examined for restrictions as it is being moved through its full range of movement. From the available evidence it would appear that the owner undertook the modification, and subsequent adjustments, by himself and would therefore have only been able to check visually for restrictions with the control column set at fixed positions. The investigation also discovered that one of the lock nuts on the control rod had been fully backed off, which raises the possibility that it was not properly locked by the owner following the embodiment of the modification or subsequent adjustment of the control system. It is for these reasons that duplicate inspections are carried out following disturbance of aircraft control systems.

The requirement for duplicate inspections is brought to the attention of owners by PFA Technical Leaflet 2.01‘*Responsibilities of the Aircraft Owner*’, which states:

> *‘Where control systems are broken down and re-assembled (other than those designed for connection prior to each flight by the pilot), duplicate inspections are required. If two PFA inspectors are not available, a pilot/owner may carry out the second inspection.’*

Instructions on the requirement for duplicate inspections following the disturbance of flying controls during maintenance are also provided to PFA inspectors in Notes to PFA Aircraft Inspectors (SPARS). It was noted on another RAF 2000, examined during this investigation, that whilst an inspector had signed for inspecting the work following embodiment of MPD 2006-03, there was no record of the duplicate inspection having been carried out. The owner of the gyroplane confirmed that a duplicate inspection had not been carried out because he did not appreciate that such an inspection was required. There was no requirement in the manufacturers Product Notice (40) and the only indication in the MPD that a further inspection might be required was the following statement:

> *'During embodiment and after completion, the work must be inspected at appropriate stages by a person approved either by the CAA or the PFA. Compliance with this MPD and appropriate inspections should be in accordance with normal PFA procedures and recorded in the aircraft log book.'*

Two people were killed on 21 August 2004 in an accident involving a flexwing aircraft following the incorrect modification of primary structure. Whilst a duplicate inspection was required, it was not carried out. As a result of that accident the following Safety Recommendation was made to the Civil Aviation Authority (CAA):

> **Safety Recommendation 2005-085**: It is recommended that the Civil Aviation Authority ensure that Service Bulletins involving work conducted on primary aircraft structure include a statement that duplicate independent inspections are required, and that both inspections are to be recorded in the aircraft logbook.

In their response to this recommendation the CAA wrote:

> *'The CAA accepts this recommendation insofar as it relates to the need for a duplicate inspection. However, the CAA does not consider it appropriate to amend Service Bulletins with requirements for duplicate/independent inspections. This requirement is contained in the BMAA guide to airworthiness which identifies the need to carry out independent inspections whenever work is carried out on primary structure and the CAA consider this to be the most appropriate place for this information. The CAA has written to the BMAA and microlight aircraft manufacturers requiring them to identify alterations and modifications that affect primary structure in service Bulletins and other change documents.'*

The CAA response relies on the fact that the owner/inspector recognises that the disturbance to the control system, or primary structure, warrants a duplicate/independent inspection. However, some owners might not possess the necessary knowledge to realise that an additional inspection is required. There are also a number of sports aviation aircraft where the wing is fitted, or unfolded, and the control system reconnected prior to flight without there being a need to carry out a duplicate/independent inspection. It is therefore possible that following a modification there could be some confusion as to when a duplicate/independent inspection is required, and therefore the following Safety Recommendation is made:

> **Safety Recommendation 2007–052**
>
> It is recommended that the Civil Aviation Authority includes a statement in all Mandatory Permit Directives affecting aircraft operating under Permits-to-Fly to clearly advise owners if the work content requires a duplicate or independent inspection.

In the absence of any technical evidence of engine or rotor system failure, the possibility of rotor blade to airframe contact due to gyroplane manoeuvring must be considered. The flight tests conducted by the CAA test pilot determined that at air speeds above 70 mph IAS, the gyroplane becomes longitudinally dynamically unstable. Additionally the gyroplane was directionally statically unstable with the doors fitted. Of significance was the pronounced 'open loop' divergent nose-down pitch attitude at 70 mph recorded on the flight test data.

The last four GPS data points recorded on the accident flight are indicative of the gyroplane pitching nose-up then nose-down. The points recorded are groundspeeds of 83 mph, 72 mph, 80 mph and 35 mph. From these ground speeds a tail wind component of 4 mph should be subtracted in order to obtain airspeed, although it should be noted that GPS based speeds are subject to errors arising from inaccuracies in GPS position data. Nonetheless, on that basis the gyroplane was slowed from 79 mph to 68 mph in 4 seconds. This could have been the result of aft cyclic to climb or a reduction in power to slow down or a combination of both. The gyroplane then accelerated from 68 mph to 76 mph in one second. This represents either a large nose-down attitude change and/or an increase in tail wind component. The final data point recorded three seconds later was 31 mph.

It is probable that the rotor blades stopped, as seen by the witness, while the gyroplane was accelerating from 68 to 76 mph, and at that point, only its momentum was carrying it forward. The wreckage indicated a near-vertical impact and therefore the 35 mph data point was not the moment the gyroplane struck the ground. The witness did not hear the engine power reduce but it did appear to stop. This may have been the engine stopping due to the rotor contact with the tail or the pilot suddenly closing the throttle.

Conclusions

From the information set out three possible causes were identified:

1. The pilot suffered either a total or partial incapacitation which may have rendered him unable to control the gyroplane. It pitched rapidly nose-down and the rotor thrust reduced precipitating a 'power pushover'. The rotor blades struck the tail surface and stopped.
2. The pilot had attempted to slow or climb the gyroplane for some reason, moving the cyclic aft of the trimmed, cruise position. The cyclic control was then released and the gyroplane pitched forward resulting in a 'power pushover'. In attempting to correct the nose-down pitch, a positive aft movement of the cyclic was made which caused the rotor blades to strike the tail and stop.
3. A technical failure of the gyroplane structure or flight control system occurred.

The exact cause of the accident could not be determined but the vulnerability of the gyroplane to 'power pushover' during nose-down pitching manoeuvres was considered a factor. The tendency for the gyroplane to be unstable in pitch at speeds above 65 mph was probably a contributory factor. The pilot had gained a level of experience that should have enabled him to maintain control in normal circumstances. If, however, he were distracted or incapacitated, possibly due to the dormant medical condition, this would have reduced his ability to control the gyroplane.

Reference: Houston, S. (1996) *Longitudinal Stability of Gyroplanes*, The Aeronautical Journal of the Royal Aeronautical Society, January 1966 edition.

ACCIDENT

Aircraft Type and Registration:	Robinson R44 Raven, G-EKKO
No & Type of Engines:	1 Lycoming O-540-F1B5 piston engine
Year of Manufacture:	2000
Date & Time (UTC):	11 March 2007 at 1700 hrs
Location:	Hollis Farm, Holmgate Road, Tupton, Chesterfield
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Tail rotor drive severed and damage to tail rotor and gearbox
Commander's Licence:	Private Pilot's Licence
Commander's Age:	46 years
Commander's Flying Experience:	2,722 hours (of which 300 were on type) Last 90 days - 37 hours Last 28 days - 16 hours
Information Source:	AAIB Field Investigation

Synopsis

During the landing manoeuvre, the helicopter suddenly began to vibrate and turn of its own accord. The pilot reacted quickly by landing immediately. The damage was consistent with the tail rotor having been struck.

History of the flight

The helicopter was returning to its base having carried out a training exercise at Sandtoft Airfield. The destination was a private landing site at Hollis Farm and the flight was conducted with the instructor acting as both the commander and the handling pilot. The aircraft was brought to a hover and began to manoeuvre towards the landing site. Having turned through 180º, the pilot proceeded to hover-taxi the helicopter when, according to the pilot's report, it began to "vibrate, shake and judder" and turn of its own accord. The pilot reacted quickly by landing the helicopter immediately and shutting down. Both occupants were uninjured and vacated the aircraft without difficulty. On inspection, the pilot observed that the tail rotor gearbox was missing and the empennage, although in one piece, was almost completely detached.

Subsequent examination of the site by the AAIB

The AAIB visited the site some days after the accident. The Hollis Farm landing site is a confined farmyard with a small hangar to the north, one single-storey house to the east and the main farm house to the south. The approach to the farmyard is dependant on the wind direction. On this occasion the pilot approached from the east into a large sloping field to the south of the farm house. His plan was to transition into the hover, turn back towards the east and hover-taxi to the east above the field and over the farm buildings to land in the yard. The field is level at its western edge and slopes down towards the east. It was following the 180° turn at the top of the field, while hover-taxiing down the slope, that the pilot reported the vibration had occurred.

Wreckage examination

The empennage, including the upper, lower and horizontal stabilisers, was almost detached from the helicopter. Damage to the lower stabiliser was consistent with it having been struck by one of the tail rotor blades whilst they were rotating. The tips of both blades had detached. The rear portion of the tail rotor guard had also separated and was found in several pieces; damage to its tubular construction was consistent with it having been struck from beneath in the area where it attaches to the lower stabiliser.

The tail rotor had become detached from the associated casting in the rear end of the tail boom. A metallurgical examination showed that none of the four attachment bolts had fractured. Three of the attachment lugs had fractured by overload bending and the fourth by a low-cycle, high-peak, cyclic stress, simple bending fatigue mechanism. It is probable that this fourth lug was the first to separate. It was concluded that all the damage resulted from the tail rotor blades being struck.

Discussion

The helicopter had come to rest at the bottom of the field on an easterly heading; however, the tail rotor debris had been collected before AAIB examination of the site and no ground marks were evident to indicate where the tail had struck. During sloping ground operations, the tail rotor is potentially vulnerable as it is some distance behind the pilot.

ACCIDENT

Aircraft Type and Registration:	Rotorway Executive 90, G-BUJZ
No & Type of Engines:	1 Rotorway RI 162 piston engine
Year of Manufacture:	1993
Date & Time (UTC):	27 June 2007 at 1440 hrs
Location:	Willingdale Airfield (disused), Essex
Type of Flight:	Training
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - 1 (Minor) Passengers - None
Nature of Damage:	Damage to main rotor blades, main rotor shaft, tail boom, horizontal stabilizer and canopy
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	42 years
Commander's Flying Experience:	6,500 hours (of which 309 were on type) Last 90 days - 158 hours Last 28 days - 38 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

During the recovery from a practice autorotation the rotor rpm drooped. The instructor took control and attempted to land in a field with standing crop. Shortly after landing the aircraft pitched forward and rolled. The aircraft came to rest on its starboard side and was extensively damaged.

History of the flight

The instructor planned to fly from Street Farm, Takely, to Andrewsfield and return in order to renew the type rating for a pilot whose currency had lapsed. The aircraft lifted at its maximum takeoff weight, and the pilot and instructor flew a variety of general handling manoeuvres, including an autorotation to go-around, uneventfully. About 20 minutes into the sortie, the instructor briefed for a second autorotation to be flown, with a powered recovery, to the hover-taxi. During the recovery, at approximately 15 ft agl, the student raised the collective and simultaneously opened the throttle. Whilst the engine responded, it did not appear to be producing full power and the rotor rpm drooped.

The instructor took control and, having checked that the throttle was fully open, attempted to overshoot. The instructor then realised that the rpm was still decaying, so he decided to land in the standing crop. The instructor was able to reduce the forward speed of the aircraft but shortly after landing the aircraft pitched forward and rolled. The aircraft came to rest on its starboard side and was extensively damaged.

The instructor stated that he had previously experienced low rotor rpm situations in this type of aircraft and had recovered successfully. He believed that the engine may not have been producing full power at the time of the accident. An inspection by the maintenance organisation was unable to identify a cause for any loss of power.

ACCIDENT

Aircraft Type and Registration:	Easy Raider J2.2(2), G-CBXF
No & Type of Engines:	1 Jabiru Aircraft Pty 2200A piston engine
Year of Manufacture:	2002
Date & Time (UTC):	3 June 2007 at 1427 hrs
Location:	Seaton Delavel, Newcastle
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Minor) Passengers - N/A
Nature of Damage:	Damage to the engine mount and cowls, propeller, wing fabric, rudder and undercarriage
Commander's Licence:	Private Pilot's Licence
Commander's Age:	60 years
Commander's Flying Experience:	692 hours (of which 185 were on type) Last 90 days - 10 hours Last 28 days - 6 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft suffered an in-flight engine failure, probably as a result of carburettor icing. Options for landing were limited, and the pilot had to land down wind into a cornfield. During the landing roll the aircraft pitched forward and onto its back. The pilot suffered only bruising and was able to vacate the aircraft without difficulty.

History of the flight

The aircraft took off from a farm strip 13 nm north of Newcastle Airport. The intended route took the aircraft west then south of the Newcastle Control Zone, and included a landing at Fishburn Airfield, 23 nm south of Newcastle Airport. From Fishburn, the intention was to return to the farm strip via a coastal route to the east of Newcastle.

The aircraft departed Fishburn at 1400 hrs with fair weather conditions and an easterly wind of less than 5 kt. As the aircraft approached the coast at South Shields, flying at 1,400 ft, the pilot could see a sea mist encroaching onto the land ahead, obscuring parts of the coast. He increased power and commenced a shallow dive in order to reach a point quickly where he could turn inland away from the poorer conditions. (He was prevented from turning inland immediately by the presence of the Newcastle Control Zone.) At this point the engine faltered; the pilot applied carburettor heat and noted a slight drop in engine speed. Carburettor heat was returned to cold after 30 or 40 seconds and the engine ran normally for a short while. Then without further warning the engine speed reduced to idle. The pilot did not have an adequate view of the beach at this point, so he turned inland, at a height between 700 ft and 800 ft. As he did so the engine stopped.

Options for forced landing were limited, with the majority of fields containing either standing crops or cattle, and with power lines crossing the area. There was also insufficient height or time to turn back into wind, so the pilot committed to a downwind landing into a cornfield. He was aware of the risk that the aircraft would turn over on landing in the crop, described as between 60 and 70 cm high. The aircraft touched down in the intended field, but after a short ground roll it pitched forward onto its back and quickly came to rest. The pilot was wearing a full harness and was able to release himself before vacating the aircraft through the left door. Eyewitnesses alerted the emergency services and went to assist the pilot. However, the pilot had suffered only bruising where he had been wearing the harness.

Discussion

The pilot attributed the engine problems to carburettor icing. He felt that more frequent use of carburettor heat may have avoided the situation. He also started that the speed at which the mist had rolled in from the sea had surprised him, and that he had been preoccupied with quickly getting to a position from where he could turn inland. From the weather information supplied by the pilot (temperature 14.2ºC, dew-point 11.2ºC), the conditions, when plotted on a chart widely used to predict the likelihood of carburettor icing, represented a 'serious risk' of carburettor icing at all power settings.

ACCIDENT

Aircraft Type and Registration:	EV-97 Teameurostar UK, G-CDVU
No & Type of Engines:	1 Rotax 912-UL piston engine
Year of Manufacture:	2006
Date & Time (UTC):	9 July 2007 at 1210 hrs
Location:	Broadmeadow Farm, Hayward, Hereford
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Substantial damage
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	51 years
Commander's Flying Experience:	94 hours (all of which were on type) Last 90 days - 14 hours Last 28 days - 1 hour
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft developed a high rate of descent during the finals turn and subsequently landed short of the threshold in a corn field.

History of the flight

The aircraft returned to Broadmeadow Airfield after a short local flight, and entered the left hand circuit pattern for Runway 28. The pilot selected 2 stages of flap during the downwind leg and reduced speed. During the base leg the pilot estimated his speed to be approximately 65 mph. The pilot described the turn onto finals as tighter than normal. During this turn, on short finals, the aircraft developed a high rate of descent, with a subsequent loss of height and airspeed. The pilot stated that the situation "could not be corrected in time to recover and reach the landing strip, nor could I power out for a go-around". The aircraft wheels contacted the top of the corn in a field approximately 25 m short of the threshold. The aircraft then decelerated through the standing corn and uneven ground in the field before coming to rest upright, approximately 3 m from the runway threshold. The pilot and passenger were uninjured and vacated the aircraft in the normal way.

The pilot stated that the cause of the accident was insufficient airspeed on finals. It is likely that the tight turn onto finals exacerbated this situation.

ACCIDENT

Aircraft Type and Registration:	Powerchute Kestrel microlight, G-MWGV
No & Type of Engines:	1 Rotax 503 piston engine
Year of Manufacture:	1990
Date & Time (UTC):	10 June 2007 at 2041 hrs
Location:	Charlemont, Armagh, Northern Ireland
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Minor) Passengers - N/A
Nature of Damage:	Damage to 'A' frame, foot rest and propeller
Commander's Licence:	No licence held
Commander's Age:	46 years
Commander's Flying Experience:	Approximately 60 hours total
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft collided with a hedge as the pilot attempted to avoid power lines during takeoff. A causal factor was the pilot's decision to take off part-way down the field, rather than use the full length available.

History of the flight

The pilot had already completed one successful 15 minute flight prior to the accident. On the second flight he commenced his takeoff run part way down the field. During the takeoff he realised he would not clear the power lines at the end of the field and steered the aircraft towards a meadow to his right, with the intention of landing again. The meadow was located beyond a river bounded by two hedges. He cleared the first hedge and the river, but collided with the second hedge, causing him to sustain minor injuries.

With hindsight, the pilot believed that the accident could have been avoided if he had used the full length of the field for takeoff.

Aircraft Accident Report No 4/2007

This report was published on 4 September 2007 and is available on the AAIB Website www.aaib.gov.uk

REPORT ON THE INCIDENT TO
AIRBUS 340-642, G-VATL
EN-ROUTE FROM HONG KONG TO LONDON HEATHROW
ON 8 FEBRUARY 2005

Registered Owner and Operator:	Virgin Atlantic Airways Limited
Aircraft Type:	Airbus A340-642
Nationality:	British
Registration:	G-VATL
Location of Incident:	En-route from Hong Kong to London Heathrow
Date and Time:	8 February 2005 at 0330 hrs All times in this report are UTC

Synopsis

The incident was reported to the AAIB by the operator who in turn notified the Dutch Transport Safety Board (DTSB). A Dutch investigation was opened but the following day a formal request was made by the DTSB for the AAIB to assume responsibility for the investigation. The AAIB investigation was conducted by:

Mr J J Barnett	Investigator-in-Charge
Miss G M Dean	Operations
Mr P Sleight	Engineering
Mr M Ford	Flight Recorders

Some 11 hours after takeoff, at about 0330 hrs with the aircraft in Dutch airspace and at Flight Level 380, the No 1 (number one) engine lost power and ran down. Initially the pilots suspected a leak had emptied the contents of the fuel tank feeding No 1 engine but a few minutes later, the No 4 engine started to lose power. At that point all the fuel crossfeed valves were manually opened and No 4 engine recovered to normal operation. The pilots then observed that the fuel tank feeding No 4 engine was also indicating empty and they realised that they had a fuel management problem. Fuel had not been transferring from the centre, trim and outer wing tanks to the inner wing tanks so the pilots attempted to transfer fuel manually. Although transfer was partially achieved, the expected indications of fuel transfer in progress were not displayed so the commander decided to divert to Amsterdam (Schipol) Airport where the aircraft landed safely on three engines.

The investigation determined that the following causal factors led to the starvation of Inner fuel tanks 1 and 4 and the subsequent rundown of engine numbers 1 and 4:

1. Automatic transfer of fuel within the aircraft stopped functioning due to a failure of the discrete outputs of the master Fuel Control and Monitoring Computer (FCMC).

2. Due to FCMC ARINC data bus failures, the flight warning system did not provide the flight crew with any timely warnings associated with the automated fuel control system malfunctions.

3. The alternate low fuel level warning was not presented to the flight crew because the Flight Warning Computer (FWC) disregarded the Fuel Data Concentrator (FDC) data because its logic determined that at least one FCMC was still functioning.

4. The health status of the slave FCMC may have been at a lower level than that of the master FCMC, thus preventing the master FCMC from relinquishing control of the fuel system to the slave FCMC when its own discrete and ARINC outputs failed.

During the investigation the AAIB issued six safety recommendations. Two were published in Special Bulletin S1/2005 on 08 March 2005 and four more in an interim report published in the February 2006 AAIB Bulletin.

Findings

1. The flight crew were properly licensed, adequately rested and medically fit to conduct the flight.

2. The flight crew operated the aircraft within the limits laid down by the operator's Flight Time Limitations scheme.

3. The crew carried out all normal operating procedures in accordance with their company Operations Manual, both before and during the flight.

4. The flight crew were aware of the FCMC resets which had occurred on the previous flight sector from Sydney.

5. Before departing Hong Kong Airport the flight crew performed a successful computer reset for both FCMC1 and FCMC2.

6. The first perception of a problem, by the flight crew, was when No 1 engine lost power at 0328 hrs.

7. No 1 engine ran down due to fuel starvation when its feed tank ran dry.

8. No 4 engine started to run down due to fuel starvation as its feed tank emptied.

9. At the time of the engine rundowns there was sufficient fuel on board the aircraft for the remainder of the flight to Heathrow.

10. There was no fuel leak.

11. The arousal levels of the flight crew at the time of the engine rundown were likely to have been low.

12. Following the run down of No 1 engine, the flight crew did not review the aircraft fuel status in sufficient detail to notice the impending fuel starvation of No 4 engine.

13. The flight crew attempted a relight of No 1 engine at FL380, whereas the QRH states that the maximum guaranteed altitude for a relight is FL300.

14. No 1 engine failed to relight due to the aircraft's high altitude when the relight was attempted.

15. Because there were no timely ECAM warnings of automatic fuel transfer failures, the flight crew invoked the 'TRIM TANK FUEL UNUSEABLE' procedure from the QRH.

16. The flight crew perceived that the TRIM TANK FUEL UNUSEABLE' procedure was not working because no fuel transfer arrows were displayed on the ECAM fuel SD page and significant changes to the quantity indications were not easily identified.

17. When the flight crew perceived that fuel was not transferring manually, they resorted to iterative use of other fuel transfer failure procedures listed in the FCOM compendium of emergency procedures.

18. ATC communications were good.

19. The FDR sampling rate of FCMC faults meant that it was possible for a fault lasting up to three seconds not being recorded.

20. Automatic fuel transfer ceased at 1934 hrs which was almost 8 hours before No 1 engine lost power.

21. The automatic fuel transfers stopped due to a failure of the discrete outputs from the master FCMC.

22. After 1934 hrs, the fuel remaining in Inner fuel tanks 1, 2, 3 and 4 became the only fuel usable by each engine respectively, until the selection of manual fuel transfers.

23. There were no fuel system related flight warnings following the failure of the automatic fuel transfer system.

24. Failure of the automatic fuel transfer system did not result in the aircraft's CG position exceeding the in-flight limits.

25. Total fuel quantity (as opposed to useable fuel quantity in the engine feed tanks) continued to be displayed on the SD fuel status page.

26. The flight crew did not recall seeing any amber on the fuel system display page throughout the flight.

27. The selection of the fuel cross feed valves prevented the complete rundown of No 4 engine.

28. Bench tests of FCMC1 and FCMC2 did not reveal any faults.

29. Bench tests of FDC1 and FDC2 did not reveal any faults.

30. The lack of fuel system flight warnings was due to a failure of the ARINC output buses A and B from the master FCMC.

31. A failure of both FWCs did not occur.

32. Bench tests of FWC1 and FWC2 did not reveal any faults.

33. Bench tests of SDAC1 and SDAC2 did not reveal any faults.

34. The FDC would have generated a low fuel quantity discrete, triggered at a fuel level below that for which a low fuel level signal was generated by the FCMC.

35. Because total fuel quantity was being displayed on the ECAM fuel SD page, at least one FCMC was still delivering an output.

36. The FWCs disregarded the FDC low fuel level discrete (the alternate or back-up warning signal) because one FCMC was still delivering an output.

37. FCMC2 was most likely the master FCMC at 1934 hrs.

38. The slave FCMC (probably FCMC1) may have had a lower health level, due to previous failures, than the master FCMC at 1934 hrs.

39. The slave FCMC was not able to take control as master FCMC due to its lower health status.

40. The slave FCMC was still outputting fuel quantity data on its ARINC output buses A and B.

41. The failure of the ARINC output buses A and B from the master FCMC caused a lack of fuel transfer arrows on the ECAM SD fuel display following the operation of manual fuel transfers.

42. The PFR and TSD, albeit with limitations, proved invaluable in this investigation.

43. The PFR limitations prevented a full determination of fault frequency and reasons for fault indications during the incident flight.

44. The FCMC TSD only recorded the last eight detected faults in its memory, limiting a determination of the first failure events.

45. The presentation of FWC and DMC TSD in hexadecimal code was difficult to interpret and required the aircraft manufacturer to decode the data.

46. 'FCMC1(2) FAULT' indications were common occurrences.

47. The reason for frequent 'FCMC1(2) FAULTS' was disagreements between the COM and MON processes created by asynchronous processor clocks.

48. There was an aircrew operational notice which removed the requirement for crews to make a technical log entry for a single FCMC failure with successful reset during flight.

49. Maintenance action following a 'FCMC1(2) FAULT' was to carry out a reset and BITE test. If this was satisfactory the aircraft was dispatched.

50. G-VATL had suffered a long term fault with the Inner 4 tank temperature sensor, later found to be due to a loose connector.

51. EASA CS-25 does not require an independent low fuel level warning system.

52. EASA CS-23, CS-27 and CS-29 all require independent low fuel level warnings.

Safety Recommendations

The following safety recommendations were made:

Safety Recommendation 2005-36

Airbus should review the FCMC master/slave determination logic of the affected Airbus A340 aircraft so that an FCMC with a detected discrete output failure or ARINC 429 data bus output failure cannot remain the master FCMC or become the master FCMC.

Safety Recommendation 2005-37

Airbus should review the logic of the low fuel level warnings on affected Airbus A340 aircraft so that the FDC low fuel level discrete parameter always triggers a low fuel level warning, regardless of the condition of the other fuel control systems.

Safety Recommendation 2005-108

It is recommended that the European Aviation Safety Agency introduces into CS-25 the requirement for a low fuel warning system for each engine feed fuel tank. This low fuel warning system should be independent of the fuel control and quantity indication system(s).

Safety Recommendation 2005-109

It is recommended that the European Aviation Safety Agency should review all aircraft currently certified to EASA CS-25 and JAR-25 to ensure that if an engine fuel feed low fuel warning system is installed, it is independent of the fuel control and quantity indication system(s).

Safety Recommendation 2005-110

It is recommended that the USA's Federal Aviation Administration should introduce into FAR-25 a requirement for a low fuel warning system for each engine feed fuel tank. This low fuel warning system should be independent to the fuel control and quantity indication system(s).

Safety Recommendation 2005-111

The Federal Aviation Administration should review all aircraft currently certified to FAR-25 to ensure that if an engine fuel feed low fuel warning system is installed, it is independent of the fuel control and quantity indication system(s).

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2005

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

Published November 2005.

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

Published December 2005.

2006

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

Published January 2006.

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

Published November 2006.

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

Published December 2006.

2007

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

Published January 2007.

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

Published March 2007.

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

Published May 2007.

4/2007 Airbus A340-642, G-VATL
en-route from Hong Kong to London Heathrow
8 February 2005

Published September 2007.

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