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INCIDENT

Aircraft Type and Registration:	Avro 146-RJ100, G-CFAH
No & Type of Engines:	4 Lycoming LF507-1H turbofan engines
Year of Manufacture:	2001
Date & Time (UTC):	29 March 2005 at 1819 hrs
Location:	London (City) Airport
Type of Flight:	Public Transport (Passenger)
Persons on Board:	Crew - 5 Passengers - 104
Injuries:	Crew - None Passengers - None
Nature of Damage:	Tail scrape protection strip damaged
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	34 years
Commander's Flying Experience:	5,725 hours (of which 2,549 were on type) Last 90 days - 167 hours Last 28 days - 66 hours
Information Source:	AAIB Field Investigation

Synopsis

The first officer had stabilised the aircraft on an ILS approach, at night, to Runway 10. At 400 ft the commander sighted the runway lights, took control in accordance with the Operator's procedures and disconnected the autopilot and autothrottle. During the landing flare the rate of descent appeared to be high and the commander corrected this by increasing the pitch attitude. The aircraft touched down at a body angle that exceeded the safe limit, causing the underside of the rear fuselage to contact the runway surface.

History of the flight

The crew had rested for 14 hours and 20 minutes before reporting for duty. The aircraft departed Geneva at 1650 hrs and the transit to London (City) Airport was uneventful. This was the crew's third sector of the day and was to be their second landing that day at London (City) Airport.

The forecast weather was poor and the crew loaded additional fuel. They briefed for a monitored ILS approach to Runway 10, with the first officer (FO) as the pilot flying (PF); the briefing considered the actions to be taken in the event of a go around at decision altitude. The aircraft operator's procedures required that landings by 146-RJ100s, at London (City), were to be flown by the aircraft commander. He should take control of the aircraft when he had acquired sufficient visual references to land.

The crew expected to land at a weight slightly above 39 tonnes and used the associated V_{ref} of 122 kt; 5 kt was then added to this to give an approach speed of 127 kt. In accordance with the manufacturer's landing profile, this should result in a predicted touchdown speed of 115 kt ieV_{ref} -7 kt.[1] The centre of gravity was at a mid position.

ATC radar vectored the aircraft onto an intercept heading to establish on the ILS localiser for Runway 10. The aircraft intercepted the localiser with the autopilot and autothrottle both engaged, the landing gear DOWN and the flaps set at 33º. As the aircraft intercepted the 5.5º glideslope, the airbrake was selected and the aircraft commenced the descent. At 500 ft on the Radio Altimeter (RA), the approach was confirmed as stable and at 400 ft RA the commander saw the runway lights through the rain, took control, and disconnected the autopilot and autothrottle. The decision altitude for the approach was 360 ft.

The speed remained stable at 127 kt until 200 ft RA when the FO noted an increasing speed trend. The commander reduced thrust by approximately 1% N1: this was in addition to the automatic 2% reduction, applied by the engines' full authority digital engine control system (FADEC), when the autothrottle had been disconnected.

Indications from the PAPIs confirmed that the aircraft was on the correct glide slope and, two to three seconds after the automatic call of "100 ft" (RA), the commander reduced thrust to achieve a touch down speed of 115 kt. The FO, who had been monitoring the flight instruments, saw that the IAS had decreased at one point to 120 kt, but this had been corrected immediately and the speed accelerated through 122 kt. At about 60-70 ft RA the commander noticed that the rate of descent was high and at about 40-50 ft RA he commenced the landing flare. The FO saw an IAS of 117 kt during the flare, but with a higher than normal rate of descent and almost immediately sensed the 'ground-rush'.

The touchdown was heavier than normal but the aircraft was able to stop well within the available runway length. ATC considered that a possible tail scrape had occurred and initiated a runway inspection. An external inspection of the aircraft revealed that the tail protection strip had contacted the runway surface causing light damage to the protector plate; the flight crew were unaware that this damage had occurred.

Weather conditions

The synoptic situation at 1800 hrs on the day of the incident, showed an area of low pressure, and its associated frontal systems, moving slowly east along the English Channel. The weather in the area was light rain which reduced the surface visibility to 2,000 m, with an overcast cloudbase of 400 ft and a mean sea level pressure of 1011 hPa.

The relevant TAF for London (City) Airport forecast the following conditions between 1600 hrs and 2200 hrs:

Surface wind from 070º at 10 kt, visibility 2,000 m in mist, cloud overcast at 500 ft, temporarily lowering to 400 ft, with temporary rain between 1800 hrs and 2200 hrs.

The METAR at London (City) Airport, issued at 1820, contained the following information:

Footnote

[1] Radar vectoring resulted in more fuel being used and the aircraft eventually landed at a weight of 38.7 tonnes; the correct V_{ref} for this weight is 121 kt. However, the V_{ref} of 122 kt calculated by the crew is used throughout the report.

> *Surface wind from 060º at 09 kt, visibility 2,000 m in light rain, overcast cloud at 400 ft, temperature 7ºC, dewpoint 7ºC and pressure 1,011 hPa.*

London (City) Airport

London City airport has a single, concrete runway, orientated 28/10, which is 1,508 m long and 30 m wide. The Landing Distance Available (LDA) for Runway 10 is 1,319 m and the threshold elevation is 16 ft. The end of the touchdown zone is defined by two pairs of white, high-intensity lights, either side of the runway centreline and positioned 360 m from the runway threshold. The PAPIs are set to an approach angle of 5.5º, coincident with the ILS glideslope.

Steep approach, Standard Operating Procedures (SOPs)

The aircraft flight Manual sets out the procedures to be followed when conducting steep approaches. The steep approach mode is available for airports with a glideslope between 4.5º and 6º.

On intercepting the glideslope the airbrake should be selected OUT and the approach speed (V_{ref} + 5 kt) maintained. The approach must be made with the flaps at 33°, the airbrake must be operative and visual precision approach path guidance (PAPI or cockpit display of ILS) appropriate to the steep approach angle must be used. The decision height must not be less than 200 ft above the runway threshold elevation or the obstacle clearance altitude/height (OCA/H), whichever is the greater. When a coupled ILS approach is carried out, the autopilot and autothrottle may remain engaged down to 160 ft above the runway threshold elevation. When approaching the runway, speed should be reduced to cross the threshold screen height of 50 ft at the threshold speed (V_{ref}).

The aircraft is fitted with a steep approach system which desensitises the altitude rate warning from the GPWS. This is selected ON before the steep approach is commenced.

Manufacture's Flight Operations Bulletin

In June 1989 the manufacturer issued a Flight Operations Bulletin covering 'the risk of tail strikes'. The bulletin related to the 146-300 but applies equally to the RJ100 variant and mainly covered the takeoff phase of flight.

The final paragraph of the bulletin addresses the landing phase of flight and states:

> *'With regard to the possibility of a tail strike occurring on landing, it is our opinion that this can only occur if a late flare is made from a high sink rate which would result in a heavy landing. On the -300 this implies a pitch incidence of about 8° at touch-down and a rate of decent in excess of 10 ft/sec. This is not a normal landing and cannot be considered to be typical of an in-service approach and landing'.*

Operator's Flight Operations Manual

The operator's Flight Operations Manual, Part B, contains guidance on the conduct of the steep approach and landing and considers the most likely causes of tail strikes. The guidance is as follows:

> *'Speed control is crucial during the approach and a high speed approach must be avoided as it results in the thrust levers being retarded to a position from which a rapid engine response cannot be guaranteed.*
>
> *The engine air switches must be selected OFF before 200 ft on the final approach to guarantee the Go-Around performance from the steep approach. The autopilot must also be deselected not later than 160 ft above touchdown, no Cat 2 or 3 is available from a steep approach.*
>
> *Aircraft handover from P2 to P1 occurs whenever*

the P1 is satisfied that a successful landing can be completed. Due to the higher descent rate start to retard the thrust levers at approximately 100 ft AAL at a rate to achieve flight idle on touchdown. The steeper approach attitude requires a greater attitude change to achieve the landing attitude; it is this greater flare that can lead to the increased possibility of a tail strike.

The most common cause of a tail strike on landing is a fast approach. This leads to a prolonged time in the flare, followed by a rapidly increasing ground closure rate. It is then very tempting to reduce the rate of descent by additional flaring. This technique will NOT reduce the rate of descent - at best it will cause a heavier landing than anticipated by rotating the main wheels into the ground; however it will also be very likely to cause a tail strike. The second most likely cause is an approach where, because of higher than expected ground closure rate, – (as in a steep approach) – the pilot either flares too early (causing subsequent 'sink' in the flare) or again prolongs the flare with a similar eventual effect. The 'sink' or rapid ground closure can provoke or tempt a further flare or over rotation, again causing a heavy landing with a likely tail strike.

There is no fixed advice on pitch angles for a correct landing, indeed, the pilot should be looking out at this point rather than at the PFD. For guidance, it is rather unusual to require more than four degrees pitch up in a correctly executed flare-to-land, this flare should not be increased even if it is felt that the ground closure rate is too high. A high rate of descent at this point may be checked by the application of power – always provided the runway performance permits. The technique of 'feeling' for the runway, by continuing to increase the body angle to try and achieve a smooth landing should never be used. A landing from a steep approach should be firm, as the runways are usually fairly short.

Flight Recorders

The aircraft was fitted with a Solid State Flight Data Recorder (FDR) and a Cockpit Voice Recorder (CVR). Both recorded details of the approach and touchdown.

A time-history of the relevant parameters during the incident is shown in Figure 1 as a solid line. For comparison, data is also presented in Figure 1 for a normal landing carried out earlier that day by the same crew at London City Airport in G-CFAH (time-aligned for main-wheel touchdown), this is depicted as a dashed line.

The final descent into London (City) Airport commenced from 2,000 ft RA, two minutes before touchdown, with the flaps at 33º, landing gear DOWN and the airbrake deployed. The speed during the descent varied between V_{ref} and V_{ref} +5 kt calibrated airspeed (CAS).

The data presented for the incident landing starts just over 18 seconds before the touchdown with the aircraft on the glideslope at 320 ft RA, 127 kt CAS (ie V_{ref} +5); descending at about 1,200 ft/min, with about 58% N1 on each engine[2]. Autothrottle was engaged throughout the descent until 300 ft, 17 seconds before touchdown.

Immediately after the disengagement of the autothrottle, the N1 for each engine reduced by about 3%, consistent with the FADEC synchronisation of the N1s to that of engine No 2 (the default master engine for such

Footnote

[2] For clarity, only the Power Lever Angle (PLA) and N1 for engine No 4 are shown. These are, however, representative of the other three engines.

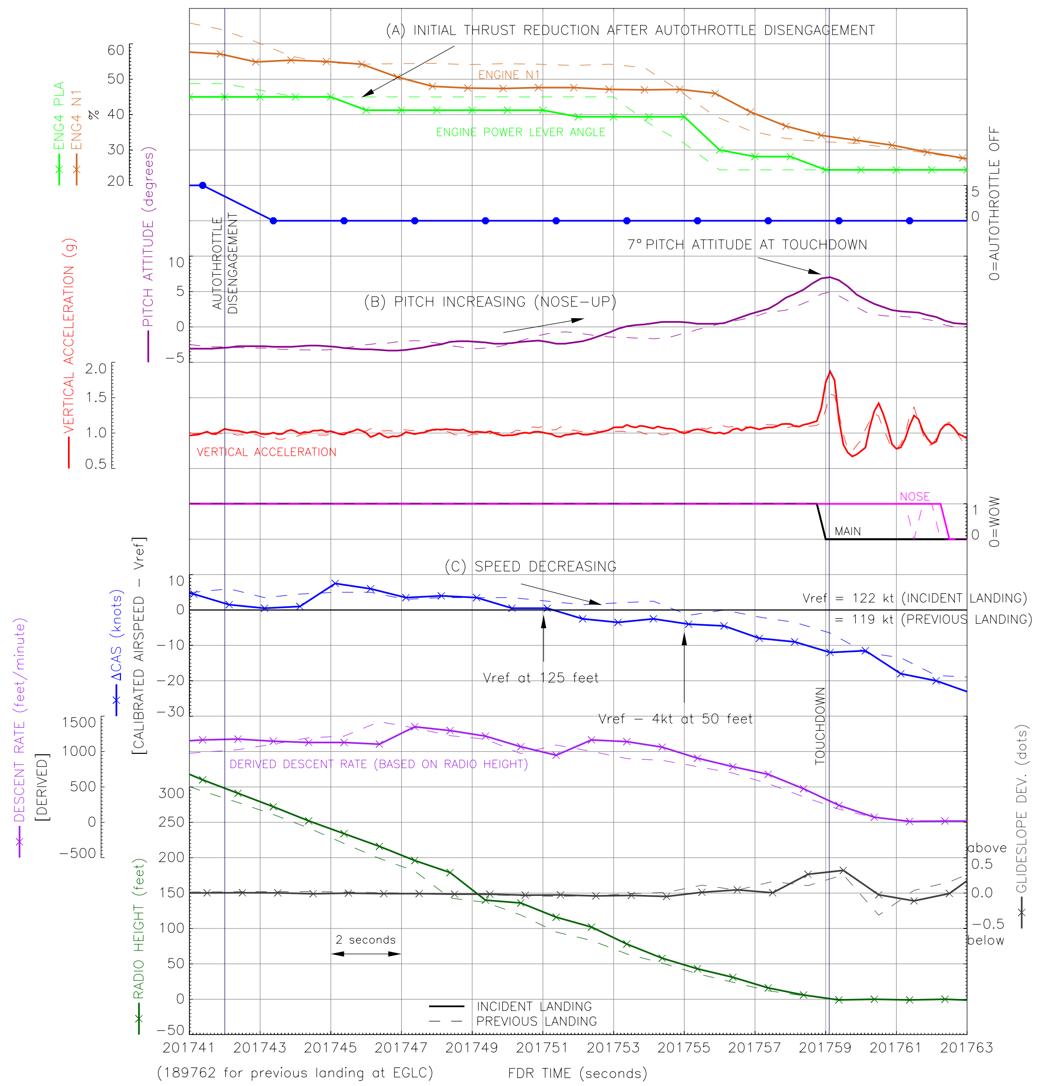


Figure 1

Salient FDR Parameters
(Incident to G-CFAH on 29 March 2005)

synchronisation) as engine control reverted back to manual control (or Thrust Modulation mode).

Three seconds after the disengagement of the autothrottle, the power levers for all four engines were retarded slightly, reducing N1 to 48% two seconds later (Point A of Figure 1). As the aircraft descended, its pitch began to increase (Point B of Figure 1) and the airspeed began to decrease (Point C of Figure 1) while maintaining the 5.5º glideslope. At 125 ft, with the airspeed at V_{ref}, the power levers were further retarded causing a slight reduction in N1. At 50 ft, when the power levers were retarded for the flare, the airspeed had decreased to V_{ref} –4 kt and the descent rate was about 1,060 ft/min (compared with V_{ref} and about 880 ft/min for the previous landing[3]).

Six seconds before touchdown, the aircraft pitch had

Footnote

[3] The derived descent rates are calculated from the rate of change of Radio Height above terrain height. The terrain height below the final part of the glideslope into London City is level (water then runway) and therefore provides an accurate and consistent measure of descent rate for this late stage of the approach.

increased to just above 0º, where it remained for three seconds before increasing steadily until touchdown. At touchdown the pitch attitude was 7º, the airspeed was V_{ref} –11 kt and the descent rate was 480 ft/min (compared with 5º, V_{ref} –6 kt and 360 ft/min respectively for the previous landing).

Aircraft information

The BAe 146 was the first aircraft to be Certificated to the JAR Part 25 requirements. The series 100 & 200 achieved UK Type Certification in February and June 1983 respectively. The Series 300, introduced to accommodate more passengers, was developed in the late eighties and received Type Certification in September 1988. Further significant developments, included: upgraded avionics, a Cat III landing capability and auto-throttle & FADEC controlled engines which were approved in April 92. This modification development was also co-incident with the remarketing of the aircraft as the Avro 146-RJ Series.

The length of the aircraft's fuselage was increased from 85 ft 11 in to 101 ft 8 in during this development. This was achieved by inserting a fuselage plug forward and aft of the wing. This increase in length reduces body angle clearance from 8.3º to 6.9º (with the main landing gear compressed).

Following the manufacturer's own test flights, the certification by the UK CAA of the steep approach profile for the 146 RJ100 was completed in 1995. The flight was made using a BAe146-300 series aircraft which has the same overall length and geometry as the RJ100. The object of the test was to clear the aircraft for steep approaches up to 5.5º glidepath angle. Some steep approach work had been done previously at a glidepath angle of 5º.

The Certification test flight included 11 approaches at a high gross mass with a forward CG. The flight examined a number of 'abuse' cases which represented the aircraft being flown at air speeds greater and less than the approach profile speeds and following a glidepath angle 2º steeper than that being requested. The 5.5º glidepath was flown at V_{ref} ± 5kt and the 7.5º glidepath abuse case was flown at V_{ref} +5 kt. The approaches were made to go-around, to assess the height loss under missed approach conditions. The test concluded that when the aircraft is flown on a 5.5º glidepath at V_{ref} - 5kt it was approaching a pitch limiting attitude (7º with a 10º geometric limit).

Stabilised Approach Criteria

The following stabilised approach criteria are set out in Part B of the operator's Operations Manual:

On all approaches:

At 1,000 ft RA, the aircraft should be in the planned landing configuration and on the correct glidepath. The airspeed should be 155 kt or less. If these criteria are not achieved consideration should be given to discontinuing the approach.

At 500 ft RA, the aircraft must be established in the planned landing configuration, the glideslope or correct vertical profile established, approach power set and indicated airspeed no more than V_{REF}+20 kt. If these criteria are not achieved then an immediate go-around must be carried out.

Analysis

The crew had achieved the required rest period prior to reporting for duty and they did not consider fatigue to be a factor contributing to the incident. The approach speed of 127 kt had been correctly calculated for the expected landing weight of slightly above 39.0 tonnes and the aircraft had been properly configured for the steep approach.

Earlier in the day, the crew had carried out an approach and landing at London (City) Airport in similar weather conditions to those prevailing at the time of this incident. From the FDR data it was established that the earlier approach and landing had followed the speed and height profile promulgated by the manufacturer. The subsequent approach, whilst initially stabilised at the correct speed, began to deviate from the landing profile when the airspeed reduced from V_{ref} + 5 kt at 150 ft to V_{ref} at 125 ft, instead of at the screen height of 50 ft. Engine thrust was also set lower than that required, the thrust levers having been moved aft when the autothrottle was disengaged. Whilst the pilot maintained the correct 5.5º glidepath, the airspeed decayed to V_{ref} -4 kt at 50 ft, at which point the power levers were retarded for the flare; the rate of descent was now 1,060 ft/min, compared to 880 ft/min at the same height on the previous landing. This high rate of descent may have been the visual cue which prompted the pilot to increase the aircraft pitch attitude in order to reduce that rate of descent.

Whilst surface wind was considered not to be a factor in the incident, the poor weather had been considered by the flight crew. Extra fuel was carried and a full briefing on the actions to be taken in the event of a go around at decision altitude was carried out in accordance with the SOPs. The crew fully expected to have to divert from the approach but obtained the required visual landing reference just above decision altitude.

The Operations Manual guidance on "*the most likely cause of tail strikes",* identifies both "*fast approaches"* and the "*higher than expected ground closure rate"* which results from steep approaches. The need to accurately maintain the target speed and not allow excess speed to develop when landing at London (City) Airport was clearly appreciated by the crew, particularly on the wet runway that night. The decreasing airspeed was noted by the FO just prior to the flare but this appeared to be corrected as he noted the increasing speed trend on the PFD airspeed indication.

Safety Actions

Since the incident, the operator has reviewed the conditions which lead to tail strikes with the BAe 146 RJ100 and has identified preventative measures developed from discussions with the manufacturer and from trials carried out in the training simulator.

An Operations Manual Amendment Notice (OMAN) was issued on 3 June 2005, promulgating the policy for the pilot not flying (PNF) to alert the pilot flying (PF) to an excessive nose up pitch attitude on approach or landing. The policy stated:

> *"For all approaches/landings, if a higher than normal pitch attitude is recognised (5° or above) in the final stages of the approach/flare the PNF must call "Attitude".*
>
> *If "Attitude" is called the PF must not increase the pitch attitude any further but is to either accept the current attitude for landing or conduct a go around".*

In order to support the OMAN, a comprehensive Tail Strike Prevention training package has been developed by the operator for use during each pilot's recurrent simulator training. It follows the normal convention of briefing, simulator demonstration by the instructor and exercises flown by the crew under training, followed by debriefing. The training addresses in detail speed control with thrust, particularly when correcting loss of airspeed, and the amount and duration of the thrust increase required, not only to prevent further loss of airspeed but to re-establish the target airspeed.

Clarification of the effect on landing distance required when applying a gust factor is also covered. An increase in the landing distance required is related to airspeed above the targets stated in the manufacturer's landing profile and specific calculations are applied utilising generalised flight manual landing data.

Throughout the training, the need to execute a go-around where there is a loss of profile target speeds or when a high nose-up pitch angle develops, is emphasised. The time taken from 50 ft to touchdown is approximately five seconds and a demonstration of a go-around from 50 ft with the airspeed at V_{ref} -5 kt is given. Emphasis is placed on the need to ensure that care should be taken not to over rotate the aircraft which might lower the main landing gear wheels onto the runway, causing structural damage. The crew under training then carry out a go-around at least twice from a height of 50 ft or below. The operator has also introduced a requirement for approaches to London (City) to be made at least every three months. Specific training on such approaches is included in the biannual simulator training.

Conclusions

This tail scrape incident occurred because the thrust set, three seconds after the disengagement of the autothrottle, was too low to maintain the required airspeed for the landing profile whilst the commander attempted to maintain the correct glideslope. A high rate of descent developed which the commander attempted to reduce by increasing the flare which caused the aircraft fuselage to exceed the body contact angle of 6.9º causing minor damage to the tail strike protection plate.

The safety actions carried out by the operator in addressing the issue of tail strike prevention provides valuable information for flight crews, in particular the increment of airspeed above V_{ref} that may be carried without increasing the landing distance required.

Safety Recommendation 2006-095

It is recommended that BAE Systems review the work jointly undertaken with the operator regarding tail strike prevention on the Avro 146-RJ100 aircraft with a view to promulgating the information to other operators.

INCIDENT

Aircraft Type and Registration:	Boeing 737-76N, G-STRH
No & Type of Engines:	2 CFM56-7B22 turbofan engines
Year of Manufacture:	2002
Date & Time (UTC):	7 March 2006 at 0945 hrs
Location:	Bristol International Airport
Type of Flight:	Public Transport (Passenger)
Persons on Board:	Crew - 6 Passengers - 38
Injuries:	Crew - None Passengers - None
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	57 years
Commander's Flying Experience:	15,000 hours (of which 7,500 were on type) Last 90 days - 125 hours Last 28 days - 47 hours
Information Source:	AAIB Field Investigation

Synopsis

Whilst establishing on the ILS for Runway 09 at Bristol Airport, the flight crew conducted a visual orbit to lose height prior to intercepting the glidepath. During this orbit, which was flown without flight director assistance, the aircraft was subject to a strong southerly wind causing it to roll out with full localiser deflection, north of the ILS centreline. At this point the aircraft was approximately 600 ft below the glidepath and below the minimum radar vectoring altitude; the crew however, were visual with the ground in the vicinity of the airfield. At 3 nm from the runway threshold, having still not re-established on the ILS localiser, the Bristol Airport tower controller instructed the aircraft to go-around. A further radar vectored ILS approach was flown and the aircraft landed from this without incident.

History of the flight

The aircraft and crew were scheduled to fly from Manchester to Banjul, Gambia via a stop at Bristol Airport. They departed from Manchester Airport at 0920 hrs and after contacting Bristol Radar at 0941 hrs, were vectored onto the ILS localiser for Runway 09. The aircraft was initially cleared to descend to an altitude of 2,500 ft and intercepted the localiser at 8 nm from the airfield whilst descending through 3,500 ft (see Figure 1). After the flight crew called that they were established on the localiser, the radar controller transmitted 'DESCEND WITH THE ILS, CONTACT BRISTOL TOWER 133.85'. The crew checked in with the tower controller, who was a trainee under supervision, and were given clearance to land. However, the first officer who was the handling pilot and who was manually flying the aircraft using flight

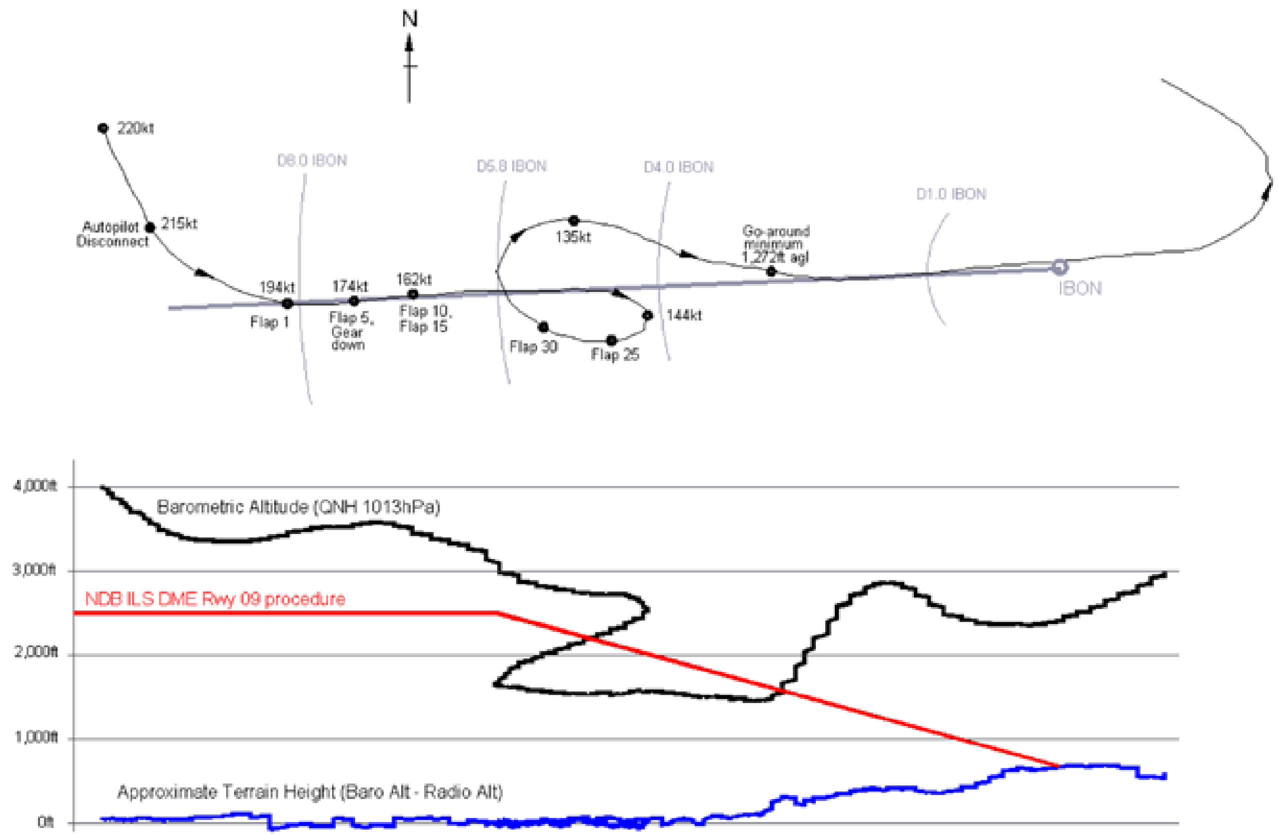


Figure 1

Aircraft positional data derived from its Quick Access Recorder

director commands, requested an orbit to lose height. At this time the aircraft was level at 2,800 ft, approximately 500 ft above the glidepath, and 5 nm from the runway threshold. The aircraft was cleared by ATC to fly the orbit and the aircraft commander declined the controller's offer of radar vectors to assist in re-establishing on the ILS. The first officer commenced a right descending turn and then switched off his flight director as it continued to give steering information towards the localiser. During the orbit, the aircraft was subjected to a strong southerly wind and the tower controller, using his radar monitor in the visual control room, could see the aircraft flying through the localiser to the north of the centreline. He transmitted 'YOU ARE GOING TO CLOSE THE FINAL APPROACH TRACK FROM THE NORTH PROBABLY AT LESS THAN A FOUR MILE FINAL, ARE YOU VISUAL WITH THE AIRFIELD?' The commander replied that they were not visual and the tower controller directed them to maintain 1,500 feet until established back on the ILS. At this point the aircraft was level at 1,500 ft; approximately 800 feet below the ILS glidepath (see Figure 1). The tower controller became concerned at the aircraft's slow progress in re-establishing onto the localiser and when the range to the runway threshold reached 3 nm, he instructed the aircraft to go-around. The flight crew realised that they were not going to intercept the localiser before capturing the glidepath and were on the point of initiating a go-around when they were instructed to do so by the tower controller.

The first officer flew the go-around manually until level at 3,000 feet and then engaged the flight director and autopilot. At this point the aircraft descended to 2,500 feet which was the previously cleared altitude still selected on the Mode Control Panel (MCP). The first officer selected 3,000 feet on the MCP and the aircraft climbed back to this altitude before a further radar vectored ILS approach was flown. The aircraft landed without incident.

Flight Recorders

The aircraft operator provided the AAIB with data which had been recorded by the Quick Access Recorder (QAR). The data covered the period from the initial approach to Bristol until the eventual landing and was used to derive Figure 1. Due to the late notification of the event the Cockpit Voice Recorder had continued to run and the pertinent recordings had been overwritten.

Meteorology

An aftercast from the Met Office revealed that the area was subject to a moistening south-westerly flow as a warm front moved across Cornwall and Devon from the west. At the time of the incident, Bristol Airport reported a surface wind of 130° at 16 kt, 8,000 metres visibility in light rain, cloud scattered at 700 ft and broken at 1,200 ft above the airfield. However Bristol Airport is situated at approximately 600 ft above sea level on the crest of a hill and as such can be subject to significantly different weather from that encountered on its approaches. The aftercast suggested that in the area where the aircraft executed its orbit, the visibility would have been 7-9 km in rain and there would have been some stratus cloud with a base of between 1,000 and 1,800 ft with further strato-cumulus cloud at a base of between 3,000 and 4,000 ft. The wind at 2,000 ft was estimated to be from 190º at 35-40 kt. The flight crew reported that they completed the original orbit in good VMC and although not always visual with the Airport, which is on the crest of a 622 foot hill and was at the time covered by a broken cloud layer, they were visual with the ground at all times.

Air Traffic Control

Bristol Manual of Air Traffic Services Part 2 Section 1 Chapter 5 states that:

> *'orbits by jet aircraft on final approach below altitude 2,500 feet either to be positioned in traffic or to lose height are not permitted. Aircraft already below this level should be instructed to climb on runway heading to altitude 3,000 feet. If the aircraft is with ADC (aerodrome controller), co-ordination with APC (approach controller) must be effected and, if necessary, aircraft should be transferred to APC for repositioning.'*

Discussion

The flight crew allowed the aircraft to descend significantly below the ILS glidepath, the minimum sector altitude and the minimum radar vectoring altitude with the airfield weather less than the company minima. This situation developed as a result of arriving at the final approach fix approximately 500 ft above the ILS glidepath. Anticipation of the likely approach path and awareness of the wind may have prevented this original situation from occurring but inevitably there will be occasions when aircraft have excess height to lose in order to intercept the glidepath. In these instances, repositioning the aircraft back onto the ILS at a more suitable height avoids the need for a high rate of descent to intercept the ILS glidepath.

Although the aircraft was in communication with Bristol Tower, control of the aircraft remained with Bristol Radar and it was necessary for the tower controller to liaise with the radar controller to approve any deviation from the original ILS clearance. Both tower and radar controllers approved the flight crew's request for an orbit but the requirement for the aircraft to maintain a minimum of 2,500 ft whilst orbiting was overlooked. This restriction, although designed to abate aircraft noise, would have kept the aircraft at the ILS platform altitude for re-establishing on the localiser. However, the tower controller, whilst monitoring the aircraft's height and position on the visual control room's radar, made a timely decision to limit the aircraft's descent to 1,500 feet until established back on the ILS.

The flight crew considered that an orbit was a pragmatic option to lose height given that they were in good VMC at that point and in visual contact with the ground. At no time were the speed, vertical rates, roll rates, terrain closure, terrain clearance or configuration changes outside the company limits. There was no concern over the lack of visual airfield references as they were intending to re-establish on the ILS for their final approach. The reported airfield weather was below circling minima which made it imperative that they re-established at the earliest opportunity. As they commenced their orbit, the decision by the first officer to deselect his flight director meant that he was flying on attitude only. He did this primarily because the flight director was giving steering information towards the localiser and it is the operating company's policy to switch the flight director off rather than fly contrary to its indications. However, deselecting the flight director also removed vertical steering information other than the ILS glidepath indication and therefore any positive guidance on a level off altitude. The MCP altitude window continued to display 2,500 feet whilst the aircraft descended to and maintained 1,500 feet. The strong crosswind also did not appear to have been considered as the orbit resulted in a roll out with full scale localiser deflection to the north of the centreline. This made re-establishing from the north (into the wind) more difficult and ultimately resulted in the go-around.

The operating company advocate the use of autopilot and autothrottle in normal operation. However the company Operations Manual also states:

> *'Continuous use of automatic systems leads to loss of basic knowledge of power settings/pitch attitudes and reduced ability to fly accurately with low workload. Pilots are therefore required regularly to fly the aircraft manually, with emphasis on manual approaches with and without the flight director. Good weather conditions and uncongested airspace should be chosen'.*

One of the reasons for using automation is the reduction in crew workload with commensurate increase in their situational awareness. Although the crew considered the orbit a relatively benign manoeuvre, full use of automation may have given them the extra capacity to compensate for the crosswind. Acceptance of radar vectors to reposition, although potentially adding a few extra track miles to that of an orbit, would almost certainly have prevented the go-around.

Follow up action

The operating company has reiterated to its flight crews the requirements that must be met when conducting a visual approach and has also issued Flight Crew Notice 51R/06 which states:

> *'If at any time, visual reference is lost, then an immediate go-around must be flown. Orbits on or during final approach in order to self position on the ILS are expressly prohibited'.*

Bristol Air Traffic Services commented that although orbits are permitted, they are not considered best practice for two reasons; controllers lose positive control of the flightpath of the aircraft (particularly pertinent when the aircraft is being sequenced with other aircraft) and noise is concentrated over a particular ground location.

On 28 March 2006, Bristol Air Traffic Services published a safety notice stating that in similar circumstances to this incident, *'ADC ATCO's* (aerodrome controllers) *should work closely with APR* (approach radar controllers*) to consider an appropriate course of action; best practice is normally to instruct the aircraft to maintain a terrain safe level, fly a suitable radar heading and transfer to APR for vectoring back into the pattern.'*

ACCIDENT

Aircraft Type and Registration:	Boeing 767-304, G-OBYJ
No & Type of Engines:	2 General Electric CF6-80C2B7F turbofan engines
Year of Manufacture:	2000
Date & Time (UTC):	16 February 2005 at 0805 hrs
Location:	Luton Airport
Type of Flight:	Public Transport (Non revenue)
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Puncture to underside of fuselage aft of nose landing gear, two fuselage frames bent, left nose landing gear tyre damaged
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	54 years
Commander's Flying Experience:	15,500 hours (of which 2,000 were on type) Last 90 days - 100 hours Last 28 days - 45 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and AAIB enquiries

Synopsis

The aircraft had been pushed back, with engines running, and the ground handling crew was then asked to tow it forward. During the manoeuvre the towbar shear pins failed, the tug was braked to a stop and the aircraft ran into the tug. Ownership of the towbar was not clear and consequently it had not been maintained and was unserviceable. The ground crew's training had not prepared them for towing an aircraft forwards.

One Safety Recommendation has been made.

History of the event

The aircraft was pushed back from a parking stand onto the taxiway centreline in preparation for a positioning flight. The ground handling crew consisted of a tug driver and a headset operator who was to relay information between the flight crew and the tug driver. The ground handling crew, together with the tug and towbar, had been supplied by the contracted agent. The aircraft's engines were started during the push-back manoeuvre and were running at idle power when the flight crew relayed an instruction from ATC requiring the ground crew to tow the aircraft forward. However, during this process the tow bar shear pins failed, and the tug driver applied the tug brakes. The aircraft continued to move forwards under its own inertia and the thrust of its idling engines causing the tow bar to jack-knife and the aircraft to strike the roof of the stationary tug; the aircraft's forward fuselage suffered damage to its skin and frames. The flight crew had been unable to see events developing on the ground, as the aircraft's structure had obscured their view.

Examination of the towbar

Examination of the two towbar shear pins revealed that both pins had suffered shear overload failures at two locations on their shanks, as intended by design. Of the four pairs of shear faces, however, one pair was heavily corroded which indicated that this shear had been complete for a considerable period of time; the other shear failures were relatively bright. The presence of an old, complete, shear failure indicated that the bolt shank had been subjected to an overload at some time in the past. It also indicated that the towbar had received no substantial maintenance since that time.

Towbar ownership, condition and maintenance

This was the only Boeing 767 towbar generally available to the handling agents and their need for it was relatively infrequent. The only other B767 towbar on the airport was retained by the aircraft's operator, who had a maintenance base there, and was provided for the use of their engineering staff. Enquiries revealed that the towbar involved in the incident had been present at the airport for some time. The operator believed that originally it had been owned by them but that they had transferred its ownership to the ground handling company some years before. The handling company believed that the towbar was still owned by the operator but that they had permission to use it when required. No records could be found to substantiate either view.

As a result, neither the ground handling company nor the airline believed they owned the towbar and, consequently, neither believed that they were responsible for its condition and neither had performed any maintenance on it for a considerable period. The Service Level Agreement between the aircraft operator and the handling company gave details of the services to be provided and the relevant conditions. The paragraph relating to tow bars stated

> *'(The handling company) will provide towbars for the pushback of (the operator's) aircraft. Any towbars in the possession of the handling agent will remain, together with responsibility for repair and replacement, however ownership remains with the (the operator)'(sic).*

The handling company's maintenance schedule for the tow bars for which it was responsible required them to be partially disassembled and inspected every ten weeks. All items of ground equipment in their control were marked with 'Asset Numbers' to enable the handling company to keep track of their maintenance; the towbar involved in this accident had no such number. The handling company operating procedures required ground crews to satisfy themselves that the equipment to be used for any task was suitable for the purpose and in a satisfactory condition. Their training was designed to ensure that they were capable of this.

Ground handling operations and training

The handling company had a modular training scheme for its staff. This consisted of theoretical and practical instruction with subsequent tests; trainees were provided with hand-outs which highlighted key elements of the training. Inquiries after the accident revealed that both members of this ground crew had recently received the training and had qualified to perform their respective tasks during 'push-back' manoeuvres. Neither had received any training in towing or 'pull-forward' manoeuvres. In his push-back training the tug driver had been instructed to apply the tug brakes in the event of shear pin failure. This would be appropriate during a push-back operation but inappropriate during towing or pulling operations as it could result in the aircraft colliding with the tug. The handling company training module for 'Towing' was designed to qualify tug drivers to tow empty aircraft, with their engines not running, on the manoeuvring area. The ground handling company had no training module relevant to towing or pulling aircraft with their engines running.

ATC at most major airports require 'push and pull' procedures, with engines running, to expedite traffic flow and ease ramp congestion. Investigations revealed that these procedures were regularly used at the airport, and the handling company's tug drivers did carry out 'pull' manoeuvres relatively frequently, although only two had undergone the 'Towing' training. Following this incident, both the handling agent and the aircraft operator have made changes to their procedures for aircraft push-back and pull-forward manoeuvres.

Oversight of airport airside ground services

Aircraft operators and airports are licensed, inspected, and audited by the CAA; there are no requirements or enforceable standards for the regulation and oversight of ground handling agents, other companies providing the ground services at airports or of the equipment they use. However JAR-OPS Subpart C, Appendix 2 to JAR-OPS 1.175 (c) requires an Air Operator Certificate (AOC) holder to establish standards for training and supervision of ground staff.

The CAA publication CAP 642 provides guidance for aircraft, airport operators and third party airside organisations, on safe operating practices for airside activities. Amongst the stated reasons for this document coming into existence was that:

> *'The airline and airport industry and their safety regulators were concerned about the level and extent of damage caused to aircraft during ground handling'.*

CAP 642 intentionally does not define the scope or standards for training to be met by the ground staff operating airside, nor does it contain any detail relating to the suitability or condition of the items of ground equipment they use.

Discussion

Whilst they have no regulatory power to do so, airport operators do oversee the quality of provision of handling services to some extent. The airport operator had, some time before this incident, become concerned about the standards of the handling company involved and had taken steps to address the problem by first requiring an improvement in performance, and, when this was not forthcoming, by giving notice to the handling company to cease operations. However, the handling company's subsequent assurances to the airport operator had resulted in the withdrawal of this notice.

This accident was the result of ground handling staff being asked to perform, at short notice, a relatively commonplace task. It was, however, unexpected and was a task for which they had not been trained. They were also using a towbar which was not maintained and which was unserviceable as a result of misunderstandings concerning its ownership. Since the push-back manoeuvre was a common one, it is considered that the training to perform it should have fallen into a defined minimum training package for ground staff qualified to handle aircraft in tug and towbar operations. There is no authority which ensures the adequacy of any training curriculum for ground handling staff, merely a general responsibility as defined in JAR-OPS.

The AAIB has been notified of a number of incidents involving mobile ground equipment. There are no required standards for the training and competence of ground handling staff, nor are there any for the suitability or condition of the items of ground equipment which they use.

Such standards as there are, appear to derive from commercial considerations rather than a requirement to minimise the possibility of damaging the aircraft, which are the focus of their operations. As a result of the absence of defined standards, it is not currently possible to regulate airside ground handling in the terminal areas. The pace of ground handling at airports which are small, and those involved mainly with general aviation, may still tolerate an unregulated regime. It is, however, considered that regulation of this increasingly busy environment at the larger airports, with high levels of ground activity around their terminals, has become necessary to avoid increasing amounts of damage being inflicted on aircraft at airport terminals.

The following Safety Recommendations are, therefore, made.

Safety Recommendation 2006-118

It is recommended that the Civil Aviation Authority reminds AOC holders of their responsibility to ensure that suitable curricula and standards are in place for the training and maintenance of competency of staff involved in the ground handling of commercial aircraft at airports and also that they should require a means of ensuring adherence to those standards.

As a result of AAIB investigations into two other ground incidents (Boeing 737 registration EI-DAP reported in AAIB Bulletin 9/2006 and DHC-8 registration G-BRYW reported in AAIB Bulletin 11/2006 (this Bulletin), Safety Recommendation 2006/060 was made, and this is repeated here:

AAIB Safety Recommendation 2006-060

It is recommended that the Civil Aviation Authority should remind airport operators that their Safety Management Systems should ensure that safe standards of maintenance and use are applied to all vehicles and mobile ground equipment used in the proximity of aircraft.

ACCIDENT

Aircraft Type and Registration:	DHC-8-311 Dash 8, G-BRYW
No & Type of Engines:	2 Pratt & Whitney Canada PW123 turboprop engines
Year of Manufacture:	1997
Date & Time (UTC):	7 October 2005 at 1822 hrs
Location:	Stand 8 at Aberdeen Airport
Type of Flight:	Public Transport (Passenger)
Persons on Board:	Crew - 4 Passengers - 50
Injuries:	Crew - None Passengers - None
Nature of Damage:	Aircraft: damage to engine, propeller and fuselage Ground Vehicle: damage to cabin and bodywork
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	31 years
Commander's Flying Experience:	5,600 hours (of which 648 were on type) Last 90 days - 99 hours Last 28 days - 28 hours
Information Source:	AAIB Field Investigation

Synopsis

The DHC-8 aircraft was parked on stand, all the passengers were on board and the engines had been started. Shortly after the Ground Power Unit (GPU) cables had been disconnected from the aircraft, and with nobody in the cab, the GPU moved forward and struck the rotating propeller on the right engine before coming to rest against the fuselage. All the occupants exited the aircraft through the passenger door and no one was injured.

The investigation identified a number of maintenance issues with the GPU. No issues were revealed with either the serviceability or operation of the aircraft, and hence this report is focussed on the GPU.

Three safety recommendations are made; these relate to the regulations for ground vehicles operating near aircraft, maintenance of the ground vehicle and the manufacturer's servicing schedule .

Ground Power Unit information

The GPU was a Houchin C762 and its diesel engine was capable of either supplying aircraft with electrical power via a generator or propelling the vehicle. It was manufactured in May 1997 and delivered to the operator at Aberdeen in June 1997. At the time of the accident 13,471 operating hours had been recorded for the GPU.

The primary motion controls of the vehicle are;

accelerator and brake pedals, a steering wheel, a hand-operated parking brake and a FORWARD-NEUTRAL-REVERSE selector lever. The FORWARD-NEUTRAL-REVERSE selector lever is situated in front of the steering column at the height of the driver's knees. The driver must depress a button on top of the selector lever to move the selector through a mechanical gate; this allows the selector lever to move out of NEUTRAL into either FORWARD or REVERSE.

There is a further switch, located on a panel behind the driver's seat, labelled SERVICE - IDLE. When the operator selects SERVICE mode the drive to the chassis is inhibited and the engine control system increases the speed of the engine so that the unit is ready to supply power to an aircraft. When the switch is moved from SERVICE to IDLE there is a delay in the system of about 10 seconds to allow the engine speed to decrease, the vehicle is then in a safe state and ready to be driven. The vehicle can only be driven away after this 10 seconds delay and if FORWARD or REVERSE has been selected.

The engine speed is regulated by the fuel pump. A governor rod connects the fuel pump to the governor lever and connections at both ends are by ball joints. Changes in engine speed are made via a cable from the accelerator pedal to the governor lever or, when in SERVICE mode, from a mechanical output from the governor to the governor lever.

Description of the accident

The aircraft was parked on Stand 8 at Aberdeen Airport and a three-man ground crew was tasked with dispatching the aircraft.

The first member of the ground crew positioned the GPU facing the right hand engine of the aircraft. He put the FORWARD-NEUTRAL-REVERSE selector to NEUTRAL, applied the parking brake and selected SERVICE mode. He then left the stand to collect the push-back tractor.

The other two members of the ground crew, the headset operator and the GPU operator, then arrived at the aircraft. Whilst the right engine was being started the GPU operator noticed that the noise from the GPU engine was quieter than usual. He checked the meter which read 110 amps, rather than the usual 115 amps; the flight crew noted that the voltage was only 22.5V, rather than the normal 28V. The left hand engine was then successfully started.

With both aircraft engines running the GPU operator selected IDLE and then started to gather the power cables which had been attached to the aircraft. Approximately 10 seconds later, the GPU started to move forwards, over the flat paved surface, towards the rotating right propeller, with nobody in the cab. As the GPU moved into the plane of the propeller it was struck by, and damaged, all four blades. The GPU subsequently struck the fuselage under the right wing, where it came to a halt.

At the time of the impact the flight crew were carrying out their 'After Start' checklist. The first officer looked out of his window, saw that the GPU had struck the fuselage and informed the commander. The commander immediately shut down the engines and, to minimise the risk of any fire, ordered the completion of the 'Engine Fire on Ground' checklist for the right engine; both fire bottles were subsequently discharged. He then contacted ATC and requested attendance of the fire services.

The cabin crew confirmed that there were no signs of smoke or fire in the cabin but that there were signs of fuel leaking from the right engine. The commander therefore made an announcement to the passengers telling them that they should disembark quickly, using the main door, and that they should leave their baggage behind. The disembarkation was uneventful and, since there were no ground staff present, the commander instructed the first officer to supervise the passengers during their transit to the terminal.

The fire service and the police arrived promptly to manage the accident site. A photograph taken shortly after the accident is presented at Figure 1.

Figure 1

Post impact photograph showing GPU and aircraft

Operating Procedures – Position of GPU for Ground Servicing

Diagrams in the Operator's Ground Operations Manual showed a GPU positioned facing away from the aircraft that it was servicing. However, it had become local practice to position the GPU facing the aircraft in order to keep the GPU exhaust fumes away from designated passenger walkways and so that the headset operator could be seen from the GPU cab. There was no documented evidence of a formal risk assessment of this local practice.

The operator raised a 'Ground Damage Alert Notice' within 48 hours of the accident. This notice referred to the Operator's Ground Operations Manual and reinforced the importance of the use of brakes or chocks, and that vehicles should be parked in such a way that should there be any movement of the vehicle it would not collide with the aircraft.

Personnel information

Ground Crew

All three members of the ground crew had been appropriately trained and were familiar with the working environment and equipment. They were in compliance with the company's Working Hours Limitations and there were no issues with staffing levels that might exert undue pressure on the crew.

Ground Vehicle Maintainer

The GPU was maintained by an engineer who was responsible for the maintenance of 15 items of ground equipment. He had over 25 years experience in the maintenance of aircraft and vehicles and operated alone, hence his work was neither signed off nor checked.

Damage to the aircraft

After the incident the aircraft was towed to a hangar where it was inspected. There were three main areas of damage to the aircraft as follows:

a) The right propeller had suffered significant damage to all four blades and to its hub.

b) The right engine had come to an abrupt halt and, as a result, the engine required a complete overhaul.

c) There was a dent in the fuselage with associated local damage to the fuselage structure.

Inspection of the GPU

Initial Inspection

There was extensive damage to the GPU cabin and the engine cover. The windscreen and the windows to the left and right doors had shattered, there were dents consistent with propeller blade strikes to the cabin, and the internal structural members of the cab around the left door were severely disrupted. Part of the leading edge of one of the propeller blades, a strip of metal about 50 cm long, had become detached and was found on the driver's seat in the cab of the GPU.

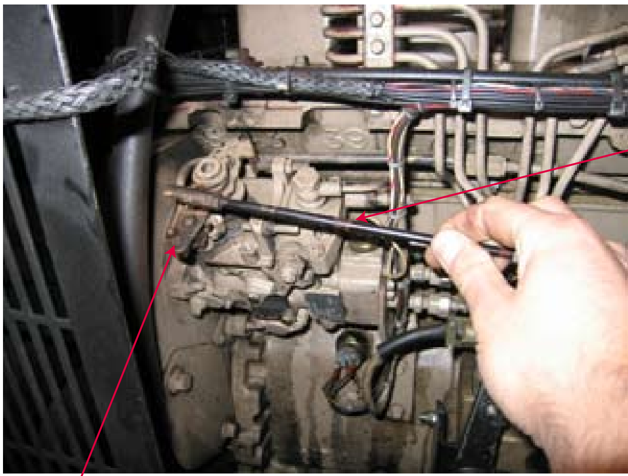


Figure 2

Photograph showing detached governor rod and worn ball joint

After the accident the GPU was taken to a vehicle maintenance facility on the airport where an inspection revealed the following:

a) Governor rod and fuel pump spring

On opening the engine cover the governor rod was found to be disconnected from the fuel pump. Further inspection revealed that the ball joint on the fuel pump lever was worn, hence the governor rod could become detached from the fuel pump lever with little effort. Figure 2 shows the detached governor rod and the worn ball joint. The spring on the fuel pump was also worn so that when the governor rod became detached from the fuel pump, the engine ran at a moderate speed and not at idle.

b) FORWARD-NEUTRAL-REVERSE selector

The FORWARD-NEUTRAL-REVERSE selector has a central button and under normal operation this must be depressed to allow the selector lever to move out of NEUTRAL. The mechanical gate mechanism was found to be worn, it was therefore not necessary to press the button prior to moving the lever. Figures 3 and 4 show, respectively, the location of the selector and the worn mechanical gate.

c) Electrical safety system for traction

A series of checks were conducted on the GPU to check the electrical safety system for traction. No defect could be identified that would allow the vehicle to move without the FORWARD-NEUTRAL-REVERSE selector being in either FORWARD or REVERSE. The 10 seconds delay, before the vehicle can move after switching from SERVICE to IDLE, worked satisfactorily.

d) Parking brake

The handbrake system was tested and it was shown that with a normal application of the lever (about four notches of the ratchet out of a maximum of six) the parking brake would hold the GPU on

Figure 3 (left)

Photograph showing location of FORWARD-NEUTRAL-REVERSE selector in front of the steering column

Figure 4 (right)

Photograph showing worn gate in the FORWARD-NEUTRAL-REVERSE selector (NB rubber gaiter removed)

level ground with the engine at normal idle or low speed settings and with FORWARD mode selected. The parking brake would not hold the GPU with the engine at moderate or higher engine speeds with the same mode selected.

e) Other defects

The near-side front tyre had exposed chords in the tread area, there was corrosion and pitting on several areas of the front brake pipes and the pins and bushes on all the road springs were worn.

Detailed Inspection

The GPU was transported to the manufacturer's facility for inspection. The inspection confirmed the findings made at Aberdeen; however, the following additional findings were made:

a) The printed circuit board that controls the electrical safety system for traction was bench tested using the manufacturer's dedicated test procedure and no fault was found.

b) It was concluded that the only way the vehicle could move forward was with the FORWARD mode selected; attempts were therefore made to assess how the selector unit might have moved to the FORWARD position. It was concluded that human intervention, or possibly a jolt as the cabin door closed, were the only realistic causes.

c) Tests found that the speed of the engine after the governor rod became detached was likely to be 1,500-1,600 rpm. This is significantly higher that the normal idle of around 1,100 rpm, but less than the maximum of 2,400 rpm.

GPU Maintenance

The GPU had been maintained at a facility at Aberdeen Airport since it was delivered as a new vehicle in June 1997. There were 24 entries in the log book for *'service'* or *'3 month service'* over the 8 year operational life of the GPU until the accident; an average of 3 services per annum. Corrective maintenance actions were also logged.

The maintainer worked alone and he had found that the level of unscheduled maintenance made it difficult for him to keep to a plan for scheduled maintenance. A defect reporting system was in place; however, there was evidence that not all defects were being reported. There was also evidence that the gate on the FORWARD-NEUTRAL-REVERSE selector had been unserviceable for at least two years.

Manufacturer's Recommended Maintenance

The Technical Manual for the Houchin C762 contains recommended servicing actions at defined intervals ranging form daily to every 12 months.

A review of the recommended servicing actions concluded that there are no specified checks that would have detected the worn ball joint, the worn spring on the fuel pump or the worn gate on the FORWARD-NEUTRAL-REVERSE selector.

Annual inspection by the Airport Authority

The GPU had completed its annual safety inspection on 28 January 2005. This is a 29-point check list, which is effectively a direct copy of the CAA recommended checks provided in CAP 642[1] with the exception that box 30 (Trailer Connections) had been deleted. All 29 boxes were ticked, indicating that the items were 'serviceable'.

Safety management of airside vehicles

Airside Safety Management - CAP 642

CAP 642 provides guidance to aircraft and airport operators, as well as to necessary third parties, on safe operating practices for airside activities; the guidance provided in this document is not mandatory. It was first issued in March 1995 on the recommendation of a working group drawn from representatives from the CAA, the Health and Safety Executive, the aircraft operators and the airport agencies. Issue 2 followed in February 2003 after a review by the working group, and incorporated revisions to reflect changes to legislation and advances in safety management practice. There was a subsequent revision in 2005 as a result of recommendations made by the AAIB concerning airbridge and aircraft towing operations.

CAP 642 provides guidance on standards for airside vehicles, and includes at Appendix C *'Model Proformae that may be suitable for use by an Aerodrome Authority dealing with Airside Vehicle Inspection Requirements'.*

Footnote

[1] Airside Safety Management Appendix C, Annex B Safety and Serviceability Inspection Forms for Ground Power Unit/Airstart Unit.

There are several proformae including at Annex B a 30-point checklist for '*Ground Power Unit/Airstart Unit*'.

Airside Vehicles – applicability of road vehicle standards

Airside vehicles have a number of different characteristics to those of road vehicles. They are designed to support the operation of aircraft; for example, towing aircraft or assisting in the loading and unloading of baggage. Therefore, the direct application of road vehicle regulation for the design and maintenance of airside vehicles is not necessarily appropriate. In addition, airside vehicles are often produced in low numbers which creates additional financial pressures on any design and maintenance regulation.

There is however a large area of commonality between airside and road vehicles and CAP 642 (section 3.5.5.) states that:

> *'all vehicles should normally be required to meet the requirements appropriate for the grant of Department for Transport test certificate'.*

Accordingly, the Vehicle and Operator Services Agency (VOSA) were contacted to assess whether the GPU would have passed a standard 'MOT' test.

The MOT for vehicles not exceeding 3.5 tonnes includes tests for *'Driving Controls'*. The procedure for this part of the MOT is to check the operation of the driving controls *'from the driver's seat'* and several reasons for failure are listed. It was concluded that the FORWARD-NEUTRAL-REVERSE selector would have failed an MOT since it was *'obviously not functioning correctly'* due to the gate not working. The worn ball joint and the worn spring on the fuel pump would probably not have been inspected as part of an MOT test since the test for driving controls is made from the driver's seat; hence these would not have resulted in an MOT failure. The corroded brake pipes and the exposed chords on the tyre were items that would have resulted in a failure of an MOT, as well as the Airport's Roadside Check (as per CAP 642).

Analysis

Three factors associated with the GPU and its operation contributed to cause this accident.

The engine speed was significantly higher than the normal idle setting, such that the vehicle could override the parking brake. This is attributed to excessive wear on the ball joint, which allowed the engine governor rod to become detached, and to the worn spring on the fuel pump, which did not subsequently set the engine to idle. Whilst the airport authority used the check list recommended in CAP 642, this does not include a check on engine controls. The worn ball joint and the worn spring were not identified or rectified by the operator's maintenance system and there was no dedicated check in the manufacturer's recommended maintenance scheme.

The GPU drive system would only allow the vehicle to move forward if it was in FORWARD mode. It was not possible to determine how the GPU drive system went into the FORWARD mode; human intervention would seem the most likely cause, unless it had been disturbed by a jolt as the cabin door was closed. The gate on the FORWARD-NEUTRAL-REVERSE selector, a safety feature, was found to be ineffective due to wear, thus allowing the FORWARD mode to more easily be selected. As with the worn ball joint and worn spring the annual check recommended in CAP 642 does not include a check on such controls. The operator's defect reporting system did not detect this failure, and there was no appropriate check in the manufacturer's recommended servicing to inspect for a worn gate in the FORWARD-NEUTRAL-REVERSE selector.

The GPU was, as had become routine, positioned facing the aircraft although this was not in accordance with the company's operating procedures. At airports such as Aberdeen, there are many activities placing demands on the available ramp space and, had this GPU been facing away from the aircraft, in accordance with the company's operating procedures, it might have struck the aircraft parked on the next ramp. The failure to adhere to the company's Standard Operating Procedure is not considered a primary causal factor since it would seem more appropriate to minimise the risk of occurrence rather than to minimise any subsequent risks.

Conclusions

The incident occurred because the GPU was being operated with a worn ball joint on the governor rod, a worn fuel pump spring and a worn gate in the FORWARD-NEUTRAL-REVERSE selector.

These three mechanical defects are attributed to:

a) Inadequacies in the operator's maintenance system, including defect reporting.

b) The lack of appropriate checks in the manufacturer's recommended servicing schedule.

Safety Recommendations

The following safety recommendations have been made:

Safety Recommendation 2006-092

It is recommended that British Airways review their operations at Aberdeen Airport to ensure that airside vehicles are maintained in accordance with the appropriate manufacturer's recommended servicing schedule and to ensure that their defect reporting system for ground vehicles operates effectively.

Safety Recommendation 2006-093

It is recommended that Houchin Aerospace update their recommended servicing schedule to include checks for governor rods, fuel pump springs and forward-neutral-reverse selectors at appropriate intervals. These changes should be promulgated to all operators of relevant equipment world-wide.

Safety Recommendation 2006-094

It is recommended that Houchin Aerospace review the design of their engine control systems for self-propelled ground equipment to ensure that safety is not compromised if there is a system failure.

Previous recommendations

Following an incident at Prestwick Airport[2], where a baggage vehicle ran into the fuselage of a stationary Boeing 737 aircraft, the following safety recommendation was made. The recommendation is equally relevant to this accident.

AAIB Safety Recommendation 2006-060

It is recommended that the Civil Aviation Authority should remind airport operators that their Safety Management Systems should ensure that safe standards of maintenance and use are applied to all vehicles and mobile ground equipment used in the proximity of aircraft.

Footnote

[2] Aircraft registration EI-DAP; report was published in AAIB Bulletin 9/2006

ACCIDENT

Aircraft Type and Registration:	Dornier 28 D2 Turbo Skyservant, HA-ACO
No & type of Engines:	2 Walter M601D-2 turboprop engines
Year of Manufacture:	1978
Date & Time (UTC):	24 June 2006 at 1200 hrs
Location:	Hibaldstow Airfield, near Brigg, North Lincolnshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to right undercarriage and right wing stub
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	31 years
Commander's Flying Experience:	562 hours (of which 93 were on type) Last 98 days - 98 hours Last 28 days - 70 hours
Information Source:	Aircraft Accident Report Form completed by the pilot

Synopsis

The aircraft suffered a heavy landing as a result of a faster than expected sink rate which the pilot was unable to arrest.

History of the flight

The aircraft had completed a parachute lift and was making an approach to land. The visibility was 10 km and the wind was from 280º at 3 kt. On short finals to Runway 26 the pilot set the propeller pitch to the flight beta range, in which the propeller blade angles are commanded directly from the power levers. The aircraft was getting too low as it approached the threshold so the pilot deselected flight beta, and the aircraft then ballooned upward slightly. Once over the threshold flight beta was again selected causing the aircraft to sink more rapidly than the pilot expected, and the aircraft touched down before the high sink rate could be arrested. The aircraft's landing was hard, with the wings being approximately level, and with the aircraft in a slightly tail-down attitude. The hard landing damaged the right wheel hub and the right wing stub was over-stressed. There was no damage to the propellers or engines. The pilot, who was using a full harness, then exited the aircraft uninjured via the door.

Aircraft information

The Dornier 28 Skyservant is a high-wing twin-engined aircraft with a tail-dragger landing gear. The aircraft configuration is unusual since the engines are mounted on wing stubs and these stubs are attached to the fuselage beneath the cockpit area. The main gear legs are fixed, and are located behind each of the two engines.

Assessment

The pilot attributed the accident to a *"too abrupt re-selection of flight beta once over the threshold causing a faster than expected sink rate"*.

INCIDENT

Aircraft Type and Registration:	Agusta A109S Grand, G-CGRI
No & Type of Engines:	2 Pratt & Whitney Canada PW207C turboshaft engines
Year of Manufacture:	2005
Date & Time (UTC):	7 April 2006 at 0919 hrs
Location:	Liskeard, Cornwall
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Tail rotor trunnion assembly, tail rotor blade and vertical fin damaged
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	61 years
Commander's Flying Experience:	10,880 hours (of which 1,100 were on type) Last 90 days - 37 hours Last 28 days - 20 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and subsequent telephone enquires

Synopsis

During the cruise, some four minutes into the flight, the helicopter suffered severe vibration. The pilot carried out an autorotation and landed safely. Subsequent investigation revealed that one of the two tail-rotor trunnion flange caps had separated, causing damage to a tail-rotor blade and the vertical fin.

The metallurgical examination showed the failure to be due to an initial clockwise torsional overload followed by a final axial tensile overload. It is possible that the initial clockwise torsional overload was applied either during the manufacture of the helicopter or during maintenance activity during the night prior to the incident flight. The maintenance manual did not contain the specific torque loading for the trunnion flange caps.

The helicopter manufacturer has since issued torque loading figures for the flange caps and has amended the maintenance manual accordingly.

History of the flight

Whilst in the cruise, and about four minutes into the flight, the pilot suddenly experienced a high level of vibration. At the time, the helicopter was flying at 155 kt and at 1,500 feet. The pilot entered into an autorotation and declared a MAYDAY, before landing safely in a field. He shut down the helicopter, noticing that the vibration seemed to worsen during this procedure. He was uninjured and exited the helicopter normally.

Inspection of the helicopter revealed that one of the tail-rotor trunnion flange caps had separated, causing damage to a tail-rotor blade and the vertical fin.

Tail-rotor system description

The tail rotor assembly consists of two rotor blades, driven from a gearbox via a drive shaft and a trunnion. The drive shaft runs from the gearbox, located within the tail boom, and connects onto splines within the tail-rotor trunnion. The trunnion then transfers drive, through the surrounding hub, to the rotor blades.

The A109S 'Grand' (Figure 1) has flange caps, with an internal thread, which locate onto the stubs at each end of the trunnion. Lock nuts then secure the assembly in place within the hub.

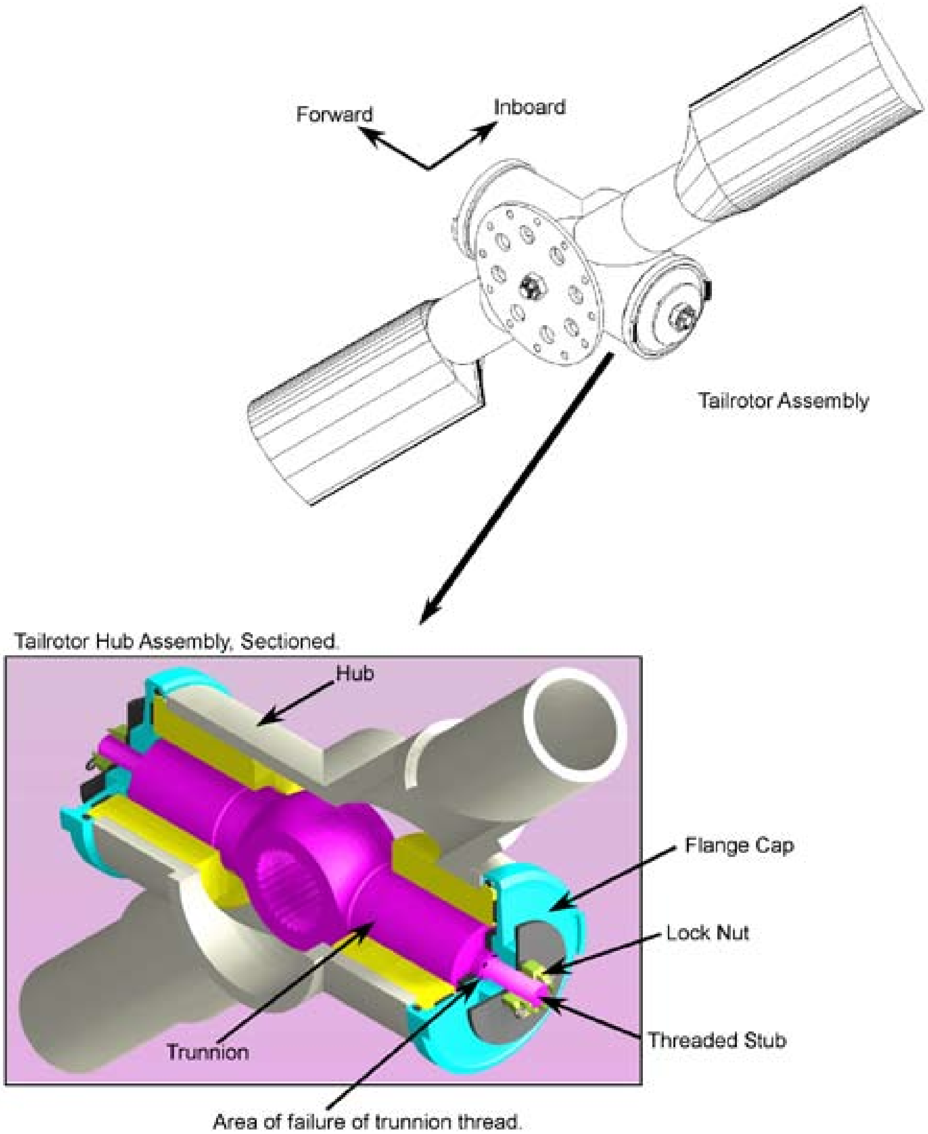


Figure 1

Trunnion assembly and drive

Component examination

The maintenance organisation removed the failed tail-rotor trunnion for detailed examination by the helicopter manufacturer. The manufacturer's metallurgical report revealed that the trunnion had failed in the undercut of one of the threaded stubs and stated that the fracture had initiated due to clockwise torsion, followed by a final tensile axial overload; there was no sign of a fatigue failure mechanism.

The metallurgist had then compared the failure on G-CGRI to four other trunnion thread failures. One of these had failed, during maintenance, on an Agusta A119 'Koala', due to an over torque as a result of a damaged thread. Two of the failures were threads broken, on purpose, by the metallurgist during proof tests. The last failure example was provided by applying a torsional load on the opposite stub thread of the trunnion removed from G-CGRI. The failure was achieved by seizing the flange cap onto the thread and then applying an increasing torque.

Comparison of these four failures, and the incident failure on G-CGRI, revealed that they were similar. However, there was a difference in that it was only the failure on G-CGRI that had shown a final axial tensile failure, whereas the others had a final torsional failure.

Maintenance history

Prior to the incident flight the helicopter had undergone maintenance. One of the tasks required the removal of the tail-rotor trunnion assembly; this necessitated the removal of the flange cap retaining nuts and the flange caps.

During the removal of the flange caps, it became apparent that one of the two flange caps could not be fully unscrewed, by hand, from one of the stubs. So, the flange cap was unscrewed until just prior to the point at which it bound on the thread, enabling the removal of the trunnion by full removal of the remaining cap.

Following the maintenance task, the engineer reinstalled the trunnion assembly, using the components originally removed from G-CGRI. The aircraft maintenance manual did not contain specific information on the installation of the threaded flange caps, so the engineer used the helicopter manufacturer's standard practices for torque loading of threaded components. Based on the size of the stub thread the engineer applied a torque of 70 lbf in. Subsequent tests of the tail rotor system were all within the maintenance manual limits.

This was the first time the tail-rotor trunnion assembly had been disturbed since the helicopter had entered service from manufacture.

Maintenance instructions

The helicopter manufacturer produced the Agusta A109S 'Grand' maintenance manual using a previous manual already in existence for the Agusta A109E 'Power'. However, the two helicopters have significantly different tail-rotor drive designs, with the A109S 'Grand' system similar to that on the A119 'Koala'. The A109E 'Power' does not use threaded trunnion flange caps that engage onto the trunnion threads. Instead, the unthreaded trunnion flange caps are located onto the hub and fixed by lock nuts alone.

This difference between the two designs led to the omission of torque loading figures for the installation of the threaded trunnion flange caps on the A109S. The manufacturer had, however, correctly quoted torque-loading figures for the lock nut.

Discussion

The vibration felt by the pilot during the very short flight was as a direct result of the loss of one of the tail-rotor trunnion flange caps. His prompt action, to land immediately, was prudent and prevented a worse outcome.

The metallurgical examination of the failed tail-rotor trunnion stub, revealed an initial clockwise torsional failure with a final tensile overload. Comparison with stubs that were, later, deliberately failed in torsion (including the remaining stub of G-CGRI's trunnion) showed similarities in the failures.

The failure on G-CGRI occurred just five minutes into the first flight after the helicopter had been in maintenance. During this maintenance input the tail-rotor trunnion assembly had to be removed, necessitating the removal of the flange caps. One flange cap could not be fully unscrewed by hand; the engineer later stated that he never applied a high torque at this stage. Indeed, the initial torsional failure was in a clockwise direction; had an over torque been applied whilst undoing the flange cap, the torsion would have been anti-clockwise.

During the reassembly of the tail-rotor trunnion assembly, the engineer was aware that the aircraft maintenance manual (AMM) did not contain the full instructions for the installation of the threaded flange caps. Therefore, he applied his own engineering knowledge and referred to the manufacturer's standard practices to obtain a torque figure. The calculated torque of 70 lbf in, which was then applied, was based on the size of the stub. This was well within the manufacturer's quoted limit of torque loading of 69-95 lbf in, which appeared in literature produced after the incident.

This had been the first disturbance of the tail-rotor trunnion assembly and its flange caps since the helicopter entered service. The only previous occasion in which a torque load would have been applied to the threaded stub, in a clockwise direction, would have been during the original installation of the trunnion during manufacturer.

The failure mode of the stub indicated that, at some point prior to the incident, a clockwise over torque had been applied, causing a crack to develop but not a complete failure of the stub. This could have occurred either during the original installation of the trunnion at manufacture or during the maintenance input immediately prior to the incident. The crack had developed within the root of one of the threads, which may have been difficult to see during a visual examination. Therefore, if a crack had developed following the installation of the trunnion at manufacture, it is unlikely this would have been identified during the subsequent disassembly at the maintenance facility. It is also possible that, had a pre-existing crack been present, then the torque applied by the engineer during the reassembly at the maintenance facility, although within later published limits, may have lengthened the crack to a length at which the normal operating axial tensile load would allow the crack to grow rapidly, causing the final tensile fracture.

In summary, a factor in the initial over torque of the stub, was the lack of published torque figures for the installation of the flange caps.

Safety action

The helicopter manufacturer has amended the maintenance manual for the A109S to introduce torque loading figures for the trunnion flange caps. It also issued an Alert Bulletin to instruct operators to inspect the tail-rotor trunnion for any damage and correct installation of the flange caps.

ACCIDENT

Aircraft Type and Registration:	ARV1 Super 2, G-BMWE
No & type of Engines:	1 Hewland AE75D piston engine
Year of Manufacture:	1986
Date & Time (UTC):	26 August 2006 at 1600 hrs
Location:	Edingale, Derbyshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Minor) Passengers - N/A
Nature of Damage:	Damage to the fin, rudder, wings, fuselage and cockpit area
Commander's Licence:	Private pilot's licence
Commander's Age:	60 years
Commander's Flying Experience:	901 hours (of which 286 were on type) Last 90 days - 19 hours Last 28 days - 7 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The engine water pump drive belt broke causing the engine to overheat. The pilot shut the engine down and during the subsequent forced landing the aircraft landed heavily on the nose wheel, which collapsed causing the aircraft to turn over onto its back.

History of the flight

The aircraft was approximately 11 nm from Tatenhill, on the second leg of a private flight from Manchester Barton to Popham, when the pilot noticed that the needle on the water temperature gauge was climbing into the red from its normal reading of 80°C. The pilot reduced the engine power and informed Coventry Radar, on 119.25 MHz, that he might need to make a forced landing and requested advice on the nearest suitable airfield. Coventry Radar advised the pilot that Birmingham was the closest airfield. However the pilot elected to return to Tatenhill as he believed that this would increase his options should he have to undertake a forced landing.

The temperature gauge remained in the red and when the aircraft was approximately 7 nm from Tatenhill the engine started to backfire and, therefore, the pilot shut it down before it could seize. In his report the pilot commented that he was surprised at how steeply he had to dive the aircraft, with the propeller stationary, in order to maintain the required glide speed. The pilot positioned the aircraft for an into wind landing into a large, flat, newly harvested field of wheat. To ensure that he did not overshoot the landing area he selected full flap, which required him to place the aircraft in a very steep dive in order to maintain the required airspeed of 60 kt. As the pilot commenced the flare he realised that the aircraft was not going to flare as expected and, consequently, he landed heavily on the nose wheel and the tips of the propeller blades. The nose wheel collapsed causing the aircraft to turn over onto its back damaging the fin, rudder, wings, fuselage and cockpit area. Although the pilot, who was wearing a lap strap and diagonal harness, struck his head against the altimeter setting knob he was able to vacated the aircraft through the shattered canopy. The pilot was taken to hospital by air ambulance where he was assessed as having sustained superficial cuts and bruising.

The pilot subsequently discovered that the water pump drive belt had failed, which resulted in the engine overheating.

ACCIDENT

Aircraft Type and Registration:	Casa 1-131E Series 2000 Jungmann, G-JWJW
No & type of Engines:	1 ENMA Tigre G-IV-B5 piston engine
Year of Manufacture:	1957
Date & Time (UTC):	18 July 2006 at 1130 hrs
Location:	Full Sutton Airfield, near York, Yorkshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Undercarriage and propeller damaged, engine shock loaded
Commander's Licence:	Private Pilot's Licence
Commander's Age:	61 years
Commander's Flying Experience:	485 hours (of which 21 were on type) Last 90 days - 19 hours Last 28 days - 8 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft bounced three times on landing, resulting in failure of the main landing gear. The pilot attributed the accident to lack of skill and experience on the type and the fact that the third bounce occurred on tarmac, which is less forgiving than grass. The investigation found no evidence to contradict this assessment.

History of the flight

The pilot was conducting a private flight from Breighton to Full Sutton. When he contacted Full Sutton the pilot was told that Runway 22 was in use with a wind from 140° at 5 kt. The pilot made what he considered to be a normal approach, flaring just beyond the runway identification numbers and making a modest bounce on touchdown. This was followed by another, heavier, bounce. On the third contact with the ground, which occurred on tarmac where the metalled taxiway crossed Runway 22, there was a "thud" which the pilot attributed to the oleos "grounding out"[1]. The pilot applied power to go around but immediately became aware of the left mainwheel entering his field of view, informing him that the landing gear was damaged. The pilot cut the power and continued to apply nose-up elevator as the aircraft descended. It made a very gentle landing on its underside and slid for approximately 30 m before coming to rest

Footnote

[1] Compressing to such an extent that the extendable oleo struts reached mechanical stops.

facing approximately 45º to the right of the runway axis. The propeller was damaged on impact with the runway and its sudden stoppage resulted in shock-loading of the engine. After turning off the fuel, ignition and electrics, the pilot and passenger exited the aircraft. The pilot removed the engine cowl to ensure that there were no fuel or oil leaks in the engine compartment.

Aircraft information

The Jungmann is a light single-engine biplane originally conceived as a basic training aircraft. The main landing gear is equipped with oil damped "oleo" type shock absorbers which, when properly serviced, reduce the likelihood of bouncing on touchdown. An engineer and pilot familiar with the type noted, however, that the oleo's leather oil seals are unreliable. Failure of an oil seal will result in a loss of damping and increase the likelihood of a bounce on touchdown. The pilot of G-JWJW commented that he checked the condition of the oleos on this aircraft regularly and considered them to be in good working order.

Although said to be "a joy to fly", the type is also considered to be nose heavy and to lack elevator authority at low speed, which can result in high rates of descent on touchdown. Some owners address these characteristics by placing ballast in the tail of their aircraft. The owner of G-JWJW intends to do likewise.

The pilot stated that G-JWJW usually bounced to some extent on landing but that he found it difficult to tell on each occasion whether it would settle or the bounces would develop into "kangaroo hops" of increasing amplitude. His normal practice, in the case of the latter, was to go around on the second bounce if it seemed "too big". On this occasion he thought that the aircraft would settle after the second bounce. He commented that the oleos had "grounded out" on a previous occasion. He noticed that the oleo struts took an appreciable time to return to their full extension and surmised that their slow restitution properties might result in reduced damping on second and subsequent bounces. Other operators of the type contacted by the AAIB had no experience of this phenomenon.

Conclusion

The pilot attributed the accident to lack of skill and experience on the type and the fact that the third bounce occurred on tarmac, which is less forgiving than grass. The investigation found no evidence to contradict this assessment.

ACCIDENT

Aircraft Type and Registration:	i) Cessna 152, G-BNXC ii) Aerotechnik EV-97 Eurostar, G-GHEE
No & Type of Engines:	i) 1 Lycoming O-235-L2C piston engine ii) 1 Rotax 912-UL piston engine
Year of Manufacture:	i) 1981 ii) 2001
Date & Time (UTC):	18 December 2005 at 1218 hrs
Location:	Moreton in Marsh, Gloucestershire
Type of Flight:	i) Training ii) Private
Persons on Board:	i) Crew - 1 Passengers - None ii) Crew - 1 Passengers - 1
Injuries:	i) Crew - 1 (Fatal) Passengers - N/A ii) Crew - None Passengers - None
Nature of Damage:	i) Aircraft destroyed ii) Substantial damage to engine and forward fuselage, left wing and landing gear
Commander's Licence:	i) Student Pilot (JAA Class 2 medical certificate) ii) Private Pilots Licence
Commander's Age:	i) 34 years ii) 62 years
Commander's Flying Experience:	i) 52 hours (of which 10 were on type) Last 90 days - 7 hours Last 28 days - Nil hours ii) 265 hours (of which 92 were on type) Last 90 days - 4 hours Last 28 days - 2 hours
Information Source:	AAIB Field Investigation

Synopsis

A student pilot was flying Cessna 152, G-BNXC, on a cross-country navigation exercise. His planned route took the aircraft overhead the disused airfield at Moreton in Marsh. The pilot of the Aerotechnik EV-97 Eurostar, G-GHEE, had a passenger on board and flew towards Moreton in Marsh where his passenger intended taking photographs. After the Eurostar had completed about 270º of turn over the disused airfield, it rolled out on a northerly heading and very soon afterwards collided with the Cessna 152 which was flying on a west-south-westerly track. The weather was fine with good visibility. The investigation concluded that the accident was caused by neither pilot seeing the other aircraft in sufficient time to take effective avoiding action. One safety recommendation was made, concerning guidance on medication.

History of the flights

Cessna 152, G-BNXC

G-BNXC was coloured predominantly white with blue markings, and was equipped with a single red anti-collision beacon. The student pilot was nearing completion of the required training for the issue of a Private Pilots Licence (PPL) and had planned to fly the aircraft on a cross-country navigation exercise. He had arrived at his flying club at Coventry Airport at about 0900 hrs that morning where he met with his flying instructor who was to authorise the flight. They discussed the exercise, which was to consist of a flight to Gloucestershire Airport near Cheltenham, where the aircraft would land, and then a return flight to Coventry. The details of the route itself had been discussed previously and so conversation concentrated on particulars such as weather information and aircraft technical status. It was a fine Sunday and the instructor specifically briefed the probability that many pilots would be taking advantage of the weather, making a good lookout essential. As part of the authorisation and briefing process the instructor issued a "Solo Cross Country Briefing Certificate" which acted as a checklist of items to be covered in the briefing such as weather, route, destination and emergency procedures. The certificate included an annotation of the altitude to be flown as "2500 QNH".

The pilot took off from Coventry Airport at 1136 hrs, and departed on a south-easterly track towards a turning point at Silverstone race circuit. Turweston Aerodrome is adjacent to Silverstone, and the pilot contacted the Air/Ground radio operator there to advise him of his presence and route, but did not state his altitude. From Silverstone the aircraft turned onto a westerly track towards Banbury, and from there turned on to a track of 253º(M); a direct course for Gloucestershire Airport. This track took the aircraft directly overhead the disused airfield at Moreton in Marsh, the site of the Fire Service College and the location of the subsequent collision with G-GHEE. The pilot did not contact any other ATC units, remaining instead on the Turweston frequency. At about the time of the accident, the Air/Ground operator and other aircraft in the Turweston area heard a brief, clipped transmission of "MAYDAY, MAY...", which was later presumed to have been made by the pilot of G-BNXC.

Aerotechnik EV-97 Eurostar, G-GHEE

G-GHEE was a three-axis microlight aircraft, coloured predominantly silver with blue markings, and was not equipped with an anti-collision beacon. The pilot, who also owned the aircraft, had planned to fly two friends from a private airstrip which was situated a few miles to the east of Cheltenham. The first flight was uneventful and lasted 50 minutes. After a change of passengers, the pilot took off again at 1205 hrs, at about the time G-BNXC was approaching Banbury. The flight was intended to be a scenic flight for the benefit of the pilot's passenger, who was an inexperienced flier. The pilot first flew to his passenger's house, which was close to the airstrip, and circled for a few minutes while the passenger took some photographs. The pilot then set course for Moreton in Marsh, where the passenger intended to take more photographs.

During the cruise to Moreton in Marsh the aircraft maintained an altitude of 1,800 to 1,900 ft amsl, which equated to about 1,000 ft agl over the Cotswold Hills. As the aircraft approached Moreton in Marsh from the south-west, the terrain beneath it reduced in elevation and the pilot commenced a descent until the aircraft was again maintaining about 1,000 ft agl. The aircraft flew north of the town before turning right to approach the Fire Service College buildings from the north-west. It then flew a right-hand turn, taking it to the east and then south of the College buildings whilst the passenger took two photographs. At some point the passenger asked the pilot if he could make a further orbit and the pilot agreed. The pilot estimated that the aircraft was now at about 800 to 1,000 ft above the disused airfield, which has an elevation of 436 ft amsl. The pilot rolled wings level for a brief period on a track of about 350º(M), with the intention of making a further right turn to take the aircraft around the College buildings once again.

Suddenly, the pilot and passenger became aware of the Cessna 152 in very close proximity, ahead and, possibly, slightly to the right. The pilot later assessed that it was at less than 50 yards range and described it as "filling the windscreen". The pilot instinctively pulled back on the control column, and the Cessna 152 was lost from view as the Eurostar pitched up, just before the collision. From his brief view of the Cessna 152 prior to the collision, the pilot of the Eurostar thought that the Cessna 152 pilot had not seen his aircraft, as he did not appear to be taking any avoiding action.

At the point of collision the canopy of G-GHEE flew open. Being a forward hinged canopy it was not lost, but the passenger was able to reach up and pull it closed, a position he held until the aircraft had landed. There was severe vibration which prompted the pilot to shut down the engine and prepare for a forced landing. The aircraft was flyable but the pilot twice experienced a wing drop to the right which he was able to correct. With the aid of some ground smoke he was able to assess the surface wind and carried out a forced landing in a field just to the north of the disused airfield's perimeter fence. Although the aircraft sustained some further damage in the landing, neither of the occupants was injured.

After the collision the Cessna 152 entered a dive and crashed on the disused airfield, within the grounds of the Fire Service College. The emergency services, alerted by the pilot of G-GHEE and several witnesses, arrived on scene soon afterwards. An air ambulance also attended the scene, but it was confirmed that the pilot of G-BNXC had sustained fatal injuries.

Pilot information

The 34 year old pilot of G-BNXC had commenced flying training in November 2003. His training had proceeded normally, though at times continuity had been affected by poor weather and aircraft availability. He was nearing the end of his training and was scheduled to undertake his final flight test within the following two weeks. He had logged 51 hours 55 minutes of flight time, which included 13 hours 40 minutes of solo flight time. The majority of his training had been flown on the Piper PA-28 aircraft, though he had flown 6 hours 35 minutes dual and one hour 55 minutes solo on the Cessna 152. He had last flown the Cessna on 17 September 2005, and his last flight, in the PA-28, was on 5 November 2005. The pilot's instructor stated that the pilot had been made aware of the effect of the aircrafts' configurations on lookout (one type is a 'high wing' configuration, the other is 'low wing') and had demonstrated an effective lookout in both types.

The pilot had twice before attempted to complete the cross-country navigation exercise, the previous flights being abandoned due to poor weather on one occasion and an aircraft technical problem on the other. He was well thought of by the club instructors who judged his handling skills to be slightly above the average and considered that he was building a good, appropriate level of confidence and airmanship.

The 62 year-old pilot of G-GHEE had started flying training on microlight aircraft in 1994 and qualified in 1995. At the time of the accident he had accumulated 265 hours of flight time, all of which was on 3-axis microlight aircraft. He acquired G-GHEE in 2001, with its first flight being in May 2002. Since that time he had flown 92 hours in the aircraft. The pilot had flown a 50 minute flight on the morning of the accident; his last flight before that was on 7 December 2005.

Aircraft wreckage

Collision debris

Collision debris from both aircraft was distributed over a region extending some 200 m north eastwards from a point slightly west of the (disused) main runway intersection, consistent with the direction of the prevailing wind that day. The debris comprised:

1. *From the Eurostar* - two large pieces of lower engine cowl, together with a number of smaller fragments of cowling.
2. *From the Cessna 152* - numerous small fragments of left wing tip fairing, fragments of skin panel and internal structure from the left outer wing; a large segment of the left aileron; fragments of aileron hinge.

It was evident from the distribution of airborne debris that the collision occurred almost overhead the runway intersection.

Eurostar

The Eurostar landed in a field of vegetables that had been recently cropped, providing firm and even ground conditions, some 900 m to the north of the point of collision. Except for an overload failure of the left landing gear strut attachment, and associated collapse of the gear, all of the damage to the Eurostar was caused by the collision. This damage comprised:

1. Break-up and separation of most of the lower engine cowl.
2. Extensive damage to the engine, its mount frame, and associated firewall attachment bolts leaving the powerplant hanging from the firewall by a single bolt.
3. Rearward bending of the nose landing gear strut beneath the fuselage.
4. Separation of the outer sections of two (of the three) propeller blades.
5. Numerous pieces of the Cessna's outer left wing structure embedded in the engine compartment and jammed around the upper section of the nose landing gear strut, including fragments of wing tip fairing, pieces of wing skin and internal structure.
6. Deformation and penetrations through the outermost 80 cm of the left wing leading edge, confirmed subsequently as having been caused by sequential strikes by the aft face of the Cessna's propeller.

Cessna 152

The Cessna crashed within the boundary of the Fire Service College, approximately 400 m southwest-by-west of the point of collision, tracking in a southerly direction. At the time of impact it was travelling at high speed, in a shallow descent, and banked to the left. The initial contact between the left wing and the ground caused the aircraft to cartwheel violently to the left before the primary impact occurred, causing severe damage to the forward fuselage and cockpit. Thereafter it slid rearwards, shedding debris as it did so, before finally coming to rest facing the direction from which it had come, approximately 100 m from the point of initial ground contact.

The circumstances of the accident, based on a substantially consistent set of witness accounts, did not suggest that a technical problem had played any part in the collision. Further examination of the aircraft remains was therefore confined to a detailed study of the impact damage sustained by each aircraft, with a view to determining how the two had come together.

Recorded information

The track of G-BNXC was captured by the Air Traffic Control radar at Clee Hill and the recorded data was available for the investigation. The same radar also captured what is believed to be parts of the track of G-GHEE, being mainly that part as the aircraft flew towards Moreton in Marsh and before it commenced its descent. The radar also recorded other aircraft tracks in the area, including tracks which crossed each aircraft prior to the collision and the track of an eyewitness' aircraft. Although limited radar data was available for G-GHEE, the aircraft carried a GPS receiver which provided track data for the whole flight. There was no recorded altitude information for either of the accident aircraft; the Secondary Surveillance Radar return for G-BNXC did not include altitude information, and the GPS equipment on G-GHEE did not record height. The tracks of the two aircraft in the minutes before the collision are shown at Figure 1.

G-GHEE approached the area from the south-west with an average recorded groundspeed of 88 kt, equating to an airspeed of about 73 kt. G-BNXC flew a fairly steady track from Banbury towards Moreton in Marsh at an average groundspeed of 74 kt, approximately equating to the pilot's planned airspeed of 90 kt.

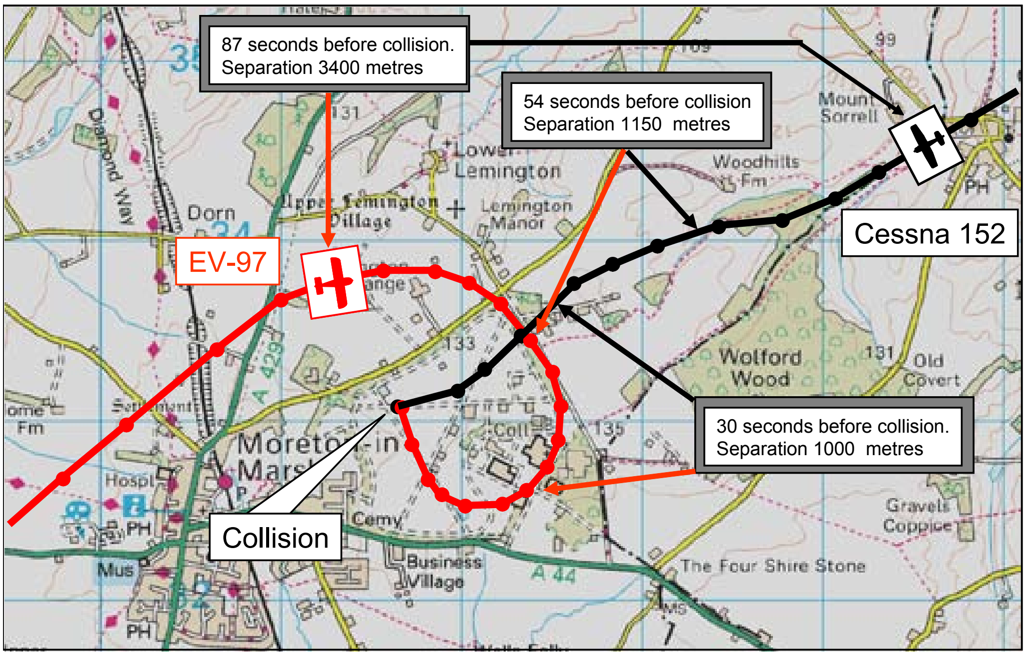


Figure 1

Tracks of the two aircraft, derived from GPS and radar information

At 2 minutes 20 seconds before the collision the aircraft were approaching the accident area from opposite directions, being approximately head-on to each other at a range of 7.6 km. As the Eurostar started its right turn in the accident area, 87 seconds before collision, the two aircraft were 3,400 m apart. The Cessna was directly ahead of the Eurostar at this stage, which would have been just to the right of the Cessna's nose. Shortly after, some 54 seconds before collision and just as the Eurostar crossed its intended track, the Cessna was seen to have altered course to the right by 20º to 25º. At this point the two aircraft were 1,150 m apart. The Eurostar then continued its right-hand turn while the Cessna turned back to parallel its original track for a short while before turning again to track directly for the centre of the disused airfield. The Cessna then resumed its original track whilst the Eurostar continued to turn right until it rolled out on a track of about 350º(M). At this point the aircraft were some six seconds from collision, the crossing angle was about 100º and the aircraft were between 300 and 350 metres apart.

Whilst there was no electronically recorded altitude information for G-BNXC, some information was recovered from the pilot's flight planning paperwork. The pilot's navigation log for the flight recorded a planned altitude for each leg of 2,000 ft amsl. This was at variance with the altitude of 2,500 ft amsl which was entered on the briefing certificate issued by his flight instructor. The pilot had flown the route on a previous occasion, but had to curtail the exercise due to an aircraft unserviceability. The navigation log for that flight was recovered and showed that the pilot had planned to fly at an altitude of 2,500 ft amsl.

Radar data also showed that another aircraft had crossed the track of the Cessna about one minute before the collision. Minimum lateral separation was about 350 metres, but corrected SSR Mode C altitude information for the crossing traffic showed that it was at 2,750 ft amsl. The aircraft was traced and found to have been on a dual training exercise; neither the instructor nor his student had seen the Cessna 152.

Eyewitness information

The two aircraft were seen in close proximity by a number of people on the ground and in the air, some of whom witnessed the actual collision. One witness was flying a light aircraft in the area at about 3,000 ft and receiving an air traffic service from RAF Brize Norton. He stated that there was a thin cloud cover between about 3,000 and 3,500 ft, with good visibility. He did not consider that the position of the sun presented a problem in terms of lookout. The two aircraft were some way below him, perhaps about 1,000 feet agl, and some two or three miles distant. Although he did not see the actual collision, the witness recalled seeing the Cessna pitching up rapidly to what he thought was about 15º to 20º of pitch, possibly with the left wing low. It appeared to gain altitude before yawing and rolling to its left and pitching nose down. However, the aircraft then seemed to start to recover from the rolling manoeuvre just before it hit the ground. The witness notified RAF Brize Norton of the accident and, at their request, remained circling overhead whilst passing further information to ATC until the arrival of the emergency services.

All of the ground witnesses reported that both aircraft appeared to be flying normally, in straight and level flight, and that there was no significant manoeuvring by either aircraft prior to the collision. Most reported seeing wreckage falling immediately after the collision. All witnesses recalled that, at the point of collision or immediately after it, the Cessna yawed and rolled before entering a steep descent. Those that were aligned with the Cessna's track did not report any pitching motion, but the closest witness, who was at some 45º to the Cessna's track and about 500 m from the point of collision, recalled an initial pitch-up and roll to the left, similar to that reported by the airborne witness. The same witness was also approximately in line with the Cessna's final descent and impact. He reported seeing the top surface of the aircraft as it descended steeply towards him, and being aware of the red anti-collision beacon (mounted on top of the fin). He thought he heard the engine cut out during the descent, and had the impression that the pilot was starting to recover from the dive but had not done so before the aircraft disappeared behind trees, after which the witness heard the sound of the ground impact.

Limitations of lookout

Maintaining an effective lookout for aircraft and other hazards is a prime task for a pilot, particularly when flying in uncontrolled airspace without positive radar assistance from Air Traffic Control. However, there are limitations in the human visual system that serve to make collision avoidance difficult by visual means alone.

The capacity of the human eye to resolve detail is not distributed evenly across the retina. The most central part of the retina is termed the fovea, and is composed only of cones - the light sensitive cells used for day vision. Cones provide high visual acuity, colour vision and contrast discrimination. Although there is good resolving power at the fovea, this ability drops rapidly only a few degrees away from it. Normal visual reflexes adjust the direction of gaze to ensure that the image of an observed object falls on the fovea for optimum resolution. Such vision, sometimes termed 'focal' vision, requires a stable image and the viewer's attention.

Away from the fovea, the density of cones reduces, and that of cells called rods increases. Rods are more sensitive to light than cones, and are used for day, night and low intensity vision. Rod vision is monochromatic and of low acuity, giving only outlines or shapes. It is, however, responsive to movement. It does not require the same degree of attention as focal vision and is important for spatial orientation and 'flow vision', which gives a sense of speed. Rod vision is sometimes referred to as 'peripheral' vision.

A distant aircraft will be perceptible to a pilot so long as it is acquired at or near the fovea. As an area of sky is scanned by the pilot, the eye naturally makes a series of jumps, or saccades, with intervening rests. The scene is only interrogated by the brain during the rest periods. A very small object may therefore be 'jumped over' or fall on an area away from the fovea – in either case it will not be detected. Each saccade-rest cycle takes a finite time and a full scan of an area of sky will take some seconds. An object missed early in the scan may have sufficient time to approach hazardously close or even collide before that area is scanned again by the pilot.

Two aircraft on a collision course maintain a constant relative bearing to each other until the moment of impact. The colliding aircraft will therefore appear in the same place on the aircraft's canopy unless the pilot makes a head movement. As the colliding aircraft is not moving relatively, it does not necessarily attract the attention of the peripheral vision system. The rate of increase in retinal size of the approaching aircraft is not linear and the image stays relatively small until very shortly before impact. Additionally, small targets may be hidden behind canopy arches or struts until very late. For these reasons pilots are taught not just to look around them, but to positively move their head as they do so.

Meteorological information

Information on the actual weather conditions was obtained from the Met Office, from the passenger's photographs and from the airborne eyewitness. At the time of the accident there was a weak ridge of high pressure covering England and Wales giving generally fine weather, though with broken or scattered cloud at 3,500 to 4,000 ft amsl, ahead of a weak warm front which was approaching from the west. Visibility at the surface would have been 25 to 40 km, and airborne visibility likewise appears to have been good. The elevation of the sun at 1218 hrs was 14º and its azimuth was 184º. The surface wind was from 230º(M) at 5 kt, the wind at 1,000 ft was from 240º(M) at 15 kt and the wind at 2,000 ft was from 250º(M) at 20 to 25 kt.

Medical and pathological information

The 34 year old male student pilot of G-BNXC held a valid JAA Class 2 medical certificate, with no limitations or restrictions and no requirement to wear corrective lenses. A post mortem examination confirmed that the pilot died from multiple injuries consistent with having been caused by the ground impact. Toxicological examination revealed the presence of two therapeutic drugs, the presence of which may have been significant.

The first drug was either Ephedrine or Pseudoephedrine (it was not possible to distinguish between these two closely related drugs). Both drugs were available without prescription, being commonly used as nasal decongestants and bronchodilators. Concentration levels were within the normal therapeutic range. Both drugs have a range of potential side effects including headache, dizziness, anxiety, tremor and potential abnormalities of heart rhythm. According to the Civil Aviation Authority (CAA) Medical Department, these drugs, and the underlying reason for taking them, would normally be disqualifying for flight.

The second drug revealed by the toxicological examination was Scopolamine, at levels consistent with it having been taken at some time within the previous 48 hours. Scopolamine is also a non-prescription drug and can be used for the treatment of motion sickness as well as gastrointestinal disorders. The pilot had previously declared a medical condition to the CAA; the drugs he had been taking were acceptable to the CAA. However, Scopolamine has a wide range of potential side effects including drowsiness, fatigue, dizziness, blurred vision and the potential to affect many cognitive processes including visual functions. Scopolamine is also not acceptable to the CAA as a medication which may be used by someone in sole control of an aircraft.

The 62 year old male pilot of G-GHEE held a National PPL medical declaration form valid until 29 March 2008. The medical standards required for the countersignature of the form by the holder's general practitioner are equivalent to DVLA group 2 standard for professional driving. The pilot did not need to wear spectacles to meet these standards.

Medical requirements

The training syllabus for the issue of a Joint Aviation Authorities (JAA) PPL includes training in human performance and limitations. This training, under the section '*flying and health*' includes awareness training of drugs, medicines and their side effects. The pilot of G-BNXC had passed the ground examination in the above subject on 8 January 2005.

Medical requirements for holders of JAA licences are contained in Joint Aviation Requirements – Flight Crew Licensing 3 (JAR-FCL 3). JAR-FCL 3.040 *"Decrease in medical fitness"* deals with general medical advice to holders of JAA medical certificates, as well as the circumstances in which the holder of a medical certificate must seek advice from an authorised medical person. It also deals with significant injuries and illnesses, and pregnancy. Further explanatory material is also given concerning medication, drugs, other treatments and alcohol.

JAR-FCL 3.040 includes the following paragraph:

> *"Holders of medical certificates shall not take any prescription or non-prescription medication or drug, or undergo any other treatment, unless they are completely sure that the medication, drug or treatment will not have any adverse effect on their ability to perform safely their duties. If there is any doubt, advice shall be sought from the AMS, an AMC, or an AME."* [1]

The CAA has reproduced much of the content of JAR-FCL 3.040 in various publications, including an Aeronautical Information Circular (AIC 99/2004) which dealt with medication, alcohol and flying and 'Safety Sense' leaflet number 24 – '*Pilot Health*'. An extract from JAR-FCL 3.040 is also reproduced on the rear of the CAA's JAA medical certificate, though this is limited to the need to notify the Authority when becoming aware of the need for the regular use of medication. The CAA's LASORS publication, which is aimed at providing general aviation pilots with a reference document on safety and licensing matters, also contains medical information, although it does not include any reference to occasional medication or self medication.

Rules of the air

The Air Navigation Order contains the Rules of the Air Regulations applicable to flights within the United Kingdom. In respect of powered aircraft, Rule 17 (2)(b)(i) states:

> *'... when two aircraft are converging in the air at approximately the same altitude, the aircraft which has the other on its right shall give way.'*

Rule 17(1)(a) states:

> *'... it shall remain the duty of the commander of an aircraft to take all possible measures to ensure that his aircraft does not collide with any other aircraft.'*

Previous accidents and Recommendations on conspicuity

The AAIB investigated two mid-air collisions which occurred in 2004. The first involved two gliders from Lasham airfield on 26 April 2004 (AAIB Bulletin 5/2005), and the second involved a Robinson R22 helicopter and a Hybred 44XLR microlight aircraft, which occurred overhead Welham Green in Hertfordshire on 6 July 2004 (AAIB Bulletin 4/2005).

During the course of the investigations the AAIB made the following recommendations to the CAA:

Safety Recommendation 2005-06

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

Safety Recommendation 2005–08

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

Footnote

[1] Aeromedical Section, Aeromedical Centre, and Aeromedical Examiner.

The relevant extracts from the CAA's responses were as follows (in respect of gliders, the CAA has no regulatory powers to require the adoption of any recommended measures):

Extract from CAA's response to Safety Recommendation 2005-06

The CAA does not accept this Recommendation. However, the CAA will review its ongoing work on the use of visual and electronic measures to enhance the conspicuity of General Aviation aircraft, particularly in the light of impending wider transponder carriage. The review will be completed by 31 December 2005 and the CAA will then consider whether the adoption of such measures should be required."

Extract from CAA's response to Safety Recommendation 2005-08

"The CAA does not accept this recommendation insofar as it is directed to light aircraft. The promotion of international co-operation and action to improve the conspicuity of light aircraft through visual and electronic means will depend upon the outcome of the review noted in Recommendation 2005-06".

A CAA working group undertook a review of conspicuity enhancements for General Aviation (GA) aircraft. The working group reviewed statistical data, previous CAA studies and emerging technological developments related to GA aircraft collision and avoidance. The review determined that UK-registered aircraft had been involved in a total of 30 mid-air collisions in the period 1995 to 2004, resulting in 27 fatalities from 14 fatal accidents. Previous studies, both in the UK and in Europe had generally promoted 'see and avoid' principles as the most effective remedy, with various aircraft colour schemes and lighting systems also being proposed.

The working group reviewed aircraft colouring, aircraft lighting and light detection systems, and active systems for electronic aircraft detection. It noted that the most common colouring on civil aircraft is white, which affords some contrast against the surface and the sky, but which studies suggest may not be as effective as the contrast provided by dark and light colours together. For example, many civil police helicopters have adopted a yellow and black colour scheme to make their aircraft more visible and thus reduce the collision risk.

The working group also noted that, whilst technological alerting systems may be useful in supplementing the pilot's own lookout, their use may introduce other human factors issues such as reliance and resource management, whilst there were also installation costs and other practical considerations for aircraft owners. The potential introduction of wider carriage of transponders[2] in the UK from 2008 would provide an opportunity to reduce the risks of mid-air collisions, whether by direct detection or interrogation of the transponder, or by rebroadcast of transponder based information by a ground station. It was noted that a forthcoming Directorate of Airspace Policy Regulatory Impact Assessment (RIA) would include the wider use by GA aircraft of transponders and electronic traffic awareness systems, and it was considered that this process would be the most effective way of assessing GA community concerns in this area.

Footnote

[2] An aircraft transponder is a receiver – transmitter that generates a reply signal upon proper electronic interrogation by an Air Traffic Control ground station or other suitably equipped aircraft. The reply signal can be used to carry specific information relating to the aircraft in which it is fitted.

The working group identified areas worthy of further research and recommended that:

1. The use of contrasting colour and reflecting surfaces to improve the conspicuity in GA aircraft is investigated,
2. Increased publicity is given to the use of the 'see and avoid' principle and transponders,
3. Full support is given to the Directorate of Airspace Policy's RIA covering GA carriage of transponders and electronic traffic awareness systems.

Analysis

General

From eye witness accounts and recorded data it is clear that both aircraft approached each other in broadly straight and level flight, and that neither was in any obvious difficulty prior to the collision. Neither the Eurostar's pilot nor passenger saw the Cessna until it was too late to prevent a collision, and the flight path of the Cessna suggests that its pilot also did not see the other aircraft in time to influence the outcome, if at all. Rules of the Air Regulations require certain actions by pilots in order to avoid collisions. However, such actions are only possible if the pilots concerned are aware of the other aircraft's presence.

The Cessna pilot

The aircraft's flight paths were such that the Eurostar would have been in the forward field of view of the Cessna pilot during the entire time his aircraft was tracking towards the eventual collision site. As the Eurostar crossed ahead of the Cessna, the Cessna pilot initiated a slight turn to the right which, as his planned route took him directly overhead the airfield, would be unusual. There are two likely explanations for this.

One explanation is that the Cessna pilot saw the Eurostar crossing his flight path ahead and deviated to the right to ensure that he would pass safely behind the other aircraft, in accordance with the Rules of the Air. If such were the case, the Cessna pilot probably did not realise that the Eurostar was in fact turning, albeit gently, when it crossed ahead of him. Once the Eurostar had crossed ahead of the Cessna, the separation between the two aircraft was never greater than about 1,000 m, so the Cessna pilot should have had no difficulty keeping the Eurostar in sight. The fact that he subsequently lost visual contact with the Eurostar suggests that the Cessna pilot perceived the Eurostar to be flying on a track which would take it clear of the area, and he therefore ceased to monitor it.

An alternative explanation is that the pilot of G-BNXC turned deliberately to afford a better view of the disused airfield, and with the pilot occupying the left seat, this would naturally have been a turn to the right. The Fire Service College used a number of old aircraft and other vehicles for training purposes, and these were distributed about the site. Together, they presented an interesting collection and it is possible that the pilot wished to get a better view of them. Had this been the case, the pilot's lookout could have been less effective as he approached the accident area.

Based on eyewitness information, the Eurostar pilot's report, and the photographs taken by the passenger, it is probable that the collision occurred at between 800 and 1,000 ft above the disused airfield, which equates to between 1,236 and 1,436 ft amsl. The pilot of the Eurostar intended to operate at this height, but it is not clear why the Cessna was at such a relatively low height during a cross-country navigation exercise, particularly as the Cotswold Hills lay only 5 nm ahead on his track, with terrain rising to above 1,000 ft amsl. The pilot was authorised by his instructor to fly at 2,500 ft amsl, which would have taken the aircraft over Moreton in Marsh at about 2,000 ft above the ground. The pilot had apparently planned to fly at 2,000 ft amsl, and although he did not report his altitude to the Air/Ground operator at Turweston, it is likely he would have been at or above 2,000 ft amsl at that point, as his track passed over the Turweston Air Traffic Zone, with an upper limit of 2,000 ft. Even at 2,000 ft amsl, the Cessna would have passed over the accident site in excess of 1,500 ft above ground level.

It is also unlikely that the Cessna pilot would have flown over Banbury at less than 2,000 ft amsl, so in all probability the pilot descended as he was approaching the disused airfield. It is unlikely that a technical problem caused the pilot to descend with a view to landing on the disused airfield as the runways, although clearly defined, were obstructed by buildings and other equipment, and the aircraft was not manoeuvring in a manner which suggested that the pilot had any intention of attempting a landing. In view of the aircraft collection on the ground at the Fire Service College, it is more likely that this was the reason behind the pilot's descent. If the Cessna were descending as it approached the disused airfield, it would have made visual detection of the Eurostar more difficult, as it would have been against a background of ground features rather than the sky.

The brief 'MAYDAY' which is presumed to have been made by the Cessna pilot after the collision, and the description of the aircraft's pitch up and final descent, suggests that the pilot had not been incapacitated in the collision but was attempting to recover the aircraft to controlled flight after it had stalled and rolled left into a steep dive. The damage to the aircraft's left wing and flying controls was such as to make a successful recovery uncertain from any height, and it is unlikely that the aircraft could have recovered in the relatively low height available.

The Eurostar pilot

As the Eurostar approached from the south-west, the Cessna would also have been in the pilot's forward field of view, and this would have been the case until the time that the Eurostar crossed the Cessna's projected track. From that time until about 30 seconds before the collision, the Cessna would have been in a rear quarter of the Eurostar, and thus unlikely to be detected, though it should be noted that the aircraft's raised 'bubble' canopy afforded good all-round vision.

However, from the moment that the Eurostar pilot commenced his right turn over the airfield, his attention would probably have been focussed to some degree towards the features on the ground which he knew his passenger wished to photograph, and away from the area to his left from which the Cessna was approaching. Even when the aircraft rolled wings level after its turn, part of the pilot's attention may still have been on the ground features, since the passenger had requested another orbit to take more photos.

Collision parameters

Simple 3D CAD models were created for both aircraft involved, in sufficient detail to allow the relationship between the patterns of damage sustained by each aircraft to be explored; in particular, the character and orientation of scrapes and paint smears observed on the Cessna's left outer wing and the distribution damage to the Eurostar's nose and engine. The analysis confirmed that the Eurostar had been tracking approximately at right angles to the Cessna, approaching the Cessna's left side, and that the lower segment of its propeller arc, lower engine cowl, and the upper part of the nose landing gear strut had impacted the Cessna's left wing end-on, approximately as illustrated in Figure 2. The precise attitude of the Eurostar in roll and pitch could not be determined, but neither was extreme.

Figure 2
Initial impact

The propeller damage on the outer leading edge of the Eurostar's left wing was consistent with it having made a glancing contact with the rear face of the Cessna's propeller disc. In order for this to occur, the aircraft must have yawed rapidly relative to one another during the collision sequence so that their flight paths were approximately parallel. The Eurostar's occupants report that during the collision sequence the canopy burst open. The absence of any collision damage to the Eurostar's (open) canopy or fin, together with the absence of any contact between its right wing and the Cessna's fin and rudder, suggest that the Eurostar had rolled to the left somewhat (relative to the Cessna) and *climbed over* the top of it before contacting its propeller, in the manner illustrated in Figure 3.

Pilots' field of view

In the final seconds preceding the collision the relative bearings between the aircraft were constant, meaning that each aircraft would have appeared to the other pilot to be stationary in the canopy or windscreen. The 3D computer models were also used to assess each pilot's field of view during the seconds before the collision.

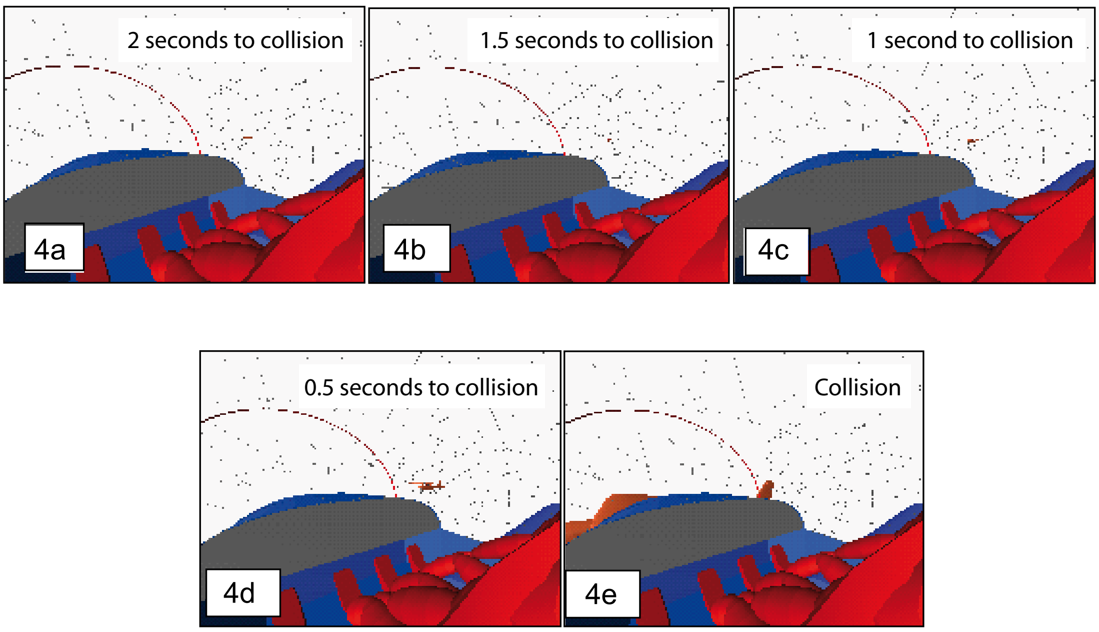
Figure 3
Final contact

This analysis suggested that, unless the Eurostar had been banked to the left, its pilot would have had a direct line of sight to the Cessna and that it would not have been obstructed by the instrument panel, cockpit surround or any other part of the aircraft. However, the angle subtended at his eye by the Cessna (ie the size of image formed on his retina), would have been very small and would have changed very little until the final second or so before the collision. If the Cessna had been in the Eurostar pilot's peripheral field of view, where visual acuity is poor and *rate of change* (movement across, or growth of image size on, the retina) is the primary factor in triggering a response, it is unlikely that he would have registered its presence in time to take effective avoiding action. Figures 4a through 4e mimic the images that would have been produced if a camera with a standard lens was positioned at the Eurostar pilot's eye position, pointed towards the Cessna, and the shutter triggered at half-second intervals during the final 2 seconds prior to the collision. The small size of the Cessna in relation to the overall field of view, even up to a very late stage, is clearly evident, as is its rapid rate of growth during the final half second.

A similar analysis to assess the Cessna pilot's probable field of view suggested that the Eurostar was likely to have been hidden behind the left screen pillar until about half a second prior to the collision, as shown in the sequence of *photo images* in Figures 5a through 5e. Had this been the case, then no effective avoiding action could have been taken by him in the time available.

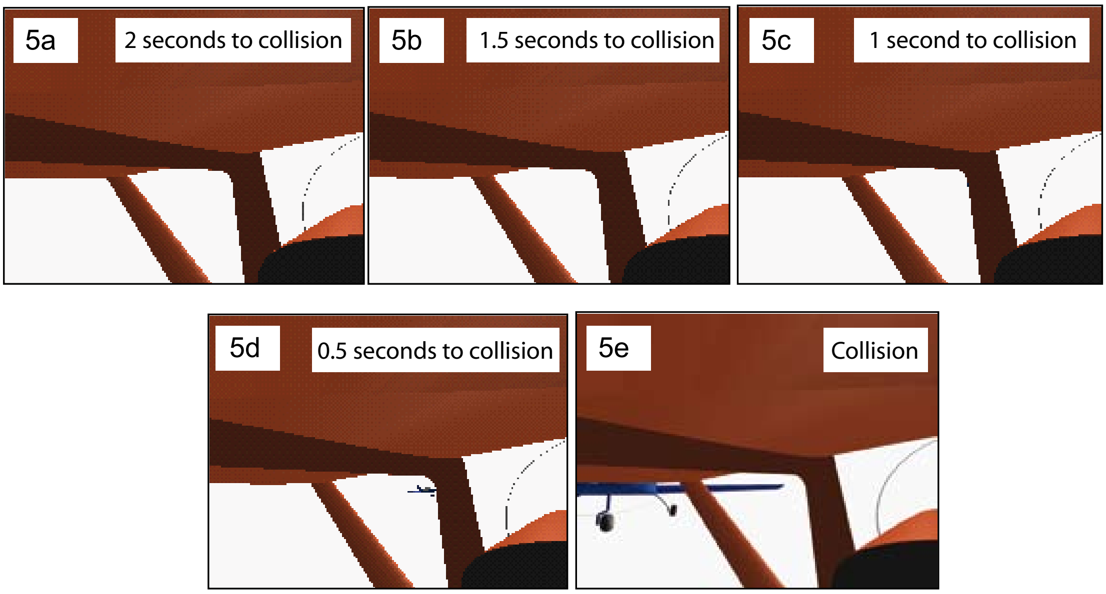
Pilot self-medication

The pilot of G-BNXC was found to have been taking two non-prescription drugs which may have affected his ability to operate his aircraft safely. The pilot would have been aware of the hazards of self medication, as these were covered during his ground training. However, the pilot had previously been taking medication, for a declared medical condition, which was approved by



Figures 4a to 4e

Simulated view from the Eurostar, G-GHEE



Figures 5a to 5e

Simulated view from the Cessna 152, G-BNXC

the CAA. He may have been unaware that other drugs used to treat the same condition did not carry the same approval. It is not known if use of the drugs themselves contributed to the accident, but the nature of their possible side effects, which include drowsiness and impairment of visual functions, is such that their use represents a potential contributory factor in the accident. Therefore the following Safety Recommendation is made:

Safety Recommendation 2006-117

The CAA should review the guidance that is contained in LASORS, such that the regulations regarding occasional medication, rather than just the regular use of medication, are emphasised.

Conclusions

The accident occurred because the pilots involved did not see each other's aircraft in sufficient time to take effective avoiding action. Each pilot's attention may have been focussed to some extent on ground features at the expense of lookout, and the Eurostar may have been obscured behind the left screen pillar of the Cessna. The geometry of the collision and the limitations of the human visual system are such that detection of the other aircraft by either pilot would have been difficult once they had each become established on a collision course.

ACCIDENT

Aircraft Type and Registration:	Cessna 152, G-BTIK
No & type of Engines:	1 Lycoming O-235-L2C piston engine
Year of Manufacture:	1970
Date & Time (UTC):	19 July 2006 at 1135 hrs
Location:	Andrewsfield, Essex
Type of Flight:	Training
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Nosewheel collapsed, engine and propeller damaged
Commander's Licence:	Student pilot
Commander's Age:	42 years
Commander's Flying Experience:	40 hours (of which 40 were on type) Last 90 days - 8 hours Last 28 days - 4 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and subsequent AAIB enquiries

History of the flight

Following a series of circuit exercises with her flying instructor, the student pilot was making her first solo flight; the flying instructor observed the flight from the ground. The visibility was good, the wind was from the east at approximately 11 kt, and Runway 09 was in use.

The flight appeared to progress normally until the aircraft touched down in a nose-low attitude and bounced. Two further bounces followed before the nose landing gear broke off and the propeller struck the ground, causing damage to the propeller, engine and firewall. The aircraft came to a halt on the runway and the pilot vacated the aircraft without injury. There was no fire.

The student pilot had taken flying lessons over a period of some two years, at two flying schools, and had flown regularly with the instructor who sent her solo. The instructor reported that they had flown a number of circuits prior to the solo flight, all to a safe standard. These circuits included three go-arounds and practice in recovery from a bounced landing. The instructor commented that she believed that the student was fully ready for a first solo, and that she could not have done more to prepare the student for a first solo flight.

ACCIDENT

Aircraft Type and Registration:	Cessna 182Q, G-BWRR
No & type of Engines:	1 Continental O-470-U piston engine
Year of Manufacture:	1978
Date & Time (UTC):	11 August 2006 at 1310 hrs
Location:	Lower Withial Farm, Pennard, Somerset
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 3
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to horizontal stabiliser, right strut, lower engine cowling and nosewheel spat
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	63 years
Commander's Flying Experience:	1,946 hours (of which 224 were on type) Last 90 days - 40 hours Last 28 days - 16 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft was landing shortly after a rain shower had passed overhead the airfield. Following a normal touchdown the aircraft became airborne again having hit an undulation in the grass surface. The pilot made a small power application to arrest the descent and touched down again further down the strip. On brake application the pilot perceived little braking effect due to the slipperiness of the wet grass. The aircraft overran the runway causing slight damage. There were no injuries.

History of the flight

The flight was planned from Fishburn, County Durham to Lower Withial Farm. The weather was as forecast, with a wind from 320º at 25 kt, a cloudbase of 3000 ft, and unlimited visibility. Lower Withial Farm has a grass Runway 05/23 which is 500 m in length with a slight upslope towards the east. There is a 10 ft high hedge at the approach end of Runway 23.

On arriving to the north of the farm strip the pilot noted scattered rain showers in the local area and circled for five minutes to allow the rain showers to clear towards the south. The forecast wind for the area was from 320º at 8 kt which accorded with the actual conditions reported on the Bristol ATIS broadcast and the indications from the windsock. The pilot made an initial approach onto Runway 05; however his GPS indicated a tailwind of 5 kt so he aborted the approach and repositioned for an approach to Runway 23. The aircraft was configured with flaps selected to 40º and an approach speed of 60 kt was used. The GPS indicated a headwind of 5 kt.

The approach was normal and the aircraft touched down in the first third of the strip, however during the landing roll the aircraft struck an undulation halfway along the strip and became airborne again. The pilot applied a small amount of power to arrest the descent which had the effect of using up more of the remaining length of the strip. When the aircraft touched down again the pilot applied the brakes. There was little deceleration due to the slipperiness of the wet grass following the recent shower. The aircraft was by this time approaching the end of the runway, beyond which was an electric fence. The pilot considered it would be too risky to attempt a go-around. He tried to steer the aircraft, with minimal effect, and the aircraft passed through the electric fence, striking a parked car before coming to rest approximately 10 m beyond the fence. The pilot shut down the aircraft and all the occupants exited the aircraft unaided.

Aircraft performance

Information in the Pilots Operating Handbook gives a 40% landing distance increase for operation on a dry grass runway. Applying this factor, performance figures from Cessna give a landing distance from 50 ft of 582 m, which includes a ground roll of 256 m. They stated that for:

> *'wet grass there would be little or no braking. Also, if the grass was fairly wet, then the pilot could experience hydroplaning'.*

The Civil Aviation Authority Safety Sense Leaflet 7c '*Aeroplane Performance*' details variables affecting performance. It states:

> *'Landing on a wet surface, or snow, can result in an increased ground roll, despite increased rolling resistance. This is because the amount of braking friction is reduced, due to lack of tyre friction. Very short wet grass with firm subsoil will be slippery and can give a 60% increase (1.6 factor).'*

ACCIDENT

Aircraft Type and Registration:	DH82A Tiger Moth, G-AHVU
No & type of Engines:	1 De Havilland Gipsy Major 1C piston engine
Year of Manufacture:	1941
Date & Time (UTC):	8 July 2006 at 1045 hrs
Location:	Goodwood Aerodrome, Chichester, West Sussex
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Left vertical strut damaged
Commander's Licence:	Private Pilot's Licence
Commander's Age:	52 years
Commander's Flying Experience:	766 hours (of which 21 were on type) Last 90 days - 19 hours Last 28 days - 7 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft sustained minor structural damage to a vertical strut due to a heavy landing.

History of the flight

During the landing on Runway 14 at Goodwood, following an uneventful flight from Rendcomb, the aircraft sustained damage to a vertical strut located on the left side of the cockpit. The pilot reported the wind as being from 200º at 5 kt. The pilot assessed that the damage was as a result of a heavy landing, possibly due to an 'air pocket'[1].

Footnote

1 air pocket – defined as '*sudden and pronounced gust imparting negative vertical acceleration; downdraught'* source : The Cambridge Aerospace Dictionary.

ACCIDENT

Aircraft Type and Registration:	DH82A Tiger Moth, G-EMSY
No & type of Engines:	1 De Havilland Gipsy Major 1 piston engine
Year of Manufacture:	1940
Date & Time (UTC):	15 August 2006 at 0850 hrs
Location:	Old Sarum Aerodrome, Wiltshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passenger(s) - None
Injuries:	Crew - None Passenger(s) - N/A
Nature of Damage:	Minor damage to underside of lower left wing and small tear in fabric. Fin and elevator damaged on G-SLYN
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	72 years
Commander's Flying Experience:	Approximately 20,000 hours (of which 30 were on type) Last 90 days - 8 hours Last 28 days - 4 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot.

Synopsis

While taxiing out for takeoff, the pilot of G-EMSY saw a parked Piper Warrior too late to avoid it and the lower left wing of his aircraft struck the tail of the Piper.

History of the flight

The pilot of G-EMSY was taxiing out on the grass towards the runway. He was aware of a row of aircraft parked on his right side and that the nearby parking slots on his left side were empty. Then, as he approached the edge of the runway, he suddenly became aware of another aircraft, G-SLYN parked on his left side. With no brakes on the Tiger Moth, he immediately attempted to turn right and switched off the magnetos but the lower left wing of his aircraft struck the tail of the parked aircraft.

At the time of the accident, the visibility was good, the surface wind was light and the grass was damp. The pilot acknowledged that the collision resulted from his poor lookout.

ACCIDENT

Aircraft Type and Registration:	Europa, G-TAGR
No & type of Engines:	1 Rotax 912 ULS piston engine
Year of Manufacture:	2004
Date & Time (UTC):	21 July 2006 at 1305 hrs
Location:	1.5 miles West of RAF Syerston, Nottinghamshire
Type of Flight:	Private
Persons on Board:	Crew 1 Passengers 1
Injuries:	Crew None Passengers None
Nature of Damage:	Nose landing gear collapse and significant damage to lower fuselage and wing mounts
Commander's Licence:	Private Pilot's Licence
Commander's Age:	57 years
Commander's Flying Experience:	394 hours (of which 29 were on type) Last 90 days - 5 hours Last 28 days - 1 hour
Information Source:	Aircraft Accident Report Form submitted by the pilot/owner and subsequent testing

Synopsis

Shortly after taking off from RAF Syerston the pilot noticed that the engine was not running at maximum speed and, as the aircraft climbed through 200 ft, it began running roughly with its speed decreasing. The pilot reduced the power setting, which resulted in the engine running smoothly for a short while, but when increased power was demanded to initiate a climb and return to RAF Syerston, the engine again began to run roughly and failed to respond to throttle inputs. The pilot carried out a forced landing in a crop field which resulted in the collapse of the nose landing gear and damage to the lower fuselage and wing mounts. In the absence of any identifiable technical defect, it was considered that fuel vapour locking, caused by the use of un-insulated fuel lines within the engine compartment, had caused the loss of power.

History of the flight

The pilot/owner had planned to fly with a friend to Waterford, via Swansea. As the aircraft would need to operate close to its maximum all up weight, the pilot positioned the aircraft to RAF Syerston on the previous evening to make use of the longer runway. This flight lasted for approximately 1.5 hours and, apart from a short period of 'rough running' when climbing through 2,500 ft, the flight was uneventful. On the day of the accident, the engine started normally and no abnormalities were observed during the pre-takeoff power checks. Some 15 minutes later, the takeoff was commenced and, initially, appeared normal. Shortly after rotation, the pilot noticed that the engine was only producing 5,100 rpm instead of the expected maximum of 5,500 rpm but, as it was running smoothly and the aircraft was climbing at 500 fpm, he decided to continue with a gentle climb to allow the airspeed to build up. After passing 200 ft, the engine began to misfire and its speed decreased below 4,800 rpm. The pilot reduced the power setting to see if the misfiring could be corrected. At 4,000 rpm, the engine ran smoothly and, with 15º of flap set, the aircraft was able to maintain its altitude. The pilot then slowly increased the engine power setting and attempted to climb, with the intention of carrying out a wide circuit and returning to RAF Syerston. However, the engine failed to respond and began to misfire severely. As the aircraft was now descending through 200 ft the pilot turned 'in to wind' and identified a suitable field for a forced landing. While concentrating on maintaining flying speed the pilot misjudged the final stages of the approach and landed heavily with the aircraft in a slightly nose down attitude. This, together with a pronounced upslope of the landing field, resulted in the nose landing gear failing and the aircraft's nose and propeller striking the ground. Both occupants were uninjured and able to leave the aircraft unaided.

Investigation

The pilot had built the aircraft in 2004 from a kit and installed an engine supplied by the airframe manufacturer. The engine had run for 51 hours prior to the incident and had been maintained by Rotax approved engineers since its installation.

An aftercast provided by the Met Office showed that, although the air temperature was 29ºC, the humidity was relatively high and therefore there was a possibility of carburettor icing at low power settings. Before taking off, the aircraft had been on the ground with the engine running for approximately 15 minutes, presumably at both low and high power settings, with the attendant risk that some carburettor ice could have formed whilst running at low power. Although the initial part of the takeoff at high power was apparently normal, the possibility that ice could have built upon that already in the induction system could not be fully discounted.

The fuel tank on a Europa has two lobes on its lower side to allow it to sit over the rear portion of the fuselage landing gear bay, which is used in the mono-wheel variant of the aircraft. Fuel is then pumped from each lobe, on selection, to the engine by both an electrical and mechanical fuel pump. At the time of the accident fuel was being supplied by the left side of the tank. Tests carried out by the owner after the incident confirmed that, although some debris was found in the fuel filter associated with the left lobe, the supply from each side of the tank was over twice the engine's maximum fuel consumption rate. The tests also confirmed that the fuel return line was free from obstruction. An inspection of the ignition system showed all cables to be free from cracking and visible damage.

Photographs provided by the owner show that the fuel lines to and from the mechanical fuel pump were routed over the right inlet manifold, Figure 1; this complies with the recommended routing in the manufacturer's build manual. The manual also recommends that these lines are provided with an insulating sleeve to prevent heat transfer into the fuel. This recommendation was introduced[1] by the kit manufacturer as a result of several

Footnote

[1] Europa Aircraft Service Bulletin No 1 of June 1997

cases of fuel vapour lock occurring during takeoff, which manifested itself as rough running and engine stoppage. The fuel lines fitted to G-TAGR were un-insulated and constructed with braided steel reinforcement.

Given the use of un-insulated fuel lines in an area of the engine bay which would be subject to significant heat build up, and the high ambient temperature on the day, the possibility that the engine's rough running and power loss was caused by a vapour lock, which interrupted the flow of fuel to the engine, also could not be dismissed.

Figure 1

ACCIDENT

Aircraft Type and Registration:	GROB G115, G-BOPT
No & type of Engines:	1 Lycoming O-235-H2C piston engine
Year of Manufacture:	1988
Date & Time (UTC):	26 July 2006 at 1350 hrs
Location:	Barton Aerodrome, Manchester
Type of Flight:	Training
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Nose landing gear collapse and propeller damage
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	77 years
Commander's Flying Experience:	22,000 hours (of which 34 were on type) Last 90 days - 5 hours Last 28 days - 5 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

Following a training flight, the student pilot carried out a landing on Runway 27L. The landing was heavy, resulting in several bounces and an eventual collapse of the nosewheel. The commander assessed that the student pilot had rounded out too high, resulting in the aircraft sinking and the subsequent hard landing and bounce.

History of the flight

The instructor (commander) was converting the student pilot onto the GROB 115. The student was in the middle of a flight instructor course, having already gained a commercial pilot's licence. The training flight had been without incident and the student pilot flew the aircraft back to Barton to continue some training in the circuit.

The student flew the approach to Runway 27L; initially he was high but he corrected this error. The aircraft then landed heavily, on all three landing gears, and bounced. It then bounced again, after which it yawed and rolled to the left. The commander took control, during which the nosewheel collapsed and the propeller struck the ground. The aircraft finally came to rest to the left of the runway. Both occupants were uninjured and exited the aircraft normally.

The instructor assessed that the student pilot rounded out too high, resulting in the aircraft sinking and the subsequent hard landing and bounce. The instructor added, as a personal comment, that he was concerned about the landing technique of some pilots, accustomed to flying light aircraft onto long paved runways. The availability of long paved landing surfaces seemed to encourage higher approach speeds and pilots would allow this excess speed to dissipate by closing the throttle earlier than would normally be expected. This resulted in them adopting a landing technique unsuitable for shorter grass runways, such as those in use at Barton.

ACCIDENT

Aircraft Type and Registration:	Grumman AA-1B, G-BDLS
No & Type of Engines:	1 Lycoming O-235-C2C piston engine
Year of Manufacture:	1975
Date & Time (UTC):	17 November 2005 at 1239 hrs
Location:	Near Bugbrooke, Northamptonshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - 1 (Fatal) Passengers - 1 (Fatal)
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Private Pilot's Licence
Commander's Age:	35 years
Commander's Flying Experience:	80 hours (of which 6 were on type) Last 90 days - 4 hours Last 28 days - 1 hour (flying hours estimated)
Information Source:	AAIB Field Investigation

Synopsis

A recently qualified pilot was on a flight with a passenger when the aircraft entered a spin. The pilot was unable to recover from the spin and the aircraft crashed. The pilot and passenger were fatally injured. The aircraft had no apparent defects prior to the accident although it was found to be overweight and the Centre of Gravity (CG) was beyond the aft limit. It is considered that a combination of the aircraft's weight, its CG being out of limits, and the pilot's inexperience, all lead to the aircraft unintentionally entering a spin. The aircraft was not certified for spinning.

History of the flight

The pilot kept his aircraft in a hangar at Cranfield Airport and at about 1000 hrs on the day of the accident he telephoned the hangar staff to request they tow the aircraft outside. The pilot arrived later that morning with a passenger and had the aircraft refuelled, asking the refueller to completely fill the tanks. The refueller confirmed that he filled each wing tank full as instructed, the fuel receipt showed the aircraft was refuelled with 47 litres of Avgas at 1140 hrs. Neither the hangar staff nor the refueller noted anything unusual with the aircraft.

The pilot and passenger boarded the aircraft and after starting the engine called ATC for taxi instructions at

1200 hrs, informing them that they would be departing for a local flight to the north. There was a delay in receiving their taxi instructions due to the number of aircraft operating at the time, but the pilot was eventually cleared to taxi for Runway 21 and the aircraft took off at 1218 hrs. Three minutes later the pilot transferred to London Information, his initial call being at 1222 hrs:

> "GOLF BRAVO DELTA LIMA SIERRA GRUMMAN AA ONE DEPARTED CRANFIELD TWO MILES NORTH OF WOBURN ENROUTE NORTHAMPTON FOR NAVIGATION EXERCISE RETURNING TO CRANFIELD ALTITUDE ONE THOUSAND SIX HUNDRED FEET VFR ESTIMATE NORTHAMPTON AT THREE FIVE REQUEST FLIGHT INFORMATION SERVICE"

The pilot was given a flight information service and at 1237 hrs he reported to ATC that he was overhead Northampton at 5,000 feet and that he estimated being overhead the town of Corby at 1250 hrs. At 1239 hrs the pilot made the following distress call.

> "MAYDAY MAYDAY MAYDAY GOLF LIMA SIERRA HAS GONE INTO A SPIN LOSING HEIGHT RAPIDLY"

No further transmissions from the pilot were received.

Witnesses described seeing an aircraft at about this time in a flat spin, descending near the village of Bugbrooke, about 17 nm north-west of Cranfield. The aircraft was seen to spin through between five to eight rotations before hitting the ground in a field. Witnesses described hearing the engine stop and seeing a white trail coming from one wing tip when it was in the spin. Members of the public were quickly at the aircraft where they found the pilot had died and the passenger had sustained serious injuries. The passenger was able to say a few words to the first person at the scene, but was not able to say what had happened. The emergency services arrived a few minutes later and the passenger was transferred to hospital by air ambulance, but died that evening from his injuries.

Weather

The Cranfield ATIS broadcast, valid at 1200 hrs, reported the following weather conditions: wind, 300º at 8 kt; visibility 15 km; cloud, FEW at 2,000 feet; temperature +5ºC; dew point, 0ºC; QNH: 1017 mb.

An aftercast obtained from the Met Office, described the weather in the vicinity of the accident site at 1200 hrs as: wind at 5,000 feet, 330º at 24 kt with no evidence of turbulence in the area; visibility between 20 to 40 km with some shallow cumulus cloud between 2,000 to 2,500 feet.

Aircraft description

The Grumman AA-1B is a two seat, low wing aircraft fitted with a fixed tricycle undercarriage, sliding canopy and side-by-side seating. The aircraft is powered by a Lycoming four cylinder, horizontally opposed, air cooled, carburettor equipped piston engine with a power rating of 108 BHP, which drives a two bladed fixed pitch propeller. The wings incorporate a non-tapered tubular spar, which is used to form the two fuel tanks. Each tank contains 9.9 imperial gallons of useable fuel and is selected by a three position valve located beneath the instrument panel which can be selected to OFF, LEFT or RIGHT. Each tank has a fuel contents sight glass, mounted on the left and right side of the cockpit wall. The aircraft is also equipped with conventional manual flying controls operated by a system of pulleys, cables, rods and torque tubes. The flaps are operated by an electric actuator connected to the flap torque tube. An elevator trim tab is fitted to the right elevator, which is operated by a trim wheel situated between the two seats. Movement of the trim wheel causes a control rod to be screwed in or out of the trim control screw jack mounted at the base of the fin. G-BDLS was also equipped with a stall warning system which had the angle of attack vane mounted near the right wing tip.

The Type Certificate for the AA-1B specifies the Maximum Take-Off Weight (MTOW) and Centre of Gravity (CG) range (in inches aft of the datum) as follows:

Maximum Take-off weight	1560 lbs
Maximum baggage	100 lbs
Centre of gravity at 1560lb	+78.25 in to +80 in

The aircraft was equipped with an Air Speed Indicator (ASI) marked in mph and knots which, in line with normal convention, had the flap, normal and caution operating ranges marked with white, green and yellow arcs. The marks on the ASI corresponded to stall speeds with power off, at a maximum weight of 1,560 lbs, of 61 mph with flaps (V_{s1}), and of 64 mph without flaps (V_{so}). These speeds were displayed on a placard fitted to the aircraft instrument panel. The placard also showed the increase of stall speed with bank angle:

	Bank Angle (degrees)			
	0	20	40	60
Flaps up	64 mph	66 mph	73 mph	91 mph
Flaps down	61 mph	63 mph	70 mph	86 mph

Aircraft handling

Longitudinal stability

The stability of an aircraft is its ability to return to its original flight condition following a disturbance from an external force such as air turbulence. A stable aircraft is one where the aircraft returns to its original flight condition following a disturbance, whereas an unstable aircraft is one where the aircraft will continue to deviate from the original flight condition. The longitudinal stability is dependent on the relative position of the aircraft aerodynamic centre to the CG and adequate longitudinal stability is normally achieved by ensuring that the CG remains forward of the aerodynamic centre. If an aircraft is loaded such that the CG is behind the specified aft limit, then the longitudinal stability of the aircraft will reduce and the aircraft might possibly become unstable in pitch. The impact on aircraft handling is that the pilot will need to apply more nose down elevator trim than normal and there will also be an increase in control sensitivity, which would make it more difficult to control the aircraft in pitch.

Stall speed

A light aircraft will always stall at the same angle of attack regardless of the airspeed, weight or load factor. Therefore, given that the lift from a wing is dependent on the angle of attack and the aircraft airspeed, the effect of increasing the aircraft weight is to increase the airspeed at which the stall will occur.

Spinning

A spin, which is characterised by a high rate of descent and a high yaw rate while the aircraft is in a stalled condition, can occur when a wing drops as the aircraft enters the stall. Not all aircraft are certified for spinning and there is no assurance that on these aircraft types recovery from a spin is possible under all circumstances. Such aircraft types are, therefore, required to be fitted with a placard stating that spins are prohibited. G-BDLS was fitted with such a placard on the instrument panel in front of the pilot.

The position of the CG can have a significant effect on an aircraft's ability to recover from a spin. Even when aircraft are certified for spinning, a CG aft of the rear limit can make it more difficult, or even impossible, to recover from a spin.

Grumman AA-1B spinning characteristics

There have been a number of spinning accidents involving the AA-1 series of aircraft. The AA-1, which preceded the AA-1B, was subjected to a spin evaluation trial during which difficulty was experienced in recovering the aircraft. As a result both the CAA and FAA currently prohibit spinning on the AA-1 series of aircraft.

It was not known if the pilot had access to, or had read, an owner's manual, but none was found and for the purposes of the investigation a copy of the aircraft manual had to be obtained from another owner. The manual describes the AA-1B as:

> *'the most responsive and high performing light aircraft on the scene today'.*

It goes on to describe the stall characteristics as:

> *'conventional in all configurations with elevator buffeting occurring 3 mph above the stall'.*

The manual also states:

> *'an audio stall warning horn begins to blow steadily 5 to 10 mph above the actual stall'.*

There are numerous warnings throughout the manual reminding the pilot that spins are prohibited including one in the section on stalling which states:

> *'Avoid uncoordinated use of the controls at the stalling speed as this may result in a spin. SPINS ARE PROHIBITED'.*

Nevertheless the manual does describe the recovery technique to be used in the event of an inadvertent spin. The owner of the manual examined described his AA-1B as being a very responsive aircraft, which is quick to loose speed, particularly in a turn.

Maintenance and fault history

The aircraft had been regularly maintained in accordance with the Light Aircraft Maintenance Schedule. The last maintenance activity recorded in the aircraft log book was an Annual Star undertaken on the 15 June 2005 at 2369:20 airframe hours. The aircraft was last weighed on 23 June 2004 and the Certificate of Airworthiness was signed on 17 June 2005.

The last entry recorded in the aircraft log book was made on the 7 August 2005 at 2381:55 airframe hours; this was the last flight made by the previous owner. Data stored on the GPS, landing charges and fuel receipts found in the aircraft indicated that the pilot had flown six flights with a total duration of approximately 6.5 hours between purchasing the aircraft and the start of the accident flight. The previous owner, and the maintenance organisation who undertook the Annual Star, have stated that the aircraft was in good condition for its age with no known faults or problems.

Aircraft weight and balance information

The aircraft weight and balance at the time of the accident was estimated by using the known fuel load at takeoff, the empty weight established at the last aircraft weighing, the weights of the occupants provided by the pathologist and the weight of the baggage as weighed by the AAIB after the accident. The result of the CG calculation was as follows:

Phase	Weight	Centre of Gravity aft of datum
Takeoff	1,740lb (180lb over MTOW)	+80.65 in (0.65 aft of rear limit)
Spin	1,715lb (155lb over MTOW)	+80.47 in (0.47 aft of rear limit)

Crash site examination

The aircraft crashed in a small muddy field of winter wheat and came to rest orientated on a heading of 196º(M). In order to make the aircraft safe, and enable medical assistance to be provided to the pilot and passenger, the emergency services removed the structure from around the top of the cockpit, switched off the magnetos and electrical switches and cut the electrical leads to the battery. They also caused considerable disruption to the ground around the aircraft. Nevertheless, impact marks in the soft ground indicated that the aircraft struck the ground in a nearly level attitude, whilst yawing to the right (clockwise) with little or no forward motion.

Both wings had been badly damaged by the main wheels being forced into the lower surfaces and there was no evidence of fuel in either of the wing fuel tanks. All the control surfaces were found to be intact and continuity of the primary controls was established. There was also no evidence of a control restriction having occurred. Mud marks on the right wing tip fairing, damage to the right aileron trim tab and pitot probe mounted on the left wing, distortion of the tail pylon and fin all indicated that the aircraft was rotating to the right when it struck the ground.

The top engine mounts had failed allowing the engine to pivot forward by approximately 15º about the lower mounting brackets. The engine had suffered very little impact damage. No fuel was found in the fuel pipes or components between the fuel selector switch and the carburettor. Both propeller blades were undamaged and streaks of mud along the leading edge of one of the blades indicated that the propeller was not rotating when the aircraft struck the ground.

All the cockpit instruments, controls and circuit breakers were set in the expected positions for the cruise phase of the flight. Both occupants had been wearing three point harnesses, which had subsequently been released by the emergency services. The buckle and anchoring points on both harnesses were found to be intact. The back of the passenger's seat frame had failed close to the pivot point and the pilot's seat frame had failed at the left pivot point.

Stored in the baggage area behind the occupant seats was a cockpit cover, spare radio, flight bag, a second bag containing all the aircraft records, a towing arm and a can of oil.

Detailed wreckage examination

Stall warning system

All the components in the stall warning system were functionally tested and found to be serviceable. Whilst the electrical wiring had been cut and damaged there was no indication that this damage occurred prior to the accident.

Flying controls

The flying controls were dismantled as far as possible and the cables, bearings, pulleys and control rods were examined. The condition of the components was typical for an aircraft of this age. All the controls operated in the correct sense and there was no evidence of any pre-existing fault or control restriction. Damage to the flap actuator indicated that when the aircraft crashed the flaps were retracted and damage to the control yoke was consistent with approximately 30° of left roll having been applied. It was not possible to determine accurately the position of the rudder and elevator. It was noted that the elevator trim control rod had been screwed almost fully into the trim jack, indicating that prior to impact, the aircraft had been trimmed close to, or at, the fully nose down position.

Fuel system

It was established, by filling the wing fuel tanks with water, that when the main wheels were forced into the lower surfaces of the wing they severed the fuel tank water drain pipes and punctured the right fuel tank. This damage allowed all the contents of the fuel tanks to quickly drain away. The fuel sight gauges had also shattered in the impact, allowing fuel to be released. The fuel selector and the electrical and mechanical fuel pumps were all assessed to be serviceable. The fuel selector was at the LEFT tank position and no fuel was found in the fuel line between the left tank and carburettor. However a small quantity of fuel was discovered in the fuel pipe between the selector valve and the right fuel tank.

Engine

Despite the force of the impact, the damage to the engine was mainly restricted to the controls, induction and exhaust systems. All of the accessories were found to be serviceable and the magnetos were successfully run on a test bed. The colour of the spark plugs indicated that all the cylinders were operating normally. Witness marks on the air inlet indicated that the carburettor heat was set at COLD, and the position and damage to the controls in the cockpit and on the carburettor indicated that the mixture was set at RICH and the throttle was near to the IDLE position when the aircraft crashed. The fuel bowl on the carburettor was approximately two-thirds full of fuel. The carburettor float, needle and valve all worked smoothly.

The engine was fully stripped and its condition was assessed as being typical of an engine of its age and usage, with no indication of any defect that would have led to its failure prior to impact.

Pathology

The post-mortem revealed no medical factors which could have contributed to the accident. The pathologist determined that the occupants had been subjected to a peak deceleration of 20 to 40g. The accident was non-survivable.

Radar

Radar recordings were obtained from Heathrow and Debden radars which showed the aircraft's flight. There were no returns recorded which might have indicated the presence of other aircraft in the vicinity either before or at the time of the accident.

Global Positioning System (GPS)

A portable GPS unit was recovered from the aircraft from which data was successfully downloaded. The GPS recorded UTC time, elapsed time, aircraft position in UK national grid coordinates, magnetic track and groundspeed. The latter was derived by point-to-point calculation of distance over time. Data was recorded at a variable rate depending on the aircraft manoeuvre, but did not exceed one sample every two seconds.

From the data log of the accident flight, the aircraft departed Cranfield at 1218 hrs and climbed at a rate of 350 ft/min to an altitude of 5,000 feet. The aircraft initially flew on a south-westerly track until it had crossed the M1 motorway before turning onto a north-westerly track of between 320°(M) to 330°(M) at a groundspeed of 60 to 65 knots.

At 1232:30 hrs the aircraft commenced a gradual turn onto a westerly track during which the groundspeed increased from 60 kt to 73 kt. The aircraft then made a more rapid change of track at 1234:17 hrs back onto a north-westerly track of 313°(M) during which the groundspeed reduced to a minimum of 49 kt before increasing again to about 68 kt.

The aircraft remained on a generally north-westerly track at 5,000 feet at a groundspeed of 68 kt until at 1237:05 hrs the groundspeed reduced again, this time to 39 kt, before returning to 60 kt.

At 1238:24 hrs, the track altered slightly onto 335°(M). At this time the groundspeed was 63 kt and the altitude was 5,100 feet. Between 1238:42 hrs and 1238:47 hrs the data shows a climb of 22 feet and a further climb over the next four seconds of 76 feet. The aircraft then commenced a high rate of descent, reaching a calculated maximum of 8,700ft/min. Subsequent data shows the rate of descent then reduced to a final rate of 2,200 ft/min. Groundspeed initially varied before reducing to less than 20 kt, consistent with the aircraft descending rapidly. Extrapolation of the data shows the aircraft impacted the ground at about 1239:55 hrs.

Pilot background

The pilot had been awarded an RAF Flying Scholarship in 1988 and had undergone a concentrated period of flying training with a civilian organisation at Cranfield Airport over a three and a half week period that summer. During this time he completed 25 hours flying, all on the Cessna 150.

His logbook shows no further entries until he once again started flying training at Cranfield, thirteen years later in the summer of 2001, with a different civilian flying school. This period of training lasted three and a half months during which time he completed 22.5 hours, all on the Piper PA38. This included a spinning training exercise on 22 September 2001. On this flight the instructor demonstrated two spins followed by the pilot entering and recovering from four spins, two to the left and two to the right. The pilot's flying ability was described as being generally above average although the instructor felt that, occasionally, the pilot could appear to be over confident in his own flying abilities.

The next logbook entry indicates that the pilot then stopped flying again for four years until in 2005 he undertook a ten day course at a flying school in the USA to complete his JAA Private Pilot's Licence. This involved 29.5 hours flying on the Cessna 152. This training included tuition on calculating aircraft weight and balance and students were required to complete weight and balance checks before flight. He finally gained his licence on 29 July 2005 since which time there were no further entries recorded in his logbook.

On the 27 August 2005 the pilot flew for around 35 to 40 minutes with the previous owner of G-BDLS before agreeing to purchase the aircraft. The previous owner remarked that the pilot flew the aircraft "nicely". A month later, on the 30 September 2005, the pilot collected the aircraft and flew it back to Cranfield with a passenger.

Analysis

The last radio call from the pilot, witness statements, ground marks and damage to the aircraft are all consistent with the aircraft entering a spin to the right (clockwise) from which it did not recover.

Engineering examination of the aircraft has revealed no pre-existing defects which may have caused the aircraft to either enter or fail to recover from the spin. Witness reports that the engine stopped prior to the impact are consistent with the lack of damage to the propeller blades and engine accessories. The position of the engine controls and lack of fuel in the pipe between the left fuel tank and carburettor suggests that during the spin the fuel in the left tank was forced outwards, towards the wing tip, leading to fuel starvation once the remaining fuel in the pipes had been exhausted. It is likely that the white trail seen coming from the aircraft was fuel leaking out from either the fuel tank filler cap, or vent system. However, the engine stopping should not on its own have prevented the aircraft from recovering from a spin.

The aircraft had the required placard stating "SPINS PROHIBITED" mounted in a prominent position on the instrument panel in front of the pilot. There was no evidence that the pilot had previously attempted to deliberately spin the aircraft and, therefore, it is unlikely that he was either unaware of the spin prohibition or had entered the spin deliberately. The pilot should also have been aware of the stall speed of the aircraft, which was clearly marked on the ASI and on the placard on the instrument panel.

The effect of being over the certified maximum weight with a CG outside the aft limit would have been to increase the stall speed and reduce the longitudinal stability. The position of the elevator trim was consistent with the pilot having selected full nose down trim and confirms a significantly aft CG position. Consequently, the aircraft would have been more sensitive in pitch and the pilot's workload in maintaining speed and height would have been greater than if the CG had been within limits.

Data from the GPS appears to indicate that the speed variations coincided with periods of increased cockpit work load. There were two major deviations in GPS ground speed observed in the recorded data. On the first occasion the ground speed dropped from approximately 63 to 49 kt which coincided with the aircraft making a change of track through approximately 40 degrees. The second major deviation occurred just prior to the pilot making a position report to ATC, when the groundspeed reduced from approximately 68 to 39 kt. Using the estimated wind conditions at 5,000 ft these minimum groundspeeds equated to airspeeds of approximately 72 and 61 kt respectively. For the aircraft at maximum certified weight the stall speed for the prevailing conditions would have been 64 mph (55 kt) wings level rising to 73 mph (63 kt) at 40 degrees of bank. For an overweight aircraft these stall speeds would have been higher; however it appears that the aircraft remained above the stall speed on these occasions. Consideration was given to there being a fault in the pitot static system, which might have caused the ASI to over read; however the airspeed always recovered to the higher value and the variation appeared to coincide with some other activity.

The GPS data records no further notable loss of ground speed; however about two minutes after the second major deviation the aircraft entered the spin. GPS data shows that at that time there was a short but significant increase in the rate of climb to 1,140 ft/min. It is considered that this possibly required an increased angle of attack that exceeded that required to stall the aircraft and this resulted in the aircraft entering the spin.

The pilot had received training in spin recovery, however, this was limited to only one flight conducted some four years prior to the accident. It is unlikely that with such limited training an inexperienced pilot in this type of aircraft and with the CG outside the aft limit would have been able to recover the aircraft from the spin.

There is no evidence available to explain why the sudden increase in rate of climb occurred. There was no evidence of another aircraft in the area that might have acted as a distraction, or caused a disturbance through its wake vortices. The weather was also not thought to have been a factor. However, a combination of reduced aircraft stability and increased pilot workload may have been a factor.

It is not known if the pilot realised that the aircraft was overweight and outside its CG aft limit when he departed on the flight. He undertook weight and balance calculations during his training four months earlier and would have been tested on the importance of this aspect in order to gain his PPL. Yet there was no evidence of any weight and balance calculations having been made by the pilot for any of the flights he flew in this aircraft. The pilot's recent flying experience was fairly concentrated with his flying training undertaken in the USA over a 10 day period on a Cessna 152, which has different handling qualities to the Grumman AA-1B. There is no evidence that the pilot took the opportunity to fly with an instructor in order to familiarise himself with his new aircraft. CAA Safety Sense Leaflet 1 advises pilots that before they fly a new aircraft type they should study the Pilot's Operating Handbook or Flight Manual and be thoroughly familiar with the airframe limitations, operating speeds and weight and balance calculations. The leaflet also recommends that even if not legally required to do so, pilots of new aircraft should have one or more check rides with an instructor.

Conclusion

The aircraft was in the cruise at 5,000 feet when it stalled and entered a spin from which the pilot was unable to recover. It has not been possible to establish the exact cause of the aircraft stalling however no mechanical or environmental factors are thought to have contributed to the accident.

The pilot was properly licensed to carry out the flight and had received recent training in calculating an aircraft's weight and balance. The aircraft was however significantly overweight at takeoff and the CG was outside the aft limit. It is believed this would have made the aircraft less stable.

The aircraft type is prohibited from spinning because it has a history of being difficult to recover from the spin, a situation made worse on this occasion by the position of the aircraft's CG. Spin recovery under these circumstances would have been difficult to achieve.

ACCIDENT

Aircraft Type and Registration:	Jabiru UL-D, G-JAAB
No & type of Engines:	1 Jabiru 2200B piston engine
Year of Manufacture:	2006
Date & Time (UTC):	15 August 2006 at 1805 hrs
Location:	Rochester Airport, Kent
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Nose leg suspension arm, front wheel spat and propeller
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	38 years
Commander's Flying Experience:	88 hours (of which 36 were on type) Last 90 days - 27 hours Last 28 days - 6 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

History of the flight

The pilot reported that after start he taxied slowly from the main apron along a grass taxiway towards the threshold of Runway 20. The aircraft went over a small bump in the taxiway at which point the nose gear failed and the propeller struck the ground. The pilot carried out an emergency shutdown and both he and his passenger vacated the aircraft.

Aircraft inspection

Subsequent inspection of the aircraft revealed that a nose leg suspension bracket had failed. The pilot stated that only part of the suspension is visible during the walk round and that it is possible that the bracket had been damaged during an earlier flight.

ACCIDENT

Aircraft Type and Registration:	Mooney Aircraft Corporation M20J, G-EKMW
No & Type of Engines:	1 Lycoming IO-360-A3B6D piston engine
Year of Manufacture:	1991
Date & Time (UTC):	16 October 2004 at 0648 hrs
Location:	Jersey Airport
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Fatal) Passengers - N/A
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Private Pilot's Licence
Commander's Age:	45 years
Commander's Flying Experience:	783 hours (of which 311 were on type) Last 90 days - 40 hours Last 28 days - 3 hours
Information Source:	AAIB Field Investigation

Synopsis

Shortly after takeoff, the aircraft suffered an engine malfunction and the pilot attempted to return to the airfield. During the turn, the aircraft appeared to stall and impacted the ground in a nose low attitude, fatally injuring the pilot. A defect was discovered within the engine's dual magneto, which had recently been refitted following a 500 hr inspection, affecting both ignition systems. This led to a loss of power, accompanied by misfiring, that was consistent with aural evidence from witnesses. Issues concerning quality control of maintenance activities and maintenance data were identified during the investigation. Four safety recommendations are made.

History of the flight

The pilot used this aircraft most weekends to commute between mainland UK and Jersey. Six days prior to the accident he flew the aircraft to Jersey from Fowlmere, Cambridgeshire and parked it on the grass outside the airfield's flying club. It remained there until the evening before the accident when he taxied it onto the adjacent hardstanding in preparation for refuelling. He submitted his airways flightplan and stowed his baggage on the aircraft that same evening.

The following morning, Saturday 16 October, the aircraft was refuelled with 63 litres of AVGAS 100LL giving a total fuel load of approximately 230 litres. At 0733 hrs, the pilot requested, and was granted, start clearance from ATC and seven minutes later he taxied the short distance to holding point A1. He was cleared to depart via an ORTAC 1A Standard Instrument Departure and at 0746 hrs he took off from asphalt Runway 27; this has a takeoff run available of 1,645 m. Shortly after takeoff, the pilot transmitted 'GOLF MIKE WHISKEY EMERGENCY PAN MAYDAY MAYDAY MAYDAY RUNNING ROUGH RUNNING ROUGH'. The tower controller replied 'YOU ARE CLEAR LAND, THE WIND IS 280/12 KT'. Shortly afterwards, the aircraft impacted the ground in a shallow valley below the runway elevation, just short of the airfield boundary, and caught fire. The pilot received fatal injuries in the accident.

Airfield accident response

Jersey ATC alerted the airfield's Rescue and Fire Fighting Service (RFFS) to the accident immediately after the aircraft disappeared from the view of the visual control room. Due to the fact that the air traffic controllers could not see the accident site, and thus had to estimate the range from the airfield, only proximate location information was given. The RFFS watch commander received information that a single engine aircraft had crashed with one person on board and decided to send one fire appliance. Acting on ATC reports that the accident site was possibly close to a local seaside café, this appliance left the airfield by Emergency Access Gate 4 and travelled by public road to the café area. When they reported that no accident site or smoke could be seen, a second appliance was subsequently dispatched to assist with the search from within the airfield boundary. This appliance proceeded along the Bravo Taxiway to holding point Bravo 2 and became visual with the accident site. It proceeded through a maintenance gate, travelled a short distance along a public road and, on reaching the site some minutes after the accident, rapidly extinguished the fire. Hand-held portable radios were used to communicate with ATC and the watch commander. Communication occasionally had to be relayed from ATC via another station to the watch commander.

The airport is regulated by the Harbours and Airport Committee of the States of Jersey but aspires to meet the regulations laid down in the CAA Civil Aviation Publications (CAPs). CAP 168, titled *'Licensing of Aerodromes'*, states that '*the AFS should be able to respond to an airfield accident within two minutes under favourable conditions'*; obviously, guidance towards off-airfield accident response times cannot be given.

Witness information

Several witnesses provided consistent information on the aircraft's flightpath. Shortly after takeoff, when the aircraft was at a height of approximately 200 ft, witnesses heard two distinctive 'pops' from the engine, as if it was backfiring. These were followed by sounds of the engine spluttering which, possibly, stopped before impact. The aircraft was seen to climb to approximately 300 ft and then commence a left turn; this was confirmed by data from the airfield radar. This turn was initially level but, after the aircraft had turned through about 90°, the nose appeared to rise slightly, before the left wing and then the nose dropped. The aircraft entered a dive from which there was no sign of attempted recovery. During the dive the aircraft was seen to rotate slowly.

Weather

A meteorological observation was taken immediately after the accident at 0750 hrs. This recorded a surface wind of 290°/12 kt and a visibility of greater than 10 km. There was also a broken layer of cumulonimbus cloud with a base of 1,600 ft above the airfield and a temperature of +10°C. The meteorological weather forecaster at the airport also reported that rainfall in the previous week had been significantly heavier than average for Jersey. On the previous Monday and Tuesday a total of 60 mm of rain had fallen compared with the monthly average for the whole of October, of 92 mm.

Local terrain

Jersey Airport is located on level ground at 274 ft amsl. At the westerly end of Runway 27, the ground drops away steeply approximately one mile before the coastline. From the position where the pilot reported his rough running engine, the terrain ahead contained few areas suitable for a forced landing and, as the tide was in at the time of the accident, this negated the possibility of a beach landing.

Aircraft stalling sharacteristics

The Mooney M20J pilot's operating handbook (POH) recommends an initial climb speed of 71 KIAS prior to landing gear retraction and then 91-100 KIAS for the normal clean climb. At maximum takeoff weight, the POH indicates that, with idle power and 30° angle of bank, the aircraft would stall at 65.5 KIAS. A stall warning system provides an aural warning at 4 to 8 kt above the actual stall speed and the POH states that at maximum weight a stall could lead to an altitude loss of 290 ft. Data from the airfield radar suggests that the aircraft did not climb higher than approximately 300 ft above the airfield. A familiarisation flight was undertaken in a similar aircraft to examine the potential handling characteristics of a turnback. It was noted that, with the probable conditions encountered immediately prior to the turnback, a small application of bank would activate the stall warning system, commonly followed by wing drop if pitch attitude was increased.

Pathology

The pathological examination of the pilot revealed that he died from multiple injuries. No evidence was found of any disease, drugs or alcohol which could have caused or contributed to the cause of this accident. Toxicological analysis revealed the probability of an elevated level of carbon monoxide in the pilot's muscle tissue. The pathologist's report concluded however, that the level of carbon monoxide saturation:

> *'would not be expected to produce any symptoms or decrement of performance in an individual, particularly at the low altitude of this short flight'.*

Wreckage examination

Examination in situ

The aircraft had struck the upward sloping side of a gulley bordering the southern boundary of the airfield, at a point approximately 200 m to the left of the far end of Runway 27. At the time of impact, it was heading approximately 170ºM and pitched approximately 10º below the horizon, but approximately 40º nose down relative to the local terrain. The impact drove the engine rearwards and upwards against the firewall, and the whole of the forward section of the aircraft was effectively crushed back to the line of the wing spars. This was consistent with an impact speed significantly above the aircraft's stall speed and probably in excess of 80 kt. Both the structural deformation and the distribution of debris implied rotational momentum to the left at impact, consistent with the aircraft having been in a spiral descent to the left, possibly associated with an attempted recovery from either an incipient or early-stage spin to the left.

The integral fuel tanks in the both wings had split and a severe post impact fire developed, fed by the fuel from the disrupted tanks. The fire destroyed most of the cabin interior and instrument panel. Both fuel filler caps were in place, and secure. The rubber seal from the left filler cap was undamaged and in good condition; the seal from the right filler cap also appeared to be in good condition, except for some localised embrittlement and cracking caused by heat from the post impact fire.

The propeller had come to rest with one blade projecting vertically, and the other crushed up against the underside of the engine: the former was completely undamaged, the latter exhibited only very slight rotational scoring, consistent with the engine having been either stopped or rotating at very low power at the time of impact.

All of the aircraft's extremities were present in the wreckage, and it was evident that nothing had separated prior to ground impact.

Detailed examination of the wreckage

The wreckage was recovered initially to a hangar on the airfield, where it was subject to more detailed examination.

The fuel system in the fuselage, including the fuel selector valve and electric boost pump, was disrupted during the impact and the delivery pipework in the wing damaged by a combination of impact forces and post impact fire. Consequently, the pre-impact status of the fuel system could not be determined. No residual fuel was present in either fuel tank, but approximately 5 cc was recovered from the boost pump. This was found to be clean, free of visible water contamination, and its colour and odour were consistent with AVGAS 100LL.

The remains of the pilot's throttle lever, propeller, and hot air controls suffered deformation and potential disturbance in the impact, but their post impact positions were broadly consistent with those which would be set for takeoff. The burnt remains of the flap screw jack actuator were recovered, and it was later established from the position of the internal screw-jack mechanism that, prior to impact, the flaps were in the fully retracted position.

The engine and propeller were subsequently taken to an approved overhaul facility, where they were subjected to bulk disassembly and inspection, under AAIB supervision. Key components were disassembled further and inspected internally at this stage. At a later stage in the investigation, further detailed examinations of key components were undertaken at the AAIB facility at Farnborough.

Engine strip examination

Preliminary visual inspection showed extensive impact damage to the engine's ancillary components, including the mechanical fuel pump, propeller governor, magneto, and fuel injector housing. The air inlet trunking was severely deformed and consequently the pre-impact integrity of the induction seals between individual trunks and the sump casing could not be established; however, no evidence was found to suggest that these seals had been leaking prior to impact. All spark plugs exhibited normal appearance except for external signs of the post impact fire; the colour and condition of all electrodes, in particular, was normal. The propeller shaft was bent, causing some rotational stiffness of the crankshaft, but otherwise it turned without obstruction allowing the integrity of the drive train to the camshaft, and the correct operation of associated pushrods, rockers and valves, to be confirmed. Bulk disassembly showed that all valve heads were intact and that the pistons and cylinders were in good condition with normal carbon build-up in the cylinder heads.

The engine-driven fuel pump casing was fractured in the impact, but its internal components were all in a serviceable condition; in particular, the diaphragm was intact and in good condition. The fuel injector was damaged externally by the impact but both diaphragms were intact, and the fuel metering mechanism was clear of obstruction and judged to have been in a serviceable condition prior to the accident.

A detailed examination of the exhaust system revealed the presence of several very small apparent cracks in the 'muffler', which had been opened up by the extreme deformation which occurred to this component in the impact. Metallurgical examination showed these crack like features to be associated with small regions of lack of fusion in the welding, occasioned during the manufacture of this component.

The magneto securing clamps were loose and, consequently, the magneto body could be rotated on its mount. As found, the magneto was positioned close to the limit of its range of adjustment. A loose magneto, resulting in incorrect ignition timing, has the potential to produce symptoms of the type reported by witnesses on the ground. Therefore, the magneto and associated clamping hardware was subjected to careful examination, which established that this feature was produced by the impact, and had not been pre-existing. Specifically, analysis of a series of microscopic witness marks at the clamp interfaces established that the clamps had loosened as a result of inertial forces during the accident, and that the magneto had been close to the centre of its adjustment range at the time of ground impact. The magneto was subsequently disassembled and examined internally for evidence of pre-impact abnormality.

Detailed magneto examination

The magneto installed on G-EKMW was a Teledyne Continental Motors (TCM) D-3000 series dual unit, in which duplicate electrical circuits are served by a common drive shaft, rotating magnet, and low tension contact points cam, all of which are housed in a common casing.

The magneto had been heavily sooted in the post-impact fire but had not itself been subject to significantly elevated temperatures. The LEFT side of the cover had partially broken away in the impact and the associated distributor casing, high tension (HT) harnesses and capacitor had separated with it. The LEFT side plastic distributor drive gear, situated inside the cover adjacent to the damaged region, had broken into several pieces. The spade connection at the LEFT side low tension contact points assembly, to which the LEFT capacitor earth wire had been connected, was pulled out of alignment by this wire as the capacitor was wrenched from its housing in the impact. In summary, all of the damage described thus far was consistent with being caused by the impact; in other respects, the magneto was internally free of impact damage.

With the cover removed, the input shaft was rotated manually by turning the impulse coupling, to check for continuity of mesh between the surviving RIGHT distributor drive gear and its pinion on the drive shaft. This confirmed the integrity of both the input pinion and the driven gear, but whilst conducting these checks it was noted that the low tension contacts cam did not rotate consistently as the input shaft was turned. Further investigation revealed that the cam retaining screw in the end of the shaft was loose and that the cam was not fully jammed down onto the tapered section of the shaft and was slipping[1].

Microscopic examination of the cam securing screw, in situ, revealed minor bruising on the sides of the slot in the head of the screw, evidently made by a screwdriver used to loosen the screw; no comparable bruises could

Footnote

[1] The contacts cam is mounted on its shaft by means of a taper, the drive being transmitted solely through friction developed at the taper interface by the interference fit between the cam and shaft. The function of the securing screw is twofold. Firstly, it provides the initial force required to 'jam' the cam down tightly on to its taper. The extent of this jamming is such that subsequent disassembly requires use of special tooling to lever the cam off its taper. Secondly, it maintains a preload on the taper, preventing the cam from working loose during subsequent operation of the engine, particularly during the step-loading across the taper which occurs during engine start when the impulse coupling comes into operation.

be found in a tightening sense. It was thus evident that the screw had been undone on at least one prior occasion. So as to permit the operation of the cam and associated contacts points to be checked, the head of the cam securing screw was index marked and tightened just sufficiently (approximately one quarter turn) to engage the cam on its taper and cause it to rotate consistently with its shaft. It was established that both contacts operated smoothly with no evidence of stiffness or binding, despite the LEFT 'moving' contact having been pulled slightly out of alignment with its fixed contact by wrenching of its capacitor lead during the impact.

Upon removal, the cam retaining screw was found to be undamaged and its condition was that to be expected of a previously used screw. Specifically, the remains of the integral nylon self locking patch on its thread were crushed down into the thread, and its lock washer was partially crushed, to an extent comparable with that of a new 'sample' screw after having been installed, correctly torque tightened, and then removed. There was no evidence of any additional locking compound on the thread, i.e. the type of compound applied in liquid form during re-assembly[2].

Detailed examination of the cam assembly and adjoining components showed that loosening of the cam retaining screw could not be attributed to impact forces, either directly or indirectly; or to thermal effects, as evidenced by an absence of heat damage on adjoining parts including oil impregnated felt pads in direct contact with the cam.

Relevant maintenance activity

Routine maintenance of the aircraft was carried out by a flying club at the pilot's local airfield, the owner of which had also helped him to source his aircraft prior to purchase. The most recent scheduled maintenance was a 150 hr/Annual inspection, carried out between 19 and 30 July 2004 at 794 total aircraft hours, some 25 hrs prior to the accident. Nothing of relevance to this accident was recorded during that inspection.

The magneto was due for a 500 hr inspection at 886 hrs. On 20 September 2004, at 818 hrs, it was removed from G-EKMW and sent to an EASA[3] Part 145 approved organisation[4] for this work to be carried out. Upon completion of the inspection, an EASA Form One Authorised Release Certificate was issued, dated 24 September, and the unit was returned to the aircraft's maintenance organisation who re-installed it on G-EKMW on 5 October 2004. The engine oil and filters were also changed at this time and, upon completion of satisfactory ground runs, the aircraft was released to service. The owner subsequently flew the aircraft to Jersey, apparently without problems; the accident occurred on the aircraft's next flight, the following weekend, during the takeoff for the return flight.

Magneto inspection

The EASA Part 145 organisation that carried out the magneto 500 hr inspection was a provider of overhaul, repair, and maintenance services, covering private and corporate aircraft, and aircraft equipment, including magnetos. It was established, from the technician who carried out G-EKMW's magneto inspection, that he had followed his usual practice when carrying out the work, which essentially comprised:

Footnote

2 This is not required by the current or previous issues of the Maintenance Manual.

Footnote

3 European Aviation Safety Agency.

4 International Aerospace Engineering, Cranfield Airfield.

- Disassembly
- Cleaning
- Visual inspection
- Checks of winding resistances etc.
- Re-assembly[5]
- Rig testing

Upon completion of this work, and after the unit had been rig tested and assessed as satisfactory, an Authorised Release Certificate was raised and signed by the EASA Part 145 organisation's Chief Engineer. This certificate included the statement:

> *'Above work carried out iaw with the maintenance manual 500 Hour inspection (SB643) & SB645 (AD96-12-07) carried out.'*

It was the technician's practice during D-3000 series magneto inspections (as distinct from overhauls) to replace only those parts which, in his judgment, warranted replacement based on their condition. With regard to the cam locking screw specifically, he would deem it necessary to replace this item if, upon inspection, he could find none of what he described as the wax-like lacquer (locking material) on its threads or if the spring lock-washer had become flattened. On this occasion, no replacement parts were used and none were billed to the customer. In this regard, the work did not comply with the requirements of the manufacturer's Maintenance Manual (MM) current at the time, which specifies replacement of a number of components including, inter alia, the points contact cam retaining screw. The technician was unaware that the current MM called for replacement of these items, and the cam retaining screw specifically, not only during an Overhaul but also during a 500 hr Inspection; or that the manual mandated replacement of the cam retaining screw in the event of it being loosened or removed, for whatever reason. He became aware of this only after it was drawn to his attention during the course of the investigation and after checking the MM for himself. He confirmed that, because of this misunderstanding, he had never replaced the cam screw or the other specified parts as a matter of course during Inspections, although he was aware of the requirement to replace cam screws during a magneto overhaul. However, it is understood that it was his normal practice, when installing the cam locking screw, to apply thread-locking compound to the screw threads prior to final assembly, notwithstanding the fact that this was not called for in the MM.

Maintenance manuals

Manuals held by the EASA Part 145 maintenance organisation

At the time of the 500 hr inspection, in September 2004, the applicable MM was Teledyne Continental Motors "Service Support Manual" No X42003-1, dated June 2004. The maintenance organisation did not have a copy of this version of the manual but held instead the previous version, No X42003, issued in July 1989, which they believed at that time was current. The maintenance manual against which the Authorised Release Certificate had been issued was therefore out of date by some four months.

The EASA Part 145 maintenance organisation also held a copy of a MM published in 1983 by Bendix, the original manufacturer of the D-3000 series magnetos. This was kept in the electrical workshop alongside the July 1989 manual, albeit marked by a coloured sticker to

Footnote

[5] This included the use of a torque wrench to tighten the cam retaining screw to the specified torque, and a specially made pulley attached temporarily to the opposing end of the shaft to prevent it from turning against the applied torque.

signify that had been superceded. It was evident from its well-thumbed condition that the 1983 manual had seen extensive use in the workshop whereas, by comparison, the 1989 manual was relatively clean.

Relevant differences between the 1983, 1989, and 2004 versions of the MM

The following summarises the main differences between the various versions of the MM, insofar as they apply to replacement of the cam retaining screw.

Teledyne Continental Motors 'Service Support Manual' document No X42003-1, dated June 2004, Appendix 1[6]

X42003-1 mandates the replacement of a range of parts including the contact cam retaining screw and lock washer assembly, the threads of which incorporate a patch of plastic material to stiffen the threaded assembly and reduce the risk of the screw loosening in service. The instruction to replace this screw appears initially in the *Disassembly* section of the manual, where it features in a list of items *'…which must be replaced…'*. It also is referenced specifically in this same section of the manual in a note headed *'CAUTION',* which directs that this screw must be replaced *'…whenever it is loosened or removed'*. These instructions are reiterated, in broadly similar format and wording, in the '*Periodic Maintenance'*, *'Overhaul*' and '*Assembly'* sections of the manual.

Footnote

6 Appendix 1 summarises the Instructions, Cautions and Warnings taken directly from the TCM X42003-1 Service Support Manual, regarding the removal, inspection and installation instructions pertinent to the cam securing screw.

Teledyne Continental Motors 'Service Support Manual' document No X42003, dated July 1989

This manual (the latest version held by the company at the time of the 500 hr inspection) contained similar instructions mandating replacement of the cam retaining screw to those found in the June 2004 version, summarised above. However, the form of words employed was different, and appeared to place less direct emphasis on the requirement to replace the cam securing screw, after disturbance, regardless of the underlying reason for that disturbance.

Bendix Overhaul Manual L-1176, July 1983

This manual covers overhaul and repair activities only, and apparently pre-dates any requirement for periodic inspection. It contains a single instruction to replace the cam retaining screw, contained in the '*Disassembly'* section, which states '*Discard the self-locking cam screw and washer assembly (14)'*.

Currency of the MM

The EASA Part 145 organisation's belief that its July 1989 manual (which was current until June 2004) was current at the time it issued the Authorised Release Certificate for the magneto, was founded upon:

- … the understanding that it had purchased, in early 2004, via TCM's website, a subscription service covering MM revisions/updates for the whole of 2004, and
- …the fact that no update had been received via the subscription service for the manual in question.

The TCM Ignition Systems Master Service Manual Publications Price List, of April 2001, for magnetos, lists the prices of all of their related publications. This list describes the 'Master Service Manual' by reference to Form No X40000. A renewal subscription is stated below this heading, referenced to Form No X40000SUB, and it was this to which the organization had subscribed, believing it to relate to the Master Service Manual. However, the TCM web site indicated that the reference X40000SUB related to Ignition Systems subscription services, Domestic and International, (January – December), generally. The organisation had not purchased a Service Bulletin set separately but had firstly purchased the Master Service Manual, to include the Service Bulletin Set and, by implication, their updates, together with the renewal subscription. The prices quoted in the April 2001 price list show that a Master Service Manual would cost US$105 and a renewal subscription, referenced X40000SUB, US$40. By contrast, a full set of Active Service Bulletins was US$10, a considerably lower amount. However, by the time of the 2004 renewal subscription, the cost of the Service Bulletin Set renewal had risen to US$50 and it was this cost that led them to believe that they had purchased more than the Service Bulletins[7]. In fact, the 'online' transaction receipt obtained for the purchase of the subscription service described the item purchased, for US$50, as a Subscription Service Domestic & International (January - December 2004), referenced to Part No X40000SUB, under the overall heading of 2004 Service Bulletin Subscription Renewal.

Footnote

[7] Also on the Price List was the statement '*Each Master Service Manual contains one copy of each of the following publications'*. A list then follows, which includes *'Active Service Bulletins'* referenced to form X40000SBS. A footnote is linked to this reference stating '*Service Bulletin set purchased separately will not be updated after initial purchase of set. Set includes all active service bulletins as of factory ship date'*.

The organisation remained unaware of the June 2004 manual's existence until informed during this investigation and, similarly, was unaware until that time that its subscription service from TCM did not cover MM updates.

Investigation into the underlying reasons for the organisation's confusion over the TCM subscription service, and its out-of-date MM, revealed a series of errors and omissions in the information posted on TCM's website which, coupled with the nature of the subscription provided, possibly explained both these misunderstandings. It also established that a number of other EASA Part 145 maintenance organisations had unwittingly used out-of-date manuals as a result of erroneous and misleading information on the TCM site, and identified further issues of concern which implied a systemic breakdown in TCM's control and distribution of technical documentation.

Additional information

The manufacturer's Service Bulletin 608, states,

> *'...If incorrectly torqued, there is a possibility that it [the screw] will "back-out", resulting in magneto malfunction. The use of a self-locking cam retaining screw reduces the possibility [sic] of "back-out" (by means of a nylon patch that creates an interface [interference] fit of the threads) in the event that incorrect torque is applied.'*

Service Bulletin 608 arose from the mandatory introduction of self-locking screws in 1979. The screw in question was of the self locking type.

Quality assurance issues

The EASA Part 145 maintenance organisation

Quality control within this organisation was the responsibility of a single, part time, Quality Manager working two days per week. The organisation's Quality Systems Procedures document, which underpinned, in part, its EASA Part 145 approval, set out:

- A schedule of 12 monthly internal audits covering its full range of activities, timetabled so that each area of activity was assessed and reported upon once in each 12 month period. At the relevant time, these audits were conducted by the Quality Manager. Each audit generated a report, which comprised a simple, single A4 page, document divided into three main sections: the first two sections were headed *'Remedial action required'* and *'Remedial action taken',* with attendant signature blocks for the Quality Auditor and Chief Engineer respectively; the third section showed the status of the report, *'Closed'* or *'Open'*.
- A schedule of quarterly external audits, each covering a cluster of related activities/areas. At the relevant time, these audits were carried out by an independent consultant retained by the maintenance organisation solely for that purpose. The reports issued by the consultant comprised a one page statement listing the date of the audit, the areas examined, and any findings made.

Internal audit

Of the twelve work areas scheduled for internal audit, two are of relevance to the 500 hr inspection carried out on the magneto from G-EKMW:

Technical Library

This area was scheduled for audit in September each year, and the audit comprised a spot check as to the currency and completeness of a set of manuals chosen randomly from the technical library. The most recent report of relevance, dated 18 September 2004, stated that control of incoming documents and registration of publications was '*Carried out as & when received*', and that *'Production of* [a] *new register* [is] *still in progress*'. The audit reports as *'satisfactory'*: FADs Volumes 1, 2 (CAP 473) & 3 (CAP 474); Mandatory A/C Mods (CAP 476); Bi-Weekly Issue No (2004/18); Air Navigation Orders; Airworthiness Notices; and the microfiche documents covering the Cessna 421C, 172 & 182 series aircraft. TCM manuals were not amongst the documents selected for audit on that occasion.

Electrical Workshop

This area was scheduled for audit in November of each year. The TCM Service Support Manual covering the magneto in question was actually held in the Electrical Workshop, not the technical library, so as to be available for immediate reference by the technicians concerned. The internal audit report for this area, carried out on 20 October 2004, assessed the following as *'Satisfactory*':

General housekeeping

Correct Equipment in use

Calibration of tools in date. Correct labeling. Correct storage

Library up to date

Correct and latest S.B's[sic], A.D's[sic] and manufactures[sic] information to hand

Correct signing and release of equipment

It is notable that the audit assessed the Library as being *'up to date'*, despite the 1989 issue of the magneto MM being some four months out-of-date at the time of the audit. (The MM in question, however, had been current for some 16 years.) No record appeared to exist as to what this audit actually constituted in practical terms, but the Quality Manager asserted that, whilst carrying out this audit, he telephoned the Technical Library of a major TCM distributor in the UK to enquire as to the issue date of their magneto MM. From the information he received in reply, he inferred that the 1989 issue of the manual before him was still current.

The investigation subsequently established that the UK based TCM distributor's manuals were also out-of-date at that time and remained so for a further four months, due to the errors and omissions apparent on the TCM website.

External Audit

- Technical Library. The most recent external audit report covering the technical library (together with personnel training records, and technical records) was dated 17 November 2004. The report stated simply *'There were no findings in this audit',* and made no specific reference to the technical library per se.
- Electrical Workshop. The 2004 external auditor's report covering the Electrical Workshops, dated 21 April of that year, also covered the maintenance areas, the hangar, the avionics workshop and two product items. The report made no specific reference to the Electrical Workshops, which the consultant involved explained was because "there were no non-compliance findings at that time."

Despite the work relating to magneto inspections not following the current MM procedures directly, some findings made were in relation to failures to make appropriate reference to MMs in paperwork which arose from a Cessna 310 Annual Inspection.

CAA Audit

In addition to the audits instigated by the maintenance organisation, the CAA surveyor responsible for their regulatory oversight carried out his own periodic audits.

His most recent audit of the organisation's work on magnetos was carried out in July 2003, when he looked at the servicing of a magneto, but of a different type from that fitted to G-EKMW. At that time he checked the test rig/equipment, and noted that the manual used in relation to that activity was X42002-1, which was current at that time; he made no formal findings or observations in relation to magneto servicing. Item five on the surveillance report recorded that *'it is not evident that a Library Register is available that shows details of publications used and their respective control numbers.'* The CAA have reported that the organization accepted this finding, in writing, and undertook to implement a library register. The organisation was also asked to ensure that their manuals were up-to-date by contacting the equipment manufacturers.[8] The CAA surveyor was subsequently given an assurance that a subscription service for renewals/amendments was in place. The organisation believed that it had complied with this advice by purchasing what was understood to be a current set of magneto manuals and Service Bulletins, together with update subscriptions to both.

Footnote

8 When the CAA audit a company, they point out that examination of engineering activity is only to be carried out on a sample basis at each visit. Hence, a different aspect of the company's activities will be looked at in detail during each audit. They also advise that under the terms of an EASA Part 145 approval, the responsibility for ensuring that work is carried out correctly primarily lies with the approved company.

Electrical technician's training

The technician who carried out the 500 hr magneto inspection had significant experience of such work, extending back to the early 1980s. He had received training specifically on Bendix/TCM magnetos, whilst in the service of a previous employer, but that employer is no longer trading and the records covering this training are believed to have been lost or destroyed.

The training records held by his current employer showed that he had undergone a regular programme of training comprising, in all, some nine modules since the start of the record in 1999. These courses, which covered a range of subjects, were delivered in a mix of instructed and self-learn courses; the former method being used for technical training on specific types/makes of equipment, and the latter for training on more generalised topics. He joined the EASA Part 145 organisation in 1994 and completed a Human Factors Training JAR 145 JAA/CAA/FAA course in April 2003.

TCM Quality Control issues

TCM technical documentation

Current Publications Listing on the TCM website

TCM provides on its website a range of information, including the current amendment status and 'effective' dates of technical manuals and related data published by the company in support of its products, published in a document headed '*Current Publications Listing'*. This five page .pdf document, which is accessed via the '*Bulletins & Manual's* section of the site, lists the current document number, ie revision status, and amendment/issue dates for some 140 technical manuals and related publications (not including ADs/SBs), together with part numbers and descriptions of related documents and services. Page Nos 1 to 4 list the *'Document No*, *Application'*, and *'Date'* for approximately 140 engine manuals (*'Operators, Maintenance',* and *'Overhaul'* manuals*;* and *'Illustrated Parts Catalogues*') grouped by engine model. Page five lists similar details for TCM Publications, Videos, and Reference Manuals, including the series of Service Support Manuals covering TCM magnetos. The header section of each page is dated to show when the *'Current Publications Listing'* itself was last amended.

During this investigation, significant anomalies of relevance to the maintenance organisation's omission to update its D-3000 series magneto manual were identified in the *'Listing'*:

The listing's amendment date (the date shown in the header section) was March 2004, implying that:

- No changes had been made to the listing since March 2004
- None of the manuals or other documents in the body of the listing had issue dates later than March 2004
- In fact, page five showed the June 2004 version of the D3000 series magneto manual, document No X42003-1; all of the other publication dates were prior to March 2004.
- Inquiries showed that at least two other maintenance organisations dealing with TCM magnetos had been misled by the incorrect date in the *'Listing'* header: one, an agent and major overhaul agency for these magnetos, discovered its error in February 2005; the other, also an agent, was unaware of the revised manual's existence until informed by the AAIB.
- Part No X40000SUB was described as Subscription Service – Domestic & International

(January – December). The X40000 prefix to this part number is the same as the part number of the item immediately below it in the listing, "X40000", described as IGNITION SYSTEM MASTER MANUAL, implying that item X40000SUB is a subscription service for the IGNITION SYSTEM MASTER MANUAL updates. In fact, this item was a subscription for ignition system Service Bulletins, and did not cover manuals.

TCM's management of technical documentation

Because of the inherently transient nature of all web-based information, it was not possible to construct a full history of changes made to the TCM *'Current Publications Listing'* over time. However, a study of printouts from the *'Listing'* held on file by one EASA Part 145 organisation, who was also a UK distributor, provided several snapshots of its content over a period extending back to August 2004, ie shortly before the date of G-EKMW's 500 hr magneto inspection. These snapshots, together with related correspondence and other records held on file, revealed a series of long-term errors and omissions affecting the *'Current Publications Listing'*, and serious systematic problems with TCM's management and distribution technical documentation, exemplified by the loss of data integrity concerning the current status of its technical publications.

In February 2005, TCM were notified by fax and e-mail of the anomalous (March 2004) header date, together with anomalous entries pertaining to six of the (engine) manuals listed at that time. In its reply, dated 9 March 2005, TCM said it was unaware that the X42003 manual had been revised to X42003-1 June 2004, and asked for suggestions as to what the correct status should be.

TCM's response to notifications of omissions

In late September 2005, some seven months after TCM was notified of the incorrect (March 2004) header date in the *'Listing'*, this error remained uncorrected. Prompted by concern over this and other issues pertaining to the *'Listing'*, TCM's International Sales and Service Manager, based in the UK, attended a meeting at the AAIB where these issues were identified and discussed in detail. This meeting was followed up by an e-mail, in which the AAIB listed the specific issues of concern and requested that an appropriate person at TCM be tasked with taking appropriate action to rectify the situation. No response to this e-mail was received, and by early November 2005, the *'Listing'* posted on the web site was still showing the incorrect (March 2004) header date.

Of the six other errors reported to TCM in February 2005, only one of these had been corrected by early November 2005. The header date on the *'Listing'* at this time still had not been updated, and continued to show March 2004.

On 2 November 2005, prompted by an increasing concern over TCM's lack of action or acknowledgement of the issues of concern brought to its attention, the AAIB advised both the FAA and EASA of the situation and suggested that these organisations take appropriate safety action to ensure the published material was current. The FAA subsequently advised that, during an FAA meeting with TCM held during the week of 14 November 2005, these issues were discussed. The *'Listing'* was subsequently updated on 16 November 2005, and its header date amended accordingly; however, of the six anomalous entries relating to engine manuals brought to its attention originally in February 2005, only three had been amended.

Supply to customers of out-of-date (superceded) material

In November 2004, the UK based TCM distributor placed an order with TCM for the full set of magneto Service Support Manuals, part No X40000, for delivery direct from TCM to the distributor's end-customer based in Northern Ireland. Inquiries made in October 2005, on behalf of the AAIB, established that the set of manuals supplied included the out-of-date July 1989 X42003 D-3000 series magneto manuals, despite these having been superceded in June 2004 (some four months previously) by X42003-1.

Quality of spare parts distributed through the approved supply chain

Having been informed by the AAIB of its belief that the contacts points cam had become loose in flight, and having discovered that both the 1989 and 2004 versions of the magneto Service Support Manual mandated replacement of the self-locking cam retention screw, the EASA Part 145 maintenance organisation that inspected G-EKMW's magneto recalled those Bendix/TCM dual magnetos upon which they had carried out 500 hr inspections. This was for precautionary replacement of the cam retaining screw/lockwasher assemblies. To meet the associated demand for replacement parts, appropriate spares, including the self-locking screw assemblies, were sourced from an 'approved' supplier.

Whilst carrying out the recall work, it was noted that one of the newly sourced screws had no locking patch on its threads. This defective screw, together with the all of the other new screws and the old screw removed from the magneto in question, were forwarded to the AAIB for assessment. Visual comparison of the new screws, totalling 21 in all from two batches, showed that both the extent and the thickness of the locking patch on the threads varied significantly. This variation ranged from the previously identified 'missing', through 'marginal' to 'acceptable'. Variations were also evident in the thickness of the new spring lock washers, a thick and a thin variant; the latter being some 20% thinner, with a correspondingly reduced crush-depth.

Analysis

Sequence of events

The pilot's 'emergency' PAN/MAYDAY radio call included the phrase "rough running", twice, and this was confirmed by witnesses on the ground who reported hearing the engine making popping/backfiring noises as the aircraft reached about 200 ft in the climbout. The period of time over which the engine was heard to make these unusual noises could not be established exactly, but was unlikely to have been more than a few seconds.

Shortly after the radio call, the aircraft was seen to turn left, through approximately 90º, before the left wing dropped and the nose sliced down, following which it entered a steep descent into the ground. Examination of the aircraft's wreckage showed that the engine was stopped, or practically stopped, and that it was either in the incipient stages of a spin to the left or, possibly, that it was in the process of recovering from a spin to the left, at the time it struck the ground.

From an operational perspective, the pilot was forced into handling an engine problem at one of the most critical stages of flight, ie, shortly after takeoff, but too late to permit a landing immediately ahead on the runway distance remaining. He therefore had to decide whether to return to the airfield, or to attempt a forced landing in the area ahead of the aircraft. The ground in potential gliding range of the aircraft, from its maximum height of around 300 ft aal, contained few areas suitable for a forced landing and the pilot was likely to have been aware of this from his many previous departures off this runway. Had the engine been producing some power, returning to the airfield might have appeared to have been a realistic option, in lieu of the lack of suitable alternative landing sites ahead, but with the inherent risk that the engine might fail completely at any time. Had the engine ceased to produce any power prior to the turn back, the pilot would have been faced with an almost impossible decision. However, having initiated the turn back towards the airfield, it is considered likely that a subsequent loss of airspeed, arising from a further reduction or total loss of power, or increased angle of bank from a perceived need to tighten the turn, or a combination of the two, caused the aircraft to stall. What is beyond doubt is that the left wing dropped and the incipient spin would have been irrecoverable, given the height available.

Engine exhaust system

The minor defects in the welds of the exhaust system appeared to have allowed crack like features to have formed as the muffler was deformed in the impact. It was not established if, or to what extent, exhaust gasses might have leaked into the heating system or ambient cabin air from these areas but, if leakage had occurred, any concentration of carbon monoxide would have been very low and potential exposure time would have been relatively short. These minor defects were considered to have been present since manufacture and no evidence was discovered that the possible escape of exhaust gasses had caused problems to the pilot on previous flights. Despite the observation in the pathologists report that the toxicological analysis revealed the probability of an elevated level of carbon monoxide in the pilot's muscle tissue, the pathologist's opinion was that level of carbon monoxide saturation would not have produced any symptoms or decrement of performance, particularly at the low altitude of the flight. Therefore, carbon monoxide poisoning was not considered to have been a contributory factor in the accident.

The loss of engine power

Strip examination of the engine, its associated components and, as far as possible, its fuel system, failed to identify any pre-accident defects that would have caused the loss of power just after takeoff. Therefore, other possibilities were considered, including the possibility of water in the fuel and the condition of the dual magneto.

Possible water contamination of the fuel

Prior to the accident flight, the aircraft had been parked on the airfield during a period of unusually heavy rain. In common with many light aircraft, the integral fuel tanks on this aircraft were in the wings, with the filler cap assemblies on the top surface of the wing. Hence, there is potential for rain water to enter the fuel tanks, but this would be dependant on the fit of the caps, and the condition of the seals. During the examination of the wreckage, both filler caps were found to be in place and secure; both associated seals were judged to have been in good condition, despite one being slightly affected by the post crash fire. As there are no other apertures in the fuel system directly exposed to the elements, the possibility that rain water entered the aircraft's fuel system prior to the accident flight was considered remote. Water may form in a partially filled fuel tank as a result of condensation, but to produce a quantity that may influence the operation of an engine, usually requires generally low temperatures over an extended period, and infrequent use of the aircraft, which was not the case with G-EKMW. These factors were considered to mitigate against water in the fuel being a causal factor in this accident.

It is the normal practice to take a sample of fuel from the tanks and inspect for water, prior to the first flight of the day. It was not established if the pilot of G-EKMW carried out such checks generally or prior to the accident flight, but no evidence was discovered that water in the fuel had been a problem with the operation of this aircraft prior to the accident.

Magneto condition

In general, the magneto had been in good condition and appeared to have been well maintained. However, the examination of the magneto's remains identified that the contact points cam retaining screw was loose enough to permit slippage to occur between the cam and the shaft upon which it was mounted. It was established that the shaft, the cam and the cam retaining screw were all undamaged. Had the cam and retaining screw been correctly installed prior to the aircraft's impact with the ground, such that the cam was gripping the shaft as intended, then it is considered highly unlikely that the cam could have loosened due to impact forces without damaging the screw. Also, the nature of the forces experienced during such an impact would have precluded the screw from 'backing-off' by some 1 to 1.5 turns, the amount which would have been necessary to allow the cam to become free. Therefore, it was concluded that the cam and screw were loose prior to impact.

Dual magneto issues

The magneto in question was of the dual type, manufactured initially by Bendix and subsequently by TCM, in which two independent high-tension magneto inductive circuits are excited by a single magnet, rotating on a common drive shaft within a common housing. A single, four-lobed, cam mounted on the outer end of the common drive shaft operates a pair of independent low tension contact assemblies, one per inductive circuit. It follows that any loss of drive to the cam, whether partial or total (or indeed any other malfunction or failure affecting the common drive shaft/magnet assembly) will cause both LEFT and RIGHT sides of the magneto to malfunction. Consequently, it would not have been possible to restore power by using the magneto (ignition) switch in the cockpit to isolate the fault, an option which may have been available had the engine been equipped with two fully independent ignition systems.

Loose/slipping cam

Any slippage of the cam on its shaft with the engine running would have disrupted the ignition timing, most likely causing backfiring in the exhaust and spit-back through the induction system, all the while the engine was turning. This would be consistent with the symptoms reported by witnesses on the ground and the overall sequence of events, including the pilot's radio report of an engine problem. It was not possible to determinethe time period over which the slippage of the cam on its shaft occurred, but this was likely to have been short. The slippage could have been progressive as the screw began to loosen, but it is highly likely in any case that the engine would have ceased to produce any effective power almost immediately. (The aircraft appeared to witnesses to, initially, take off normally, with the onset of the problem occurring at a height of between 200 and 300 ft, very shortly after which, control of the aircraft was lost.)

Re-assembly of G-EKMW's magneto cam assembly, to check the fit of the taper using the cam retaining screw tightened to the specified torque, resulted in the cam jamming tightly onto the taper. Poorly-matched taper geometry can therefore be ruled out as a possible causal or contributory factor in the cam becoming loose. It seems likely, therefore, that since re-assembly, the cam was being held in contact with the shaft by the retaining screw with sufficient frictional force to enable it to rotate without slipping, but with insufficient force to cause it to jam onto the taper.

To provide additional security against the cam retaining screw 'backing off' in service, a modified self-locking screw, incorporating a nylon patch on its threaded section to create an interference fit, was introduced via Bendix Service Bulletin (SB) 608, issued in 1979. The '*Detailed Instructions'* section of the service bulletin included, under the heading *'CAUTION'*, the following instruction: *'If self-locking screw is removed at any time, always replace with a new self-locking screw and torque to the specified value.'* This instruction was incorporated, inter alia, into the maintenance manual, and was given increased emphasis in subsequent issues of the manual. Although the cam retaining screw on G-EKMW's magneto was of the (correct) type specified by the manufacturer, ie a self locking screw, it clearly was not a new item; bruising of the screws slot indicated that it had been undone on at least one occasion. The fact that it had been re-used, contrary to the requirements of SB 608 and MM instructions, meant that the self locking effectiveness of the screw would certainly have been reduced to some extent as a consequence.

The fact that the technician did not follow his usual, albeit non-authorised, practice of applying liquid locking compound to the screw's threads prior to final assembly, meant that any degradation of the screw's self locking capability, caused by its re-use, was not compensated for on this occasion.

Notwithstanding the fact that a previously used screw was installed, without additional locking compound, this type of magneto had been in widespread service, apparently satisfactorily, prior to the introduction of the modified screw in 1979. Unless unauthorised use of locking compound on these screws was widespread practice prior to SB 608, the fact that the original version of the screw (without the self-locking patch) apparently served, for the most part at least, in a satisfactory manner up to that time suggests that some other causal and/or contributory factors were involved for the cam screw on G-EKMW to come loose. Specifically, it suggests that the screw may not have been correctly torque tightened. The viability of this scenario is given credence by the background information given in Service Bulletin 608, which stated,

> *'...If incorrectly torqued, there is a possibility that it [the screw] will "back-out", resulting in magneto malfunction. The use of a self-locking cam retaining screw reduces the possibility [sic] of "back-out" (by means of a nylon patch that creates an interface fit of the threads) in the event that incorrect torque is applied.'*

The above quotation suggests that the self-locking feature was introduced primarily to prevent an inadequately tightened screw from backing out, the implication being that a correctly tightened screw, even without the revised locking features, would not normally back out in service.

On balance, should the screw have had even a minimal self-locking capability, and provided the screw had been correctly tightened at the time of installation, it is considered unlikely that it would have backed off almost immediately, and the cam become loose on the taper, so soon after its return to service. It is concluded, therefore, that the magneto malfunction was most probably caused by the instructions laid down in the appropriate D-3000 series Service Support Manual not being followed, specifically:

- Not torque tightening the cam retaining screw to the specified value and to a lesser extent
- Re-use of an old self locking cam retaining screw

In relation purely to outcome, ie, leaving aside the manual compliance issues relating to the technician's customary use of locking compound on the cam retaining screw threads, the fact that no locking compound was used, on this occasion, was considered to have been a contributory factor in the magneto malfunction.

The poor quality and variability exhibited by a number of new cam retaining screw assemblies examined by the AAIB, obtained via the legitimate supply chain, is a cause for concern and warrants investigation by TCM, withdrawal of substandard parts from the supply chain, and action to correct the quality control deficiencies which allowed such items to reach the market.

The 500 hr magneto inspection

The EASA Part 145 organisation's omission to update to the June 2004 revision of the manual relating to the magneto, which was issued several months before it carried out the 500 hr inspection, appears to have been a genuine oversight to which the following factors contributed:

- Long-term errors on the TCM website, pertaining to the status of its technical publications. (The maintenance organisation was not alone in holding an outdated version of the D-3000 series manual because of this.)
- A combination of confusing and misleading descriptive information on the TCM website relating to the purchase of subscriptions to receive Service Bulletin updates, which could be misconstrued as a subscription for maintenance manual updates.
- The omission on the part of the maintenance organisation to scrutinise the on-line receipt received for what it believed was a subscription to receive Maintenance Manual updates, but which the receipt actually stated was the Service Bulletins subscription service.

Significant differences between the 1989 and 2004 issues of the Maintenance Manual

Both the 1989 and 2004 versions of the D3000 series magneto MM clearly state that the cam retaining screw must be replaced at overhaul, inspection, or whenever it is removed or loosened for any reason. However, it is believed that this instruction is potentially nullified by the inherent requirement to slacken and tighten this screw at least once, and possibly on more occasions, before final tightening, as part of the procedure for setting the internal timing of the magneto. The assembly section of the manual gives instructions to 'loosely install the cam using an old screw', and on completion of internal timing instructions it instructs that the [final] 21-25 in.lbs torque be applied to a new screw. It is considered that the emphasis given to replacing the screw with a new item, after timing adjustments are complete, is insufficient and could readily be missed, notwithstanding the presence in this section of a 'caution' note requiring replacement if the screw is removed or loosened at any time.

The TCM web site is used by its customers as the principal source of up-to-date information about the status of its various technical publications, including MMs, ADs, and SBs. It is therefore essential, for the maintenance of air safety, that this information is timely, presented in a clear and consistent manner, and above all that it is free of errors and omissions. In the case of the information pertaining to the TCM D3000 series magneto Service Support manual X42003, dated July 1989, and its successor X42003-1, dated June 2004, this was not the case. The result was that, not only did the maintenance organisation which inspected the magneto from G-EKMW remain unaware of the revised 2004 manual until late 2005, but several other EASA Part 145 organisations in the UK (and possibly others worldwide) were similarly misled and continued to rely on manuals long after they had been superseded.

Whilst both the July 1989 and the June 2004 versions of the Maintenance Manual specified replacement, inter alia, of the cam retaining screw during 500 hr inspections, the form of words used in the 2004 version placed significantly greater emphasis on the requirement for these items to be replaced, regardless of the type of work being undertaken.

1983 Bendix Overhaul manual

Retention of outdated manuals carries with it significant safety implications. Arguably, the practice can be justified provided that such documents are held solely for exceptional reference purposes, and their location and use subject to appropriate oversight and control. In this case, however, both the 1983 and 1989 manuals were held in the electrical workshop, albeit with a coloured sticker affixed to the former to denote its uncontrolled status. The 1983 manual was not only immediately accessible for reference by workshop staff but its well-used condition, compared with the relatively cleaner condition of the 1989 version, suggested that it had seen significantly more workshop use than the 1989 version. At the time of the subject magneto's inspection, the 1989 manual should have seen some 15 years of use, whilst the 1983 manual should have been used for only some six years. This is considered to be inconsistent with the relatively 'well used' condition of the 1983 manual when compared to that of the 1989 edition.

Other evidence, of a circumstantial nature, also suggested that the 1983 manual may have enjoyed pre-eminence over the 1989 version. Specifically, the working practices used by the technician during his inspection of the magneto from G-EKMW are consistent with those laid down in the 1983 overhaul manual, issued when there was no requirement for 'inspections' per se, but were not consistent with the practices laid down in the 1989 manual covering inspections as well as overhauls.

In summary, it appeared that the work practices in use at the time the magneto was inspected were essentially those laid down in the 1983 manual.

Quality control issues

Training and work practices

The technician who carried out the inspection of G-EKMW's dual magneto reportedly received type-specific training on the magneto in question, but some considerable time after the modified cam retaining screw had been introduced by Service Bulletin 608 in 1979. The associated requirement, always to replace the self-locking cam retaining screw, whenever it was loosened or removed, should have been emphasised during that training. Because of the passage of time, and the loss of training records from that period, it was not possible to establish whether this actually occurred.

The technician was honest and straightforward when providing information during the investigation about his working practice, vis a vis replacement/re-use of the cam retaining screw, and the other items which the MM specified should be replaced. He simply followed his usual practice in the genuine but mistaken belief that replacement of the cam retaining screw was required only during magneto overhauls, ie, that it was not mandatory during magneto inspections. During the investigation, after re-reading the (out of date) 1989 copy of the maintenance manual provided by his employer, he realised his non-compliance for the first time.

In relation to the company's retention and apparent continued use of the 1983 manual it is possibly significant that, when the technician first worked on the type of magneto in question in the early 1980s, there was no requirement to carry out inspections per se. It appears that his work practices were established at that time, whilst carrying out overhauls, and that he appeared not to have studied the 1989 manual, or adapted his methods to meet the requirements for inspections. The fact that he was allowed to follow unauthorised and inappropriate procedures for so long raises questions regarding oversight of his work by his employer and, to some extent, of the system used for regulatory authority oversight.

Quality audits

The quality assurance policy of the maintenance organisation which inspected the magneto and, specifically, its audit procedures, were set out in the exposition document which formed, in part, the basis for its approval by the CAA as an EASA Part 145 Maintenance Organisation. The company's internal audit policy appears to have been comprehensive in terms of both its scope and frequency, and similar comments apply to its stated policy for external audit cover. However, in terms of their practical applications, none of these audits subjected the physical work being carried out to effective scrutiny.

Both the internal and external audits comprised a series of sample checks, the primary focus of which appeared to be directed towards the paperwork generated as a by-product of the engineering activity as opposed to critical scrutiny of the core engineering activity, ie, the various certificates generated, implementation of ADs, SBs etc and general housekeeping. Scrutiny of the 'paper trail' certainly had the benefit of being amenable to a pro-forma 'tick the box' approach in respect of both audit tasking and reporting, and this aspect of the audit process remains valid and necessary. However, there appears to have been little critical scrutiny of the core engineeirng activity per se. Similar observations are considered to apply to the CAA's periodic audits, carried out as part of its oversight function.

The lack of focus on the maintenance organisation's physical engineering activity is reflected in the CAA approved audit reports generated. Its internal audit reports comprised single sheet A4 documents, each of which covered as many as four areas of activity (departments). The information provided in these reports as to what was actually scrutinised was extremely limited, no information was given as to the methodology used and, from a third party's viewpoint, they provided very little insight as to the quality of engineering. Similar comments can be made about external auditor's reports, although these were somewhat more detailed, particularly in relation to the findings made, and they did provide some insights into the quality of the organisation's engineering activity.

With specific regard to the organisation's core engineering activity, it is of concern that the technician who carried out the 500 hr inspection on the magneto from G-EKMW had been carrying out similar inspections for at least 15 years without being aware that the relevant manual mandates replacement of the cam retaining screw…..*'whenever it is loosened or removed'*. It also calls into question the extent and/or effectiveness of any independent oversight which may have been applied to his activities, either directly by his line management or the various audit processes.

The CAA state that it is for the approved organisation to ensure that their authorised personnel work within the defined terms of reference, using the correct data etc. Also, the day to day responsibility for ensuring the competency of its staff rests with the EASA Part 145 approved company as it would be impracticable, and not required by the Regulations, for any regulatory authority to establish individual staff competencies. Their role is to satisfy themselves that the organisation has procedures in place to achieve this and, by sampling, that it has evidence that the organisation is following its internal procedures. However, this event highlights the intrinsic shortcomings of the quality assurance audit methodologies used, which focus heavily upon the processes/paperwork aspects of the work.

Process worksheets

The apparent lack of the correct torque having been applied to tighten the cam screw during re-assembly does not appear to have been the result of any inherent lack of skill or experience on the part of the technician concerned, or of the equipment he normally used. In the absence of any alternative, a likely explanation is that his sequence of work was probably broken at a critical point, possibly by some distraction or disturbance, and the final tightening of the screw was compromised or missed altogether as a consequence. The technician concerned, however, has stated the following:

> *'...I would never leave an operation incomplete, except for an evacuation of the hanger, or a person needed assistance in an emergency, and then on return I would start the operation from scratch. If asked to do another job, the task in hand would be completed to a stage where it could be left or the task would be completed before starting another job. I have often missed a tea break, part of a lunch break or stayed late to complete a job or task in hand.'*

The fact that the maintenance organisation did not make use of pre-planned process sheets, or worksheets, for magneto overhauls/inspections is considered to have been a factor in the omission to fully tighten the screw.

Had a properly set out work or process sheet been available for these activities at the time of G-EKMW's inspection, based upon and used in conjunction with the manufacturer's MM, then not only would it have:

- provided a framework for the series of operations to be carried out
- made provision for the technician to confirm and document completion of key stages
- listed the materials required, thus facilitating both provision of parts to the workshop and spares-provisioning back-office functions

but the very act of drawing up such a process sheet would, in itself, have required someone other than the technician to critically review the procedures specified in the manual[9]. This process of review would need to be undertaken afresh on each occasion the manual is updated, to ensure that any relevant changes in the manual are reflected in a revised process sheet. Furthermore, drawing up a suitable process or work sheet requires objective scrutiny of the manual, and any inconsistencies, apparent errors, or omissions in the manual itself are therefore more likely to be identified and followed up with the manufacturer at an early stage.

In summary, had the 500 hr inspection of the magneto followed a properly drawn up process sheet, a new cam screw (together with the other items listed in the manual for replacement) would have been provisioned automatically, and the key stage of final torque tightening of this screw would have been much less vulnerable to omission or error.

Footnote

[9] Once the 2004 issue of the relevant maintenance manual had been recieved by the organisation, it's Chief Engineer drew up such process sheets. He points out '*that had the up-to-date manual been communicated to them from TCM correctly*', such process sheets(s) would have been drawn up ealier.

Safety Recommendations

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

Safety Recommendation 2006-028

It is recommended that International Aerospace Engineering review their internal processes to ensure that they comply with the standards required under their EASA Part 145 approval focussing, in particular, on areas relating to the provision of maintenance information and staff training.

In response to this recommendation IAE has stated that:

> *'it believes that it does comply with the standards required under its EASA [Part] 145 approval. It continues to monitor such compliance as a necessary and ongoing element of its business.'*

Safety Recommendation 2006-029

It is recommended that the Civil Aviation Authority review their quality audit programmes, which underpin its EASA Part 145 approvals of maintenance organisations, to ensure that such audits include adequate sampling and objective scrutiny of the physical engineering activities.

In response to this recommendation the CAA have stated the following:

> *'From a regulatory standpoint, CAA oversight and audit methodology is established to satisfy the EASA Part 145 Regulations. A review of the audit records completed over the last three years for this organisation shows that as well as regulatory compliance verification checks, audit samples of three examples from the product line were carried out on each visit'*

> *It is not the regulators role to implement a quality audit programme to supplement that of the approved organisation'*

The CAA have also stated that they recognise the utilisation of pre-planned work/process sheets, where appropriate, represents best practice, and the adoption of this practice is encouraged. However, they cannot require EASA Part 145 organisations to implement this practice if it is not specified within the Regulation. The following safety recommendation is therefore made:

Safety Recommendation 2006-030

It is recommended that the European Aviation Safety Agency (EASA) should amend the EASA Part 145 Regulation to require that EASA Part 145 approved maintenance and component overhaul organisations use pre-planned work/process sheets when carrying out work on safety critical components.

Whilst the extent to which the outdated manual actually contributed to the technician not replacing the screw could not be determined, there is no doubt that, if the 2004 version of the manual had been issued by the company to the electrical workshop prior to the 500 hr inspection, then that action alone ought to have prompted critical study of its content: ideally at a supervisory level, but certainly by the technicians involved in carrying out work covered by the manual. Had this taken place, the long-standing contraventions associated with re-use of cam screws should have been identified and rectified prior to G-EKMW's 500 hr inspection. The non-current D3000 series magneto Service Support Manual was therefore considered to be a causal contributory factor in the magneto failure.

The presence of errors and omissions on the TCM website was considered a major factor in the maintenance organisation's ability to update its D3000 series magneto manual, leading to the issue of an Authorised Release Certificate covering the 500 hr inspection on the basis of an out-of-date manual. The following safety recommendation is therefore made:

Safety Recommendation 2006-031

It is recommended that the Federal Aviation Administration require Teledyne Continental Motors to conduct a critical review of their processes for the support of maintenance organisations which maintain/overhaul their products, to ensure that concise and current technical data, and spare parts of acceptable quality, are always readily available.

In response to this safety recommendation, Teleydyne Continental Motors has stated the following:

- TCM will critically review its technical publication management system, and will maintain current publication status on-line
- TCM has reviewed and re-written the process to improve the release of approved documentation
- TCM uses Service Bulletins to expedite dissemination of updated technical information
- TCM encourages customer feedback regarding technical information in its technical publications
- TCM customers can receive 'kits' that include all the necessary replacement parts for magneto inspections or overhauls
- TCM takes steps to verify supply chain quality, is subject to FAA audits, annual reviews per AS9001 standard, and only uses approved suppliers/distributors.

ACCIDENT

Aircraft Type and Registration:	Morane Saulnier Rallye 235E, G-BWWG
No & type of Engines:	1 Lycoming O-540-B4B5 piston engine
Year of Manufacture:	1979
Date & Time (UTC):	28 June 2006 at 1314 hrs
Location:	Mullaghmore, Northern Ireland
Type of Flight:	Private
Persons on Board:	Crew - 1 Passenger - 1
Injuries:	Crew - None Passenger - None
Nature of Damage:	Propeller and nose landing gear leg, lower engine cowling scraped
Commander's Licence:	Private Pilot's Licence
Commander's Age:	73 years
Commander's Flying Experience:	450 hours (of which 266 were on type) Last 90 days - 2 hours Last 28 days - 2 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The approach was normal but just before touchdown the pilot realised that the aircraft was a little too fast and it bounced. On the second touchdown the nose landing gear leg collapsed.

History of the flight

On arrival at the destination airfield the pilot carried out a left orbit and noted that there appeared to be no other aircraft in the circuit or moving on the ground. He then positioned the aircraft into a left-hand circuit for Runway 18 and noted that the windsock indicated a light southerly wind. The approach was normal but just before touchdown the pilot realised that the aircraft was a little too fast and it bounced. On the second touchdown the nose landing gear leg collapsed. The pilot considers that the accident was caused by touching down too fast and the resulting bounce overstressed the nose leg assembly.

ACCIDENT

Aircraft Type and Registration:	i) Pierre Robin HR200/120B, G-BYLH ii) Pierre Robin HR200/120B, G-BXGW
No & type of Engines:	i) 1 Lycoming O-235-L2A piston engine ii) 1 Lycoming O-235-L2A piston engine
Year of Manufacture:	i) 1999 ii) 1997
Date & Time (UTC):	27 August 2006 at 0835 hrs
Location:	Leeds (Bradford) Airport, Yorkshire
Type of Flight:	i) Training ii) Training
Persons on Board:	i) Crew - 2 Passengers - Nil ii) Crew - 2 Passengers - Nil
Injuries:	i) Crew - Nil Passengers - N/A ii) Crew - Nil Passengers - N/A
Nature of Damage:	i) Left aileron deformed and wing tip fibre glass section ripped ii) Damage to right navigation light
Commander's Licence:	i) Commercial Pilot's Licence ii) Commercial Pilot's Licence
Commander's Age:	i) 27 years ii) 27 years
Commander's Flying Experience:	i) 642 hours (of which 55 were on type) Last 90 days - 138 hours Last 28 days - 51 hours ii) 800 hours (of which 564 were on type) Last 90 days - 250 hours Last 28 days - 84 hours
Information Source:	Aircraft Accident Report Forms submitted by the pilots

Synopsis

As aircraft G-BXGW was taxiing towards Runway 32 at Leeds (Bradford) Airport, its right wingtip collided with the left wing of aircraft G-BYLH which was parked adjacent to the taxiway with its engine running.

History of the flight

The aircraft commanders involved in this collision were both scheduled to carry out training details with their respective students and were employed by the same company. They were parked adjacent to each other on the south-western side of Taxiway 'F' (see Figure 1). After the engine had been started, G-BYLH was taxied to the western mouth of the main apron where engine power checks were completed with the aircraft pointing north-west. Meanwhile G-BXGW had been started and the crew carried out power checks on Taxiway 'F' before ATC instructed them to taxi to the 'L1' hold for Runway 32 via Taxiways 'G' and 'L'. Due to limitations on available space, the operating company parks some of its aircraft on the western side of Taxiway 'F' and it was necessary for G-BXGW to be taxied to the right of the taxiway centreline in order to avoid these parked aircraft. This was the situation as G-BXGW passed the mouth of the main apron where G-BYLH was positioned. As they passed, the right wing tip of G-BXGW collided with the left wing of G-BYLH which was protruding slightly into the taxiway. Both aircraft were shut down and the crew, who were uninjured, vacated through the normal exits.

Follow up action

As a result of this incident, aircraft operating on the south side of the airfield now complete their power checks at the appropriate runway holding point rather than on or adjacent to the taxiway in the start up area.

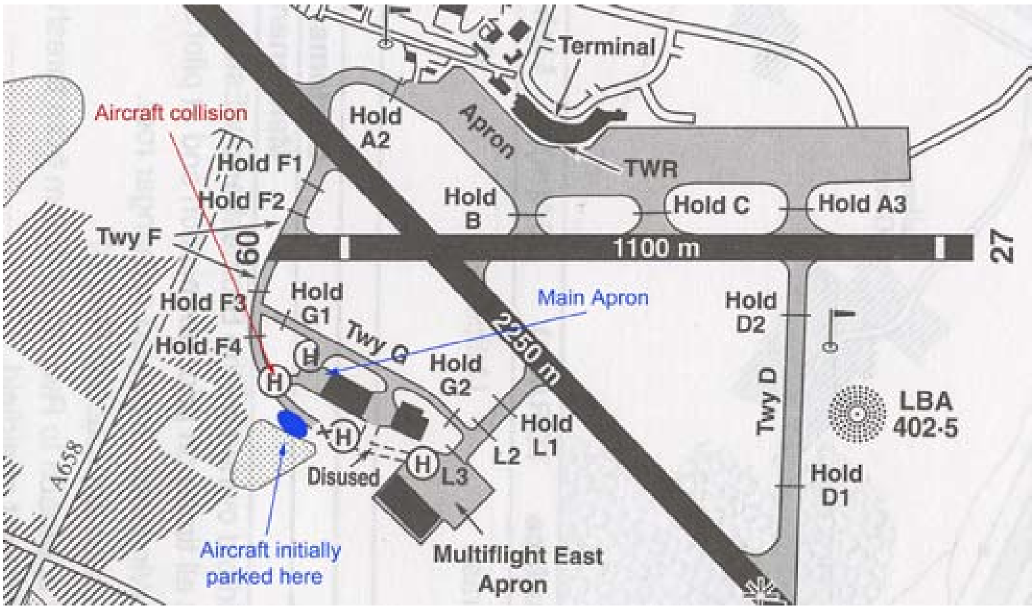


Figure 1

ACCIDENT

Aircraft Type and Registration:	Pierre Robin DR400/120A, G-GBVX
No & type of Engines:	1 Lycoming O-235-L2A piston engine
Year of Manufacture:	1979
Date & Time (UTC):	29 July 2006 at 1700 hrs
Location:	RAF Leuchars, Fyfe
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Minor) Passengers - N/A
Nature of Damage:	Damage to nose landing gear mountings
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	25 years
Commander's Flying Experience:	84 hours (of which 11 were on type) Last 90 days - 17 hours Last 28 days - 4 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

After several attempts to land in a crosswind on Runway 09 at RAF Leucars, during which the aircraft bounced several times, the pilot successfully landed on Runway 22. At the time there were conflicting indications from the three windsocks at the airfield, possibly caused by a change in the wind from on-shore to off-shore, or vice versa.

History of the flight

The pilot, together with another pilot, had made a number of flights during the course of the day, without incident. After the other pilot had stopped flying for the day, the pilot in question decided to fly one more circuit off Runway 09, before returning the aircraft to the hangar. Upon contacting the tower to announce his position downwind for his final landing, the tower controller reported an 8 kt cross-wind. In light of this, the pilot checked the three windsocks on the airfield and noted that the windsock at the 09 threshold was pointing west, the one at the 27 threshold was pointing approximately east, and the northern windsock was pointing approximately north-north-west. Anticipating a turbulent approach, the pilot resolved to 'add a few knots' to the approach speed and, after setting up for the descent, reduced the engine speed to 1,500 rpm. He then selected full landing flap at the appropriate speed and set up his initial approach at 80 kt. In response to his call, "Turning finals to land", the tower controller informed him again of an 8 kt cross-wind, but the pilot could not recall whether it was conveyed as a wind speed and direction, or as a cross-wind component.

The pilot continued what he regarded as a normal descent, reducing his speed to 70 kt, once established on the extended centreline. Thereafter, he continued his approach using the crab method, with the nose pointing to the right of the centreline to counter the wind from the right. The approach proceeded without incident, in a more stable and manageable manner than he had anticipated, until at about 25 to 30 ft above the runway. Having cleared some raised arrestor cables at the approach end of the runway, which he regarded as the defacto runway threshold, he gradually closed the throttle and reduced the airspeed, initially to just under 60 kt, and then to just below 55 kt as he flared the aircraft. He reported no problems during the initial stages of the touchdown: the descent rate did not feel excessive, the flare itself was not prolonged, and rudder was used to align the aircraft with the runway just prior to touching down on the main wheels. However, as the nose wheel was being lowered, the right wing lifted slightly, the nose wheel came firmly down onto the runway and the aircraft immediately started to oscillate 'jerkily' in pitch before bouncing into the air again. During the bounce, the pilot lowered the right wing using aileron but the aircraft very quickly touched down again and bounced higher into the air. After applying power during the bounce, he climbed ahead and announced his intention to go-around.

Following a normal downwind leg, the aircraft was again set up for a full flap approach but, on this occasion, the pilot decided that he would try a technique that he had used previously on another aircraft, involving raising the flaps immediately after touch down in order to help the aircraft 'settle' on the runway. After an uneventful decent to a touchdown point slightly further up the runway, the aircraft 'settled' and, as the pilot felt the main wheels bear the weight of the aircraft, he quickly raised the flaps. After a moment, however, the right wing lifted as before, this time more severely, which was not easily corrected. Again, the nose wheel was forced onto the runway and again the aircraft started to oscillate in pitch, but this time "startlingly quickly"; the pilot did not have time to apply power as the bounces were occurring so rapidly. After the third contact with the runway, the aircraft bounced much higher and rolled more markedly to the left. At the apex of this bounce, which the pilot estimated was around 10 to15 ft above the runway, the nose dropped and he applied full aft stick, managing almost to level the aircraft as the nose wheel contacted the runway. Again, the aircraft bounced into the air and, again, the pilot applied full power, climbed away and transmitted "going around".

Suspecting a veering and unpredictable wind, the pilot requested Runway 22, which was approved. After a normal powered approach, an uneventful landing was accomplished and the aircraft taxied back to the hangar. A subsequent inspection of the aircraft identified damage to the nose landing gear mountings.

Conclusions

The pilot believes that, except for his raising of the flaps during his second attempted landing, there had been nothing unusual in his handling of the aircraft, which he had previously landed in cross-wind conditions on several occasions without difficulty. He reports that RAF Leuchars is known to have a period during some evenings, the time of which is variable and hard to predict, when the prevailing wind changes from on-shore to off-shore, or vice-versa. He believes that this condition was probably the explanation for the conflicting windsock indications.

ACCIDENT

Aircraft Type and Registration:	Piper PA-28R-200-2 Cherokee Arrow II, G-BCGS
No & type of Engines:	1 Lycoming IO-360-C1C piston engine
Year of Manufacture:	1972
Date & Time (UTC):	19 August 2006 at 1515 hrs
Location:	Little Gransden Airfield, Cambridgeshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 2
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to right main landing gear, right wing and right stabilator
Commander's Licence:	Private Pilot's Licence
Commander's Age:	54 years
Commander's Flying Experience:	455 hours (of which 202 were on type) Last 90 days - 7 hours Last 28 days - 2 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft was landing after a one hour flight from an airfield in Dorset. The pilot decided to approach at a faster speed than normal and land with an intermediate flap setting because of a turbulent crosswind. However, he was unaware that the grass runway was very wet following recent heavy showers of rain. The aircraft landed about one third of the way down the runway and ran off the end.

History of the flight

The aircraft was preparing to land at its normal base following an uneventful flight from Compton Abbas, Dorset. The aircraft joined the circuit and, from the windsock, the pilot estimated that the surface wind was from 200º at 10 kt, which favoured a landing on the grass Runway 28. However, he was unable to obtain other weather and airfield information because the airfield radio was unattended, which was not unusual when there was no flying training taking place. In particular, he was unaware that there had recently been heavy showers of rain at the airfield and that this had left the grass surface very wet. The pilot stated that he had obtained a Terminal Area Forecast (TAF) for Cambridge Aerodrome before the flight, which had predicted showers of rain, but on arrival overhead the airfield there was broken cloud and it did not appear that there had been any recent rain.

On final approach the pilot decided that he would land with two stages of flap, rather than full flap, and maintain a slightly higher airspeed than normal to give him greater control in the turbulent crosswind. He reported that the airspeed and intermediate flap setting 'encouraged' the aircraft to float and that it touched down on the runway centre line about one third of the way down the runway at 85 mph, about 15 mph faster than normal. Application of the toe brakes had little or no effect and the aircraft skidded on the wet surface. The pilot then applied the parking brake in short bursts, with some success, but soon realised that he would not be able to stop the aircraft within the remaining runway distance. He decided not to initiate a go-around, because of the aircraft's low speed, and started a gentle turn to the left to avoid rough ground beyond the end of the runway. The aircraft ran over the runway end markings and continued its left turn through about 90º. In the process the starboard main landing gear collapsed and the aircraft came to rest about two metres beyond the end of the runway. None of the occupants were injured and they exited the aircraft normally after the pilot had shut it down.

The aircraft had a calculated landing weight of 2,548 lbs. For the prevailing conditions, the aircraft Flight Manual indicated that the unfactored Landing Distance Required (LDR), with a full flap configuration on a dry tarmac runway, was 411 metres. The CAA's General Aviation Safety Sense Leaflet (SSL) 7B, entitled *Aeroplane Performance*, advises increasing the LDR by a factor of 1.3 for a landing on a wet grass runway - giving an amended LDR of 534 metres. The Safety Sense leaflet also recommends that the Public Transport factor of 1.43 is applied to that figure, increasing the LDR still further to 764 metres, although it adds the proviso that the aircraft should be able to land in the distance required without the Public Transport factor added. The published Landing Distance Available on Runway 28 at Little Gransden Airfield is 570 metres.

The pilot concluded that the accident was the result of a high work load during the turbulent final approach and late recognition of the combination of the crosswind, the high approach speed, the wet surface and lack of braking action. However, having touched down about one third of the way down the runway, approximately 15 mph faster than normal and on wet grass there was little possibility of stopping on the runway remaining.

The CAA's General Aviation SSL 1C, entitled *Good Airmanship Guide*, states that:

> *A good landing is a result of a good approach. If your approach is bad, make an early decision and go-around. Don't try to scrape in. Plan to touch down at the right speed, close to the runway threshold, unless the field length allows otherwise…. Go-around if not solidly 'on' in the first third of the runway, or the first quarter if the runway is wet grass.*

INCIDENT

Aircraft Type and Registration:	Piper PA-32RT-300, G-RHHT
No & Type of Engines:	1 Lycoming IO-540-K1G5D piston engine
Year of Manufacture:	1978
Date & Time (UTC):	25 May 2006 at 1530 hrs
Location:	Fox Heading Lane, St Johns, Spalding, Lincolnshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	No damage
Commander's Licence:	Private Pilot's Licence
Commander's Age:	38 years
Commander's Flying Experience:	304 hours (of which 94 were on type) Last 90 days - 11 hours Last 28 days - 1 hour
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

A land owner reported that an aircraft had landed on part of his property adjoining Fenland Airfield. In his report the pilot considered that the takeoff performance appeared to have been deficient and the aircraft was failing to climb. A decision was taken to land ahead rather than attempt to cross a row of trees. The investigation noted that the perception of reduced performance might be attributed to a newly overhauled engine which had not been fully run in.

Background

The pilot, who was also the owner, reported that the aircraft was fitted with an overhauled engine in May 2006. A number of test flights were reported to have been carried out without incident. During the return flight from Fenland to the home base of Sywell, however, the pilot noticed that the climb rate was lower than expected and a vibration was being transmitted through the control column. He reported this subsequently to the engineering company who requested that he return the aircraft to enable them to check it over. During the climb-out from Sywell the pilot again noticed the climb rate was not as good as usual.

On discussing the problem with the engineering company, the pilot was assured that some power and vibration anomalies were to be expected with a newly overhauled aero engine. The engine was fully tested on the ground and the pilot was then happy to proceed.

The takeoff attempt

The pilot stated that he calculated the aircraft weight, established to his satisfaction that sufficient takeoff distance was available on Runway 36 at Fenland and proceeded to take off. After a run of approximately 400 metres, the IAS was showing 50-55 kt and the aircraft did not appear to be accelerating normally. By this time he judged that there was insufficient distance available to stop, so two stages of flap were selected, the aircraft was rotated at 55-60 kt and the aircraft was held in ground effect whilst it accelerated to 60-65 kt. Thereafter, the aircraft did not appear to be accelerating. Having been airborne for approximately 300 metres, the occupants realised that the aircraft was not climbing. As they were approaching a row of trees, they decided that the safe course of action was to land immediately in the wheat field over which the aircraft was then flying. The landing was successful, without damage to the aircraft or injury to the occupants.

Subsequent events

The aircraft was recovered from the field and comprehensively examined by the engineering company. Late the same day the aircraft was pronounced fit to fly and a further flight was carried out using Runway 18 for takeoff. The engineer, who was also a well qualified pilot, accompanied the incident pilot on this occasion. Although the takeoff and climb out were successful, the incident pilot still considered that climb performance was not as expected. A number of hours were flown over a few days with the power setting at above 75%. The climb performance seemed to vary and vibration was at various times both present and absent. Another pilot also encountered poor takeoff performance and vibration whilst flying the aircraft. A subsequent flight covering six hours at 75% power seemed to rectify the performance. Once more than 20 hours had been accumulated by the aircraft following fitment of the overhauled engine, the takeoff and climb performance appeared to the incident pilot to be entirely normal and remained so thereafter.

Behaviour of overhauled engines

It should be noted that new or overhauled engines, which have not been extensively run at high power on test plant before installation must be operated in flight for a significant period at higher than normal cruise power to run in the piston rings and cylinder bores. This process creates a better fit which in turn reduces and stabilises oil consumption as well as reducing friction and consequent power loss. Prior to this, oil consumption is generally high, quantities of oil passing the rings into the combustion chambers. This phenomenon frequently creates plug fouling during ground running and low powered flight. A single cylinder may suffer more from this than other cylinders in the same engine. Should a single plug foul, incomplete combustion in that cylinder and hence loss of peak combustion pressure will occur. The lower torque contribution from that cylinder will be less immediately obvious on a six cylinder unit (as in G-RHHT) than on a four cylinder type. High power operation, provided some plug functioning occurs in the affected cylinder, will raise the combustion temperature and if sustained will tend to burn off the oil fouling, leading to disappearance of vibration in flight. Prolonged reduced power running such as during a descent or during ground operation may allow the fouling to return as a result of reduced combustion temperature.

A lengthy flight at high power creates precisely the conditions required to run in the rings and cylinders, reducing oil passage into the combustion chambers and reducing the chances of plug fouling. These factors may all have conspired to create inconsistent running following overhaul, succeeded by correct behaviour and satisfactory performance once the lengthy high powered flight took place.

ACCIDENT

Aircraft Type and Registration:	Piper PA-38-112 Tomahawk, G-BYLE
No & Type of Engines:	1 Lycoming O-235-L2C piston engine
Year of Manufacture:	1982
Date & Time (UTC):	22 October 2005 at 0839 hrs
Location:	Near Biggin Hill Airport, Kent
Type of Flight:	Training
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - 2 (Fatal) Passengers - N/A
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Commercial Pilot's Licence with Flying Instructor Rating and CAA authorised Flight Examiner
Commander's Age:	60 years
Commander's Flying Experience:	4,451 hours (no record of any experience on type) Last 90 days - 39 hours Last 28 days - 18 hours
Information Source:	AAIB Field Investigation

Synopsis

Shortly after takeoff the aircraft experienced an engine problem which was probably the result of water contamination of the fuel. In the resultant situation, the recommended option was to land straight ahead into a field. However, possibly influenced by a partial engine recovery, the commander decided to attempt to turn back towards the departure runway. The aircraft had turned through approximately 180º to the left when it stalled and crashed.

Background to the flight

A few months prior to the accident flight, the commander had contacted the Chief Flying Instructor (CFI) of the Flying Club that operated G-BYLE and offered his services as a flying instructor. The CFI had known the commander for many years, knew that he was an experienced instructor and examiner, and had agreed that he would employ him when an additional instructor was required.

On Thursday 20 October 2005, the CFI contacted the commander and asked him if he would be available for instructional duties on Saturday, 22 October. The commander agreed and arranged to be at the flying club early on the Saturday morning. The CFI was aware that, sometime after the initial contact, the commander had visited the club and spoken to his other full-time instructor.

The student involved in the accident had been a member of the flying club since 22 January 2005. Since then, he had completed 26 flights totalling about 29 hours. He had not flown solo and had last flown an instructional flight on 1 October 2005, three weeks before the accident.

The previous flight of G-BYLE had been on 20 October 2005, two days before the accident, when two other pilots had flown the aircraft from Biggin Hill to North Weald and back. At the completion of the flight, the pilots' recollection was that the fuel gauges indicated between $^1/_3$ and $^1/_2$ full in each of the two wing tanks. They also commented on two aspects. Firstly, on initial application of electrical power, the fuel gauge had indicated that the left fuel tank was empty; a visual check of the tank contents indicated that it was about $^2/_3$ full. However, after engine start, the fuel gauge indicated correctly and did so for the rest of the flight. The pilots also noted that, during the pre-flight external checks it was necessary to drain three fuel-tester containers of water from the left fuel tank (a typical, tubular fuel drain test container holds approximately 35 cc of liquid). There was no indication of water in the right fuel tank or the gascolator.

History of the flight

On the day of the accident, the flying club operations assistant arrived at about 0720 hrs to open up the club. A few minutes after she did so, the student arrived and had a cup of coffee before taking the keys of G-BYLE and going to do the pre-flight external checks on the aircraft. Shortly after, the commander arrived and introduced himself to the operations assistant. She had been pre-warned by the CFI that the commander would be doing some instructing and arranged for him to complete the club membership form. She also showed him where the student records were kept and saw him take out a record and read it. He then commented that he would be doing a circuit detail, checked the Technical Log for the aircraft and booked out for the flight. He also commented that, as there would be no need for a long brief, he would go and join his student at the aircraft.

While the student was alone at the aircraft, the airport refuelling truck arrived and its operator began refuelling aircraft. G-BYLE was the second aircraft refuelled at about 0755 hrs and 65 litres were loaded into the aircraft to fill both fuel tanks.

Analysis of the radio recording from Biggin Hill 'Tower' on frequency 134.800 MHz, showed that G-BYLE checked in at 0818 hrs with a request to taxi for a circuit detail. Paperwork later found in the aircraft revealed that the commander had logged the brake release time as 0820 hrs. The paperwork also showed that the commander had noted the latest Biggin Hill weather report. The club CFI was also flying that morning and had heard G-BYLE call for taxi clearance. Shortly after, as the CFI taxied away from the aircraft power check area, he saw G-BYLE waiting to taxi in to the area. The next radio communication from the aircraft was at 0830 hrs when G-BYLE reported ready for departure. The controller instructed the aircraft to hold position and was then busy with other aircraft on the frequency. At 0834 hrs, G-BYLE transmitted again that the aircraft was ready for departure and the crew were advised that they would be called back as there was another aircraft departing on Runway 03. Then, at 0837 hrs G-BYLE was cleared to take off from Runway 21 for right hand circuits with a surface wind of 240º/ 05 kt. After acknowledging this clearance, the next transmission from G-BYLE was at 0838 hrs with the following message: "ER LIMA ECHO I'VE GOT A PROBLEM CAN I COME BACK AND LAND ON ZERO THREE". The controller immediately cleared the aircraft to do so and to make a left turn. G-BYLE confirmed that the aircraft would turn left. At 0839 hrs, the controller cleared the aircraft to land on Runway 03 but received no reply.

When the tower controller heard the initial call from G-BYLE, he noted that the aircraft was already in a turn to the left. Following his transmission to G-BYLE, he then instructed another aircraft to go-around from an approach to Runway 21. The approach controller was also in the visual control room and had watched the aircraft. She had seen it turn slightly to the right after takeoff and then start turning to the left. By then, the tower controller was concerned that the aircraft would not make it back to the airfield and activated the crash alarm. The aircraft disappeared behind trees to the south of the airfield in a nose-down attitude.

The crash alarm was recorded as being activated at 0839 hrs and the AFRS recorded their arrival on the crash scene at 0844 hrs. The local Fire Service arrived on the scene at about the same time. There was no fire and with no indication of life from the occupants of the aircraft, the fire fighters laid and maintained a foam blanket around the area of the aircraft.

Near the airport, there were witnesses who saw the aircraft during its last moments of flight. One witness had previously worked as an aircraft engineer at the airport. He was in the driveway of his house, located some 400 metres south of the airport, when he heard a "*popping*" noise from an aircraft and looked towards it. The aircraft, which he recognised as a Piper Tomahawk, was coming from the airport. It appeared to have turned to the right because the normal departure from the southerly runway was directly over his house. The aircraft was much lower than normal and appeared to be descending. He then heard the engine noise increase and sound "*smooth*" for a couple of seconds before going back to the "*popping*" noise. He described the "*popping*" noise as similar to that occurring during a magneto check when one magneto was particularly bad resulting in a large rpm drop. The aircraft continued towards the south and he lost sight of it behind a tree. He moved position and saw it again. It was very low and almost in plan view. He was then aware of the aircraft pointing almost directly towards him at about 50 feet agl. His impression was that it was flying very slowly and he thought that it had just started a turn towards the left when the left wing went down sharply. He saw the aircraft strike the ground almost vertically with the underside pointing towards him but at an angle. During the last manoeuvres, he could not hear any engine noise. He asked his wife to ring the emergency services and he ran towards the aircraft but it was apparent that the occupants had not survived. Near the aircraft he could see and smell a substantial amount of fuel. One other witness, who is also an aircraft engineer, also heard the aircraft. His impression was that the throttle had been retarded and he thought that the pilot was practising an engine failure after takeoff. After one or two "*pops*" from the engine, he was no longer aware of any engine noise. He saw the aircraft turn to the left with its bank angle increasing to about 85 to 90º. Then, the nose of the aircraft came down and the aircraft dived towards the ground but rolling left as it did so. There were other witnesses who saw the aircraft in its last moments of flight. Their descriptions of the aircraft's manoeuvres were generally consistent and none of the witnesses mentioned seeing smoke, flame or liquid coming from the aircraft. One witness stated that she had seen something drop from underneath the aircraft shortly before the crash; she described the object as round and black and thought that it was a wheel.

Weather

The METAR for Biggin Hill Airport at 0820 hrs on the day of the accident showed a surface wind of 240º/05 kt varying between 200º and 300º, visibility of 10 km or more, cloud scattered at 2,000 feet and broken at 2,500 feet, air temperature of 11ºC with a dew point of

9º C and a QNH of 998 mb. Using the CAA carburettor icing chart, these conditions would be conducive to serious icing at any power.

The Met Office provided information on the rainfall between the previous flight of G-BYLE and the accident flight. The nearest site where rainfall was recorded was at Kenley, some 5 nm from Biggin Hill. This indicated that a total of 12.6mm ($^{1}/_{2}$ inch) of rain had fallen between 0700 hrs and 1900 hrs on the day before the accident.

Medical

Post-mortem examinations revealed no evidence of pre-existing natural disease in either pilot which could have caused or contributed to death or to the accident. Both pilots had died from very severe multiple injuries of the type typically seen in high-energy crashes; death would have been virtually instantaneous. It was not possible to deduce which of the pilots was handling the aircraft at the time of the crash. The relative weights of the pilots were as follows: commander 82.1 kg (181 lb), student 95 kg (209 lb).

Medical enquiries indicated that the commander had been undergoing some treatment but had not informed the CAA. The pathologist did not consider that the unreported medical condition had any bearing on the accident.

Operational aspects

The Pilot's Operating Handbook (POH) for the aircraft was held in the flying club. Relevant extracts from the POH were as follows:

1. The basic empty weight of the aircraft was 1,236 lb (which included 12 lb of unusable fuel).
2. The maximum allowable weight of the aircraft was 1,670 lb. The CG limits at maximum weight were between 73.5 and 78.5 inches aft of datum.
3. The total fuel capacity was 32 US gallons (26.6 Imperial gallons).
4. The best angle of climb speed was 61 KIAS and the best rate of climb speed was 70 KIAS.
5. The stalling speed 'clean' in level flight at 1,670 lb weight was 48 KIAS.
6. The procedures for an engine power loss during takeoff (if airborne) included the following advice: '*At low altitudes with a failed engine, turns should not be attempted, except for slight and gentle deviations to avoid obstacles. A controlled crash landing straight ahead is preferable to risking a stall which could result in an uncontrolled roll and crash out of a turn.*'

The estimated weight of the aircraft based on a full fuel load less taxi fuel (approximately 175 lb) and the respective weights of the commander (191 lb) and student (209 lb) was 1,811 lb. This was 141 lb above the maximum allowable weight. The CG was estimated as 76.7 in aft of datum, which was within the limits specified at the maximum allowable weight.

The flying club had registered with the CAA as a facility for PPL training.

The club had a flying order book which included the following instructions:

1. '*It is required that all Pilots, Students and flying Staff read this Order Book every six months and sign the signature book accordingly.*' Note: There was no evidence of any signature book.

2. *'Flying instruction may only be conducted in Company operated aircraft, by instructors so approved by the Chief Flying instructor.'*
3. *'All licenced Pilots intending to use Company aircraft, must undertake an initial Dual Check Flight with a Company Instructor before being allowed to Fly solo in a Company aircraft. This rule applies regardless of the Pilot's previous experience.'*

Examination of the commander's logbook indicated that he normally operated from Redhill Aerodrome but had also flown from Biggin Hill Airport. Most of his recent flying had been in Cessna 152 and Grumman AA-5A aircraft. There was no available record that he had completed any flights in a Piper PA-38 between 20 September 1996 and the date of the accident.

The commander was last re-validated as a Flying Instructor on 13 September 2003, valid until 12 September 2006. He had also renewed his CAA Flight Examiner qualification in September 2005.

The student's regular instructor considered that the student was enthusiastic and conscientious in his approach to flying and assessed him as being close to solo standard. He was also confident that the student would be comprehensive in his pre-flight external checks. The instructor also confirmed that the normal procedure for fuel selection was to change the tank selection prior to the engine power check. He had also discussed with the student, the actions in the event of an engine failure after takeoff, and had briefed him never to attempt a 'turnback' in that situation. Finally, the instructor also stated that he and his students would normally select carburettor heat to 'HOT' approximately every 5 minutes on the ground if the aircraft was held on the ground prior to takeoff; for takeoff, the heat selector would be at 'COLD'.

The airport procedures for takeoff from Runway 21 were for the aircraft to remain at or below 500 ft QFE until passing the upwind end of the runway; the circuit height was 1,000 feet QFE. Beyond the airport boundary to the south, the ground falls away towards a valley.

Wreckage examination at the scene

The aircraft crashed onto a residential road forming part of a housing estate in the valley just to the south of the airfield, at a position approximately 400 metres from the end of Runway 21 and some 160 ft below runway level.

The pattern of structural damage together with ground marks and other evidence at the scene indicated that the aircraft had been in a steep descent, pitched approximately 70º nose down and sideslipping to the left with some rotational momentum to the left. These parameters were consistent with an incipient spin to the left. The impact into the tarmac roadway was severe and the forward fuselage and wing leading edges were crushed back almost as far as the main landing gears. During the final part of its descent, the aircraft's left wing severed an overhead domestic electrical supply cable; its nose and right wing struck the bonnet and side panels respectively of a light van parked in the roadway. Despite severing the electrical supply cables and the breakup of both integral fuel tanks, which released all the fuel on board the aircraft, there was no fire; nevertheless, the wreckage and surrounding roadway were comprehensively covered with foam by fire fighters attending the scene.

No evidence could be found at the scene to show that the engine was operating under power at the time of impact. The propeller had broken away from the crankshaft during the impact, but the fracture characteristics were consistent with a predominantly bending mode of failure with no evidence of a significant torsional component of failure. One blade, which was folded back beneath the remains of the engine, was heavily and irregularly scored on its forward face in the tip region, and more regularly at an approximately 45º angle to the chord over a region nearer the root. The other blade projected vertically, clear of the wreckage, and was undamaged except for a rearward bend at approximately 30% span. The condition of this blade matched damage to the bonnet of the van which the aircraft had struck including transfer of red paint from the propeller tip. Both the condition of the propeller itself and the pattern of damage and paint transfer on the van's bonnet were consistent with the propeller having been effectively stopped at the time of impact.

The engine was extensively damaged in the ground impact. In particular, the carburettor casing and float chamber had broken open; the mechanical fuel pump mounting had fractured, and its associated pipework partially torn away; and the fuel strainer and water drain assembly (gascolator) was broken apart. These components specifically, and the wreckage generally, were extensively contaminated with water and foam applied by the emergency services and no unimpaired samples of fuel could be recovered.

The cockpit controls would have been subject to significant disturbance during the impact sequence, and no reliable indications as to their pre-impact state could be determined at the scene.

Detailed examination of the wreckage

The wreckage was recovered to the AAIB's facility near Farnborough for detailed examination.

Engine

The engine was taken to an approved engine overhaul agency, where it was disassembled and inspected under AAIB supervision.

The engine suffered extreme damage in the impact but it was possible to confirm that there had been no mechanical failure of core components and nothing was found to suggest that there had been any pre-impact failure of relevant ancillary parts. All spark plugs were of normal appearance and it was possible to confirm by test that the left magneto was serviceable at the time of impact.

Fuel system

At the time of impact, the fuel selector valve was set to supply the engine from the left tank. However, the fuel system pipework was extensively disrupted by the impact and no fuel residues were recovered. Each of the fuel filler caps was in place and in the locked position, but the left cap was loose to the extent that it could be rocked on its seat. The right cap was somewhat looser than expected, but it did not rock on its seat.

The PA-38 filler cap is a deceptively complex mechanism. The seal assembly comprises a stack of three gaskets: a thin rubber gasket seal which abuts the face of the filler neck, backed by two very thin and stiff spring gaskets. The stack is clamped centrally within the concave underside of the fuel cap housing resulting in the stack adopting a slightly conical profile. When the cap is locked down into position by the action of a bayonet mechanism, the rubber sealing gasket is pressed down onto the face of the filler neck. The relatively soft material of this gasket accommodates any small surface imperfections whilst the thin (slightly conical) backing gaskets act as a circumferential spring which pushes the gasket down around the whole periphery to accommodate any larger-scale undulations which may exist at the seal interface.

The sections of fuel tank roof incorporating the fuel filler caps and their associated housings were excised from the remaining wing structure and the effectiveness of each of the cap seals as a barrier against water ingress was tested. When held under a water tap, it was found that the seal on the left cap admitted water at a rate of between 750 cc and 860 cc per minute; no water passed the seal on the right filler cap. Careful measurements to check for possible impact deformation of the mating surfaces eliminated impact damage as a possible cause of the poor seal. It was evident that the seal was defective prior to the accident, and that if conditions prior to the flight had been conducive to rainwater finding its way in substantial quantities into the area surrounding around the filler cap, then it could readily have entered the tank.

Examination of the filler cap bayonet mechanisms revealed that on each cap the projecting lugs (which abut the bayonet-cams) were grossly worn, to the extent that each lug was worn right through, beyond its full thickness, see Figures 1 and 2. The effect of this wear was to reduce significantly the extent to which the cap was pulled down onto its seat, with a commensurate reduction in the amount of compression of the seal assembly and an associated loss of seal effectiveness.

Age-related cracking was clearly visible around the periphery of the rubber sealing gasket from the left cap, but for the most part these cracks did not extend into the working (contact) area of the seal. This cracking was less significant in terms of the deterioration in seal performance than the reduced compression of the seal assembly caused by the wear in the bayonet mechanism.

Flying controls

No viable evidence remained as to the positions of the flying controls at the time of impact, but nothing was found to suggest any malfunction or abnormality affecting these systems.

Cockpit settings

The throttle and mixture controls were each in the fully forward position 'as found', but it was not possible reliably to determine their pre-accident settings. The magneto key was broken off during the impact, with the surviving part of the key aligned with the left magneto position. Normally, the ignition switch would be set to both (ie to left and right magnetos), and would only be set

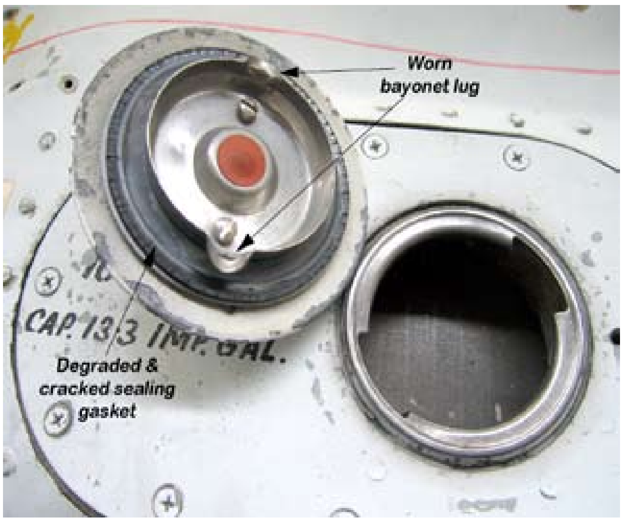


Figure 1

Fuel filler cap

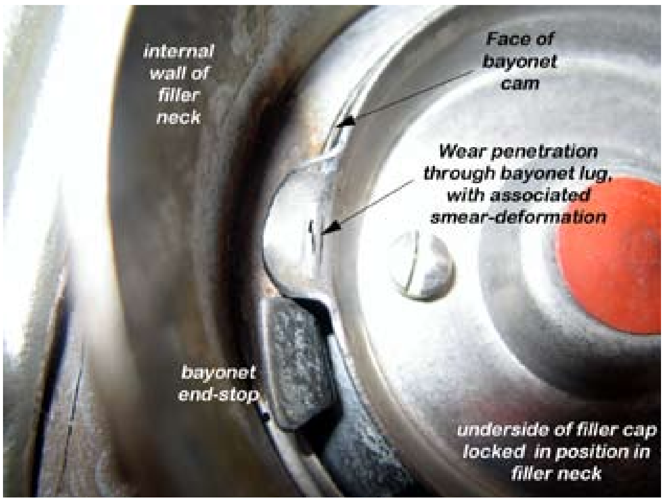


Figure 2

Underside of filler cap showing worn bayonet cams to a single magneto (whether left or right) in an attempt to isolate a faulty ignition system. It was not possible to establish whether the selection to left was caused by disturbance as the key broke off in the impact, or whether it was set to that position prior to impact. However, if it was the latter, then it was likely to have been put there in an attempt to restore engine power. Microscopic bruises were evident on the carburettor heat control consistent with it having been in the on (hot) position at the time of impact.

Stall warning system

The electrical coil of the stall warning horn in the cockpit was disrupted as a result of a connecting wire being torn away in the impact, and the stall-warning vane on the wing leading edge was ripped way from the leading edge during the impact. As a consequence, the pre-accident effectiveness of the stall warning system could not be established.

Maintenance records

The aircraft's documentation showed that it had undergone a 50 hour inspection on 12 October 2005 at 6,401 airframe hours, and that subsequently it had flown a further $1^1/_4$ hours by the time of the most recent log book entry on 20 October, two days before the accident. Prior to that, it had undergone a 150 hour inspection on 12 August 2005 at 6,353 airframe hours, some 50 flying hours prior to the accident.

The technical documentation covering the relevant period contained no entries of significance. The applicable Light Aircraft Maintenance Schedule (LAMS) calls for inspection, inter alia, of "…Tanks, filler caps, …" as part of 'task 74' of the 150 hr inspection. The work pack for the 150 hour inspection carried out on 12 August 2005 reported no findings against this item.

Tests & research

A series of engine test runs were carried out to explore the likely effect of water in the fuel supply to the engine of a PA-38, using a time-expired Lycoming O-235 engine of the same type as that installed in G-BYLE. The tests established that a single 'packet' of water of 25 cc or more entering the carburettor causes an immediate loss of power and stoppage of the engine. Packets of 20 cc volume or less did not cause stoppage provided that they reached the carburettor at intervals which gave the engine time to recover. However, they resulted in a significant rpm reduction followed by stagnation and/or pronounced hesitation or 'hunting' followed by recovery. On those occasions when the engine hesitated badly, there was an abrupt audible change, as though the ignition was being switched rapidly off and on again.

Analysis

General

The accident resulted from an attempted turnback following an engine malfunction. During the turnback, the aircraft stalled and struck the ground in an almost vertical attitude. This analysis considers the possible reasons for the engine problem and the relevant operational aspects.

Engineering

Cause of the engine malfunction

The condition of the propeller leaves no doubt that the engine was stopped, or almost stopped, when the aircraft struck the ground. The witness evidence also points strongly to loss of engine power after takeoff, as does the position of the carburettor hot air control at the time of impact (ON) since hot air is not likely to have been used during takeoff except in an attempt to restore a loss of power. The 'as found' position of the magneto switch (left magneto selected) could also be indicative of attempts to rectify a power loss.

Detailed examination of the engine remains showed that it was mechanically sound at the time of impact. Whilst the possibility of a subtle ignition, carburation, or fuel system malfunction could not be ruled out totally, no evidence of such could be found and indeed it was possible to establish that at least one of the aircraft's dual magnetos was serviceable. The fuel valve was selected to the left tank, and the mechanical fuel pump was serviceable. On a balance of probability, therefore, the evidence does not suggest that the power loss was caused by a mechanical or electrical malfunction or fuel starvation. There is, however, strong circumstantial evidence suggesting that the engine stopped because of water in the fuel.

Extreme disruption of the engine and fuel system by the impact combined with extensive post-accident water contamination by the fire service precludes any positive conclusion being drawn as to whether or not water was actually present in the fuel supply to the engine. However, it was positively established that the left filler cap seal was ineffective against the ingress of water and it is significant that an unusually large amount of water was drained from this tank during pre-flight checks by a different pilot on the preceding flight two days before. Given that it had rained heavily for 12 hours on the day before the accident, it is possible that a significant quantity of water had entered the left fuel tank by the morning of the accident flight. It is not known whether water drain checks were carried out prior to the accident flight or, if they were, by whom and when in relation to refuelling of the aircraft that day. However, assuming that water checks were carried out, if the sample drawn from the left tank had comprised 100% water, then the lack of a visible fuel/water boundary could have been misinterpreted as 100% fuel. On the available evidence, it must be concluded that there would have been some water present in the left tank that morning, quite possibly an abnormally large amount. Even if water drain checks were carried out, there is a strong possibility that significant amounts remained in the system at the start of the flight. Depending upon which tank was selected for start-up and taxi, and the subsequent management of the fuel system, it is possible that this water may not have entered the engine supply in sufficient quantities to affect it adversely until the aircraft was in the climb out.

The tests conducted to explore the effect of water in the fuel were not designed to replicate conditions on the accident flight, not least because of the number of unknown parameters involved, but rather they were intended to establish some baseline parameters regarding the volume of water needed to cause stoppage of an engine of this type at full power, and to characterise the engine's response in qualitative terms. The movement and vibration of an aircraft in motion, both on the ground and in flight, would tend to disperse any water in the tank and it would be likely to enter the system pipework as a series of separate 'packets', rather than as a continuous flow of neat water. As any such water makes it way through the tank pipework, selector valve, gascolator and fuel pump, its progress towards the carburettor would be halted temporarily as water separated out and filled any cavities acting as traps, for example in the gascolator. Thereafter, it would continue to make its way towards the engine, still in the form of packets of water mixed with fuel, and it is probable that it would reach the carburettor in small packets. If the volume of one of these packets was greater than 25 cc, immediate engine rundown and stoppage would result. If 20 cc or less, the effect would be to cause the engine to run down, stagnate briefly with audible hesitations or hunting, and to recover before the next packet of water caused further hesitations, or stoppage depending on its size and the rate at which the water entered the carburettor. These symptoms are not dissimilar to those reported by witnesses.

Although it cannot be proven, the available evidence points very strongly to power being lost because the fuel supply to the engine was contaminated by water that entered the left wing tank via an ineffective filler cap seal.

Filler cap effectiveness

Whilst the rubber sealing gasket on the left cap had visibly degraded and cracked, for the most part these cracks did not extend into the interface region, and were not in themselves responsible for the absence of an effective seal. Rather, the loss of seal effectiveness was almost wholly caused by wear in the bayonet fittings, which reduced the distance through which the cap was pulled down onto its seat in the filler neck as it was locked down. It was not possible to measure precisely the extent of this wear, but the depth of wear in the lugs alone, illustrated in Figure 3, exceeded the rubber gasket's thickness by some 40% and approached the total thickness of the complete gasket stack. The reduced compression of the fitted cap meant that the seal was no longer in proper contact with the seat and the cap would be prone to leakage. Any appreciable wear in the bayonet cam faces would also have contributed to a poor seal.

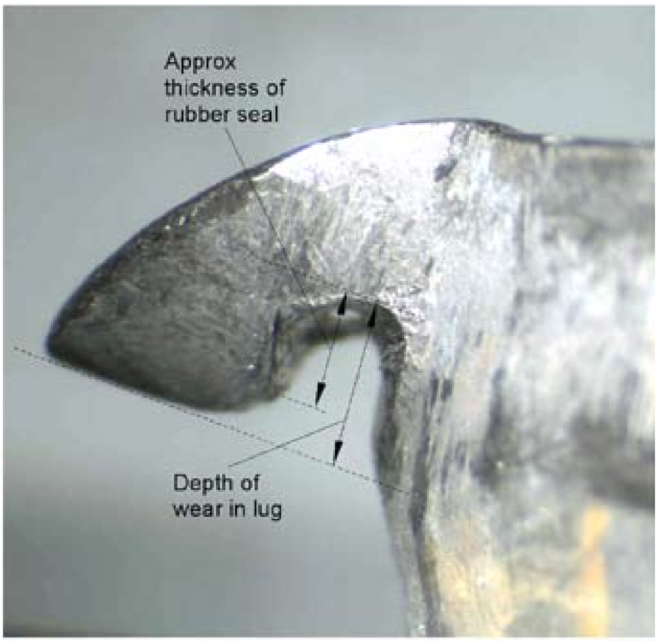


Figure 3

Illustration of wear in bayonet lug
(viewed from the side)

The 150 hour check calls for inspection, inter alia, of the fuel tank filler caps, but in practice it is likely that inspections of apparently simple items like fuel filler caps would be somewhat cursory and, in the case of PA-38 filler caps, would be likely to focus mainly on the condition of the rubber seal. Wear in the cam element of the bayonet mechanism might not be identifiable visually. Moreover, even significant wear in the lugs would almost certainly be missed unless attention was directed specifically to them.

Given the typical age of PA-38 aircraft currently in service and the probability of significant bayonet wear in the filler caps of such aircraft, it is considered that the existing requirements for fuel cap inspections under the CAA LAMS system may be insufficiently explicit to assure continued effectiveness of the filler caps of these aircraft. However, it is recognised that the LAMS schedule is generic and intended to cover all light aircraft on the UK register, and that consequently it may not be appropriate to introduce type-specific detail into the LAMS schedule.

Therefore it was recommended that:

Safety Recommendation 2006-075

The UK CAA should alert light aircraft owners, operators and maintainers of the dangers inherent in using worn, degraded or loose-fitting fuel tank filler caps.

Safety actions taken

The UK CAA undertook to publicise in a forthcoming GASIL[1] the fuel cap wear issues identified during this investigation.

One manager of a sizeable fleet of light aircraft stated that the type of fuel filler cap fitted to many of the PA-28 range of aircraft is identical to that fitted to the PA-38. On learning of the fuel cap maintenance issues disclosed by this accident, his company had examined all the PA-28 and PA-38 aircraft within its managed fleet. Of the 50 aircraft, the company found it necessary to refurbish or replace about 30 fuel filler caps. This high incidence of defects suggests that wider action by the authorities responsible for maintenance oversight in Europe would be appropriate. Therefore, it was recommended that:

Safety Recommendation 2006-109

The European Aviation Safety Agency should instigate a one-off inspection of PA-28 and PA-38 aircraft fuel filler caps to identify any with unserviceable rubber gaskets or excessive wear in the metal locating lugs and require refurbishment or replacement of any defective caps.

Operational aspects

The commander had not previously flown with the student or with the flying club. Although he was an experienced instructor and examiner and had reviewed the student's training records, it was surprising that the commander had not had a more formal briefing with the student to ensure that both were properly prepared for the flight. Additionally, there was no evidence that the commander had previously flown in a Piper PA-38. Although he was licensed to fly the aircraft, it would have been prudent for him to have had a familiarisation flight with another club instructor prior to undertaking a flight with a student.

The student had gone alone to the aircraft to complete the external checks and while he was there, the aircraft was refuelled to full. It is likely that the student, who was considered conscientious, also completed a 'water check'. It is also likely that water was present because the aircraft had been parked outside, the left filler cap was loose, its seal was ineffective and there had been rain since the previous flight. It was not possible to determine whether this check was completed before or after the refuelling and whether the student detected any water in the fuel tester container. If he completed the check immediately after the refuelling, water in the tank could have been temporarily dispersed. Soon afterwards, after the fuel had been sampled from the tank drain point, water may have gathered at the lowest point in the tank. Alternatively, it is possible that the container may have been completely full of water on the student's check and that the inexperienced student assumed that this fluid was all fuel. It was also not possible to determine whether the commander had carried out a 'water check' or whether he had relied on the student. The possibility remains that the fuel system was contaminated with water regardless of whether the 'water check' had been done.

The atmospheric conditions were also conducive to carburettor icing and the aircraft had been held at the holding point for some 7 minutes. However, it was a standard club procedure for carburettor heat to be applied every 5 minutes if held on the ground before takeoff. For takeoff, the carburettor heat should be off and normal procedure would be to check the engine parameters with full power applied during the ground roll. Any adverse indication should have resulted in the pilot stopping the takeoff.

Footnote

[1] General Aviation Safety Information Leaflet.

It was not possible to determine who was handling the controls during takeoff but, if the commander was not handling the aircraft, he would probably have been following through on the controls. Normal airmanship procedure prior to any takeoff would be for the commander to brief the actions to be taken in the event of a problem on takeoff. It was not possible to determine what, if any, contingency plans were briefed by the commander prior to takeoff. However, once there was any indication of a problem, the commander would likely have taken control. There was some slight variance in the witness accounts about the noise of the aircraft. There was no doubt that there was an engine problem but some difference in opinion as to whether there was any temporary recovery. For the commander, a total engine stoppage would have left him with no choice other than to land ahead and there were fields ahead, which would have been suitable for a forced landing.

The excess weight of G-BYLE would have increased its stalling speed in level flight from 48 to 50 KIAS. However, in a 60º angle of bank turn, the stalling speed would have further increased to 70 KIAS which was identical to the best rate of climb speed. Consequently, the aircraft would probably have been prone to stalling immediately a level, steep turn was attempted.

All flying training emphasises the importance of setting up for a landing straight ahead in the event of an engine failure in a single-engine aircraft. This advice is normally included in aircraft type flight manuals and was included in the POH for G-BYLE. However, there is always a natural temptation for a pilot to attempt to rectify the problem and to return to a runway; this is particularly true when the problem is not a total engine stoppage. This may have been more relevant on the takeoff from Runway 21 when the lower ground to the south would have given the pilot a visual impression that the aircraft was well above the ground.

There was also evidence that the carburettor heat had been applied and the magneto switch may have been set to LEFT instead of BOTH. It is improbable that an experienced instructor would permit his student to takeoff with these two controls incorrectly set, irrespective of his lack of experience on type, since these controls and their correct positions for takeoff are common to most light aircraft. The magneto switch position may have changed during ground impact but not the carburettor heat control. Consequently, the 'as found' settings may be indications that either the commander or the student was attempting to recover the engine to full power.

It was also apparent that the handling pilot, who by this stage was probably the commander, was attempting to turn the aircraft back towards the airport. In that situation, the control of airspeed and height would have been critical and any recurrence of the engine problem would have resulted in the crew having few options other than to continue the turn. In this accident, the excess weight of the aircraft would also have meant that control in the turn would have been even more critical in an aircraft with which the handling pilot was not totally familiar. When the engine problem first occurred, the safest option would have been to land straight ahead. Once the crew initiated and maintained the turn to the left, the final engine stoppage meant that an accident was unavoidable.

Conclusion

The accident occurred following an engine problem shortly after takeoff, when the handling pilot attempted to turn back towards the airport and lost control of the aircraft. Although it was not possible to eliminate carburettor icing as a potential causal factor, it was more probable that the engine problem resulted from water contamination of the fuel. Two safety recommendations have been made relating to fuel filler cap deterioration and inspection.

The commander was very experienced and would have been well aware of the dangers associated with any attempt to turn back after a problem on takeoff. Once the turnback had been initiated, he was not well placed to control the aircraft in a critical condition because of his lack of currency on type. The performance of the aircraft would also have been adversely affected by its excess weight.

Safety Recommendations

The following safety recommendations were made:

Safety Recommendation 2006-075

The UK CAA should alert light aircraft owners, operators and maintainers of the dangers inherent in using worn, degraded or loose-fitting fuel tank filler caps.

Safety Recommendation 2006-109

The European Aviation Safety Agency should instigate a one-off inspection of PA-28 and PA-38 aircraft fuel filler caps to identify any with unserviceable rubber gaskets or excessive wear in the metal locating lugs and require refurbishment or replacement of any defective caps.

ACCIDENT

Aircraft Type and Registration:	Piper PA-38-112 Tomahawk, G-LFSD
No & type of Engines:	1 O-235-L2C piston engine
Year of Manufacture:	1982
Date & Time (UTC):	9 September 2006 at 1044 hrs
Location:	Hawarden Airport, North Wales
Type of Flight:	Training
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to nose wheel, engine, propeller, fuselage and wings
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	29 years
Commander's Flying Experience:	1,489 hours (of which 1,140 were on type) Last 90 days - 154 hours Last 28 days - 37 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

On approach for a planned touch-and-go landing the aircraft encountered a downdraft. The touchdown was heavier than normal although the aircraft climbed away normally. On the subsequent landing the nose landing gear collapsed.

History of the flight

The flight was planned as a training exercise to include a number of circuits with touch and go landings on Runway 23 at Hawarden. The wind was from 160º at 13 kt. On about the third or forth circuit the aircraft encountered a downdraft; the student successfully counteracted the increased descent rate with power and regained the approach path. As the student flared the aircraft prior to touchdown it suddenly sank and the landing was heavier than normal. Once on the ground the aircraft began to drift to the right so the instructor took control, regained the centreline and continued with the touch and go. The aircraft responded to the steering demand normally and there were no unusual sounds or vibrations. The aircraft climbed away and continued into the circuit as normal.

Another touch-and-go landing was planned and the student carried out a good approach and landing. No wind shear was experienced on this occasion. As the aircraft touched down the nose landing gear collapsed and the propeller struck the runway. The aircraft skidded on its nose before coming to rest on the runway. Both occupants were uninjured and exited the aircraft without difficulty.

The instructor considered that the landing gear collapse was due to damage caused on the previous heavy landing.

ACCIDENT

Aircraft Type and Registration:	Pitts S-2A Special, G-ODDS
No & type of Engines:	1 Lycoming AEIO-360-A1E piston engine
Year of Manufacture:	1980
Date & Time (UTC):	1 August 2006 at 1212 hrs
Location:	White Waltham Airfield, Maidenhead, Berkshire
Type of Flight:	Training
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Propeller, left upper and lower wings and engine shockloaded
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	67 years
Commander's Flying Experience:	20,393 hours (of which 125 were on type) Last 90 days - 112 hours Last 28 days - 47 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

Whilst taxiing to the fuel pumps, after an uneventful flight, the Pitts Special collided with a parked and unoccupied Cessna 150.

Background information

The main aircraft parking area at White Waltham consists of three numbered rows on the grass orientated north-east/south-west. Each row has a securing cable running the length of it to a marker board at the beginning of it. Line One, the most southerly line, extends out into the airfield more than Lines Two and Three by approximately 70 m. At the time of the accident there was a Cessna 150 parked at the end of Line One with a gap of 65 m between it and the next aircraft. There was no marker board at the beginning of this line.

History of the flight

The instructor, who was in the rear of the aircraft, reported that he was taxiing the tail-wheeled aircraft to the fuelling pumps after an uneventful aerobatic instructional sortie. Whilst taxiing he was discussing the flight with the student, who was in the front. As the aircraft passed the first line of parked aircraft, Line Three, the student suddenly stopped talking and the instructor noticed her head was lowered; the instructor realised that she was feeling nauseous.

After the aircraft had passed past the second line of parked aircraft, Line Two, the instructor was looking to the right to see that he was clear of the Line Two marker board and to see if the student was alright. He was also looking to see which side of the fuel pumps was clear for his aircraft. He was just about to stop the aircraft to see if the student needed any assistance when she started talking again and said she was feeling better. At this moment the aircraft was approaching the third line of aircraft, Line One.

The instructor intended to turn slightly right to taxi through the gap between the main line of parked aircraft and the Cessna 150 that was on the end of Line One. At this point he was predominately looking to the right in order to see the aircraft on his right and his route to the pumps. Almost immediately the Pitts Special struck the Cessna 150 parked at the end of Line One.

Having shut down the engine the instructor and student vacated the aircraft uninjured. The airfield fire tender and engineers were quickly in attendance to offer assistance.

Damage assessment

The repair agency reported that the following damage was sustained as a result of this accident. The Pitts Special sustained damage to its propeller, the left interplane strut, the left upper and lower wings, and the pitot head. The engine was shock-loaded when the propeller struck the wing. The Cessna 150 sustained damage to the leading edge of its left wing. Its propeller was bent during the collision and so its engine was also shock-loaded.

Discussion

In an open and frank report the instructor attributed the accident to a combination of circumstances. These include: being distracted by the student feeling unwell, being slightly complacent with the taxi route, inadequate lookout to the front and left, and Line One being longer than the other lines. He added that because the pilot's forward view in the Pitts Special is much obstructed, keeping a good lookout by weaving a tail-wheeled aircraft's nose was the main learning point.

Since this accident the marker board at the beginning of Line One has been replaced.

ACCIDENT

Aircraft Type and Registration:	Rans S6-ES, G-BYOU
No & type of Engines:	1 Rotax 582-48 piston engine
Year of Manufacture:	1999
Date & Time (UTC):	29 June 2006 at 1900 hrs
Location:	Baxby, North Yorkshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Collapsed nose gear, broken propeller blades, damage to forward fuselage and engine shock loaded
Commander's Licence:	Private Pilot's Licence
Commander's Age:	55 years
Commander's Flying Experience:	420 hours (of which 8 were on type) Last 90 days - 14 hours Last 28 days - 8 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft's main wheels struck a hedge moments before landing. The pilot, who was converting from flex-wing to three-axis aircraft, attributed the accident to his inexperience flying three-axis aircraft.

History of the flight

The pilot had completed six hours of dual training with a qualified instructor as part of his conversion from flex-wing to fixed-wing. He was flying solo and consolidating his circuit training. The wind was light from the east-south-east and the visibility was very good.

The aircraft was on final approach to land on Runway 15, and had full flap deployed. Runway 15 is relatively short, being approximately 350 m long, and the pilot was deliberately aiming to land short. As the aircraft descended the main wheels caught the top of a one metre high hedge ahead of the runway. The subsequent landing was heavy, the nosewheel collapsed, the engine was shock loaded, the propeller was broken and there was some minor damage to the engine cowlings. The pilot was wearing a lap and diagonal harness and was uninjured. He exited the aircraft via the cockpit door.

The pilot attributed the accident to his lack of experience flying three-axis aircraft.

ACCIDENT

Aircraft Type and Registration:	Reims Cessna F152, G-BTFC
No & type of Engines:	1 Lycoming O-235-L2C piston engine
Year of Manufacture:	1979
Date & Time (UTC):	27 July 2006 at 1145 hrs
Location:	Bute Airfield, Kingarth, Isle of Bute
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - 1 (Minor)
Nature of Damage:	Damage to nose gear and propeller
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	61 years
Commander's Flying Experience:	232 hours (of which 18 were on type) Last 90 days - 4 hours Last 28 days - 2 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft bounced on its main wheels on landing and in the subsequent ground roll the nosegear leg folded back under the fuselage and the propeller was damaged. There were no serious injuries to the two occupants.

History of the flight

The pilot had flown 18 hours on type and had landed at Bute on eight previous occasions. There was a light south-westerly breeze, 15 km visibility and no significant weather conditions. The pilot elected to land on Runway 27 and made an approach. He initiated a go-around when he realised that he was likely to land long.

After making a second approach, the aircraft bounced on its main wheels on landing, but not so much that the pilot thought a go-around was necessary. The aircraft bounced again, and the nose gear struck the grass runway in an area with a significant upslope. The nose gear then folded back under the fuselage and the aircraft slid to a halt on the runway.

The pilot switched off the fuel, master switches and magnetos, and both he and his passenger exited through the left and right doors respectively. The passenger sustained a bruise to his left knee; the pilot was uninjured.

The pilot considered that, with hindsight, he should have commenced a go-around after the first bounce on the mainwheels. He considered the steep approach, the short runway length, the lack of significant headwind and the downhill slope at the start of the runway to be contributory factors.

Airfield information

The grass strip at Bute Airfield is 480 metres in length and is aligned 09/27. Aircraft landing on Runway 27 make an approach through a gap cut in the woods, made approximately 10 years ago, that is approximately 100 m wide. Trees mask much of the road that runs along the easterly edge of the airfield, hence the need to consider the possibility of high-sided vehicles presenting an obstacle. Typically a fairly steep approach to Runway 27 is therefore made. Runway 27 initially slopes downhill, and then rises, before sloping down again.

INCIDENT

Aircraft Type and Registration:	Reims Cessna FR172K, G-PJTM
No & type of Engines:	1 Continental IO-360-KB piston engine
Year of Manufacture:	1977
Date & Time (UTC):	25 June 2006 at 1340 hrs
Location:	Final approach to Runway 09 at Filton, Bristol
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to propeller and engine cowling
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	42 years
Commander's Flying Experience:	904 hours (of which 500 were on type) Last 90 days - 49 hours Last 28 days - 21 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and examination of the propeller by AAIB

Synopsis

Whilst on approach to Filton, a loud 'thud' was both heard and felt by the pilot. Damage was subsequently found to be present on the propeller blades, the cowling and on the cooling fins of the two front right cylinders on the engine. There was no direct evidence to indicate that the aircraft had struck an airborne object, or that any part of the aircraft had become detached to cause the observed damage. A witness mark on one propeller blade suggested that the object may have been a tool which migrated forward from the engine compartment to be struck by the propeller.

History of the flight

Following an uneventful flight from Haverfordwest, the aircraft was on final approach to Runway 09 at Filton when, at a distance of 3.8 nm from the threshold and at a height of 1,300 ft, there was what the pilot described as a "very loud and forceful thud" at the front of the aircraft. The engine continued to run normally but, fearing damage to the nosewheel, the pilot declared a PAN and shut down the engine immediately prior to touchdown to reduce the risk of damage. However, the landing was uneventful and, having stopped on the runway, the aircraft was met by airfield operations staff.

Aircraft examination

Subsequent inspection of the aircraft revealed that both propeller blades had sustained heavy impacts on their rear faces, Figure 1, one of which had resulted in a bulge appearing on the surface of the front face. There was also a significant impact on one of the leading edges that had resulted in the removal of material, Figure 2. In addition, the forward face of the engine cowling had received one or more impacts that had caused the paint to flake off over a considerable area, Figure 3. Inside the engine compartment, there was evidence of mechanical damage over a small area of the fins of the front two cylinders (Nos 3 and 5) on the right side, Figure 4. No part of the aircraft had become detached which could have been responsible for the observed damage.

Figure 1

Impact damage to aft face of propeller blade

Figure 2

Damage to propeller leading edge

Figure 3

View showing damage to front of engine cowling

Figure 4

View of marks on cylinders

Analysis

It was considered unlikely that the damage was caused as a result of a collision with an airborne object, as it is unlikely that such an object could have penetrated the propeller disc to make the marks on the cylinders fins. The nature of the damage to the blades suggested a direct impact from behind, as opposed to a glancing blow, with the object ricocheting between the propeller disc and engine/cowling, damaging the cowling and fins, before falling away. Whilst a list of possible objects capable of causing such damage could include a model aircraft, there was no residue on the propeller or elsewhere that pointed to such an occurrence.

The aircraft had undergone a '50 hour' maintenance check approximately four flying hours prior to the incident. The available evidence suggested the possibility that a loose article left in the engine compartment had migrated forwards and out of the cooling air intake. It could then briefly have ricocheted between the propeller disc and the engine/cowling before falling away. However, the object would have had to move forwards against the airflow through the engine compartment, although this would have been much reduced on the approach in comparison to the cruise.

As a suggestion of the type of article that could have been responsible for the damage, Figure 5 shows a photograph of a ratchet adaptor, the serrated edge of which appears to be similar to that seen on the propeller blade shown in Figure 1.

Figure 5

Type of article that may have caused the damage to the aircraft

ACCIDENT

Aircraft Type and Registration:	Rockwell Commander 114, G-DDIG
No & type of Engines:	1 Lycoming IO-540-T4B5D piston engine
Year of Manufacture:	1978
Date & Time (UTC):	19 July 2006 at 2040 hrs
Location:	Fearn Airstrip near Tain, Ross-shire, Scotland
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 3
Injuries:	Crew - None Passengers - None
Nature of Damage:	Gear and propeller damaged; engine shockloaded
Commander's Licence:	Private Pilot's Licence
Commander's Age:	52 years
Commander's Flying Experience:	516 hours (of which 11 were on type) Last 90 days - 12 hours Last 28 days - 4 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

After a bounce on landing, the pilot initiated a go-around by applying full power and retracting the flap. The flaps retracted fully rather than to the normal Flaps 20 for a go-around and the pilot was unable to prevent the aircraft sinking onto the runway with a subsequent nose landing gear collapse.

History of the flight

After a short local flight, the pilot returned to the airstrip for landing. The airstrip was an old military airfield with an asphalt surface and orientated approximately east/west. The weather was good with a calm surface wind and the pilot established his approach with Flap 35 for a landing on Runway 29. He considered that his approach was stable until, at an estimated 20 feet agl, he was aware of an increased descent rate. He applied some power but the aircraft bounced on landing. The pilot decided to go-around, applied full power and selected the flap control to the 'UP' position. He was then aware of a loss of lift and the aircraft tracking to the left of the runway but yawing to the right. The nose landing gear collapsed and G-DDIG came to rest at the edge of the runway. After switching off the battery, the pilot followed his passengers out of the aircraft.

The pilot later commented that the aircraft needs a lot of nose-up trim on approach and when he applied full power for his go-around, he then needed to apply forward trim.

Assessment of the cause

The pilot commented that the flaps are electrically actuated and controlled by a three-position switch; these positions are UP, NEUTRAL and DOWN. The switch is spring-loaded in the down sense such that it must be held in the DOWN position to extend the flaps and when released, it returns to the neutral position. However, when the switch is moved to the UP position to raise the flaps, it will stay there until returned to the neutral position by the pilot.

For a normal go-around, the flaps should only be retracted to Flaps 20. The pilot considered that the accident resulted from the flaps retracting fully while he was attempting to trim the aircraft during the go-around.

ACCIDENT

Aircraft Type and Registration:	Van's RV-6A, G-RVSA
No & type of Engines:	Lycoming IO-360-A4M piston engine
Year of Manufacture:	2004
Date & Time (UTC):	15 July 2006 at 1601 hrs
Location:	Inverness Airport
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to nose landing gear
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	52 years
Commander's Flying Experience:	17,031 hours (of which 3 were on type) Last 90 days - 110 hours Last 28 days - 42 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

During takeoff from a grass strip, the nosewheel suddenly dug in to the ground, causing the aircraft to pitch forward and damage the nose landing gear. The flight continued to Inverness, where abrasion damage occurred to the nosewheel spat and wheel attachment fitting during the landing.

History of the flight

The pilot and passenger had planned a flight to Inverness from a grass strip at Knockbain Farm, near Dingwall, in Ross-shire. The east-west runway has an up-slope at each end, with a crest in the middle. The commander reported that just before the aircraft attained flying speed, which was at the crest of the runway, the nosewheel suddenly dug into the ground, causing the aircraft to pitch forward. This was accompanied by a jolt, which the pilot heard and felt through the controls. However, he continued with the takeoff, the aircraft becoming airborne a few seconds later, but was sufficiently concerned about the event to carry out a fly-past at the airstrip, where observers on the ground confirmed that the nose landing gear was damaged. The leg had been bent aft by approximately 30º and the nosewheel yoke assembly distorted such that the front of the wheel spat was pointing downwards at an angle of around 45º.

The pilot decided to continue the flight to Inverness, where, during the landing, the nosewheel was held off the runway surface until the speed had reduced to approximately 15 kt. The nosewheel yoke attachment nut and the spat sustained abrasion damage as the aircraft rolled to a halt.

This was the first occasion the pilot had flown the RV-6A aircraft into Knockbain. Although he only had three hours on type, he has considerable general aviation experience and owns a Piper Cub, which he has frequently operated into this airfield. He commented that the relatively high tyre pressure and short wheelbase of the Vans may contribute to a tendency to porpoise on certain surfaces; a characteristic that may well have been exacerbated by his relative inexperience, and which he considers makes the aircraft unsuitable for this type of airstrip. Additionally, he commented that any change in the wind speed and direction at the time the aircraft reached the runway crest during the takeoff may have contributed to the pitch down event.

ACCIDENT

Aircraft Type and Registration:	Van's RV-6A, G-RVSH
No & type of Engines:	1 Lycoming IO-360 piston engine
Year of Manufacture:	2004
Date & Time (UTC):	25 June 2006 at 1331 hrs
Location:	Blackbushe Airport, Surrey
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damaged propeller and damage to owner's car
Commander's Licence:	Private Pilot's Licence
Commander's Age:	43 years
Commander's Flying Experience:	178 hours (of which 52 were on type) Last 90 days - 1 hour Last 28 days - 0 hours
Information Source:	Aircraft Accident Report form submitted by the pilot

Synopsis

The aircraft hit a motor car during a 'jump' start.

History of the event

The aircraft was parked and tied-down in a space at Blackbushe Airport. When the pilot arrived to fly it, he found that the battery was flat, so he drove his Land Rover vehicle onto the airfield, parked it on the right of the aircraft and removed the vehicle battery. He then used jump leads to connect the vehicle battery to the aircraft battery, which is mounted inside the cockpit, and successfully started the aircraft engine. Unfortunately, as he was removing the jump leads his forehead nudged the throttle open, resulting in breakage of the left tie-down, and the aircraft started to move. Because the right tie-down was intact, the aircraft swung to the right, colliding with the vehicle. Damage was limited to the propeller of the aircraft and the front bumper of the vehicle.

The pilot considers that he was inattentive to the throttle control when removing the jump leads and it would have been safer to remove the aircraft battery and charge it on a battery charger.

ACCIDENT

Aircraft Type and Registration:	Robinson R22 Beta, G-OHSL
No & type of Engines:	1 Lycoming O-320-B2C piston engine
Year of Manufacture:	1989
Date & Time (UTC):	8 August 2006 at 1200 hrs
Location:	Blackpool Airport
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Tail rotor damage
Commander's Licence:	Private Pilot's Licence
Commander's Age:	40 years
Commander's Flying Experience:	117 hours (of which 104 were on type) Last 90 days - N/K Last 28 days - 4 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

Whilst landing in the lee of a hangar at Blackpool Aerodrome, the helicopter was caught by a gust of wind, causing the tail rotor to strike the ground.

History of the flight

Following an uneventful cross-country flight, the pilot obtained landing clearance from Blackpool Airport and was informed the wind was 250/11kt. He brought the helicopter to a hover and was requested to briefly hold position in order to give way to a light aircraft. He was then instructed to land in front of a hangar on the apron and call for fuel. Whilst in a stable hover in front of the hangar, and in the process of lowering the collective lever, the pilot reported that a sudden gust of wind caused him to overcompensate on the cyclic control, with the result that the tail rotor struck the ground. The helicopter then spun round, making approximately two revolutions, before coming to rest on its skids. The pilot shut down the aircraft and, after exiting, noted that the tail rotor was damaged, with oil leaking from the tail rotor gearbox.

The helicopter stand in question was located immediately to the east of the hangar and the training manager of the helicopter operating company was concerned as to its suitability for light helicopters during landing when the wind was from the west. Telephone inquiries were made of two of the helicopter operators at the airfield who, whilst agreeing that turbulence could be experienced in close proximity to the hangar, stated that there was no evidence to suggest it was significantly worse than elsewhere.

In an unrelated move, the airfield operators are currently reorganising some of the facilities as part of an expansion of operations. This has resulted in the 'H' marks being removed, with their new positions yet to be decided.

ACCIDENT

Aircraft Type and Registration:	Rotorway Executive, G-BRGX
No & type of Engines:	1 Rotorway RW 152D piston engine
Year of Manufacture:	1991
Date & Time (UTC):	12 May 2006 at 1800 hrs
Location:	Commonswood Farm at Horns Cross, near Northiam, East Sussex
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - 1(Minor) Passengers - None
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Private Pilot's Licence
Commander's Age:	44 years
Commander's Flying Experience:	364 hours (of which 293 were on type) Last 90 days - 2 hours Last 28 days - 0.5 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and telephone enquiries by the AAIB

Synopsis

Whilst in the climb after lift off, the pilot noticed smoke in the cockpit. During a precautionary autorotative landing the smoke suddenly thickened and the aircraft landed heavily. A severe ground fire precluded determination of the cause of the airborne fire.

History of the flight

The purpose of the flight was associated with the helicopter's Permit to Fly renewal. After pushing out from the workshop, it was fuelled with 35 litres of Mogas from 20-litre jerry cans: some spillage was noted and the exterior was wiped down. Having completed the pre-flight checks, the pilot and passenger boarded the aircraft and started the engine, after which they noticed that the alternator low-voltage light illuminated and stayed on. The engine was shut down for investigation, which resulted in the alternator drive belt being changed.

The access panels were replaced, the engine restarted, and with all indications normal the pilot lifted the helicopter into the hover for about one minute, checking the available power as he did so. Next, he hover taxied to the far end of the airstrip, some 800 metres away, where he demonstrated handling to his passenger and verified the hover flight envelope. About nine minutes after lifting-off, the helicopter departed the airstrip to the east, with the pilot noting a climb rate of 720 fpm at an airspeed of 60 mph with all temperatures and pressures normal, if a little high due to the high weight and ambient temperature.

As the pilot established a cruise climb, at about 800 ft agl he had the first indication of smoke in the cabin, and he therefore started a gentle turn back to the departure point. The indications strengthened, so he increased the turn rate and initiated a descent which he turned into an autorotation in anticipation that the engine might fail. He could now feel the heat from the engine bay so he increased speed to 80 mph from the normal 60 mph autorotation speed and, passing 300 ft, he started an 'S' turn for a run-on landing. At about 50 ft agl, as he started to flare, the cockpit filled with smoke, obscuring forward visibility and the instruments and all he could now do was execute the run-on landing in this condition. The aircraft bounced once gently and skidded forward before coming to rest with the right (passenger side) skid collapsed and the tailboom separated but the helicopter remained upright. The passenger evacuated through a hole in the front canopy without injury, whilst the pilot exited through the left door with a slight burn to his left arm.

The aircraft was beyond salvage so it was left to burn out. The extent of the fire was so severe that any meaningful examination to establish the cause was precluded, however the pilot does not rule out the possibility that spillage during the refuelling could have pooled in the belly pan and he is certain the fire was fuel-based because of its rapid progression.

ACCIDENT

Aircraft Type and Registration:	EV-97 TeamEurostar UK, G-IHOT
No & type of Engines:	1 Rotax 912-UL piston engine
Year of Manufacture:	2004
Date & Time (UTC):	16 June 2006 at 1800 hrs
Location:	Barling farmers strip, Essex
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Right main gear leg separated, nose gear leg collapsed, damage to fuselage and right wing, propeller tip damage and engine shockloaded
Commander's Licence:	Private Pilot's Licence (Microlights)
Commander's Age:	47 years
Commander's Flying Experience:	454 hours (of which 82 were on type) Last 90 days - 47 hours Last 28 days - 5 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and further enquiries by the AAIB

Synopsis

During the takeoff ground roll the aircraft pitched up earlier than the pilot had expected. He lowered the nose to prevent a premature liftoff but then the aircraft started turning rapidly to the left. The pilot was unable to correct for the left turn in time and the left wing tip hit high grass in a field adjacent to the runway. The aircraft then spun almost 180 degrees to the left causing the right main landing gear leg to separate, the nose gear to collapse and the propeller to hit the ground.

History of the flight

The pilot was planning a flight to Sandown Airfield on the Isle of Wight with one passenger. The weather conditions were good with a light southerly wind, scattered clouds at 3,000 feet and a visibility greater than 10 km. The initial takeoff roll from Runway 18 (grass) was normal. The aircraft had a tendency to turn left due to the propeller slipstream and torque effects, for which the pilot compensated by applying right rudder pedal. Before the normal liftoff speed was attained the aircraft started to pitch nose up and this took the pilot by surprise because it occurred significantly earlier than usual. To prevent a premature liftoff the pilot lowered the nose back onto the ground. The nosewheel did not touch the ground heavily but the aircraft started turning rapidly to the left, at a speed of approximately 30 to 35 mph. The pilot was unable to correct the left turn in time and the left wing tip hit high grass in a field adjacent to the runway; the aircraft spun almost 180 degrees to the left causing the right main landing gear leg to separate, the nose gear to collapse and the propeller to hit the ground. The pilot and his passenger were able to exit the aircraft unassisted.

Description of the aircraft

The EV-97 TeamEurostar is a kit-built aircraft manufactured by Evektor-Aerotechnik. G-IHOT had been assembled by Cosmik Aviation Ltd in the UK and sold as a Ready-to-fly aircraft in the microlight category with a Permit to Fly. The EV-97 is an all-metal fixed-wing aircraft with tricycle landing gear, as depicted in Figure 1. It has a steerable nosewheel that is controlled by the rudder pedals: left pedal results in a left turn and vice versa. The aircraft is also fitted with toe-operated hydraulic brakes that permit differential braking to assist with steering.

Analysis

In an honest and open report the pilot stated that the basic cause of the accident was his '*failure to make an immediate and appropriate correction to the left turn as soon as this turn became apparent.*' The pilot learnt to fly on a flex-wing microlight aircraft[1] in which the pedals moved in the same manner as on G-IHOT but resulted in opposite nosewheel steering. On a flex-wing microlight aircraft left pedal results in a right turn on the ground and right pedal results in a left turn (similar to the steering from a bicycle handle-bar). The pilot stated that controllability on the ground was the biggest difficulty he encountered when converting from flex-wing microlights to fixed-wing microlights. Although he had no recollection of doing so, he considered it possible that he inadvertently applied left pedal to correct for the left turn. His surprise at the early pitch up, and the subsequent suddenness of the turn when the nosewheel was lowered to the ground, could have contributed to an incorrect or delayed pedal input. The pilot believed that the early pitch up was probably caused by him holding the stick too far aft during the initial ground roll.

Figure 1

G-IHOT before the accident

Footnote

[1] A flex-wing aircraft has a wing that is controlled by moving a horizontal bar to shift the weight of the aircraft relative to the wing (the same way that a hang-glider is controlled). Flex-wing aircraft do not have rudders.

ACCIDENT

Aircraft Type and Registration:	Gemini Flash 2 Alpha microlight, G-MTJZ
No & type of Engines:	1 Rotax 503 piston engine
Year of Manufacture:	1987
Date & Time (UTC):	11 July 2006 at 1100 hrs
Location:	Field in Rocester, near Uttoxeter, Staffordshire
Type of Flight:	Training
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - None
Nature of Damage:	Nosewheel collapsed and wing damaged
Commander's Licence:	Private Pilot's Licence (Microlights) with Instructor Rating
Commander's Age:	47 years
Commander's Flying Experience:	670 hours (of which 120 were on type) Last 90 days - 60 hours Last 28 days - 19 hours
Information Source	Aircraft Accident Report Form submitted by the pilot and further enquiries by the AAIB

Synopsis

During a cross-country flight the engine failed due to fuel exhaustion. The subsequent forced landing in a field caused the nosewheel to collapse.

History of the flight

The Gemini Flash 2 Alpha is a two-seat flexwing microlight aircraft as depicted in Figure 1. The student pilot, who owned the aircraft, was on a training flight with his instructor. They had departed from Otherton airfield and were carrying out a cross-country flight to Darley Moor airfield, 20 nm to the north-east. The weather was good with no cloud, visibility greater than 10 km and a light south-westerly wind. The planned route was not direct but involved a circuitous route of approximately 40 nm. While cruising at approximately 1,000 ft agl, 4 nm from the destination, the engine suddenly lost power as a result of fuel exhaustion. The instructor took control of the aircraft and decided to carry out a forced landing in a field, and then change fuel tanks once on the ground. During the glide approach to his selected field he encountered an unexpected downdraft which forced him to turn and land in a less suitable field. The aircraft hit a rut in the ground which caused the nosewheel to collapse and the right wing tip to hit the ground.

Figure 1
Gemini Flash 2 Alpha flexwing microlight

Fuel system and fuel burn rate

The aircraft was fitted with two 20-litre fuel tanks located behind the aft seat. The tanks can be changed in flight but, according to the instructor, it was an awkward procedure that involved reaching aft with one hand to move the fuel cock. It was not possible to see the fuel cock while seated so the procedure had to be done by feel.

Both fuel tanks were full prior to departure, giving a total fuel load of 40 litres. The instructor stated that with two people onboard the aircraft typically cruised at 50 mph and used fuel at a rate of 15 litres per hour. The engine ran out of fuel approximately one hour after departure so the actual fuel burn rate was closer to 20 litres per hour. The instructor believed that the high temperature of the day (29°C at Otherton) caused them to use a higher power setting than normal and this resulted in the higher fuel burn rate.

Conclusion

The aircraft had sufficient fuel onboard for the flight but the fuel in one tank alone was not sufficient given the conditions of the day and the high power setting used. Because changing tanks in flight was an awkward procedure the instructor elected to land in a field. However, the field he had selected could not be reached so he landed in a less suitable field which resulted in the nosewheel collapse and subsequent aircraft damage.

ACCIDENT

Aircraft Type and Registration:	Lindstrand LBL 210A hot air balloon, G-BZDE
No & type of Engines:	None
Year of Manufacture:	2000
Date & Time (UTC):	16 April 2006 at 1814 hrs
Location:	Near Bordon, Hampshire
Type of Flight:	Public Transport (Passenger)
Persons on Board:	Crew - 1 Passengers - 10
Injuries:	Crew - None Passengers - None
Nature of Damage:	Scorching and abrasion damage to balloon envelope
Commander's Licence:	Commercial Pilot's Licence (Balloons)
Commander's Age:	49 years
Commander's Flying Experience:	827 hours (of which 141 were on category B balloons) Last 90 days - 12 hours Last 28 days - 6 hours
Information Source:	AAIB Field Investigation

Synopsis

The hot air balloon carried one pilot and 10 passengers on an evening pleasure flight. After several attempts to find a suitable landing site, the pilot decided to land the balloon in a field containing high voltage power lines. The pilot was forced to climb to avoid a tree a short distance before the power lines, after which there was insufficient distance either to land safely or to guarantee clearing the power lines in a continued climb. The pilot therefore initiated a rapid descent, but the balloon envelope contacted the power lines whilst the basket was still airborne. The basket then sank to the ground, with no reported injuries to its occupants.

History of the flight

The hot air balloon was being operated by a company which specialised in balloon pleasure flights and had been operating since 1985. On this occasion 10 passengers were to be carried on a flight departing from a site about 7 nm north of Winchester for a flight which was planned to last for between 45 and 75 minutes.

On the day of the accident flight, staff at the operator's headquarters checked the weather conditions and decided they were suitable. This decision was passed to the pilot, who also checked the latest weather reports on the internet at his home and made a note of the relevant details. The pilot then drove to the company's headquarters where he met the two-man ground crew who were to assist with the launch and recovery of the balloon and who would remain in visual and radio contact with the balloon during the flight.

The pilot and ground crew had arrived at the launch site and met their passengers by 1600 hrs, and the pilot conducted a safety briefing which took about 15 minutes. The briefing included the correct positions to adopt during landing, and all passengers practised adopting the positions before the flight. After satisfying himself that the weather remained suitable and there were no showers approaching from upwind, the balloon was launched at 1653 hrs.

The flight progressed normally in an east-south-easterly direction and the pilot was able to confirm from his on-board GPS receiver that the actual winds were very close to those forecast. Altitude varied, to a maximum of about 1,500 ft. About 35 minutes into the flight, the pilot announced to the passengers that he was looking for a suitable landing site. The passengers were prepared for a landing on a few occasions, and were aware of the pilot discussing possible sites with the ground crew by radio, but each chosen site was deemed unsuitable on closer inspection and each time the landing was abandoned.

As the balloon approached the town of Bordon in Hampshire, the pilot was aware that the balloon had already been airborne longer than planned, and he thought the countryside beyond the town would offer fewer suitable landing sites. He identified two fields which he considered suitable for landing and briefed his ground crew accordingly. The chosen fields were a short distance before the town, and immediately before an industrial site which effectively formed the far boundary of the fields. A broken tree line formed the near boundary in the direction of approach, and what appeared to be a fence separated the two fields, though it later became apparent that only the posts were present. The further field had high voltage power lines running approximately north-south through it.

The pilot decided to land in the nearest of the two fields, which was also the larger of the two. However, as he neared the field he noticed a track crossing the further field and, as this suggested better access for the ground crew, the pilot decided to adjust his approach to land in the further field instead. He stated that he was aware of the power lines crossing the field, but considered that there was adequate space to land, provided that the balloon could be landed at the near edge of the field.

The balloon crossed the edge of the first field, passing very low over the boundary trees. The pilot stated that he then became aware that the balloon was drifting to the left, towards a large prominent tree on the edge of a wooded area that adjoined the fields. The pilot initiated a climb to clear the tree, aware as he did so that there would be much less space available on the far side to bring the balloon down safely before the power lines were reached.

When it became clear that the balloon would contact the tree, the pilot warned the passengers who were by this stage in their landing positions, seated within the basket with their backs to the direction of travel. The basket hit the right side of the tree some way below the top and passengers had the impression that the balloon's speed was considerably reduced by this contact. Immediately after it hit the tree, the pilot attempted to bring the balloon down into the field before the power lines, using maximum deflation of the envelope. He was aware that the power lines now represented a serious hazard to the balloon and he had rejected the possibility of climbing over them, fearing that this might lead to the basket itself hitting the wires. He warned the passengers to expect a hard landing and initiated maximum deflation by operating the control which allowed rapid deflation of the envelope.

The pilot was unable to land the balloon before the envelope contacted the power lines. The basket was still an estimated 20 to 50 ft above ground at this point. There was an initial bang and a flash as it did so. Most of the passengers, who were seated within the basket facing rearwards, were unaware of the power lines until this point. As the deflating envelope slid off the wires, the balloon's basket descended gently to the ground, coming to rest upright. There was a further loud bang and flash, probably as the metal crown ring at the top of the canopy made contact with the wires.

Most of the balloon envelope drifted away from the basket, though part of it did land across some of the passengers. The pilot instructed the passengers to remain in the basket while he assessed the situation, but could see that the motion of the power lines overhead was reducing and there appeared to be no reason not to allow the passengers to disembark. Those passengers under part of the envelope were hindered slightly in their exit from the basket, but were able to do so unassisted. The emergency services arrived shortly afterwards, alerted by local residents; it was established that none of the passengers or the pilot had suffered any injury.

Accident site

The accident events centred on two adjoining fields on the western outskirts of the town of Bordon (Figure 1). Originally a single field, it was divided into two by fence posts. Although this gave the appearance that the fields were physically separate, there were in fact no wires between the posts. The westerly field was the larger of the two, bounded at its western edge by a hedgerow which contained a number of moderately sized trees. A wooded area protruded into the two fields from the north, forming a 'V' shape, at the point of which was the large tree which the balloon basket struck shortly before contacting the power lines. The distance from the tree to the centreline of the power lines, in the direction of flight of the balloon, was 89 m. The protruding wooded area formed a 'neck' across the fields divided by the fence posts.

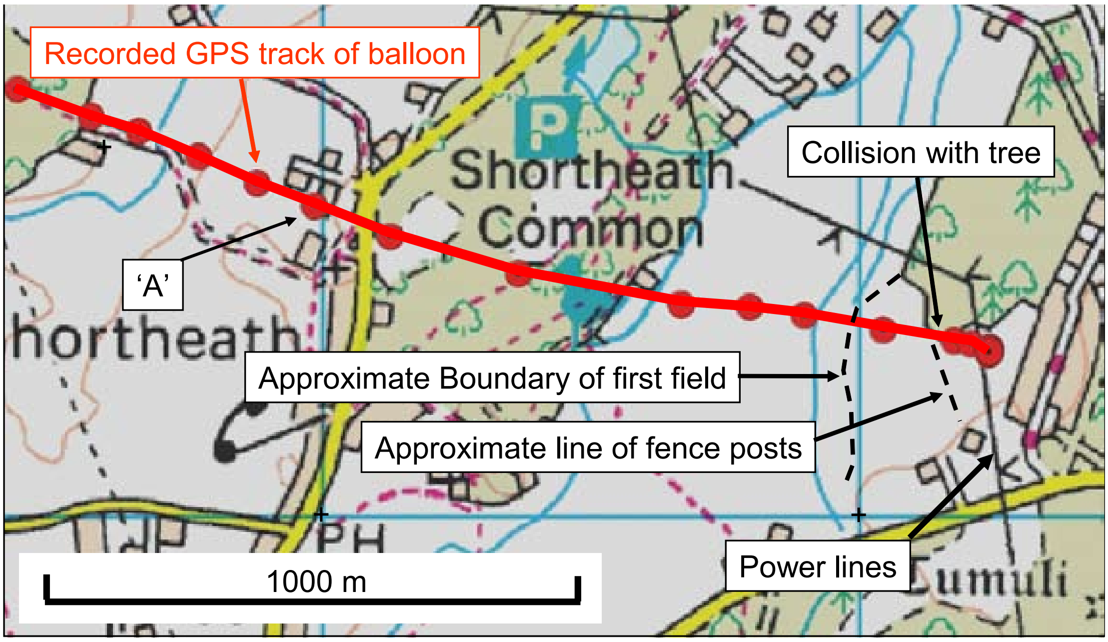


Figure 1

The two fields were of very different appearance, with the larger field to the west containing light coloured stubble and the smaller field to the east being mainly grass. The smaller field contained the 132 kV power lines, running approximately north-south. They were supported by one tower in the field at 32.3 m height, and another in the wooded area to the north. Immediately behind the power lines was an area of industrial buildings which formed the eastern boundary of the site. A track led into the easterly field from a minor road to the south.

GPS-derived information

The pilot was equipped with a hand-held GPS receiver which recorded time, position, groundspeed, and track. GPS altitude was not recorded. The data showed that after launch at 1653 hrs the balloon made good an average track of 110º(M). Groundspeed during the first half of the flight peaked at 17 kt but was generally between 10 and 15 kt. Overall, the groundspeed reduced as the flight progressed and in the last 14 minutes of flight did not rise above 10 kt. As the balloon approached the accident area it was tracking an average 114º(M) with a ground speed of 6 to 8 kt, which took the balloon towards the centre of the pilot's chosen field. Then, at 3 minutes and 30 seconds before the balloon struck the tree, the track drifted some 11º to the left, and became an average 103º(M). The new track took the balloon directly towards the tree which it was to hit. The tree was still 500 m away once the track had changed, and the boundary of the first field was about 325 m away. The new track still crossed the first field, but did so at a narrower point, as the field itself was irregularly shaped.

Eyewitness information

Several witnesses saw the balloon at low level in the accident area, though no one reported seeing the actual moment when the balloon struck the tree or the power lines. One witness under the balloon's track (Position 'A' at Figure 1) saw the balloon pass directly overhead at low altitude. The witness reported hearing the balloon's burner, and had the impression that it had climbed slightly to clear the narrow low ridge on which his house stood. After passing, it continued at low altitude in the direction of the accident site before disappearing from view behind trees.

Balloon description

The balloon envelope of G-BZDE, with a nominal volume of 210,000 cu.ft, was constructed from 28 gores, each of which was made up from smaller panels. Between the gores ran 28 vertical load tapes, which came together at the top of the envelope at a crown ring made from aluminium alloy. Three different fabrics were used in the construction of the envelope. The top third was of 'Hyperlife', a high-strength silicon-coated nylon fabric, and the panels at the bottom nearest the burner were of flame-resistant Nomex. The bulk of the envelope was of ripstop nylon coated with polyurethane. The overall height of the balloon from the bottom of the basket runners to the crown ring at the top was 25.44 m.

The basket was attached to the lower end of the load tapes via stainless steel wires and was divided into five compartments in a 'double T' arrangement. This created a centre section, occupied by the pilot, his flight equipment, four fuel cylinders and associated pipework, and four passenger compartments, two either side of the pilot. In addition to the burners, control of the balloon was achieved by four control lines. Two lines operated rotational vents in the envelope, while the remaining two lines operated the 'parachute' in the top of the envelope to control the escape of hot air. Of these two lines, one was intended for use in the air, while the other, controlled by a red line, operated a 'Q-vent' rapid deflation system. This system was intended for use only after landing and its use whilst airborne was prohibited.

The balloon was equipped with a triple burner fed by four 60 litre fuel tanks. Each tank should have lasted for up to 30 minutes, providing for a maximum 90 minute flight duration and about 30 minutes reserve. When examined, the fuel tanks contained fuel for up to a further 25 minutes flying at an average fuel consumption.

Damage to the balloon

The balloon was examined at the manufacturer's facility. Damage to the envelope was separated into three distinct areas and affected 20 panels. The three areas were the crown ring, the 'Hyperlife' fabric and the ripstop nylon fabric.

The crown ring showed evidence of conduction damage on its outer edge and on the inside face. Several of the load tapes attached to the ring had hardened and become discoloured, caused by either conduction or heat generated within the metallic ring. The 'Hyperlife' fabric showed signs of melting and burning, with numerous horizontal lines close by, consistent with it having come into contact with at least one power line. This damage was 4.8 m in vertical extent, about a line 22.3 m above the basket base. There was also some tearing of the fabric. The polyester load tapes did not show any obvious signs of damage.

The lower ripstop fabric damage was mainly in a horizontal line 7.65 m above the basket base, with both melting damage and tearing of the fabric. Again, there was no evidence of load tape damage.

Meteorological information

The pilot had viewed the latest meteorological report and noted the wind information given in the ballooning forecast for the afternoon of the accident. This forecast a 2,000 ft wind from 300º(M) at 15 kt and a surface wind from 290º(M) at 8 kt .

The Met Office provided an aftercast for the period of the flight. The synoptic situation at 1800 hrs showed an unstable north-westerly airflow covering much of the British Isles, with rather cloudy weather and isolated slight showers. The surface wind would have been generally from 300º(M) at 3 to 6 kt, the 1,000 ft wind from 300º(M) at 10 kt and the 2,000 ft wind from 310º(M) at 13 kt. A weak cold front was crossing the accident area at about the time the accident occurred. It is possible that the winds just ahead of the front varied by about 20º from those quoted, though the wind speeds across the front appear to have been unchanged.

Effect on power supplies

At 1814 hrs the envelope contacted the 132 kV power lines and two protection circuits within the electrical distribution network operated, isolating the power and affecting the supply to 62,500 customers. The protection circuits were designed to re-close automatically after 15 seconds if the fault had cleared. One of the circuits did so, but the other immediately re-opened, closing again after 30 seconds had passed. Normal electricity supply was then restored to all but about 600 homes, which were without power for about 30 minutes. Technical staff from the electrical distribution company attended the scene and established that the power lines were undamaged, though small pieces of fabric remained adhered to the upper earth cable. No further action was required on site.

Manufacturer's flight manual

The flight manual provided by the manufacturer covered all the balloon types it produced. The manual contained the following information under the heading *'low level obstacles'*:

"Care must be used when flying close to the ground, in order to anticipate and correct changes in flight direction which could cause a collision. It is important to make the decision to ascend or descend and keep to the decision. It is always better to maintain or increase a vertical direction of motion than to reverse it. So if a balloon is in danger of a collision and is already going down, a quicker response will be achieved by pulling the parachute to increase the rate of descent.

Do not fly into powerlines. If powerlines are to be overflown, then it is good practise for the balloon to be ascending whilst the crossing is made. If contact is unavoidable, then descend as fast as possible so that any contact is with the envelope and not the flying wires or basket assembly. If the envelope is suspended in the wires, do not try to remove it until the power has been switched off. Do not allow crew to touch the basket if it is suspended above the ground and the power is still on."

Analysis

The pilot had attempted to land on a number of occasions, but the possible landing sites had proved to be unusable. He considered that opportunities for finding suitable landing sites were becoming fewer and, being aware that he was using 'reserve' fuel, would have felt under a degree of pressure to land the balloon without much further delay. It is probable that the repeated, aborted landing attempts had resulted in a higher fuel consumption than normal.

At first, the balloon was tracking towards the centre of the first of the two possible fields, and the one chosen initially by the pilot. His recollection that the balloon drifted to the left at a relatively late stage, which forced him to initiate a climb to avoid the tree, is not supported by the recorded GPS data. Although a change of track did occur, this took place whilst the balloon was still some way from the first field and more than three minutes away from the contact with the tree. As the balloon crossed the trees at the boundary of the first field, it was steady on a track towards the tree which it was to hit and also the eventual point of contact with the power lines.

The track on which the balloon crossed the first field not only took it over the highest trees on the field boundary but also presented a shorter distance in which to land, compared with the distance which would have been available had the balloon maintained its original track. The combination of a shorter available distance and high obstacles on the approach would have reduced the chances of a successful landing in the first field, and the tree which the balloon was to strike later would have presented a hazard to the envelope if it had overrun or blown onto the tree after landing.

From the accounts of those on board, and an eyewitness over which it passed shortly before the collision, the balloon was maintaining a relatively low height as it approached the eventual landing area. This probably also accounted for the reduced overall groundspeed in the latter part of the flight, as the wind strength closer to the ground was less than that aloft. With reduced height, an accurate, steep final descent would not have been practicable, and judgement of the final descent path would have been more difficult, such that the risk of overshooting the desired landing point would have increased. Additionally, it would have been more difficult for the pilot to readily assess distances available and clearances from potential hazards in the landing area.

The pilot reported that he had rejected a landing in the first field at a relatively late stage in favour of the second field because of its better access, and he was confident that the balloon could be landed safely before the power lines, provided it could be landed at the beginning of the field and immediately after the fence posts. Because it was a late change of intention, this must have been when the balloon was tracking towards the tree and not, as the pilot perceived it, towards the clearer area to the right of the tree.

Once it became clear to the pilot that the balloon was tracking towards the tree and unlikely to land and stop before it, he initiated a climb. Crossing the first field at low level, the tree may have presented a more obvious hazard than the power lines beyond, and it would have been difficult for the pilot to judge whether sufficient distance was available to land beyond the tree and before the pylons.

It is likely that the balloon's true proximity to the power lines only became clear to the pilot after the basket had struck the tree. The balloon was ascending at this point, and the general guidance to pilots faced with obstacles at low level was not to attempt to reverse the balloon's vertical direction. The pilot was aware of this but was not confident that the basket would clear the power lines so immediately took the decision to initiate a descent. By this stage the pilot was clearly aware that the balloon would contact the power lines, so he took the action to use the 'Q-vent' rapid deflation control. Although use of this control in the air was normally prohibited, the pilot was complying with the guidance in the manufacturers flight manual to *"land as soon as possible"* if contact with power lines was unavoidable.

Once the pilot had committed to reversing the vertical direction of the balloon, contact with the power lines was inevitable. However, his actions to bring the basket down as rapidly as possible may have saved the basket or its metal support wires from contacting the power lines, thus reducing the risk to the basket and its occupants.

ACCIDENT

Aircraft Type and Registration:	Lindstrand LBL 317A hot air balloon, G-CDHN
No & Type of Engines:	Burners: Lindstrand Jetstream Quad
Year of Manufacture:	2005
Date & Time (UTC):	9 August 2005 at 1930 hrs
Location:	Old Park Farm, Liskeard, Cornwall
Type of Flight:	Public Transport (Passenger)
Persons on Board:	Crew - 3 Passengers - 9
Injuries:	Crew - 1 (Serious) 1 (Minor) Passengers - 1 (Serious) 8 (Minor)
Nature of Damage:	Balloon was undamaged
Commander's Licence:	Commercial Pilot's Licence (Balloons)
Commander's Age:	58 years
Commander's Flying Experience:	1,612 hours (of which 1,472 were on type) Last 90 days - 56 hours Last 28 days - 22 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and further enquiries by AAIB

Synopsis

The balloon took off from a site 6 nm to the north-west of Launceston. It flew in a southerly direction down the east side of Bodmin Moor towards Liskeard at various altitudes. In the course of the flight the occupants of the balloon saw several military jet aircraft manoeuvring in the same area. After a flight of about one hour, the pilot selected a field to land in. In the latter stages of the approach to land the passengers were aware of a high ground speed and the pilot stated that the rate of descent suddenly increased to 600 fpm. The balloon made a hard landing and the basket started to slide across the ground. The balloon struck a number of obstructions during the ground slide and three passengers fell from the basket. One of these passengers and a crew member, who remained in the basket, were seriously injured.

History of the flight

A group of nine people had booked a flight in a balloon. The balloon took off from a launch site at Maxworthy, in north Cornwall, at 1825 hrs for a flight that was planned to last one hour. The weather conditions were good.

The first 10 to 15 minutes of the flight were conducted at a relatively low altitude, in order to make good a track of 140ºM towards the passengers' properties. After passing these houses, the balloon climbed to 3,500 ft amsl and tracked 200ºM, at approximately 17 to 20 kt. About 25 minutes into the flight, as the balloon crossed the A30 trunk road, the pilot reported that he observed two military jet aircraft flying over and around the eastern side of Bodmin Moor. The balloon descended to 2,000 ft amsl as it skirted the eastern side of Bodmin Moor, and the pilot stated that the military aircraft could still be seen flying abeam and to the south of the balloon, at a distance of about 2 to 2.5 nm and at very low level.

After the balloon was clear of the moor, and had passed over the village of St Cleer, the pilot commenced a further descent to approximately 800 ft agl. Prior to this the passengers had rehearsed the position they were to adopt for the landing, under the pilot's instruction. This was in addition to the briefing and rehearsal that the pilot had conducted before the takeoff.

The pilot reported that the military jets continued to carry out very fast, low level runs but, because the balloon was lower, their horizontal proximity was more apparent. He also stated that the tree tops showed noticeable signs of disturbance in their wake.

By this stage the balloon had been airborne for about one hour and was approaching the town of Liskeard. The pilot instructed the passengers to assume their landing positions because he could see that they were flying towards an area of grass fields, immediately beyond a wooded area, about 1 nm to the north-west of Liskeard. Earlier, he had started a descent towards another field but had abandoned that approach when he decided that the field was unsuitable for a landing. He reported that as the balloon crossed the wood, at a height of 400 to 500 ft agl and a rate of descent of 200 fpm, two military jet aircraft flew across in front of the balloon, from east to west, at approximately the same level and about ½ nm to the south. They then disappeared from view behind the balloon's canopy. At the same time, the balloon's vertical speed indicator instantaneously showed a 600 fpm rate of descent and, despite the application of full burners, the balloon appeared to be 'knocked' onto the ground with significant force.

A few seconds prior to the impact, when it was obvious to the pilot that he could not arrest the rate of descent, he turned off the burners and took hold of the red, rapid deflation line. As the balloon landed, the pilot activated the rapid deflation mechanism. The basket was dragged at speed along the ground for 80 m, on its side, until it struck a wall at the far end of the field. The balloon then took off again, despite the vent at the top of the canopy being open. The pilot partially closed the top of the canopy and operated the burners in an attempt to stabilize the situation. However, he reported that too much heat had been lost from within the canopy and the balloon started to descend again. It flew another 100 m over the next field, missing a line of telegraph wires adjacent to its far side, cleared a country lane and landed for the second time on a wall on the far side of the lane.

When the basket landed on the wall it started spinning, as if the occupants were in a 'tumble drier'. In the process, three of the passengers were thrown out while the basket was dragged for about 60 m across the corner of the field beyond the wall. One of these passengers became entangled with a rope which slipped free as the basket struck another field wall. The basket cleared that wall and came to a halt about 10 m on the other side, in a fourth field. The rapid deflation was now complete and the balloon canopy lay on the ground, in the same direction in which it had been travelling, on the far side of the basket.

One of the passengers, who had been thrown out of the basket, and a crew member who remained within the basket received serious injuries. All the other passengers and the pilot, who was supported by a harness, received minor injuries. There was no fire and the pilot reported that the balloon and its equipment were undamaged. He estimated that the balloon landed at between 1925 and 1930 hrs.

A member of the public arrived at the scene shortly after the landing and called the emergency services. The time of that call was recorded as being made at 1941 hrs. Two ambulances attended and, after initial treatment, took the seriously injured to hospital.

Other statements

With one exception, the nine passengers and two crew members assisting the pilot were consistent in their accounts of the last few minutes of the flight. They had been instructed to take up the landing position, as briefed earlier, and were all in this position as the balloon descended towards the ground. Although they had seen, and sometimes heard, military jet aircraft earlier in the flight, they did not hear any aircraft as they were approaching the field where they landed. One passenger, however, stated that he could still hear the jet aircraft flying around at the time that they were landing.

Before the landing, one of the passengers recalled the pilot instructing them to hold tight because they were likely to be dragged along after the landing. All of the passengers were conscious of the high horizontal speed, which seemed to increase the closer they got to the surface, but considered that the rate of descent was steady, not fast and it caused them no concern. One of the crew members considered that the rate of descent was quite fast and the other could feel the balloon descending faster once she had adopted the landing position.

They all described the landing as very hard and three of the passengers recalled that the balloon's burners were operated during the ensuing ground slide before it took off again. On this occasion, the sensation of vertical acceleration in the climb was more pronounced than at the beginning of the flight.

It was estimated that the balloon climbed to at least 200 ft agl, before descending and landing a second time; this landing was described as hard. Following this the basket was reported to have tumbled as if the occupants were 'in a washing machine'. Three of the passengers fell out as the basket was dragged across the third field, base first, before it stopped in the fourth field in an upright attitude.

A witness, who lived on the north-west edge of Liskeard, saw the balloon making its approach to land and commented that it appeared to descend from a height of about 300 ft agl. He saw the balloon land initially and, after travelling through a hedge, take off again before landing a second time. He described the weather as fine with a very gentle wind. He did not recall seeing or hearing any jet aircraft.

Following the landing, a lady walked up the field from a nearby farmhouse after having the balloon's presence drawn to her attention by her husband. He had noticed the stationary, collapsed canopy and the basket from an upstairs window in the farmhouse. Earlier, both of these people had heard jet aircraft flying past but neither of them had seen the aircraft, nor did they see the balloon landing.

Other aircraft and recorded data

Four Tornado jet aircraft were notified as operating at low level in the area during the balloon flight. One of these was operating as a singleton and had cleared the area by 1855 hrs.

The other three Tornados were part of an exercise and were notified as operating in the area between 1910 hrs and 1930 hrs, between heights of 200 ft and 2,000 ft agl. As the aircraft transited from north to south towards the area where the balloon was operating, the lead aircraft split off and took a more westerly route down the east side of Bodmin Moor. The other two aircraft, operating as a pair, followed a track down the east side of the River Tamar valley. Some of the aircraft's movements were recorded on radar. However, as they descended to a lower height, beneath the radar horizon, they disappeared from its view. In addition to the radar recordings, two of these aircraft had on-board equipment which also recorded the flights. The third and last aircraft, which followed the second aircraft as part of the pair, was unable to record its flight because its Head Up Display (HUD) was unserviceable.

The radar and on-board recordings were compared. They agreed with each other and also confirmed the routeings which had been planned before the three Tornados took off. The radar recordings are shown on Figure 1. The first and second Tornado aircraft tracks near to the balloon's landing site, which were reconstructed from the on board equipment recordings, are shown at Figure 2. The more westerly and lead aircraft passed 1.9 nm to the north-west of the balloon's landing site, south bound, at approximately 450 ft agl, at 1917:35 hrs, before turning away to the west. The second aircraft passed 0.6 nm to the north of the balloon landing site, west bound, at 1919:39 hrs, at about 350 ft agl and approximately 420 kt. The third aircraft was reported as being 2 nm astern of the second aircraft and slightly to the north of its track. On that basis, this third aircraft would have passed about 0.6 nm to the north of the landing site, at a similar height and speed to the second aircraft, at approximately 1919:56 hrs.

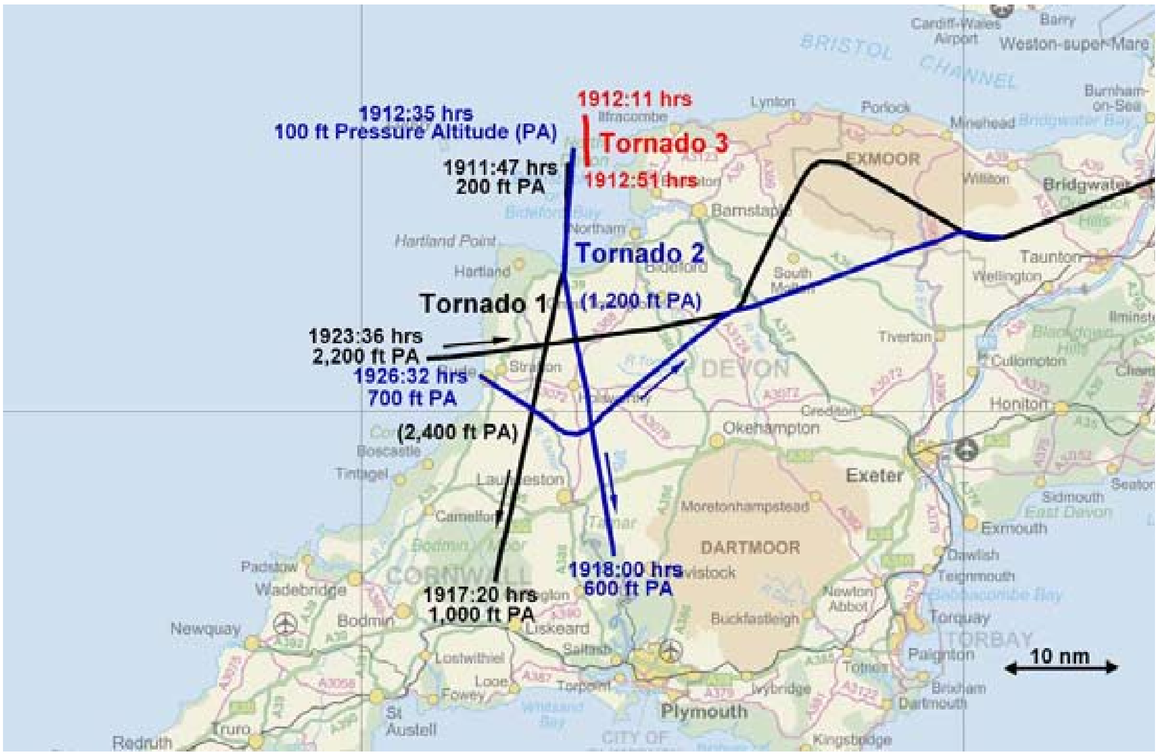


Figure 1

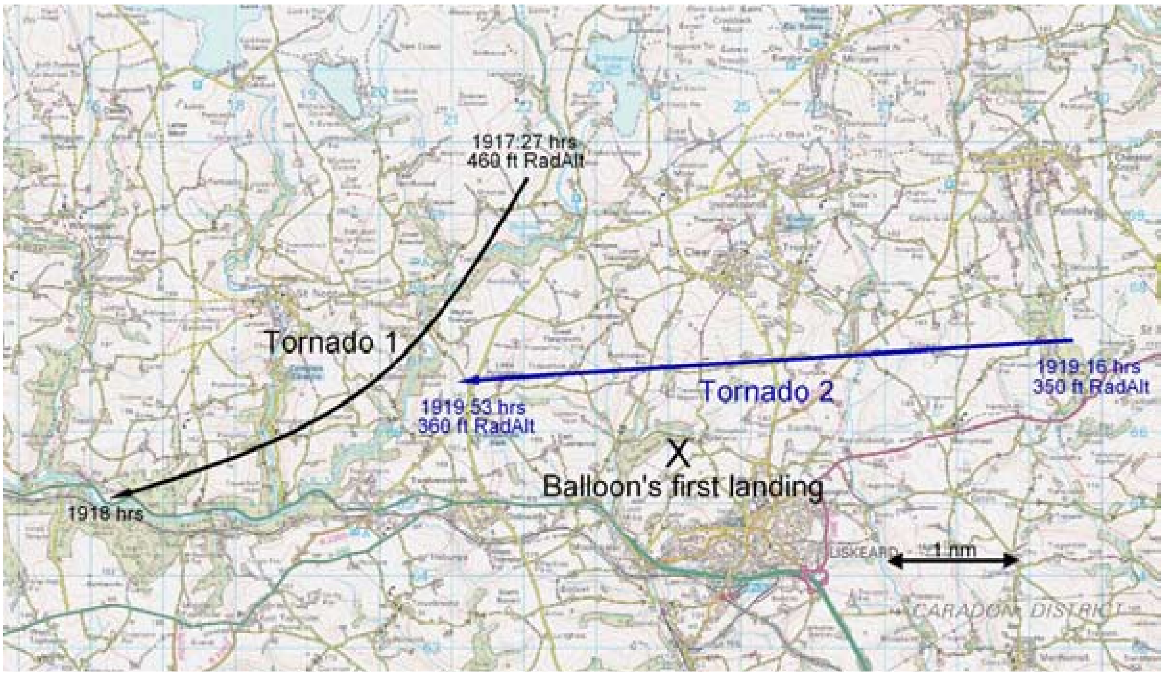


Figure 2

The balloon was equipped with hand held GPS equipment, which retains track information in its memory. The pilot was able to read the groundspeed from it during the flight. However, the memory was overwritten by subsequent flights, after the accident, and no data from the accident flight was retrievable. One of the passengers commented that he was told by the pilot that the GPS was switched off before the landing, so it was unlikely that it could have revealed an accurate time for the landing or the balloon's ground speed at that stage of the flight.

Another balloon took off from the same launch site 10 minutes after G-CDHN. It flew at lower altitudes, covered less ground and had a more south-easterly track. It was reported as making a 'stand-up' landing, with no ground slide, at 1935 hrs, about 9 nm to the north-east of G-CDHN. Neither of these balloons was detected by the radar.

The pilot reported that he made a mobile 'phone call at 1921 hrs, whilst airborne, to advise the ground crew that he would be landing in 5 to 10 minutes. The call lasted nine seconds. He stated that he made another call at 1938 hrs, after the balloon had landed and he had walked some 400 yards round to the next field where some of the passengers had been thrown out of the basket. During that conversation he advised the ground crew of the balloon's position and their situation. That call lasted five seconds.

Photographic evidence

The lead Tornado aircraft and most westerly of the three military jets, was recorded on a passenger's video camera. This enabled the balloon's position to be estimated as 1 nm to the north-east of the northern end of Siblyback Lake at 1917:15 hrs, as the military aircraft flew past on a southerly track down the west side of the lake. This put the balloon's location at approximately 3.7 nm to the north of its eventual landing site. The video also showed that the sun was approaching the western horizon at the time.

Another passenger took two still photographs. The first was taken a matter of seconds after the balloon had launched and showed the launch site. The second photograph showed the two masts on Caradon Hill, and was identified as being taken when the balloon was 0.75 nm north of the village of St Cleer and 2 nm north of the eventual landing site. According to the camera's clock, the second photograph was taken 62 minutes 4 seconds after the first. The time interval equated to an average straight line groundspeed for the balloon of 12 kt.

Meteorology

An aftercast for the evening of the accident showed that a ridge of high pressure extended across the county of Cornwall from the south-west. Surface visibility was estimated to be between 7 to 12 km and there would have been isolated patches of a few cumulus clouds with a base at 1,000 ft amsl. The estimated wind velocity at various altitudes was as follows:

Altitude (ft amsl)	Wind Velocity
2,000	030º at 18 kt
1,000	030º at 17 kt
500	030ºat 08 kt
Sea level	360º at 03 kt or calm

The surface wind in the area of the accident at 1930 hrs would have approximated to the wind velocity between 500 and 1,000 ft amsl ie about 030º at 12 kt.

The air-to-ground visibility enabled passengers to report seeing both the north and south coasts of Cornwall at the same time during the flight. This indicated visibility in excess of 20 km. Video taken during the flight also showed that there was no cloud in the vicinity of the balloon.

The afternoon ballooning forecast for the south-west of the British Isles on 9 August 2005, for the period from midday to dusk, predicted a surface wind from 350º(T) at 05 kt but variable at 5 kt for a time around southern coasts. Moderate, locally strong, thermals were forecast to decay from 1800 hrs and no inversions or lee waves were predicted. 5 to 10 kt onshore sea breezes were forecast, mainly around southern coasts.

Sunset at Liskeard on 9 August 2005 was at 1949 hrs.

Limitations

The maximum surface wind speed for landing the balloon, as specified in the manufacturer's Flight Manual, was 15 kt.

Previous incidents

AAIB Bulletin No 12/2000 includes a report on an incident in which a Lindstrand LBL 105A Hot Air Balloon, registration G-BUZI, was affected by the wake turbulence created by an Airbus A310 aircraft. The pilot of that balloon reported that, after the A310 had flown over the balloon, he noticed a ripple in the balloon canopy, before the canopy was violently forced downwards below the basket. A few seconds later the canopy swung violently upwards and all the occupants of the basket were thrown to the floor. The report stated that the balloon continued to be affected by turbulence before the pilot managed to regain some control and carry out a gentle, emergency landing in a field. In the course of regaining control, the pilot had had to burn through the canopy material to get heat into the envelope because the mouth of the canopy had closed.

Analysis

The indications are that, at their nearest, two military jet aircraft had flown 0.6 nm to the north of the balloon's eventual landing site, from east to west, 17 seconds apart, at about 350 ft agl and approximately 420 kt. The second aircraft probably passed that point at 1919:56 hrs when, at an average groundspeed of 12 kt - the mean over the majority of its flight - the balloon would have been 2.5 nm to the north of that aircraft and 3.1 nm north of the landing site. At that speed, the balloon would have touched down first at 1935:30 hrs; over 15 minutes after all the military aircraft had departed to the west. Therefore, the turbulent air, which the pilot saw around the tops of the trees after the jet aircraft had flown past the wood, would have had time to dissipate; its dissipation having been aided by the wind which was blowing the balloon southwards.

The pilot estimated that the landing time was earlier, between 1925 hrs and 1930 hrs. If so, the balloon's average ground speed over the last 3.7 nm, and therefore the average speed of the wind in which it was travelling, would have been between 17.4 kt and 28.6 kt. The direction of that wind would also have carried the wake turbulence, generated by the military jets, away to the south of the landing site. The earlier the balloon landed, the faster the wake turbulence would have moved south and the quicker it would have been dissipated.

There was little evidence to indicate that the military aircraft created the conditions which the balloon pilot reported whilst making his approach to the field. The report on a previous incidence of a hot air balloon being struck by wake vortices, albeit behind a larger aircraft, described that balloon being violently upset by the turbulence. That contrasted with the steadiness of the balloon in this event. The passengers, with one exception, two crew members and a witness on the ground who saw the balloon land, did not see or hear military jet aircraft at the time the balloon was landing. This was supported by the recorded data which was recovered after the accident.

It was not possible to determine the balloon's groundspeed at touchdown but the distance covered from the first touchdown until the balloon came to a stop, added to the retarding effects of striking the field walls, suggests that there was considerable forward momentum. It is likely that there was a local wind effect, which was not forecast, that created a particularly challenging situation on the final approach to land.

ACCIDENT

Aircraft Type and Registration:	Mainair Rapier microlight, G-MZON
No & type of Engines:	1 Rotax 503-2V piston engine
Year of Manufacture:	1998
Date & Time (UTC):	5 July 2006 at 14:29 hrs
Location:	Selby Home Farm, Stanton, Netherwitton, Northumberland
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - 1 (Serious) Passengers - 1 (Serious)
Nature of Damage:	Aircraft trike unit destroyed
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	46 years
Commander's Flying Experience:	Approximately 107 hours (of which 50 were on type) Last 90 days - 5 hours Last 28 days - 0 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft failed to climb away after takeoff and in order to avoid colliding with a building, the pilot attempted to make a right turn. The aircraft then descended rapidly out of control and collided with a dry stone wall.

History of the flight

Prior to the accident flight, the pilot had completed an uneventful solo flight. On that occasion he had taken off to the west, accepting a slight tailwind, as the airstrip slopes downhill in this direction. He noted that the climb performance had been poor, but attributed this to the tailwind.

The pilot then planned to undertake a further flight with a passenger. Noting from the wind sock that the easterly wind had increased in strength, he decided to take off into wind this time, even though the strip sloped upwards, as it had been recently lengthened to give an increased margin of safety when taking off uphill. He ensured that his passenger was securely strapped in and briefed him prior to departure. The pilot then taxied the aircraft to the beginning of the strip, checked that the trim and hang point were correctly set and applied full power for takeoff. The aircraft lifted off at 50 mph and climbed to a height of 50 ft, but failed to climb any higher. Realising that they were in danger of colliding with one of the buildings beyond the eastern end of the strip, he attempted to make a right turn. The aircraft then descended rapidly out of control and struck a dry stone wall, causing severe injuries to the pilot and passenger and severely damaging the trike. A local landowner assisted in their evacuation.

The weather conditions at the time of the accident were good, with an easterly wind of approximately 8 kt and an ambient temperature of around +30ºC.

In the pilot's assessment, contributory factors to the accident were the reduced climb performance due to the high ambient temperature and the possibility of a down draft or rotor effect from the buildings and trees located near the eastern end of the strip.

ACCIDENT

Aircraft Type and Registration:	P & M Aviation Quik GT450 microlight, G-GTSO
No & type of Engines:	1 Rotax 912-UL piston engine
Year of Manufacture:	2006
Date & Time (UTC):	9 May 2006 at 1415 hrs
Location:	Halsall, near Ormskirk, Lancashire
Type of Flight:	Training
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - 1 (Serious) 1 (Minor) Passengers - N/A
Nature of Damage:	The airframe and propeller were destroyed and the engine was damaged
Commander's Licence:	Private Pilot's Licence (Microlights) with instructor rating
Commander's Age:	50 years
Commander's Flying Experience:	1,415 hours (of which 65 were on type) Last 90 days - 98 hours Last 28 days - 48 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot.

Synopsis

The aircraft was engaged on an instructional flight for a flex-wing pilot who had not flown for about two years. After some general handling, the pilot under training carried out two practice forced landings. During the recovery from the second of these, from a height of about 40 feet agl, the aircraft struck the ground. The instructor reported that power was applied slowly during the manoeuvre and the control bar was pulled, rather than pushed, and he was unable to prevent this control input.

History of the flight

The aircraft was engaged on an instructional flight for a flex-wing pilot who had not flown for about two years. After the pilot under training (P U/T) had successfully completed some general handling over the coast in good weather, and with a wind from the west-south-west at 5-10 kt, the aircraft was flown inland to carry out some practice forced landings (PFLs).

When it was apparent that the first PFL would not have been successful, the P U/T performed a go-around at a height of about 100 feet agl, using the correct technique, and made another attempt. The instructor considered that the field which the P U/T selected on the second occasion was more suitable, being an open area with no obstacles. In fact, the instructor had used this second field a number of times before, sometimes touching down on the main wheels. He allowed the aircraft to descend to a height of about 40 feet agl before instructing the P U/T to 'power out'. The P U/T recalled pushing the control bar forward and the aircraft accelerating. However, the instructor stated that power was applied slowly and the control bar was pulled back, and he was unable to prevent this control input. The aircraft struck the ground in a nose down attitude at 55-70 mph, with full power applied, and was reported to have travelled a further 20-30 feet before stopping. The instructor turned off the engine, fuel and electrics, and both occupants released themselves from the aircraft. The instructor then called the emergency services on his mobile 'phone. The aircraft suffered substantial damage but there was no fire. Later, it was assessed that only the engine was repairable. The instructor received a serious back injury and was flown to hospital by air ambulance. The P U/T sustained minor injuries to an ankle and his back.

The instructor concluded that the accident was the result of the late application of power and the control bar being pulled, rather than pushed, during the go-around. The P U/T recalled raising the nose of the aircraft during the go-around although he thought that the nosewheel was the first part of the aircraft to strike the ground. The instructor also considered that allowing the aircraft to descend to such a low height contributed to the accident. There was no evidence that it came within 500 feet of any person, vessel, vehicle or structure.

The instructor commented that the rigidity of the trike keel and monopole prevented the aircraft from inverting when it struck the ground, probably saving both pilots, who were wearing lapstraps, from more serious injuries. Also, the field which they struck was described as having been left fallow for two years and had a soft surface, which he again felt prevented more serious injuries.

ACCIDENT

Aircraft Type and Registration:	Pegasus Quantum 15-912, G-BYDM
No & type of Engines:	1 Rotax 912 piston engine
Year of Manufacture:	1998
Date & Time (UTC):	2 March 2006 at 1630 hrs
Location:	North Coates Aerodrome, Lincolnshire
Type of Flight:	Private (Training)
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Minor) Passengers - N/A
Nature of Damage:	Extensive
Commander's Licence:	Student pilot
Commander's Age:	Not known
Commander's Flying Experience:	Not known
Information Source:	Enquiries by the AAIB

Synopsis

While landing on Runway 05 the aircraft bounced. During the ensuing manoeuvres it touched down nose gear first and the aircraft overturned.

History of the flight

The pilot had reportedly recently bought G-BYDM and had contacted a flying club with the aim of completing his licence. He informed the club that he had previous experience of flying weight shift microlight aircraft and had been close to achieving a licence. He was given some dual flying in G-BYDM and the instructor assessed him as a competent pilot who was close to the standard required for the flight test. His last dual flight was some two days prior to the accident.

On the day of the accident, the pilot took off on Runway 23 for a solo navigation exercise. The weather was good and the surface wind on takeoff was reported as westerly at 10 kt. After approximately 50 minutes, the pilot returned and joined the circuit for some touch-and-goes on Runway 23. His flying instructor was watching the initial circuit and transmitted to the pilot that there was a tail wind on Runway 23 because the wind had changed to approximately 040º/10 kt. The student then changed to Runway 05 and was seen to do two circuits but with a go-around each time. On his third circuit, the aircraft was seen to bounce on landing. It then bounced twice more with reducing airspeed before touching down on the nose gear resulting in the aircraft overturning.

Subsequently, the pilot reportedly commented that he should have gone-around after the first bounce.

ACCIDENT

Aircraft Type and Registration:	Renegade Spirit UK microlight, G-TBMW
No & type of Engines:	1 Rotax 582 piston engine
Year of Manufacture:	2004
Date & Time (UTC):	2 July 2006 at 17:30 hrs
Location:	Brooklands Farm Strip, near Alconbury, Cambridgeshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 Passengers - N/A
Nature of Damage:	Substantial damage to wings and fuselage
Commander's Licence:	Private Pilot's Licence
Commander's Age:	38 years
Commander's Flying Experience:	680 hours (of which 73 were on type) Last 90 days - 12 hours Last 28 days - 5 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

During a pass along the runway the right wing stalled and the aircraft spun to the ground.

History of the flight

The aircraft was approaching Brooklands Farm airstrip and the pilot decided to fly overhead at a height of about 100 feet to check that the runway was clear. The weather was described as 'clear with strong thermal gusts and an east/south-easterly wind of 10-12 kt'. As the aircraft banked to turn right, towards the dead side of the runway, the right wing stalled and the aircraft spun to the ground. The pilot suffered a broken leg and a broken nose and a small fire was extinguished with a hand-held extinguisher.

The pilot admits that he had been flying too slowly, given the nature of the weather conditions.

ACCIDENT

Aircraft Type and Registration:	Shadow Series CD, G-MYUS
No & type of Engines:	1 Rotax 503-2V piston engine
Year of Manufacture:	1995
Date & Time (UTC):	22 July 2006 at 1220 hrs
Location:	5 miles West of Boscombe Down, Wiltshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Minor) Passengers - N/A
Nature of Damage:	Severe airframe damage
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	56 years
Commander's Flying Experience:	165 hours (of which 53 were on type) Last 90 days - 8 hours Last 28 days - 0 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

Whilst on a local flight from Old Sarum Airfield, the aircraft encountered extremely heavy rain, strong winds and reducing visibility. The pilot commenced a precautionary landing but was suddenly enveloped in torrential rain, which deprived him of any visual attitude reference. The engine then failed. The aircraft landed heavily in a cornfield, causing severe damage to the airframe. The pilot, who received minor injuries, had a disability and remained in the aircraft, summoning help using his mobile telephone. There was no fire.

History of the flight

The pilot's intention was to carry out a few circuits at Old Sarum Airfield, near Salisbury, and then fly to Fordingbridge via Alderbury visual reference point (VRP) before returning to Old Sarum. He had checked the weather forecast and was aware that thunderstorms were predicted for later in the afternoon.

Engine start was at 1135 hrs and a short time later, the aircraft took off from Runway 24. After conducting three 'touch and go' circuits, the pilot climbed the aircraft to 1,200 ft and headed towards Alderbury. However, when abeam the VRP, he observed lightning to the northeast of his position. He decided to abandon his original plan and headed westwards to go around Salisbury and return to the airfield from the east. While passing south of Salisbury, the visibility rapidly deteriorated, the wind picked up and he had to descend to maintain visual contact with the ground. The wind speed continued to increase to an extent that severely reduced the ground speed. Realising that a precautionary landing was necessary, the pilot saw a suitable field ahead but was suddenly enveloped in torrential rain. This reduced the visibility to near zero, depriving him of any visual attitude reference. The engine then failed and the pilot struggled to maintain control in what were by this time extremely difficult conditions. A few seconds later, at approximately 1220 hrs, the aircraft landed heavily in a wheat field, with the airframe sustaining significant damage. Shortly afterwards, a gust of wind tore off the partially separated right wing, which came to rest on top of the cockpit canopy. The pilot subsequently commented that this served as a useful shelter from the rain for the following few hours. He had had no time to transmit a radio message prior to landing, but was able to summon assistance from the flying club with his mobile phone. Although he had suffered no significant injury in the accident, he suffers from a disability and was not capable of walking to safety.

According to the aircraft owner/operator, the engine failure was the result of heavy contamination of the engine filters with rainwater. However, it is considered that this probably had little effect on the outcome as the pilot, faced with appalling flying conditions, had already made the decision to land. After the accident he assessed the cause as his failure to recognise and act upon the rapidly deteriorating weather situation.

ACCIDENT

Aircraft Type and Registration:	Skyranger 912(2), G-CCKF
No & type of Engines:	1 Rotax 912-UL piston engine
Year of Manufacture:	2003
Date & Time (UTC):	18 July 2006 at 1344 hrs
Location:	Near Eshott Airfield, Northumberland
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Minor) Passengers - N/A
Nature of Damage:	Engine seized, propeller damaged, moderate damage to airframe
Commander's Licence:	Private Pilot's Licence
Commander's Age:	73 years
Commander's Flying Experience:	585 hours (of which 196 were on type) Last 90 days - 43 hours Last 28 days - 25 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and subsequent enquiries by the AAIB

Synopsis

The engine failed shortly after takeoff and, in the ensuing forced landing, the aircraft stuck a fence and pitched inverted, causing minor injuries to the pilot and moderate damage to the aircraft. It was quickly established that the engine oil filter had become detached, allowing oil to escape and the engine to seize from oil starvation.

The oil filter had been replaced the previous day with a 'FRAM' automotive oil filter, instead of the Rotax-approved part. The FRAM filter has a slightly larger diameter thread which makes it incompatible for use on this type of engine.

Two safety recommendations were made, with the intention of preventing similar accidents in the future.

History of the flight

On the day of the accident the pilot decided to conduct a short flight, given the favourable weather conditions: fine and sunny, with an easterly wind at 4 kt. Mindful that the engine oil and filter had been changed the previous day, she pulled the propeller through several times to prime the engine with oil before starting. As a further precaution, after starting, the engine was run at 3,000 rpm for several minutes. The aircraft was then taxied to the run-up area where the power checks were completed. All engine indications were normal and the aircraft departed on Runway 08. The takeoff and initial part of the climb were uneventful and, at about 800 ft agl, the pilot retracted the flaps and commenced a right turn to enter the circuit to land. At this point the engine made a 'clattering' sound and the propeller stopped. Given the limited height, the pilot was forced to select a small field of cut crop in which to make a forced landing, as all the other fields within gliding distance contained standing crops. She initially tried to contact Eshott Radio on 112.85 Mhz but, on receiving no reply, changed to Newcastle on 124.37 MHz and transmitted a 'MAYDAY'.

The aircraft landed long and was unable to stop within the boundary of the field. It struck a fence at the edge of the field, causing the nosewheel to detach and the aircraft to pitch upside down. The pilot was wearing a full harness and sustained only minor injuries.

Attendees to the scene observed that the engine oil filter had come adrift from its mounting spigot and was only being held on by the exhaust stub, Figure 1. Also, the inside of the engine cowl was coated in oil and, later, trails of oil were found on the ground coinciding with the aircraft's movements and at the engine run-up area.

Figure 1

View on front of engine showing detached oil filter resting on exhaust pipe

Oil filter replacement

The pilot, who was also the aircraft owner, had performed an oil and filter change on the engine the day before the accident. She had obtained a FRAM PH 5911 filter from the owner of another Rotax-powered aircraft, who stated that the filter was suitable for use on the engine.

However, when the pilot proceeded to install the filter, she experienced some difficulty in placing it onto its mounting spigot, because of the proximity of the exhaust stub and the fact that the new filter was slightly longer than the Rotax filter which had been removed. She eventually succeeded and began threading it onto the spigot, but had difficulty in turning the filter. She sought assistance from an acquaintance, who noted that the filter seemed to be an abnormally loose fit on the spigot. He queried this, but the pilot assured him that the part was suitable. He continued to thread the filter onto the spigot, noting that it only tightened up appreciably at the very end. He gave the filter a final tighten with a strap wrench.

Oil filter examination

The PH5911 filter was examined by the AAIB. The thread on the filter was found to be severely damaged, with the majority of the threads having been stripped. It was also evident that the filter had been cross-threaded during installation. The thread damage is shown in Figure 2.

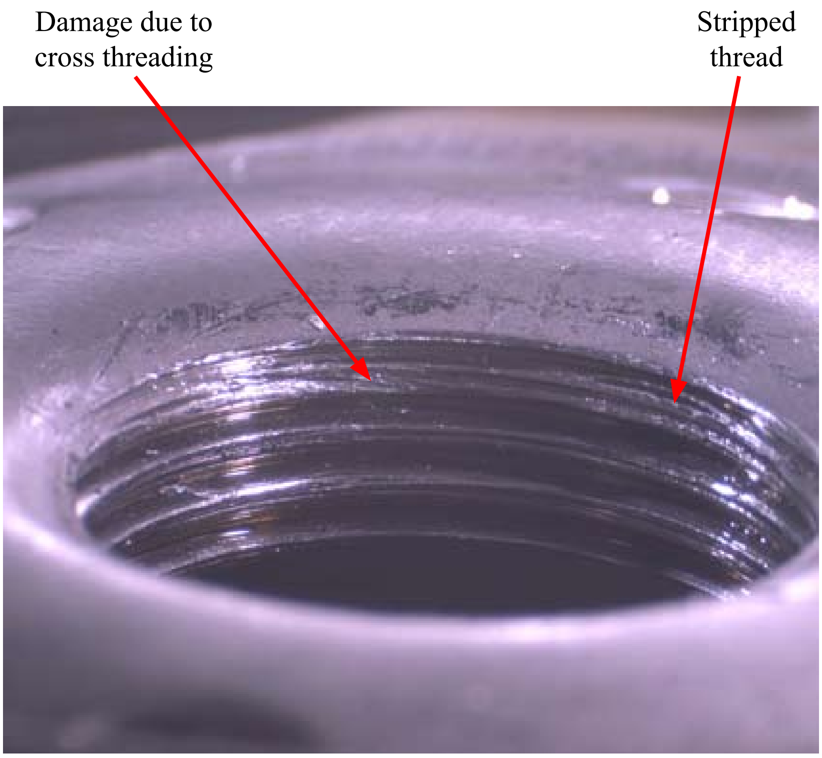


Figure 2

Oil filter thread damage

Oil filter comparison

A dimensional comparison between the FRAM and the Rotax filters revealed two significant differences.

Firstly, the FRAM filter possesses an M20 x 1.5 thread, the 'M20' identifier denoting a metric thread of 20 mm diameter, the '1.5' a thread pitch of 1.5 mm. The thread specification on the approved Rotax filter is ¾ x 16 inches, denoting a thread of ¾ inch diameter (19.05 mm), with 16 threads per inch, giving a thread pitch of 1.59 mm. Whilst the thread pitches are similar, the thread on the FRAM filter is 0.95 mm greater in diameter than that of the Rotax part. When the FRAM filter was trial fitted to a new oil filter mounting spigot, it was found to be a very loose fit.

The second key difference is in the length of the filters, with the FRAM filter being approximately 4 mm longer than the Rotax item.

Engine manufacturer's advice

The Rotax UK distributor advised that there is only one oil filter approved for use on the Rotax 912-UL engine. This oil filter is black in colour and bears the markings: *'ROTAX PART NO. 825701(706)'* and *'FOR ROTAX ENGINE TYPE:912/914'*. There is no approval from the engine manufacturer to use any other filter.

Discussion

The comparison of the two filters showed that whilst the FRAM filter can be made to fit onto the Rotax 912 engine, the larger thread diameter means that the depth of thread engagement is much reduced. However, the depth of thread engagement is sufficient to enable the filter to be tightened, giving the impression that it is securely installed.

The fact that the filter was finally tightened using a strap wrench, rather than by hand, as is customary, may be significant, as this would have placed a higher than normal static load across the partly engaged threads. When the filter became pressurised with oil with the engine running, the loading on the threads would have increased even further, probably to the point where the threads stripped. This was confirmed by the trails of oil on the ground coinciding with the aircraft's movements, and at the run-up area, indicating that the threads on the filter failed not long after the engine was started.

Given the already limited clearance between the oil filter mounting spigot and the adjacent exhaust pipe, the additional 4 mm of length of the FRAM filter makes it more difficult to install. This increases the probability of cross-threading, which will damage the threads, making them more likely to fail under load.

Conclusion

The accident was the result of an in-flight engine failure due to loss of oil and engine seizure, caused by the fitment of an incorrect oil filter.

Safety Recommendations

In order to prevent similar accidents in the future, the following safety recommendations are made:

Safety Recommendation 2006-107

The Popular Flying Association should remind owners of Rotax-powered aircraft that only the engine manufacturer's specified oil filters are approved for installation on their engines.

Safety Recommendation 2006-108

The British Microlight Aircraft Association should remind owners of Rotax-powered aircraft that only the engine manufacturer's specified oil filters are approved for installation on their engines.

BULLETIN CORRECTION

AAIB File:	EW/G2006/03/09
Aircraft Type and Registration:	Boeing 757-236, G-CPET
Date & Time (UTC):	10 March 2006 at 0810 hrs
Location:	London Heathrow Airport
Information Source:	Aircraft Accident Report Form

AAIB Bulletin No 9/2006, page 18 refers

The AAIB report stated:

After starting both engines, the co-pilot reported that he could smell fumes and discussed the matter with the commander. After about two minutes of taxiing, the co-pilot started to feel light-headed, euphoric and unwell, the commander also felt light-headed and the aircraft was halted on the taxiway to see if the situation improved. Both flight crew members continued to feel abnormal - the co-pilot considered himself partially incapacitated – but the cabin staff appeared unaffected. Both engines were shut down as the crew no longer felt fit to taxi the aircraft and it was towed back to the stand.

In fact the aircraft had been **pushed back** and had not **taxied** under its own power.

FORMAL AIRCRAFT ACCIDENT REPORTS
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2004

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

Published February 2004.

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

Published April 2004.

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

Published June 2004.

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

Published July 2004.

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

Published August 2004.

2005

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

Published February 2005.

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

Published November 2005.

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

Published December 2005.

2006

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

Published January 2006.

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