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(ALL TIMES IN THIS BULLETIN ARE UTC)

ACCIDENT

Aircraft Type and Registration:	Cessna 501 Citation, G-VUEM
No & Type of Engines:	2 Williams International FJ44-2A turbofan engines
Year of Manufacture:	1981
Date & Time (UTC):	19 November 2010 at 1535 hrs
Location:	Birmingham Airport
Type of Flight:	Commercial Air Transport (Cargo)
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - 1 (Serious) 1 (Minor) Passengers - N/A
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	58 years
Commander's Flying Experience:	7,200 hours (of which 3,000 were on type) Last 90 days - 127 hours Last 28 days - 50 hours
Co-pilot's Flying Experience:	1,785 hours (of which 735 were on type) Last 90 days - 85 hours Last 28 days - 38 hours
Information Source:	AAIB Field Investigation

Synopsis

The accident occurred during an ILS approach to Runway 15 at Birmingham Airport. The weather conditions were clear over the aerodrome but there was a bank of fog affecting the final approach. The aircraft descended below the Decision Altitude (DA), without the crew having achieved the required visual references, and struck the glideslope antenna. A fire broke out on the left wing and the aircraft crashed onto the grass to the right of the runway. By this time, the fog was affecting the whole of the airfield and, in poor visibility and wet ground conditions, the Airport Rescue and Fire Fighting Service (RFFS) had some difficulties locating and accessing the aircraft. However, the first vehicle was at the scene within three minutes, the fire was extinguished rapidly and a fireman assisted the commander who was, for a time, trapped in his seat. Both of the flight crew survived the accident. Also, a transplant organ, which was being carried onboard, was recovered successfully.

History of the flight

The flight crew reported for duty at Liverpool Airport at 0845 hrs. Their original task was to fly to Belfast City Airport, collect a transplant organ, and take it to Cambridge Airport. However, on their arrival at Belfast the transfer was no longer required, so they were given a new task to fly to Belfast Aldergrove Airport and collect an organ to carry to Birmingham Airport.

The aircraft departed Belfast Aldergrove at 1450 hrs with the co-pilot as pilot flying. The flight was uneventful and the aircraft was given a radar vector to intercept the ILS for a straight-in approach to Runway 15 at Birmingham.

The Runway 15 ILS course is 149°M. The autopilot was engaged and the aircraft was flying on a track of 135°M, 13 nm from the touchdown zone and at a groundspeed of 254 kt, when it crossed the localiser centreline. The aircraft then turned right onto a corrective track but once again passed through the localiser course. Further corrections were made and the aircraft passed through the localiser once more before becoming established at 5 nm. The co-pilot later reported that, because the autopilot was not capturing the localiser, he had disconnected it and flown the approach manually.

When the aircraft was at 10 nm, the radar controller broadcast a message advising of the presence of a fog bank on final approach and giving RVRs of 1,400 m at touchdown and in excess of 1,500 m at both the mid-point and stop end.

The airfield was sighted by the commander during the approach but not by the co-pilot. A handover to the tower frequency was made at around 8 nm. When the aircraft was at 6 nm, landing clearance was given and acknowledged. The tower controller then advised the aircraft that there was a fog bank over the airfield boundary, together with the information that the touchdown RVR was 1,400 m. The commander responded, saying: "WE'VE GOT ONE END OF THE RUNWAY".

The aircraft was correctly on the localiser and the glideslope at 4 nm. The Decision Altitude (DA) of 503 ft amsl (200 ft aal) for the approach was written on a bug card mounted centrally above the glareshield. Both pilots recollected that the Standard Operating Procedure (SOP) calls of "500 above" and "100 above" DA were made by the commander. However, neither pilot could recall a call of 'decision' or 'go-around' being made. At between 1.1 nm and 0.9 nm, and 400 ft to 300 ft aal, the aircraft turned slightly to the right, onto a track of 152°M. This track was maintained until the aircraft struck the glideslope antenna to the right of the runway some 30 seconds later (see Figure 3, page 11).

The aircraft came to rest in an upright position on the grass with a fire on the left side. The co-pilot evacuated through the main cabin door, which is located on the left side of the fuselage, and suffered flash burns as he passed through the fire. The commander was trapped in the cockpit for a time.

Fire and rescue

The aerodrome was Rescue and Fire Fighting (RFF) Category 9 at the time of the accident. The fire station is located to the east of Runway 15/33 (see Figure 1). At 1536 hrs, ATC reported the accident to the RFFS via the crash line. Initially, from the fire station some smoke could be seen above a fog layer but, as the vehicles deployed, the fire crews' visibility was restricted by the fog and the smoke could no longer be seen. Two fire-fighting appliances, accompanied by a fire command vehicle, deployed along Taxiway A towards the holding point for Runway 15. A further two appliances deployed onto the runway, via Taxiway T, and then travelled north along the runway. By now the fog was so thick that the fire crews could not immediately locate the accident site. The driver of one of the fire appliances, travelling north along the runway, glimpsed an orange glow at the

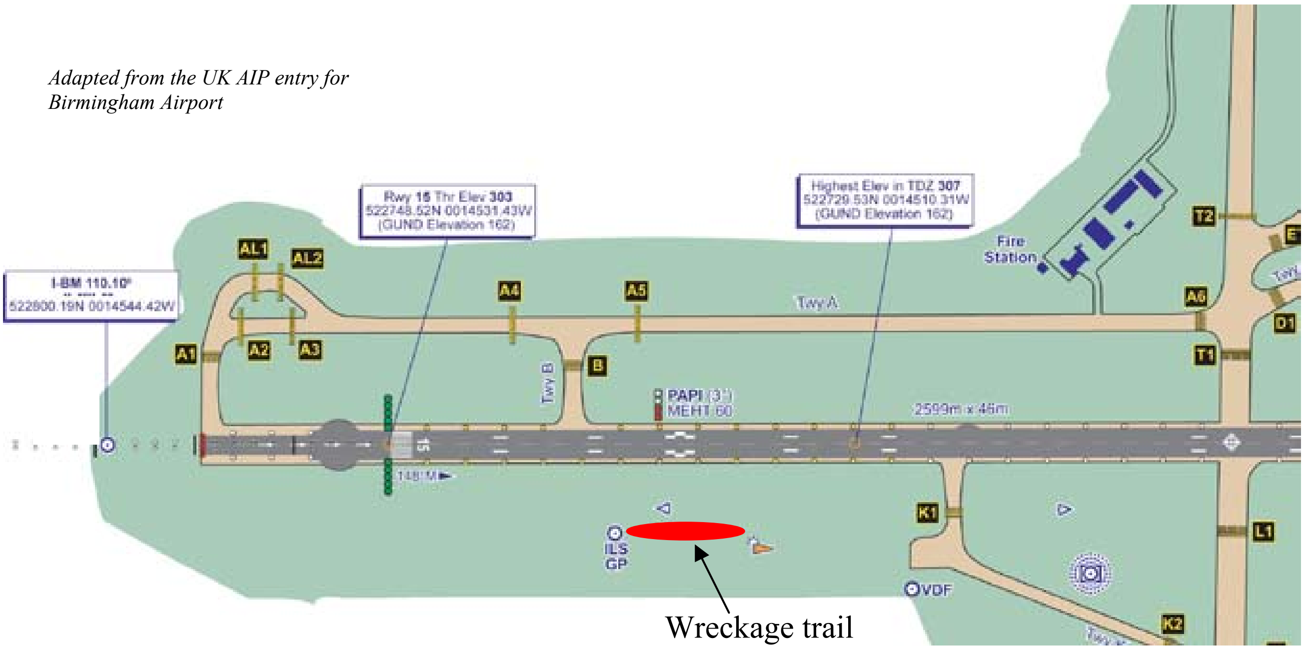

Figure 1

Accident site location

left side of the runway and turned towards it, onto the grass. The grass area was soft and made access difficult, but the vehicle reached the site at 1539 hrs and the fire crew applied foam to the left side of the aircraft. The fire was suppressed quickly and fire crewmen were able to approach the aircraft.

The other two appliances, together with the fire command vehicle, approached the accident site from the threshold of Runway 15. When one of the appliances turned off Runway 15 towards the aircraft, it became bogged down in soft ground due to the appliance's differential locks not being engaged. The other vehicles in this group altered their route, accessing the airfield perimeter track via Taxiway K, before finally reaching the accident site by driving through the airfield security fence. These vehicles arrived at the aircraft at 1542 hrs. The progress of the fire vehicles towards the crashed aircraft was recorded on the surface movement radar.

The co-pilot had vacated the aircraft and advised the fire crew that the commander was still inside. A fireman approached the aircraft and could see that the commander was moving, so he smashed the side windows to allow air into the cockpit.

When the aircraft had come to a stop, the commander realised that his right foot was trapped and he could not get out of the aircraft. Seeing the fire around him, he took hold of the portable fire extinguisher and discharged it around the cockpit. He then used his crew oxygen mask to enable him to continue breathing.

One of the firemen entered the aircraft through the right side emergency door but could not get right into the cockpit because of the confined space and the bulky nature of his breathing apparatus. However, the commander managed to free himself and crawl backwards to where he could be assisted from the aircraft. He was treated at the scene and then flown by air ambulance to a local hospital.

Another fireman went to the right side of the aircraft and noticed that the right engine was still running, so he went to get the co-pilot to return to the aircraft to assist. They were able to signal to the fireman inside the aircraft to shut down the engine. The fire crew were also able to recover the transplant organ from the cabin.

Accident site

The wreckage trail originated at the Runway 15 glideslope antenna tower, which was positioned 146 m laterally, to the west of the runway centreline, adjacent to the touchdown point (Figure 1). The 220 m long wreckage trail was oriented on a heading of 146°M. It consisted of fragments from the aircraft's nose and inboard section of the left wing, along with parts of the aircraft that had detached as it slid along the grass surface. The aircraft came to rest on its belly at the end of the wreckage trail, on a heading of 284°M and 138 m laterally from the Runway 15 centreline. Ground marks indicated that the aircraft had rotated approximately 225° to the left, whilst in contact with the ground, following the initial ground impact. The right flap and left main landing gear had detached from the aircraft before it came to rest.

The Runway 15 ILS glideslope antenna tower, which was 15 m tall prior to the accident, had sustained extensive damage due to being struck by the aircraft approximately 1 m from the top of the tower. The uppermost antenna had been detached from the tower during the impact, and the tower had been bent backwards by approximately 170°. The position light mounted at the top of the antenna tower had been torn off, exposing live electrical cables.

A section of inboard leading edge from the left wing, 80 cm in length, was found close to the base of the glideslope antenna tower. This piece of structure formed the forward skin of the integral fuel tank in the aircraft's left wing. It displayed surface witness markings indicating that the aircraft had struck the tower in a wings-level attitude.

The initial ground contact mark made by the aircraft was 57 m from the ILS glideslope tower. The left nose landing gear door and a pitot tube were found at a distance of 92 m from the ILS glideslope tower and a deep gouge in the ground surface indicated that a heavy nose impact had occurred at this location. The fibreglass nose cone, nose avionics rack and weather radar had detached from the aircraft at this point, and had been thrown 34 m forwards.

The grass surface of the wreckage trail exhibited sooting consistent with a short duration 'flash' fire of fuel vapour. The burned area extended from 3 m before the first ground mark, to the resting position of the aircraft and was approximately 15 m wide. Ground conditions at the accident site were very soft and waterlogged.

Wreckage examination

The left side of the aircraft had suffered extensive fire damage, fed by fuel that had leaked from the ruptured left wing fuel tank. The outer 80 cm of the left wing was bent upwards by approximately 25°, due to ground impact, and the fire had been severe enough to melt through the left wing's aluminium alloy structure completely. The left engine's fan blade leading edges were damaged due to the ingestion of debris whilst the engine was rotating.

The flap selector lever was in the landing position and inspection of the flap track rollers revealed that the flaps were fully deployed, at 40° deflection, prior to the accident. The aircraft's electrically heated anti-ice leading edges switch was in the OFF position. The landing gear selector lever was in the DOWN position. The left main landing gear leg had broken away from the aircraft, from the extended position, as the aircraft slid sideways over the grass surface. The right main and nose landing gear legs had been forced upwards into their stowed positions, due to overload during the ground impact. The right wing trailing edge flap had detached from the aircraft whilst the aircraft was travelling backwards over the grass surface.

The left side of the aircraft's nose had struck the ground, pushing the left side of the forward pressure bulkhead rearwards by 30 cm. This deformation had also caused the commander's instrument panel, control column and rudder pedals to translate rearwards, trapping him in his seat. Both the commander's and co-pilot's seat mountings and restraint harnesses had withstood the accident's impact loads without failure.

Orange witness marks were visible on the left side of the fibreglass nosecone. These matched the orange paint on the upper section of the ILS glideslope antenna tower and the alignment of the marks confirmed a wings-level impact attitude with the tower. An area of fuselage skin beneath the commander's side windshield, measuring 55 cm long by 45 cm wide, had been torn rearwards during the tower strike, and wiring looms immediately behind this area of skin had been severed.

A detailed examination of the aircraft's flying controls was made following recovery of the aircraft and no pre-existing defects were identified.

Pilot information

The commander was experienced on the aircraft type and had flown G-VUEM on a number of previous occasions. The co-pilot had been flying the aircraft type with the operator regularly for several years but had not flown G-VUEM as frequently as their other two aircraft. There were no particular comments of relevance in either pilot's training records.

The commander had operated a three sector flight on 17 November, an 11-hour duty period which finished at 2115 hrs. He then had a rest day before reporting for duty at 0845 hrs on 19 November.

The co-pilot had operated a two sector flight on 18 November, which finished at 1725 hrs. He then had 15 hours and 20 minutes of rest before reporting for duty at 0845 hrs on 19 November.

Commander's recollections

The commander noted that the two flights carried out earlier in the day had been uneventful. The accident flight had also been routine and the weather reports received for Birmingham indicated good conditions for the approach. There were no technical faults with the aircraft but the commander recalled that the aircraft had not captured the ILS localiser on the first attempt and did not track it correctly. The co-pilot disconnected the autopilot and continued the approach, flying manually. The commander acquired visual contact with the airfield from some distance and then, during the later stages of the approach, he only had the second half of the runway in sight. A crosscheck of altitude had been made at 4 nm. At some stage, the co-pilot had asked whether he should go around but the commander had advised him to continue. The commander called "500 above" and "100 above" and looked out for visual references. He remembered noticing that the glideslope pointer had disappeared; then he saw an obstacle immediately ahead. He thought the co-pilot must have seen it too because he heard him make an exclamation. He did not make a 'decision' or 'go-around' call.

The commander's impression when he was interviewed was that there had been a very short time, in the order of a few seconds, between his calling "100 above" and the impact. His initial impressions were that the aircraft had descended below the glideslope.

Co-pilot's recollections

The co-pilot thought that the aircraft had entered cloud at around 2,000 feet and the rest of the approach had been in IMC. He had noticed that the autopilot was not tracking the localiser but, instead, passed through it several times. He disconnected the autopilot and flew the remainder of the approach manually. He heard the commander give a "500 above" and a "100 above" call. He didn't hear a 'decision' call. At around the time he heard the '100 above' call he realised that he was no longer maintaining the localiser and asked the commander if he should go around. He recalled hearing the commander say, "no, go left". He remembered being confused by this instruction. He then caught a glimpse of the antenna ahead, too late to attempt to avoid it.

Meteorological conditions

At 1535 hrs the aerodrome was on the southern margin of an area of low cloud and fog. Earlier in the day the airfield had been affected by fog but the RVRs had not dropped below 1,500 m since 1135 hrs, four hours before the accident. In the intervening time the sky had been clear with the sun visible.

It is not known what forecast the pilots accessed before the flight to Birmingham. However, the TAF issued for Birmingham at 1059 hrs was: '*1912/2012 18005KT 0300 FG VV/// BECMG 1912/1915 6000 NSW SCT005.*' There were two fog warnings issued for Birmingham Airport before the flight left Belfast. One was issued at 0902 hrs and a second at 1116 hrs, valid from 1200 to 1600 hrs, both reported *'Fog (visibility less than 600m) expected'*. The Birmingham METAR issued at 1420 hrs, 30 minutes prior to departure, was '*12004KT 090V160 9999 4500NW FEW007 09/07 Q1011.*'

The crew received ATIS information 'E' broadcast from 1450 hrs, which stated: Runway 15 in use, surface wind from 160° at 5 kt, visibility 10 km or more, few cloud 700 ft, temperature +9°C, dew point +7°C, QNH 1011 mb.

The Instrumented Runway Visual Ranges (IRVRs) recorded for Runway 15 are reproduced in the table below:

Time	RVR (m)	RVR (m)	RVR (m)
	Touchdown	Mid-point	Stop-end
1530	1400	> 1500	> 1500
1531	> 1500	> 1500	> 1500
1532	1400	> 1500	> 1500
1533	1100	> 1500	> 1500
1534	500	> 1500	> 1500
1535	500 375	> 1500	> 1500
1536	300	> 1500	> 1500

The surface winds broadcast by ATC on the tower frequency were:

Time	Surface wind °M/kt
1520	160/5
1522	150/3
1525	050/2 040/3
1529	020/5
1531	020/4
1532	020/4

Other flight crew reports

There were a number of aircraft movements at around the time of the accident. The commander of an aircraft which landed at 1523 hrs reported that they had flown an autopilot coupled approach to minima. Just above their DA of 503 ft amsl they had flown into the top of a fog bank, through which they could see the approach lights, and then passed straight out again into clear visibility. He estimated the top of the fog to have been at between 250 ft and 280 ft aal.

The commander of an aircraft which landed at 1524 hrs reported that most of the runway was visible throughout their approach but that there was a very clear line of fog, through which the approach lights could be seen. The aircraft just entered the fog momentarily on the approach. The co-pilot commented that because there had been a deflection of the localiser during the approach he had flown the latter part visually. He noted that the aircraft had appeared to be "surfing" down the front, sloping face of the fog.

Another aircraft, inbound on a diversion from East Midlands Airport, landed at 1527 hrs. The commander reported that they had flown over a solid bank of fog or overcast cloud en-route. The edge of the fog could be seen and appeared to be moving upwind, that is in a southerly direction. He thought that they had entered the fog before reaching their DA but that he had maintained sight of the runway and it was clear for landing.

There was one departure at 1530 hrs and another at 1532 hrs. The second departing aircraft encountered fog when taxiing northbound along Taxiway A. The commander commented that it appeared to be moving towards the aircraft at around 4 kt. When the aircraft was lined up prior to takeoff, the fog was very thick and the commander commented that he could see only a limited number of runway lights ahead.

One aircraft was on the approach behind the accident aircraft. The crew could see the far end of the runway and a bank of rolling fog, but not the aircraft ahead. At 5 nm they noticed that the glideslope signal had been lost and accordingly reset their minima for a localiser only approach. They didn't enter the fog and when they were at around 800 ft aal they were instructed by ATC to go around.

Those present at the airfield described the weather conditions around the time of the accident as very unusual. Of particular note was the sharp definition between the fog and the clear area where the sun was shining and, secondly, the speed with which the fog covered the airfield.

Air Traffic Control information

The bank of fog and low cloud to the north of the airfield was seen from the Visual Control Room (VCR) but was not, at first, directly affecting airfield operations. At 1523 hrs ATC requested Airfield Safeguarding[1]. At Birmingham the time taken to complete safeguarding is normally between 15 and 20 minutes; the procedures had not been completed by the time of the accident.

At 1531 hrs there was a discussion within ATC about whether there should be a change of the runway in use to Runway 33. At 1533 hrs the tower controller broadcast a reduction in touchdown zone RVR to 1,100 m. The call was not acknowledged by G-VUEM. The controller was expecting to see the aircraft land at any moment when he noticed, on the screen in front of him,

Footnote

[1] Airfield Safeguarding is the term used to describe the protective measures that must be in place before fully protected Low Visibility Procedures can commence.

that the RVR had reduced to 500 m. He decided not to pass this information on to the landing aircraft because he thought it could cause a distraction at a critical time. He then saw a flash of orange and a pall of smoke. He activated the crash alarm and carried out the aircraft accident procedures using a dedicated checklist. He reported that by this time the whole of the airfield was obscured by fog.

At the time of the accident there had just been a change of radar controller. The oncoming controller thought that the following aircraft had been changed to the tower frequency. However, this was not the case. The tower controller was expecting the following aircraft to have been given go-around instructions, when he realised that it was continuing its approach he requested that the aircraft be sent around. The following aircraft was given go-around instructions by the radar controller when it was at 2 nm on final approach. Other inbound aircraft were instructed to enter holding patterns and diversions were then co-ordinated.

Aerodrome information

Runway 15 at Birmingham has an LDA of 2,279 m, with a width of 46 m. The landing threshold is displaced by 320 m from the start of the runway and the touchdown elevation is 303 ft amsl. The lighting at the time of the accident was selected to 100 % brightness and consisted of full (914 m) CL5B[2] approach lighting, PAPIs, Runway Centreline lights at 15 m spacing and Runway Edge lights. There was a Category III ILS installation for Runway 15. The applicable Category I minima for the NDB ILS DME approach to Runway 15 were: DA 503 ft amsl and visibility 550 m.

A flight inspection of the localiser was carried out the day after the accident and it was found to conform with the required standards.

The Runway 15 ILS glideslope antenna tower

Design requirements relating to ILS glideslope antennae towers are specified in International Civil Aviation Organization (ICAO) Annex 14 *'Aerodrome Design Manual'*. This document requires that ILS glideslope antennae towers must be located a minimum of 120 m laterally from the runway centreline. The Runway 15 glideslope antenna tower, located 146 m from the runway centreline, complies with this requirement. The manual also specifies frangibility criteria for air navigation equipment located in close proximity to runways. However, ILS glideslope antennae towers are not subject to frangibility requirements, owing to the conflicting requirements of making the antenna tower frangible versus maintaining the glideslope beam alignment in strong winds and in icing conditions.

The glideslope antenna tower manufacturer constructed the tower in four separate vertical sections that were bolted together. When struck by the aircraft, the two uppermost bolted joints gave way (Figure 2), allowing the tower to fold in the direction of the aircraft's flight path. This progressive deformation of the tower, achieved in the absence of frangibility requirements, reduced the deceleration imposed on the aircraft.

The accident site

The aerodrome's grass surface at the accident site was observed to be waterlogged when the accident occurred. The closest rainfall monitoring station to the accident site was Coleshill, 2.9 nm north-east of Birmingham Airport. Rainfall accumulation records for this station were obtained from the UK Met Office (Table 1).

Footnote

2 Calvert System comprising centreline and 5 cross bars (CL5B).

Figure 2

Runway 15 ILS glideslope antenna tower after the accident

Period (dates are inclusive)	Recorded rainfall accumulation (mm)	Average accumulation (mm)	Difference from average
1/11/10 – 19/11/10	50.2	42.7[3]	+17.6%
1/08/10 – 31/10/10	236.4	190.8[4]	+23.9%

Table 1

Rainfall accumulation totals

Footnotes

3 19/30ths of the monthly average for November, recorded over a ten year period between 2001-2010.

4 The quarterly average for the period August-October inclusive, recorded over a ten year period between 2001-2010.

The figures show that the rainfall recorded during the period of November 2010 preceding the accident was higher than average. In addition, the rainfall recorded in the period between August and October 2010 was also above average. It is, therefore, considered that the above average rainfall accumulations contributed to the waterlogged grass surface at the accident site.

Aircraft information

The operator's fleet comprised three aircraft; the Cessna Citation 501, G-VUEM, and two Citation 550s. G-VUEM was usually operated as a corporate aircraft and the other two aircraft were used mainly for charter. The co-pilot noted that he normally flew the charter aircraft and seldom flew G-VUEM. There were a number of differences between G-VUEM and the other two aircraft, including the instruments, operation of cockpit displays and equipment, engine management and aircraft performance.

G-VUEM was fitted with an autopilot which was capable of flying a coupled ILS approach. Other pilots who had flown this aircraft advised the AAIB that to intercept and track a localiser course successfully, with the autopilot engaged, the speed would need to be reduced to around 180 kt. The aircraft was fitted with three altimeters; one primary altimeter for each crew member and a standby altimeter that was installed on the co-pilot's instrument panel. All three altimeters were set to the airfield QNH. None of the altimeters were equipped with 'bugs' for setting minima. There was a flight director available for the commander but the co-pilot's side did not have this facility. The bug card was completed with the correct information and minima; the calculated approach speed was 104 kt.

The aircraft departed Belfast with 3200 lbs of fuel on board and the estimated fuel burn for the sector was 1,000 lbs.

After the accident both primary altimeters were returned to the manufacturer for functional testing. Both units passed the manufacturer's acceptance test procedures and were determined to be serviceable.

Recorded data

Flight recorders

The aircraft was not equipped with either a Flight Data Recorder (FDR) or a Cockpit Voice Recorder (CVR). It had previously been equipped with a CVR but this was removed when the aircraft was transferred onto the UK register in 1998.

G-VUEM was not required to carry recorders under the regulations for turbine-powered aircraft applicable at the time of manufacture, since its maximum certified takeoff mass was below the specified 5,700 kg, and its maximum approved passenger seating configuration was less than the 10 specified. However, in the latest edition of Part 1 of Annex 6, *Operation of Aircraft,* (International Standards and Recommended Practices) to the Convention on International Civil Aviation[5], the International Civil Aviation Organization (ICAO) requires as a Standard that, from 1 January 2016, all newly type certificated turbine-powered aircraft with a takeoff mass of 5,700 kg or less be equipped with recorders. For aircraft that are built after 1 January 2016 but to a pre-2016 type certificate, ICAO also recommends that recorders should be fitted.

Radar

Recorded radar data from the Clee Hill radar head gave positional information for G-VUEM every eight seconds during its approach to Birmingham Airport.

Footnote

[5] Ninth Edition (July 2010) which incorporates all amendments adopted by the Council prior to 27 February 2010 and supersedes, on 18 November 2010, all previous editions of Part 1 of Annex 6.

The aircraft was fitted with a Mode S transponder, so this radar data included altitude information which, for this installation, had a resolution of ±50 ft. Figure 3 illustrates the approach to Runway 15 from about 5 nm out, with the last radar return (1535 hrs) placing the aircraft about 100 m from the glideslope antenna (shown).

Figure 4 plots the approach of G-VUEM relative to the 3° glideslope and localiser (½ dot deviation lines are indicated). The aircraft's (calculated) groundspeed and intercept angle at the points where the track crosses the runway centreline are also shown, together with any significant R/T extracts. With about 3 nm to touchdown, there is a reduction in the precision and predictability of the flight path, consistent with a change from autopilot to manual flying. This point is highlighted.

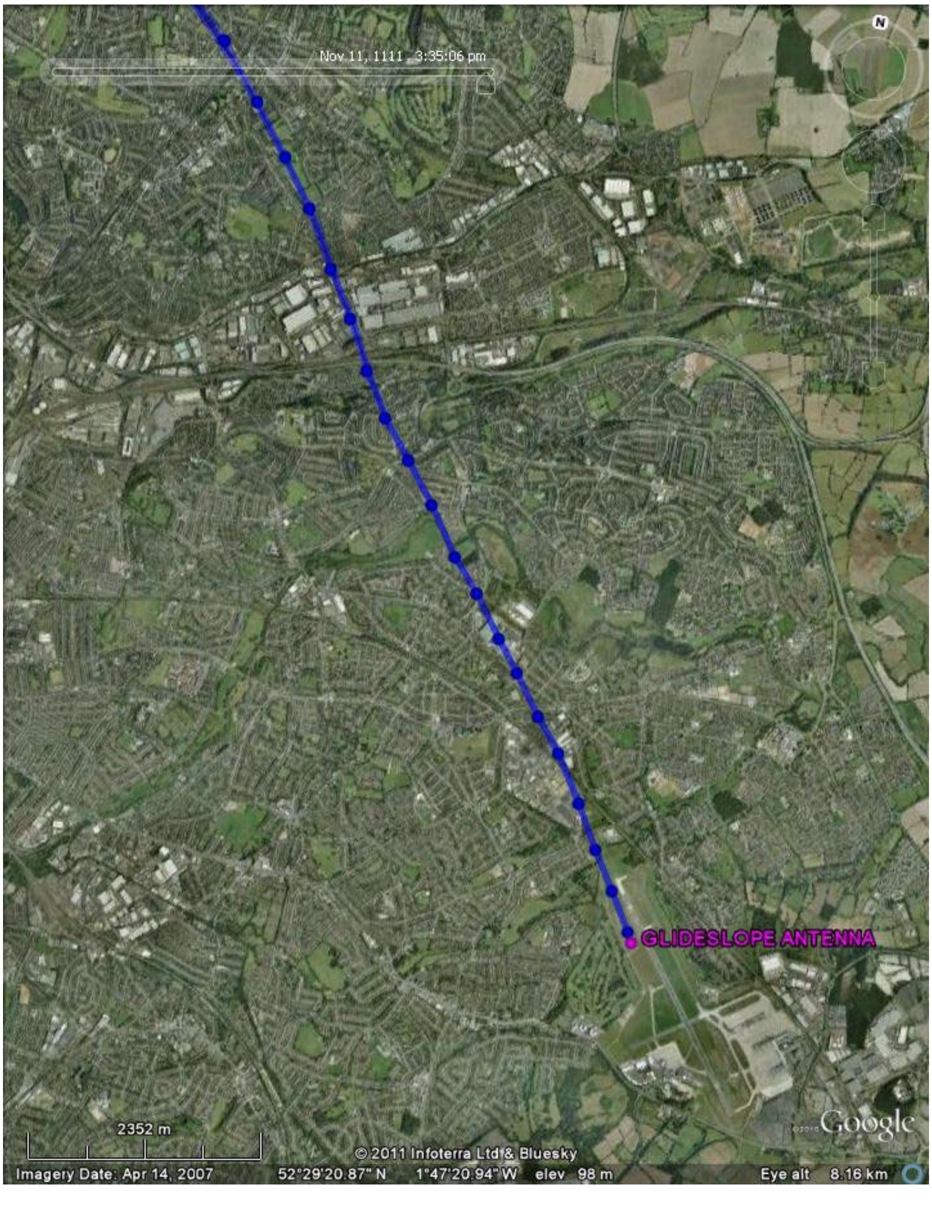

Figure 3

Approach to Runway 15 from about 5 nm of G-VUEM based radar information

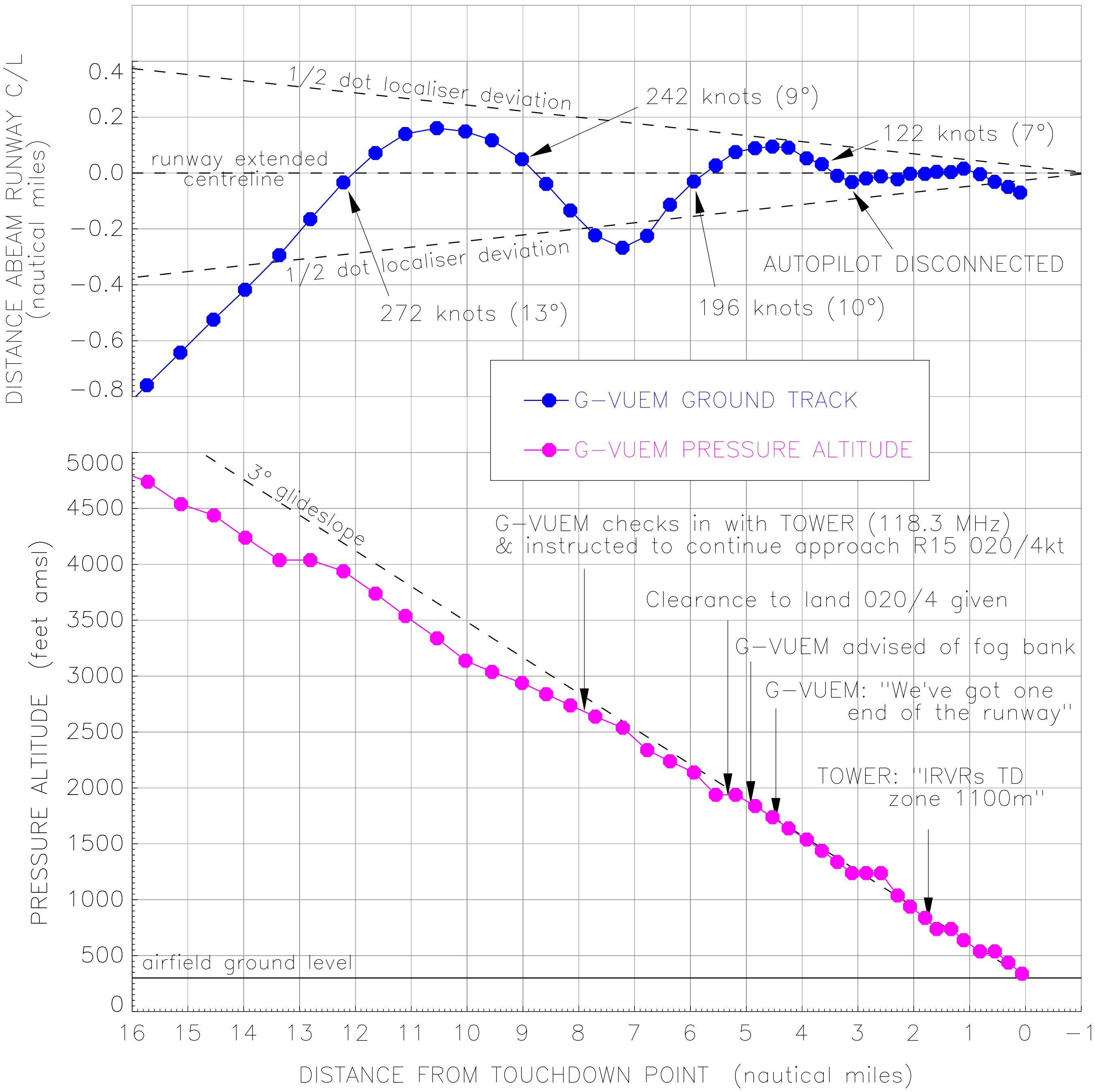

Figure 4

The position and height of G-VUEM relative to the glideslope and localiser (based on radar information) during the approach to Runway 15

Surface movement radar

Surface movement radar recordings were also available to the investigation. However, these recordings were of little use since their coverage did not include the area to the side of the runway where the accident happened.

The radar coverage itself does cover the airfield but the information displayed to the tower controllers, and subsequently recorded, is masked and only shows movement on the taxiways and runways.

CCTV

CCTV footage, taken from below the ATC tower, captured images in the direction of the crash site shortly after the landing, one of which is illustrated in Figure 5. This figure shows the extent of the fog bank over the northwest corner of the airfield.

Operator information

The operator provided Standard Operating Procedures (SOPs) in their Operations Manual (OM). There were no specific extra weather minima laid down for co-pilots to conduct approaches; such decisions were left to the discretion of the commander.

Stable approach criteria were published as follows:

> *'ALL approaches are to be made such that by 1,000 ft the aircraft is wings level, in the landing configuration at not more than Vref+10 KIAS, established on the published final approach course, and be unambiguously achieving the published (or nominal) descent slope without frequent or significant deviations in speed or rate of descent.'*

Figure 5

Frame from CCTV footage showing the fog bank and mushroom cloud from the post-crash fire

The following information was provided concerning an approach ban:

> *'Once past the Outer Marker or equivalent position the approach may be continued to landing irrespective of reported RVR/Vis provided that the required visual reference has been established at the DA/DH or MDA/MDH, and is maintained.'*

The OM stated that it was the non-handling pilot's (NHP) responsibility to monitor the approach and make the SOP calls. Standard calls to be made by the NHP on approach were: at the Outer Marker or 4 miles, as appropriate, an altitude crosscheck; a *'500 feet above'* DA call; a *'100 feet above'* DA call, and a '*decision*' call at the DA. There was also provision for calls for deviations from an expected profile. For example, with the beambar at half scale and increasing, the call was *'Beambar – go right (or left)'*.

Analysis

The TAF for Birmingham indicated there was a likelihood of fog in the morning followed by an improvement after 1200 hrs, although a fog warning remained effective up to 1600 hrs. The 1420 hrs METAR reported good visibility. En-route to Birmingham, ATIS 'E' was obtained by the crew and it also reported good visibility, with some cloud at 700 ft agl. On the approach, the commander sighted the airfield from some distance and the stable approach criteria were met by 1,000 ft aal. Thus, the circumstances were such that the crew could reasonably have expected to complete the approach in visual conditions.

In fact, the conditions were not as expected. Witnesses at the airfield described the weather as extremely unusual, both for the sharp delineation between the fog and the area of clear visibility, with blue sky and sunshine, and for the speed with which the fog engulfed the airfield. Between 1522 hrs and 1525 hrs the wind changed in direction from southerly to northerly. The fog stayed to the north of the airfield for as long as the southerly wind prevailed, but when it changed the fog moved towards the field and eventually covered it. Between 1532 hrs and 1535 hrs, the visibility at the touchdown instrumented runway visual range (IRVR) transmissometer reduced from 1,400 m to 375 m. The threshold for Runway 15 is displaced, therefore the reduction in visibility would have affected the final approach a few minutes earlier.

Airfield safeguarding was in progress, in anticipation of the introduction of LVPs and a possible runway change. However, at the time of the commencement of G-VUEM's approach, the recorded IRVRs, indicated that the conditions were still better than required for Category 1 operations.

The initial attempt to capture the localiser was made at an intercept angle of 15° and a groundspeed of 254 kt. Although on a suitable track, the airspeed was probably too fast for the autopilot to be able to capture the localiser course and the aircraft overshot the centreline several times before the co-pilot disconnected the autopilot and intercepted manually. The speed reduced steadily and the required approach speed was achieved by 1,000 ft aal. Once established on the approach, the localiser and glideslope were followed down to a height of around 300 feet aal, a point which corresponded to the SOP '*100 feet above*' call.

At this time, the aircraft was displaced slightly to the left of the localiser and a corrective heading of 7° to the right was made. The aircraft then continued on this heading, while maintaining the same rate of descent on the glideslope, until the point of impact. There were no changes to the aircraft's flightpath below 300 ft aal, which suggests that no further control inputs were made from around this time. The evidence from the wreckage examination is that, at the point of impact, the aircraft was approximately wings level and continuing on a steady track, thus no attempt had been made to go around.

Both pilots recalled the '*500 feet above*' and the '*100 feet above*' SOP calls being made but both were clear that there had been no '*decision*' call. The '*decision*' call should have been made about 10 seconds after the '*100 feet above*' call. The time from the aircraft being at a height of 300 ft aal ('*100 feet above*') to its impact with the mast was in the order of 25 seconds. Therefore, the approach had continued for a period of some 15 seconds with the aircraft descending below minima, without visual reference being obtained.

It was considered whether the SOP calls relating to the minima could have been incorrect. The post-crash evidence showed that the altimeter subscales were set correctly and that the minima recorded on the bug card were also correct. The absence of altimeter 'bugs' makes it more likely that an error may be made, causing SOP height calls to be missed. However, there were several indications that this was not the reason for the accident and it is thought probable that the minima were correctly interpreted.

The evidence suggests that the top of the fog bank coincided with the '*100 feet above*' point on the approach. Up to that point the commander probably had good external visual references, although the touchdown zone would not have been in view. The co-pilot, as the handling pilot, would have had all his attention focused on the instruments. The commander reported having looked outside the aircraft to try to acquire visual reference after making the '*100 feet above*' call. It is probable that at about this time the aircraft entered the fog and all external visual references would have disappeared suddenly. Although the approach lights were at full brightness, they were not seen. The commander may have become absorbed with seeking visual reference, in the unexpectedly altered conditions, and thereby distracted from the primary task of monitoring the approach and making the SOP '*decision*' call. He had no perception of the passage of time from the '*100 feet above*' call, believing that only a few seconds elapsed before he saw the glideslope antenna ahead of the aircraft. In fact, the elapsed time would have been around 25 seconds.

The co-pilot's task of flying the approach would have become increasingly demanding as the aircraft descended and it is probable that his attention was fully absorbed by this. This was confirmed by his erroneous perception that the aircraft was in IMC from below 2,000 feet amsl. The co-pilot reported that during the final stages of the approach, when he noticed he had lost the localiser indication, he had asked the commander whether he should go around. The response he reported he heard of "no, go left" was not what he had expected, and may correspond to the time from which no further control inputs were made. The commander could not recall having given any instructions to the co-pilot after the '*100 feet above*' call.

It is likely that the crew commenced the approach with an expectation that it would be completed visually. However, the weather conditions were unusual and the aircraft entered IMC unexpectedly, late in the approach. As an aircraft gets closer to a runway the localiser and glideslope indications become increasingly sensitive and small corrections have a relatively large effect. The task for the flying pilot becomes more demanding and the role of the monitoring pilot has greater significance. A successful outcome relies on effective crew co-ordination, based on clear SOPs. The monitoring of this approach broke down in the latter stages and the crucial 'decision' call was missed, which led to the aircraft's descent below minima.

Ignition source of the fire

The nature of the sooting pattern left on the accident site's grass surface indicates that a short duration 'flash' fire of vaporised fuel had occurred, following rupture of the aircraft's left wing fuel tank. A longer duration fire, fed by fuel continuing to leak from the damaged left wing, caused considerable damage to the left side of the aircraft. This fire continued for approximately three minutes, until extinguished by the RFFS.

Since the area of burned grass originated 3 m closer to the ILS glideslope antenna tower than the first ground impact mark, it is possible that the fire could have started immediately after the aircraft's collision with the tower. Possible ignition sources in this scenario include electrical arcing from the tower's exposed electrical cables, sparks caused by metal-to-metal contact during the collision, and fuel vapour ingestion into the left engine.

However, another possible scenario was that the fire started at some point following the aircraft's initial ground impact. If this were the case, the fuel vapour released following the aircraft's collision with the tower could have ignited, causing the sooting pattern observed at the accident site.

Fire-fighting appliance access to the accident site

The area of ground where the aircraft stopped was within the runway strip and, at the time of the accident, this grass area was soft due to recent rainfall. The omission by the driver of one appliance to engage the vehicle's differential locks, prior to driving on the soft grass surface, led to this appliance becoming bogged down. The other three appliances were able to traverse the difficult ground conditions successfully with their differential locks engaged.

Safety action

After the accident, the aircraft operator considered whether changes to their operating procedures might be made to prevent the possibility of a similar accident occurring again. A flight crew notice was issued concerning the conduct of instrument approaches. The significant changes were that all IMC approaches should, where possible, be flown with the autopilot engaged. Should this not be possible, then use of the flight director should be made. This would require the left seat pilot to act as pilot flying because there is no flight director available on the right hand instrument panel.

The Air Traffic Services provider at the airport conducted their own internal investigation. Several safety actions were identified, to be followed up. One action was for the airport operator to give consideration to the provision of recording raw surface movement radar data.

The aerodrome's RFFS personnel, who receive annual off-road driver training, have been reminded of the importance of ensuring that their appliances' differential locks are engaged before the vehicle leaves a paved surface, in the event that they are required to respond to an 'off-road' situation.

SERIOUS INCIDENT

Aircraft Type and Registration:	Cessna 680 Citation Sovereign, G-CJCC
No & Type of Engines:	2 Pratt & Whitney Canada PW306C turbofan engines
Year of Manufacture:	2008
Date & Time (UTC):	30 September 2010 at 0825 hrs
Location:	During climb after departure from London Luton Airport
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 3 Passengers - 5
Injuries:	Crew - None Passengers - None
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	51 years
Commander's Flying Experience:	6,500 hours (of which 350 were on type)
Information Source:	AAIB Field Investigation

Synopsis

The crew experienced an uncommanded transfer of fuel from the right to the left fuel tank after following the checklist procedures for a left main electrical bus fault indication. The aircraft subsequently became left wing heavy and exceeded the lateral imbalance limits. It returned to Luton Airport where a flapless landing was completed without further incident. As a result of this incident, Special Bulletin S1/2010 was published on 8 October 2010, containing two Safety Recommendations. The investigation established that the isolation of the left main bus had caused a false fuel cross-feed command which resulted in the uncommanded fuel transfer. The aircraft manufacturer has published a temporary flight crew procedure to mitigate the effects of a recurrence and has also issued a service bulletin to incorporate a design solution.

Eight further Safety Recommendations are made in this bulletin, relating to aircraft certification processes and flight recorder documentation.

History of the flight

The aircraft was operating a commercial passenger flight from London Luton Airport, to Milas-Bodrum Airport, Turkey. It departed with a full fuel load of approximately 11,000 lb. As it passed FL300 for FL320 in the climb, the DC EMER BUS L amber Crew Alerting System (CAS) message appeared. The crew referred to the Emergency/Abnormal Procedures checklist and, from the observed indications, concluded that there was a fault on the left main electrical bus. They completed the required action items, which included selecting the left generator OFF. They elected to return to Luton as the weather there was favourable and it was only 20 minutes flying time.

When the left generator was selected OFF, a number of systems lost power, including the flaps, the left fuel quantity indication and the commander's Primary Flight Display (PFD). The commander handed control to the co-pilot, who remained the handling pilot for the rest of the flight. As the flight progressed, the co-pilot became aware that an increasing amount of right aileron control input was required to maintain a wings-level attitude. A flapless landing was completed at Luton Airport without further incident.

When the aircraft was powered up again, all systems appeared to operate normally, including the left fuel quantity indication. The left tank fuel quantity indication was approximately 5,500 lb (corresponding to full) and right tank indication was approximately 3,300 lb. The crew confirmed that they had not selected the fuel cross-feed during the flight.

Fuel system

Two separate integral wing fuel tanks, each with a capacity of 5,500 lb, provide fuel for the engines and auxiliary power unit. Each engine is normally supplied from its on-side fuel tank. An electrically-driven boost pump supplies fuel pressure for engine starting. A motive-flow pump provides fuel to the engine once it is running and the boost pump is then switched off. The engine-driven fuel pump provides excess fuel flow capacity, with the excess fuel being returned to the on-side tank. The excess flow is used to operate the motive-flow pump.

A selectable fuel cross-feed facility allows either fuel tank to supply the opposite engine. When selected, the cross-feed valve is commanded open and the electric boost pump in the selected tank operates. A signal is sent to the cross-fed engine to close the motive-flow shutoff valve to the tank not in use, so that any excess fuel flow is returned to the selected tank.

The maximum permissible lateral fuel imbalance is 400 lb, but this can be increased to a maximum of 800 lb in an emergency.

Flight recorders

The aircraft was equipped with a Cockpit Voice Recorder (CVR) and a Flight Data Recorder (FDR).

The CVR recorded the first part of the flight, including the crew's acknowledgement of the DC EMER BUS L amber CAS message. It continued to record their subsequent actions until power to the CVR was lost when the crew switched the left generator OFF. The CVR is powered from the left main electrical bus.

The FDR is powered from the right main electrical bus and remained powered throughout the flight. However, many of the FDR parameters are sourced from systems powered by the left bus and these parameters were lost when the left generator was switched OFF.

The FDR data show that the EMERGENCY LEFT DC parameter became active 15 minutes after takeoff, with an associated master caution. Approximately four minutes later, the left DC generator became inactive, with another associated master caution. This was accompanied by the loss of many parameters, including the left fuel quantity. Just prior to losing the left fuel quantity parameter, 4,896 lb of fuel was indicated in the left tank and 4,856 lb in the right tank. The aircraft landed forty minutes later. The next time power was restored to all systems the left fuel quantity was recorded as 5,520 lb and the right as 3,376 lb, an imbalance of 2,144 lb. This equates to an average fuel transfer rate of approximately 50 lb per minute.

Both the left and right fuel flow parameters remained active throughout the flight and indicated similar fuel usage.

There are no FDR parameters relating to the cross-feed valve or the boost pump. Recorded data recovered from the engine controllers indicate that the motive-flow shutoff valves on both engines did not move during the incident.

Post-incident testing

During ground testing under AAIB supervision, it was established that removing power from the left main electrical bus caused the fuel cross-feed valve to open and the right fuel boost pump to operate, with the cross-feed selector switch in the OFF position. FUEL CROSSFEED and R BOOST PUMP messages were also displayed on the CAS. Tests on another, similar aircraft produced the same result.

Further investigation

Fuel control system

Normal fuel system control is fully automatic, with control being provided via the left and right electronic fuel control cards. Fuel system control is available in the flight deck through the fuel BOOST switches and the CROSSFEED selector knob. The cross-feed signal inputs on the left and right fuel control cards are electrically connected. The investigation identified that a loss of power on the left fuel control card will provide a low impedance input to the right hand fuel control card, generating a false fuel cross-feed command. This causes the fuel cross-feed valve to open and the right boost pump to start, but it does not close the motive-flow shutoff valve, with the result that uncommanded fuel transfer from the right to the left tank will occur.

Electrical system

The cause of the initial electrical event which caused the DC EMER BUS L amber CAS message to be displayed was investigated. After extensive troubleshooting and ground testing by the aircraft manufacturer's representatives, a power distribution printed circuit board was identified to be at fault. This was replaced and the fault did not reoccur.

Aircraft certification and testing

The US Federal Aviation Administration was the regulatory agency responsible for issuing the type certificate for the Cessna Citation 680 Sovereign; European type certification was later granted by EASA. There is considerable harmonisation of design standards between the USA and Europe and as such each regulator is willing to accept each other's certification through a validation process with only slight variations to meet any specific certification requirements of the accepting regulator. Nevertheless, the accepting regulator will usually be engaged with the primary regulator and the manufacturer during the initial certification process.

During the certification testing the aircraft manufacturer considered that both main electrical buses degrading to EMER was a more critical condition, from a safety analysis standpoint, than only one side degrading to EMER and therefore testing was focussed on the former condition. The test plan was written by the manufacturer and during the test plan review for certification the regulator concurred that the worst case scenario was adequate. For future aircraft designs incorporating a split bus electrical system, the manufacturer, in agreement with the regulator, intends to conduct testing with each side in turn in a degraded power mode while the other side remains in normal mode.

In this case, regardless of the cause of the initial failure, the approved checklist procedure specified in the Airplane Flight Manual followed by the crew resulted in an undesirable and potentially unsafe aircraft configuration. Therefore the following Safety Recommendation is made:

Safety Recommendation 2011-023

It is recommended that the Federal Aviation Administration (FAA) reviews the certification process for the Cessna Citation 680 Sovereign with the Cessna Aircraft Company to ensure that adherence to approved checklist procedures does not result in an unsafe aircraft configuration.

Flight Data Recorder documentation

Operator requirements

FDRs record binary data containing encoded information from aircraft systems. The FDR data is converted to engineering units (knots, feet etc.) by referencing detailed documentation specific to that aircraft installation. Commission Regulation (EC) 859/2008, referred to as EU-OPS, provides common technical requirements and administrative procedures applicable to commercial transportation by aeroplane. EU-OPS 1.160, '*Preservation, production and use of flight data recorder recordings*', (a) (4) states:

> *'(4) When a flight data recorder is required to be carried aboard an aeroplane, the operator of that aeroplane shall:*
>
> *…(ii) Keep a document which presents the information necessary to retrieve and convert the stored data into engineering units.'*

ICAO Annex 6 (ninth edition) Appendix 8 '*FLIGHT RECORDERS*' 2.3.3 also states:

> *'2.3.3 Documentation concerning parameter allocation, conversion equations, periodic calibration and other serviceability/maintenance information shall be maintained by the operator. The documentation needs to be sufficient to ensure that accident investigation authorities have the necessary information to read out the data in engineering units.'*

The operator could not provide the AAIB with controlled documentation that met the above requirements. The Regulator, in this case the CAA, had assumed that the information was readily available from the manufacturer. When asked to source the appropriate documentation, the operator referred to the company that carried out the annual replay of the FDR. That organisation had carried out the FDR raw data conversions by referencing an uncontrolled document. The CAA has published guidance for the content and format of the required documentation under CAP 731 '*Approval, Operational Serviceability and Readout of Flight Data recorder Systems and Cockpit Voice Recorders*'. The absence of readily available controlled documentation concerning FDR parameter conversions could hinder accident investigations. Therefore the following Safety Recommendations are made:

Safety Recommendation 2011-024

It is recommended that the Civil Aviation Authority ensure that UK operators of aircraft equipped with flight data recorders hold and maintain controlled documentation that satisfies the intent of CAP 731 and complies with the requirements of EU-OPS 1.160 (a) (4) (ii).

Safety Recommendation 2011-025

It is recommended that the Civil Aviation Authority include in their processes associated with the issuing of Air Operator Certificates a check to ensure that the operator's procedures comply with requirements of EU-OPS 1.160 (a) (4) (ii).

Manufacturer's requirements

The organisation most likely to possess the information and expertise required to generate a suitable FDR decode document is the organisation that designed the FDR installation. In this case, the FDR installation was 'as delivered' by the aircraft manufacturer and formed part of the aircraft's type certification. However, the aircraft manufacturer did not have any controlled documentation that provided the necessary detail. The aircraft manufacturer referred to the avionic system equipment manufacturer who was able to provide a controlled document with sufficient detail for the purposes of this investigation. However, this document is proprietary to the equipment manufacturer and was not shared with the aircraft operator, which was therefore unable to fulfil its obligations under Regulation (EC) 859/2008 to keep such a document.

FDR documentation issues have been identified in other AAIB investigations. Recent examples include the investigations into the incidents to Cessna 680, G-CDCX, on 9 December 2010 and Gulfstream G150, D-CKDM, on 6 February 2011. These involved different operators, aircraft models, aircraft manufacturers and FDR system manufacturers.

Commission Regulation (EC) No 1702/2003 of 24 September 2003 Part 21 requirement 21A.61 '*Instruction for continued airworthiness*' states:

'(a) The holder of the type-certificate…shall furnish at least one set of complete instructions for continued airworthiness…to each known owner of one or more aircraft…upon issue of the first certificate of airworthiness for the affected aircraft…and thereafter make those instructions available on request to any other person required to comply with any of the terms of those instructions. …'

This does not explicitly reference flight data recorder documentation and this is not reflected in any guidance material. However, correspondence with the CAA and EASA established that Part 21 requirement 21A.61 implicitly includes the FDR documentation. The same is true for requirements 21A.107 and 21A.120, which are applicable to holders of Minor and Major design change approvals respectively.

EASA CS 25.1529, CS 25.1729 and associated Appendix H similarly refer to '*Instruction for continued airworthiness*' and are interpreted as implicitly inclusive of the FDR documentation.

The implicit inclusion of FDR documentation in the above requirements is at odds with the lack of such documentation given that the Cessna Citation 680 Sovereign was granted an EASA type certificate. The following Safety Recommendation is therefore made:

Safety Recommendation 2011-026

It is recommended that the European Aviation Safety Agency ensures that design organisations under their jurisdiction responsible for approvals affecting Flight Data Recorder (FDR) installations, hold the documentation required for decoding the FDR data, and that the documentation is to a suitable standard and available to operators.

EASA is in the process of developing EU-OPS. Proposals include FDR recording annual inspections and other checks, in line with ICAO Annex 6, Part I and Annex II-B of EUROCAE ED-112, the flight recorder standard. These proposals further emphasise the need for appropriate FDR documentation available to the operator.

Given that the above design requirements do not explicitly require FDR documentation that supports current and proposed FDR operational requirements, the following Safety Recommendation is made:

Safety Recommendation 2011-027

It is recommended that the European Aviation Safety Agency review their certification requirements, guidance and procedures to ensure that controlled documentation, sufficient to satisfy operator flight data recorder documentation requirements, are explicitly part of the type certification and supplemental type certification processes where flight data recorder installations are involved.

AAIB correspondence with the US Federal Aviation Authority indicated that FDR documentation is not required as part of the FAA type certification process. This leaves a gap whereby system-specific documentation required by the operator is not required to be produced by the aircraft manufacturer. Therefore the following Safety Recommendation is made:

Safety Recommendation 2011-028

It is recommended that the Federal Aviation Administration ensure that controlled documentation, sufficient to satisfy operator flight data recorder documentation requirements, is part of the type certification and supplemental type certification processes where flight data recorder installations are involved.

Flight recorder documentation quality

CAP 731, produced by the CAA, provides comprehensive guidance on the level of information expected in the documentation kept by the operator. The FAA document AC 20-141B also provides guidance standards for flight data recorder documentation. No similar guidance is available from EASA; therefore the following Safety Recommendation is made:

Safety Recommendation 2011-029

It is recommended that the European Aviation Safety Agency provides guidance detailing the standards for the flight data recorder documentation required for the certification of systems or system changes associated with flight data recorders.

Aircraft manufacturer

As a result of this investigation, the aircraft manufacturer began creating a controlled document to meet the operator's needs for this aircraft type, but not to any specific document standard. Another AAIB investigation into an incident on 9 December 2010, involving a different aircraft type (a Cessna Citation X, registration G-CDCX), found a similar lack of controlled documentation for FDR parameter conversion. The following Safety Recommendation is therefore made:

Safety Recommendation 2011-030

It is recommended that Cessna Aircraft Company issue controlled documents, applicable to Cessna aircraft equipped with flight data recorders, that satisfy the EU-OPS 1.160 (a) (4) (ii) requirement, and make them available to all operators of the applicable aircraft. Furthermore, it is recommended that the documentation issued should follow the guidance given in Federal Aviation Administration document AC 20-141B and UK Civil Aviation Authority document CAP 731.

The aircraft manufacturer responded to this Safety Recommendation by issuing controlled documents AES-680-177 for model 680 aircraft and AES-75-161 for model 750 aircraft, which fully define the Flight Data Recorder parameters. These will be provided, at no charge, to any operator requesting them. The aircraft manufacturer intends to include complete parameter information with each FDR's Instructions for Continued Airworthiness (ICA) for each aircraft model. A full set of ICA documents is provided to every operator at the time of aircraft delivery.

Safety actions taken

AAIB Special Bulletin S1/2010 was published on 8 October 2010, containing two Safety Recommendations. The Recommendations and the actions taken are described as follows:

Safety Recommendation 2010-090

It is recommended that the Cessna Aircraft Company immediately informs all operators of Cessna Citation 680 Sovereign aircraft that uncommanded fuel transfer will occur during aircraft operation if the left main electrical bus is not powered.

In response to this Safety Recommendation, the Cessna Aircraft Company issued a briefing to Cessna Citation Sovereign operators on 14 October 2010. This briefing included the temporary mitigating action of pulling the appropriate FUEL BOOST circuit breaker to prevent fuel transfer should a similar condition occur. A temporary change to the Airplane Flight Manual and checklist was approved by the FAA on 15 October 2010 and this was subsequently e-mailed to the operator on 08 November 2010.

Safety Recommendation 2010-091

It is recommended that the Federal Aviation Administration (FAA) require the Cessna Aircraft Company to take suitable actions for the Cessna Citation 680 Sovereign, to prevent uncommanded fuel transfer during aircraft operation when the left main electrical bus is not powered.

To address aircraft already in service, ECR 70611 '*680 Fuel Crossfeed Improvement for Field - Service Bulletin*' was approved in December 2010 and is applicable to aircraft serial numbers 680-0001 thru 6800289 and 680-0291 thru 680-0296. Cessna issued Service Bulletin SB680-24-11 on 22 December 2010, requiring installation of diodes on the fuel control cards on all in-service aircraft. The FAA has taken actions to issue an Airworthiness Directive mandating Service Bulletin SB680-24-11. The compliance time for the SB will be within 400 flight hours or one year from the date of issuance of the AD, whichever occurs first.

To address this fault on new production aircraft, Cessna ECR 70612 '*680 Fuel Crossfeed Improvement for Production*' was approved in October 2010. ECR 70612 is applicable to aircraft serial numbers 680-0290 and 680-0297 and on. All new aircraft delivered since October 2010 have this design change incorporated.

ACCIDENT

Aircraft Type and Registration:	Piper PA-31-350 Navajo Chieftain, N678BY
No & Type of Engines:	2 Lycoming TI0-540-J2BD piston engines
Year of Manufacture:	1979
Date & Time (UTC):	2 April 2011 at 2145 hrs
Location:	JAGS McCartney International Airport, Grand Turk, Turks and Caicos Islands
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 5
Injuries:	Crew - None Passengers - None
Nature of Damage:	Flaps, propellers, right wingtip and landing gear doors
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	56 years
Commander's Flying Experience:	5,000 hours (of which 1,500 were on type) Last 90 days - 86 hours Last 28 days - 28 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

On final approach to his intended destination, the pilot selected the landing gear to the DOWN LOCKED position but it failed to extend fully. The aircraft diverted to an alternate airport and landed with the landing gear partially extended, resulting in damage to the aircraft but without injury to the pilot or passengers. Hydraulic fluid leaking from a failed hydraulic hose prevented the landing gear from operating normally.

History of the flight

The aircraft departed Ft Lauderdale Executive Airport, Florida, at 1800 hrs on a private flight to Providenciales Airport in the Turks and Caicos Islands. The pilot was accompanied by five passengers, and the fuel endurance of the aircraft at departure was calculated by the pilot to be 4 hours and 30 minutes.

The flight proceeded uneventfully until the aircraft was 5 nm from Providenciales Airport, on final approach for Runway 10, when the pilot attempted to extend the landing gear. No green DOWN LOCKED lights were observed and the red NOT LOCKED light remained illuminated, indicating that the landing gear had failed to extend fully.

The pilot continued the approach and made a low pass along the runway to permit visual examination of the landing gear by the ATC tower controller, who confirmed that the landing gear was partially extended. The pilot then entered a holding pattern to the south of Providenciales Airport for 15 minutes, whilst attempting to lower the landing gear using the manual extension handle. This attempt was also unsuccessful. ATC then cleared the aircraft for a visual approach for Runway 10, but when the aircraft was 2 nm from touchdown, ATC instructed the pilot to execute a missed approach and divert to JAGS McCartney International Airport. JAGS McCartney International Airport is on the island of Grand Turk and is 66 nm from Providenciales Airport.

On arrival at JAGS McCartney International Airport, the pilot made a low pass along Runway 11 to permit another visual examination by the ATC tower controller, who confirmed that the landing gear remained partially extended. The weather at Grand Turk was described by the pilot as being good, with scattered clouds at 1,500 ft. The pilot briefed the passengers to prepare them for a gear-up landing. Immediately prior to touchdown, the pilot positioned the fuel selector valves to OFF and closed the throttles. The aircraft landed on Runway 11, touching down on the left main landing gear leg and, shortly thereafter, settling onto the right wingtip. During the landing rollout, the left main landing gear leg retracted and the aircraft slewed to the right by approximately 90º, before coming to rest on the edge of Runway 11, halfway along the 6,362 ft runway.

The AFRS were quickly in attendance but no fire or fuel spillage occurred, and the pilot and passengers were able to exit the aircraft from the main cabin door. The pilot estimated that fuel equating to 20 minutes of flying time remained on board the aircraft following the landing.

Assessment of the cause

Following the accident the aircraft was inspected and it was apparent that a hydraulic hose, running to the actuator on the right main landing gear door, had failed, allowing hydraulic fluid to leak from the system. The loss of hydraulic fluid also prevented the emergency hand-pumped landing gear extension system from functioning.

Discussion

The aircraft was diverted from landing at Providenciales Airport in order to avoid blocking the airport's single runway and causing delays to scheduled airline flights. The aircraft carried sufficient fuel for the diversion and the pilot commented that he was willing to comply with the diversion request, as the weather conditions at JAGS McCartney International Airport were suitable for a visual approach.

ACCIDENT

Aircraft Type and Registration:	Aquila AT01, G-GAEA
No & Type of Engines:	1 Rotax 912-S3 piston engine
Year of Manufacture:	2010
Date & Time (UTC):	10 April 2011 at 0853 hrs
Location:	Blackpool Airport
Type of Flight:	Training
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Propeller, nose landing gear
Commander's Licence:	Student
Commander's Age:	30 years
Commander's Flying Experience:	18 hours (of which 7 were on type) Last 90 days - 7 hours Last 28 days - 4 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The accident occurred on Runway 10 at Blackpool Airport in CAVOK conditions and with a 140/09 wind. It was the student pilot's first solo landing after having completed six dual circuits. During the landing, the instructor observed that the aircraft rounded out too high. The nose was seen to lower and raise again, resulting in a bounce on the main wheels. The nose was lowered once more and the nosewheel and propeller contacted the ground. The student brought the aircraft to a stop on the runway and shut it down; the emergency services attended the scene. The student was unhurt but the aircraft sustained damage to the nose landing gear and propeller. The pilot considered that the approach was too fast and that a go-around should have been executed after the bounce.

ACCIDENT

Aircraft Type and Registration:	Bolkow BO 208C Junior, G-BOKW
No & Type of Engines:	1 Continental Motors Corp O-200-A piston engine
Year of Manufacture:	1969
Date & Time (UTC):	7 April 2011 at 1400 hrs
Location:	Lodge Farm, Saint Osyth, near Clacton, Essex
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Nosewheel fork bent, propeller damaged and engine shock-loaded
Commander's Licence:	Private Pilot's Licence
Commander's Age:	77 years
Commander's Flying Experience:	982 hours (of which 187 were on type) Last 90 days - 7 hours Last 28 days - 6 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

Landing at a grass airstrip, the pilot realised there was a pair of white swans grazing by the side of the runway. He applied power and lifted off until past the swans but, descending, the nose of the aircraft struck the ground hard, damaging the nose landing gear. The pilot considers this most likely occurred due to the tailskid contacting the ground with the aircraft in a nose-high attitude.

History of the flight

The pilot was returning to Lodge Farm, a small private airstrip close to Clacton airfield. Lodge Farm has a grass surface 800 metres long running east-west, so to land to the west the pilot joined the left-hand circuit at Clacton for Runway 36, turning left at 800 feet onto finals for Lodge Farm.

The pilot flew the landing approach at 70 kt, with 28º of flap, and noted what he believed to be a couple of white bags to the side of the runway (the local farmer had placed white bags on wooden poles to denote boggy areas in the field). The pilot "rounded out" and touched down. He then realised the "bags" were actually a pair of white swans grazing on corn shoots to the northern side of the runway, about 50 metres ahead of the aircraft.

Not choosing to risk contact with the swans, but concerned as to whether the aircraft would clear the building at the end of the runway, the pilot opted to apply power and lift off in ground effect until past the swans. He did this, with a moderately high nose-high attitude. When past the swans, he eased back on power and the aircraft sank, then very suddenly the nose dropped and the aircraft "pancaked onto the runway", damaging the nose landing gear and allowing the propeller to strike the runway. The aircraft came to rest on the runway and, after "turning everything off", the pilot opened the canopy and got out of the aircraft. The two swans, meanwhile, completely ignored the situation and continued to graze.

The pilot considers it possible that he stalled the aircraft but, more likely, that the tailskid may have touched the ground with the aircraft in the nose-high attitude, rotating the aircraft nose down sufficiently rapidly to damage the nose leg.

ACCIDENT

Aircraft Type and Registration:	Cessna 150M, G-BSYV
No & Type of Engines:	1 Continental Motors Corp O-200-A piston engine
Year of Manufacture:	1976
Date & Time (UTC):	8 April 2011 at 1020 hrs
Location:	Fenland Airfield, Lincolnshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Nosewheel, propeller, firewall, fuel pipe, engine
Commander's Licence:	Private Pilot's Licence
Commander's Age:	48 years
Commander's Flying Experience:	117 hours (of which 36 were on type) Last 90 days - 5 hours Last 28 days - 2 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Following an uneventful local flight the pilot joined the circuit at Fenland Airfield to land on Runway 26. The wind was calm with good visibility. At touchdown, the aircraft landed heavily on the nosewheel and then bounced back into the air, after which the pilot decided to go around. On the second attempt to land, the nose landing gear collapsed at touchdown causing the propeller to strike the ground. The aircraft then veered to the right before coming to a rest. The pilot considered that the heavy landing and subsequent bounce was due to flaring the aircraft too early.

ACCIDENT

Aircraft Type and Registration:	Grob G115D2, G-BVHF
No & Type of Engines:	1 Lycoming AEIO-320-D1B piston engine
Year of Manufacture:	1994
Date & Time (UTC):	27 April 2011 at 1807 hrs
Location:	Dundee Airport, Scotland
Type of Flight:	Training
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Engine shock-loaded, nose leg and propeller damaged
Commander's Licence:	Student
Commander's Age:	19 years
Commander's Flying Experience:	25 hours (of which 4 were on type) Last 90 days - 4 hours Last 28 days - 4 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The student, with his instructor, was flying a number of touch-and-go landings when, following a firm touch down on the main and nosewheels, the nose landing gear collapsed.

History of the flight

The student flew a number of touch-and-go landings and his instructor commented that the first two were executed reasonably well though he did notice some nosewheel shimmy. On the third landing the aircraft touched down firmly on its main and nosewheels and at the same time the aircraft experienced severe nosewheel shimmy. The instructor advised the student not to overuse the rudder pedals to compensate for the shimmy, but to reduce the pressure on the nosewheel by easing back on the control column. As this action caused the shimmying to stop, the instructor allowed the student to continue with the takeoff. On the next landing the aircraft touched down on its main wheels and as the nosewheel was lowered onto the runway it collapsed.

Nosewheel shimmy

Nosewheel shimmy is caused by excessive vibration of the wheel when it is in motion. The Grob 115D2 is equipped with an oil-filled shimmy damper that is designed to dampen out the vibration. However, shimmy can still occur if the damper is not correctly maintained, the runway surface is poor or a load is placed on the nosewheel while the aircraft is travelling along the runway at a relatively high speed. The latter effect can be reduced by landing on the mainwheels and keeping the load off the nosewheel by applying a backward pressure on the control column.

Damage to the aircraft

The maintenance organisation advised the AAIB that the nose leg collapsed as a result of the failure of the lower attachment on the shock strut and were of the opinion that the damage was due to the aircraft landing heavily on its nosewheel. The shimmy damper was assessed as being serviceable and its attachment brackets were still intact.

ACCIDENT

Aircraft Type and Registration:	Pietenpol Air Camper, G-RAGS
No & Type of Engines:	1 Continental Motors Corp O-200-A piston engine
Year of Manufacture:	1994
Date & Time (UTC):	24 April 2011 at 1745 hrs
Location:	Shobdon Aerodrome, Herefordshire
Type of Flight:	Private
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Landing gear, engine cowling and front strut
Commander's Licence:	Private Pilot's Licence
Commander's Age:	68 years
Commander's Flying Experience:	750 hours (of which 13 were on type) Last 90 days - none Last 28 days - none
Information Source:	Aircraft Accident Report Form submitted by the pilot

The aircraft was flown by a pilot with a flying instructor for dual flying experience. The pilot took off from Shobdon, flew to the Clee Hill area and then returned to perform touch-and-go practice. The grass strip adjacent to Runway 09 was being used for this exercise. The wind was reported to be 5 kt to 7 kt from the north with benign weather conditions. At a height of approximately 20 ft after the second touch-and-go, the aircraft veered to the right. The pilot started correcting when the instructor took control. The aircraft was flown across the asphalt runway to the right and landed on the adjacent grass. The landing gear collapsed on landing, damaging the engine cowling and front strut but no injuries were sustained.

It was reported that a modification had recently been approved to address undercarriage collapse issues but it had not been embodied on this aircraft.

ACCIDENT

Aircraft Type and Registration:	Piper PA-28-161 Cherokee Warrior II, G-BSPM
No & Type of Engines:	1 Thielert TAE 125-02-99 piston engine
Year of Manufacture:	1981
Date & Time (UTC):	5 November 2010 at 1545 hrs
Location:	Ranmoor Common Road, Dorking, Surrey
Type of Flight:	Training
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - 2 (Minor) Passengers - N/A
Nature of Damage:	Damaged beyond economic repair
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	41 years
Commander's Flying Experience:	800 hours (of which 387 were on type) Last 90 days - 70 hours Last 28 days - 16 hours
Information Source:	AAIB Field Investigation

Synopsis

During a training flight the aircraft experienced a rapid loss of engine power. The instructor took control and made a forced landing in a ploughed field during which the aircraft became inverted. The loss of power was attributed to a failure of the propeller reduction gearbox due to oil loss from a cracked union on the oil cooler. Analysis of data recorded by the engine's Full Authority Digital Engine Control (FADEC) unit confirmed that a defect within the propeller system had been apparent prior to takeoff and that the engine had been 'overspeeding' shortly after commencing the takeoff. No warnings or cautions were observed by the pilot or instructor until approximately 20 seconds before the loss of engine power.

History of the flight

The flight had been planned as a training exercise to simulate deteriorating en route weather conditions. The pilot and instructor completed the pre-flight inspection together and no problems were identified. After carrying out the engine start and pre-flight '*FADEC AND PROPELLER ADJUSTMENT FUNCTION TEST*', the aircraft entered the runway where a pre-takeoff power check was carried out. No abnormal engine indications were observed during any of these checks. After takeoff, the flight appeared to progress normally. No warnings or cautions were observed until approximately 12 minutes into the flight when the Compact Engine Display (CED) caution light illuminated and remained lit. The instructor observed that the propeller reduction gearbox oil temperature had increased and was in the amber range of the temperature gauge with no other changes in engine parameters being apparent.

A PAN was declared and the instructor decided to carry out a precautionary landing at Redhill Airfield, which was nearby. Approximately 20 seconds later, an audible power fluctuation was heard and the engine power gauge was observed to fluctuate between 5% and 8%. Both FADEC warning lights were flashing rapidly and the propeller rpm gauge was indicating 2,400 rpm. The instructor declared a MAYDAY and completed a forced landing in a ploughed field. After touchdown, the aircraft pitched forward and came to rest inverted. The instructor made the aircraft safe and remained with the student in the aircraft until the arrival of the emergency services. Both pilots suffered minor injuries.

Aircraft and engine description

The aircraft was a Piper PA-28-161 which had been re-engined with a Thielert TAE 125-02-99 piston engine. This was a liquid-cooled four-cylinder direct injection diesel engine which drove a variable pitch propeller through a reduction gearbox. The engine and propeller were controlled with a single 'thrust lever' which provided an input to a dual channel FADEC unit. This unit then optimised the engine speed and propeller pitch to match the pilot's control inputs.

The aircraft was fitted with a multi-function instrument which displayed the propeller rpm, engine load, reduction-gearbox oil temperature and pressure, and engine cylinder temperatures, Figure 1. Both propeller rpm and 'load' were displayed digitally and in the form of a strip of green LEDs. The propeller rpm LED strip

Figure 1

Typical Thielert TAE 125 engine layout instrumentation was marked with the maximum propeller speed of 2,300 rpm, and a red LED at the end of the rpm LED strip illuminated if it exceeded this limit. The aircraft was also fitted with a 'lightpanel' which contained two FADEC warning lights, the FADEC test knob and the CED caution light. In the event of a problem being detected within either channel of the FADEC unit, the associated FADEC warning light should flash. The CED caution light was designed to illuminate when an engine parameter exceeded its normal operational range. In addition, the CED caution light was designed to illuminate if the propeller speed remained between 2,301 rpm and 2,400 rpm for 20 seconds, or if it exceeded 2,401 rpm for two seconds.

The operation of the Thielert TAE 125-02-99 engine is detailed in the approved supplement to the aircraft's Pilot Operating Handbook (POH) and includes all of the operating limitations and checklists appropriate to the installation. Part of the pre-takeoff checks includes a *'FADEC AND PROPELLER ADJUSTMENT FUNCTION CHECK'*. This test involves pressing and holding down the FADEC knob on the 'lightpanel'. The FADEC then runs through a series of tests of the engine and propeller control systems, using each FADEC channel in turn. During the check, the respective FADEC channel warning light illuminates and the engine rpm increases to allow the propeller pitch control system to be tested. On completion of the test, the engine returns to its idle speed and both FADEC lights should be OFF. If either or both FADEC warning lights flash after the test, this indicates that a fault has been detected and the flight should not be continued. The final step of this check is to advance the thrust lever to its maximum power position and confirm that the engine is producing a minimum of 94% load with a propeller speed between 2,240 rpm and 2,300 rpm. There is no specified minimum duration for this test and the checklist used by the instructor during the accident flight stated that its duration should not exceed 10 seconds.

Investigation

The aircraft was examined in situ by its maintenance organisation and subsequently recovered to their facility for detailed examination. The engine gearbox was removed and sent to the manufacturer for further assessment. The manufacturer was able to determine that a failure within the gearbox had resulted in the loss of engine power. This failure was attributable to the loss of gearbox oil from a cracked union on the gearbox oil cooler. The mounting bracket for the oil cooler was found to have broken, allowing the cooler to move, which resulted in the cracking of the union. It could not be determined when the mounting bracket failed. The instructor confirmed that the gearbox oil level had appeared normal during the pre-flight inspection and there had been no evidence of an oil leak. An inspection of the aircraft's parking place confirmed that no oil was present on the hard standing.

A download of the engine's FADEC provided a significant amount of information regarding the engine's performance. Analysis of this data showed that, during the pre-takeoff FADEC test, the propeller did not respond correctly to the commanded pitch changes. The data also showed that the pre-takeoff power check appeared to have been carried out approximately four and a half minutes prior to takeoff. This power check lasted for approximately four seconds and the propeller rpm reached 2,305 rpm for one second. This 'overspeed' was of insufficient magnitude and duration to cause the CED caution light to illuminate.

Approximately two seconds after starting the takeoff run the FADEC recorded the propeller speed exceeding the 2,300 rpm limitation. The propeller remained in this overspeeding condition until the failure of the reduction gearbox approximately 12 minutes after takeoff. The instructor confirmed that the CED caution light had remained off until approximately 20 seconds before the loss of engine power. The reason why the CED caution light did not illuminate during the prolonged overspeed could not be determined.

The only other indication of the overspeed condition would have been the illumination of the small red LED at the end of the rpm indication strip and the reading on the digital rpm gauge which, due to the nature of such gauges, would have been continually changing. In addition, the propeller rpm and load gauge was located low on the instrument panel, Figure 1. A review of the POH supplement confirmed that pilots are only directed to check the propeller rpm during the *'FADEC AND PROPELLER ADJUSTMENT FUNCTION CHECK'*; during all other phases of flight the 'load' gauge is the primary means of confirming engine power.

The recorded data also showed that the reduction gearbox oil temperature continued to rise until approximately 12 minutes after takeoff when the first FADEC warning, regarding gearbox oil temperature, was generated and the CED caution light was seen to come on and remain illuminated.

Conclusions

The loss of gearbox oil from the cracked oil cooler union resulted in a loss of oil pressure and subsequent failure of both the propeller control system and, ultimately, the reduction gearbox. It is probable that the failure of the oil cooler mounting bracket allowed sufficient movement of the oil cooler to cause the union to crack. The timing and reason for the failure of the bracket could not be determined.

The lack of evidence of an oil leak during the pre-flight inspection and the failure of the propeller to change pitch correctly during the pre-takeoff test suggest that the union cracked at some point between starting the engine and completing the FADEC test. The loss of gearbox oil resulted in the eventual failure of the reduction gearbox and subsequent loss of power.

The failure of the propeller pitch change mechanism allowed the engine and propeller to overspeed during takeoff and in flight until the loss of engine power. The pilots were unaware of this problem until the CED caution light illuminated continuously, approximately 12 minutes into the flight. Had the CED caution light illuminated earlier, during the takeoff run or the initial stages of the climb, there may have been an opportunity for a precautionary landing to be carried out.

INCIDENT

Aircraft Type and Registration:	Rans S7 Courier, G-OJKM
No & Type of Engines:	1 Rotax 912-UL piston engine
Year of Manufacture:	2003
Date & Time (UTC):	4 May 2011 at 1520 hrs
Location:	Glenforsa, Isle of Mull
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Right landing gear, airframe and propeller
Commander's Licence:	Private Pilot's Licence
Commander's Age:	64 years
Commander's Flying Experience:	1,912 hours (of which 89 were on type) Last 90 days - 23 hours Last 28 days - 15 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

As the pilot neared Glenforsa Airfield, he was informed by the airfield manager of a turbulent crosswind and downdrafts at the beginning of the Runway 07. The pilot decided to make an approach to land and judge the conditions for himself. He brought the aircraft to within a few feet of the runway surface, flying right wing down into the crosswind. He encountered some turbulence but the aircraft remained fully controllable and so he maintained this attitude, hoping to touchdown once out of the turbulence. However, the aircraft suddenly dropped and the right wheel contacted the ground. The pilot maintained directional control and landed, unaware that the right mainwheel and axle had broken away from the undercarriage leg. As the aircraft came to a stop it turned about its right undercarriage leg and tipped forwards causing the propeller to strike the ground and part of one of the blades detached.

On inspection of the detached wheel and axle assembly, the pilot found what looked like a pre-existing crack at the fractured end of the attachment tube. He considered that although the landing was firm, it was not heavy enough to have broken the tube without an existing weakness.

In a full and honest statement the pilot advised that he had inadvertently allowed his medical and the aircraft's permit to fly to lapse.

ACCIDENT

Aircraft Type and Registration:	Tipsy Nipper T.66 Series 2, G-ATBW
No & Type of Engines:	1 Volkswagen 1834 (Acro) piston engine
Year of Manufacture:	1962
Date & Time (UTC):	3 February 2011 at 1530 hrs
Location:	South of Flemings Farm, South Hanningfield, Chelmsford, Essex
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Propeller detached from the aircraft
Commander's Licence:	Private Pilot's Licence
Commander's Age:	51 years
Commander's Flying Experience:	394 hours (of which 243 were on type) Last 90 days - 3 hours Last 28 days - 1 hour
Information Source:	AAIB Field investigation

Synopsis

Four of the six bolts that secured the wooden propeller to the engine worked loose causing all the bolts to fail and the propeller to detach from the aircraft in flight. The aircraft landed safely in a field.

The investigation discovered that two of the bolts had not been wire locked and two others had been wire locked incorrectly. While the torque on the bolts had been checked within the recommended hourly maintenance interval, due to the low usage the aircraft had flown for almost two years without the torque having been checked.

History of the flight

The pilot departed Stapleford for a local flight during which he remained on the Stapleford Radio frequency of 122.800 MHz. When just south of Hanningfield reservoir, at a height of approximately 2,300 ft amsl, the pilot felt the aircraft shake briefly from side-to-side and at the same time he heard a thud from the front of the aircraft. The engine rpm increased and as the pilot closed the throttle he realised that the propeller had detached from the aircraft. He established the aircraft in a glide and transmitted a MAYDAY call to Stapleford Radio, but on hearing no response he assumed that the propeller had damaged the aerial. The aircraft subsequently made a safe landing in a small grass field, where the pilot discovered that the radio had moved in its mounting rack sufficient to cause the electrical connector to disconnect. The pilot reseated the radio and made a relay call through an airborne aircraft informing Stapleford as to what had happened and that he was uninjured.

The operator on duty at Stapleford Radio stated that a second aircraft, airborne from Stapleford, reported that the accident aircraft had had an engine failure and was making a forced landing. The operator informed Southend ATC of the situation, by telephone, who in turn informed the Distress and Diversion Cell. The police and an RAF rescue helicopter were dispatched to the area to search for G-ATBW. Stapleford Radio was subsequently informed by the second aircraft that the pilot of G-ATBW had reported that he was uninjured and passed this unconfirmed report onto Southend ATC. The search was called off once the police made contact with the pilot.

Inspection of the propeller assembly

The propeller, which was relatively undamaged, was recovered by the police and handed to the AAIB. The spinner was still attached and the six bolts that secured the propeller to the attachment plate on the engine crankshaft had all failed at the end of the threaded portion. The remaining threaded portion of the bolts remained in the inserts (lugs) fitted to the attachment plate. An examination of the fracture surfaces on two of the bolts revealed evidence of fatigue cracking emanating from the threads, with the bolt finally failing in ductile overload. Other bolts showed evidence of overload, one of which was covered in a black dust consistent with the oxidisation of fine particles that are generated when a bolt is subjected to fretting. The black dust was also apparent in three of the other holes through which the bolts were fitted, Figure 1.

From a photograph of the heads of the bolts, taken after the spinner was removed, it can be seen that only two pairs of the bolts had been wire locked; however, a small piece of locking wire remained in the hole in the head of one of the unlocked bolts, Figure 2. The wire locking of one pair of bolts was incorrectly routed and the distortion of the wire around the head of one of the bolts indicated that this section of wire had been twisted at least once before. There were approximately 6 twists

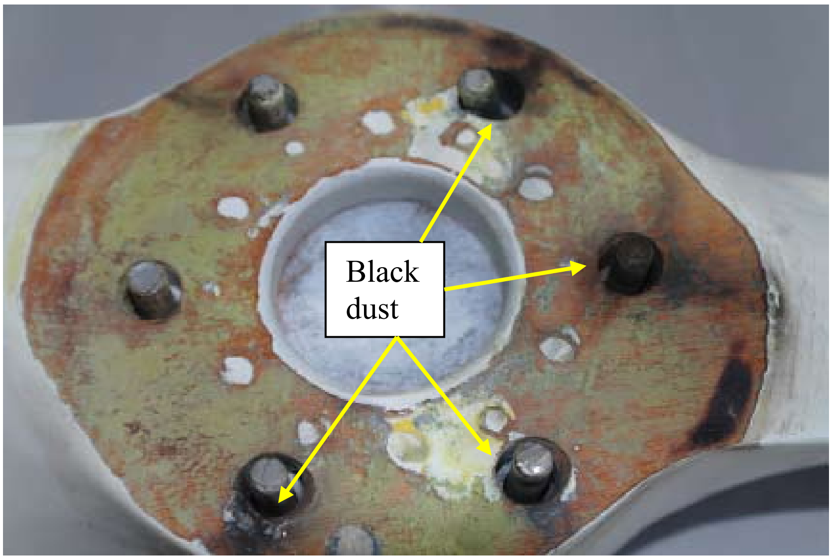

Figure 1

Black dust around bolts.

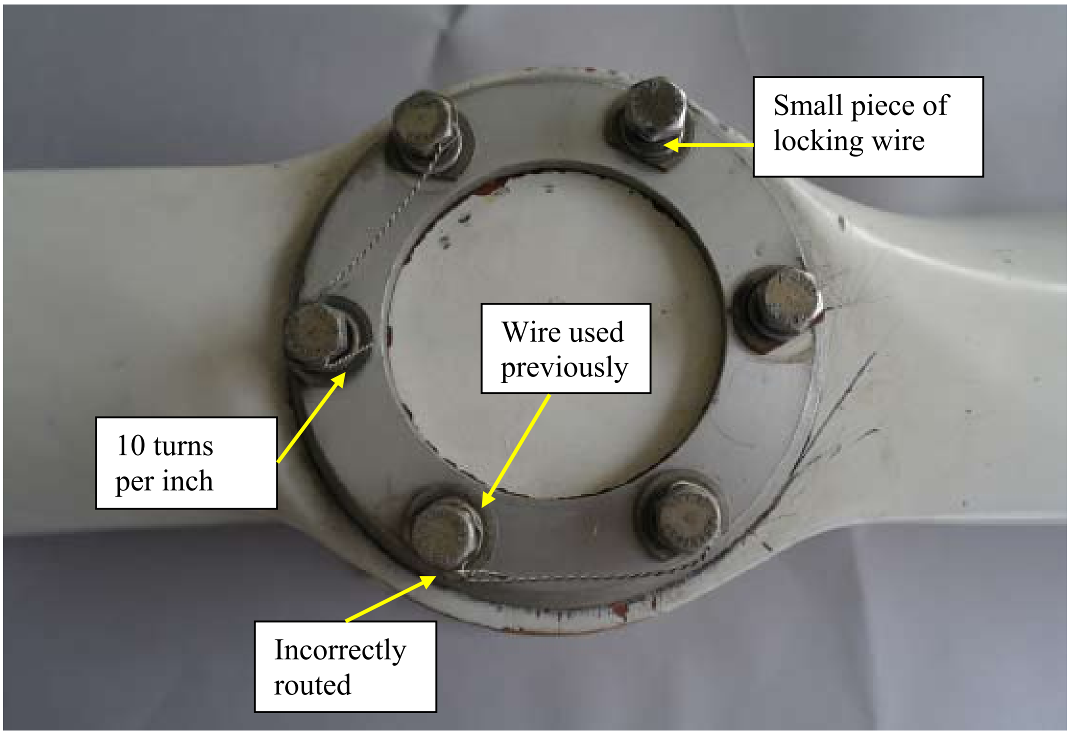

Figure 2

Wire locking on propeller bolt heads

per inch in the wire between each bolt head, which is within the recommendation of 6 to 8 twists per inch for this gauge of wire. However, the number of twists at the tail of the wire on one of the bolts was approximately 10 twists per inch. This over-twisting can result in the wire work hardening such that it becomes brittle and easy to break. Overall the standard of wire locking was assessed as being inadequate to prevent the bolts from becoming loose.

It was also noted that the marking on the head of the bolt heavily coated in black dust had different markings from the other five bolts. The marking indicated that it was an aircraft standard, high strength steel bolt. The other bolts were identified as UNF 4037 high strength alloy steel. An LAA inspector informed the AAIB that the bolts were the correct length and had not bottomed out. The use of different bolts was not considered to be a factor in this accident.

Maintenance on propeller assembly

The AAIB was provided with an extract from the aircraft maintenance manual that called for the torque on the propeller securing bolts to be checked with a calibrated torque wrench at the 25 hour inspection. In addition, at the 50 hour inspection, there was a requirement to remove and examine the propeller assembly and to check the tightness of the securing bolts again after the first flight.

The aircraft log book recorded that the propeller had been changed on 8 March 2008, approximately 37 flying hours before the accident. While there was an appropriate entry in the aircraft log book, by the owner and an LAA inspector, recording the replacement of the propeller, there was no record of the propeller securing bolts having been checked following the first flight.

The owner reported that the torque on the bolts was checked during the annual LAA inspection carried out in March 2009, approximately 24 flying hours prior to the accident. However, there was no entry in the log book or any worksheets to indicate that this work had been carried out. The LAA recommend in their SPARS[1] procedures that all work carried out on PFA [LAA] aircraft must be described and recorded. The owner stated that both he and the co-owner were present during the fitting and torque of the propeller bolts, and were supervised by an LAA inspector who wire locked the heads of the bolts. The owner recalled that the LAA inspector was not satisfied with the standard of the locking wire and so he redid it.

The owners advised the AAIB that the propeller securing bolts had not been checked or disturbed following the annual inspection carried out in March 2009 and were unable to explain the reason for the condition of the wire locking.

Propeller securing bolt torque

It is important to ensure that the propeller securing bolts are kept at the correct torque, otherwise vibration and flexing of the bolts can result in fatigue cracking. Wooden propellers are susceptible to changes in temperature and humidity, which can cause a change in the thickness of the hub resulting in a reduction of the torque on the securing bolts. G-ATBW had been kept in a heated hangar and there should not have been a large change in the temperature and humidity.

The maintenance manual calls for the torque on the propeller securing bolts to be checked every 25 hours. While the bolts had been checked within the 25 hour frequency, due to the low usage of the aircraft at the time of the accident it was almost two years since the torque had last been checked.

Audit of LAA inspectors

In 2004 the LAA (formally the PFA) introduced a four-yearly audit cycle of their inspectors. However, during this investigation it was noticed that the LAA had not yet completed the first audit cycle. Following discussions, the CAA and LAA undertook to develop and introduce a more robust and sustainable system for the auditing of LAA inspectors.

Comment

The damage to the failed portion of the bolts is consistent with them having failed as a result of a loss of torque to a number of the bolts. The damage to the ends of each bolt and the location of the black dust indicates that probably four of the bolts had worked loose leaving the remaining two bolts to take the load. It was not possible to establish if the bolts had been correctly torqued or had worked loose as a result of the inadequate wire locking or a change in moisture content in the wooden propeller hub. While the re-torque had been carried out within the required hourly maintenance interval, the low usage of the aircraft meant that the torque had not been checked in almost two years. Therefore, for such low usage aircraft, it might be more appropriate to base the re-torque of the propeller securing bolts on a calendar basis.

The LAA has published information on the maintenance of wooden propellers. They have also advised the AAIB that they will use this accident to inform their members of the necessity to check regularly the torque of the bolts used to secure the propeller to the engine, the correct way to wire lock bolts and the requirement to maintain complete records of work carried out on aircraft.

Footnote

[1] SPARS is the LAA guidance document for LAA inspectors.

ACCIDENT

Aircraft Type and Registration:	Wag-Aero Acro Trainer Cuby, G-BLDD
No & Type of Engines:	1 Lycoming O-320-A2A piston engine
Year of Manufacture:	1985
Date & Time (UTC):	6 June 2011 at 0930 hrs
Location:	Cromer Airfield, Norfolk
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Right landing gear buckled, propellers damaged and engine shock-loaded
Commander's Licence:	Private Pilot's Licence
Commander's Age:	50 years
Commander's Flying Experience:	367 hours (of which 122 were on type) Last 90 days - 22 hours Last 28 days - 7 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The pilot flew his tail-wheeled aircraft to Cromer Airfield for a landing on Runway 04. He reported that there was a 6 kt crosswind from the left and during the landing roll the aircraft hit a bump and became airborne. On touching down for a second time, the aircraft ground looped to the left before it departed the left side of the runway. At this point the right mainwheel entered a small ditch where the right landing gear buckled, the aircraft dropped onto its right wing and the propeller blades struck the ground.

The pilot, who was uninjured, exited the aircraft through the cockpit door.

ACCIDENT

Aircraft Type and Registration:	Robinson R44 Raven, G-GDOV
No & Type of Engines:	1 Lycoming O-540-F1B5 piston engine
Year of Manufacture:	2005
Date & Time (UTC):	16 May 2011 at 1443 hrs
Location:	Gidleigh Park Hotel, Chagford, Devon
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - 1 (Minor) Passengers - 1 (Minor)
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Private Pilot's Licence
Commander's Age:	72 years
Commander's Flying Experience:	667 hours (of which 70 were on type) Last 90 days - 13 hours Last 28 days - 4 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

Whilst attempting to hover to an adjacent landing position at a private landing site, the helicopter veered to the left where it struck a tree and rolled over.

History of the flight

The pilot made a local flight to land in the grounds of a hotel, which did not have a helipad. Helicopters had previously landed in a large, tree-bounded grass field located to the east of the property. Part of this field was used as a sports area and at the western side of the field was an intersecting gravel path. Further to the west of the gravel path was a smaller grassed clearing bounded on the opposite side by a riverbed.

The pilot had not landed at the hotel before and about ten days prior to the accident had spoken with hotel staff about landing information. The pilot stated that he had been advised to land on the grass either to the east or west of the gravel path.

The flight was uneventful but during touchdown the pilot and passenger felt a bump and heard a noise. The pilot commented that the touchdown had been gentle and in a level attitude but he had become concerned and so decided to reposition the helicopter. However, as he lifted into the hover, the helicopter started to rock from side to side. It then veered to the left where it struck a tree before rolling onto its right side. The pilot and passenger sustained minor injuries and exited the helicopter through the front canopy, which had broken. The helicopter was damaged beyond economic repair. Subsequent inspection by the pilot identified that there were a number of small rocks near to where he had touched down and he later stated that he thought the grass in that area "was at least 10 inches long". He considered that that he may have struck one of the rocks with a skid during the repositioning manoeuvre.

Discussion

Prior to the accident, the hotel had emailed the pilot a diagram identifying where he may land. The landing area was identified as being to the east of the gravel path and not the west. The email was delivered to the pilot's 'spam' email folder and so he did not become aware of it until after the accident. The email also advised that the helipad was not clearly marked. The pilot later stated that he considered the area indicated on the diagram as being unsuitable for landing due to its slope.

The British Helicopter Association has published comprehensive guidance on the subject of setting up an unlicensed helicopter landing site. This includes information on the touchdown and lift-off areas recommending, among others, that they are level and free from obstacles or debris. CAA Safety Sense Leaflet 17, *'Helicopter Airmanship'* provides further advice to pilots when landing at private sites, recommending that under certain circumstances, a site visit from the ground should be considered.

BULLETIN CORRECTION

AAIB File:	**EW/G2011/05/08**
Aircraft Type and Registration:	**Robinson R44 Raven, G-GDOV**
Date & Time (UTC):	**16 May 2011 at 1443 hrs**
Location:	**Gidleigh Park Hotel, Chagford, Devon**
Information Source:	**Aircraft Accident Report Form**

AAIB Bulletin No 8/2011, page 43 refers

In this report it was incorrectly stated that the helicopter had rolled onto its left side. The report should have reflected that the helicopter had rolled onto its **right** side.

The online version of this report was corrected on 3 January 2013 and the correction published in the February 2013 Bulletin.

SERIOUS INCIDENT

Aircraft Type and Registration:	Dynamic WT9 UK, G-DYNM
No & Type of Engines:	1 Rotax 912-UL piston engine
Year of Manufacture:	2007
Date & Time (UTC):	26 February 2011 at 1250 hrs
Location:	Chiltern Park Aerodrome, Oxfordshire
Type of Flight:	Training
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Nosewheel, nose leg and engine cowling
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	60 years
Commander's Flying Experience:	9,000 hours (of which 20 were on type) Last 90 days - 4 hours Last 28 days - 4 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

During the landing roll, the aircraft nose pitched up and back down twice, resulting in the propeller striking the ground and the nosewheel detaching.

History of the flight

Following an uneventful training flight, the pilot landed the aircraft on the grass strip at Chiltern Park Aerodrome. The pilot reported that about 100 m along the landing roll and as he applied the brakes, the aircraft rapidly pitched nose-up then down again, twice in succession. The final time the aircraft came to rest on the engine cowl, following collapse of the nose gear. The pilot estimated his speed at the start of the first pitch-up event to be 15 kt.

Ground marks

Ground marks left by the aircraft consisted of a short depression, 1 m long and the width of the nosewheel (Figure 1), followed 21 m later by two propeller strike marks and then a further depression that became a deep gouge (Figure 2), next to where the nosewheel was found detached. The pilot stated that the field had a reputation for good drainage and there had been no rain in the preceding days.

Discussion

After consultation with other pilots and the aircraft owner, the pilot considered that the most likely cause of the initial depression was the nosewheel sinking into soft ground, with the aircraft then pitching up as the wheel contacted firmer ground again. He considers that this may have damaged the nose gear causing the nosewheel to detach, though he could not rule out pre-existing damage to the nose gear.

Figure 1
Initial depression

Figure 2
Ground marks

ACCIDENT

Aircraft Type and Registration:	Flight Design CTSW, G-CTSW
No & Type of Engines:	1 Rotax 912ULS piston engine
Year of Manufacture:	2006
Date & Time (UTC):	1 May 2011 at 1105 hrs
Location:	Private airstrip, Killeter, Northern Ireland
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Extensive fire damage from post-accident fire
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	49 years
Commander's Flying Experience:	243 hours (of which 155 were on type) Last 90 days - 38 hours Last 28 days - 18 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The pilot had operated the aircraft from the private airstrip over the preceding two days without incident. The wind conditions on the day of the accident were similar to those of the previous day and the same runway was being used. The runway surface was grass, approximately four inches long, and damp from overnight dew. The pilot applied full power for the takeoff. After lift off, which was slightly further down the strip than on the previous days, the aircraft was reluctant to climb and the engine seemed low on power. At this point the pilot was committed to continuing with the takeoff, but the aircraft was unable to clear the boundary hedge at the end of the runway. Its main landing gear struck the hedge and the aircraft turned over, coming to rest inverted in the field beyond. The pilot was uninjured and able to vacate the aircraft unaided via the left door.

He considers that the aircraft may have been affected by a wind rotor triggered by the crest of a ridge which was slightly upwind of the far end of the runway. He commented that pilot of the next aircraft to depart the field reported encountering a strong rotor just after takeoff.

ACCIDENT

Aircraft Type and Registration:	P and M Aviation Pegasus Quik, G-CGRW
No & Type of Engines:	1 Rotax 912ULS piston engine
Year of Manufacture:	2010
Date & Time (UTC):	29 April 2011 at 1940 hrs
Location:	Farm Strip, Castlederg, County Tyrone, Northern Ireland
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Wing, control frame, propeller and monopole damaged
Commander's Licence:	Private Pilot's Licence
Commander's Age:	51 years
Commander's Flying Experience:	181 hours (of which 33 were on type) Last 90 days - 8 hours Last 28 days - 8 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The aircraft tipped onto its left side when, while taxiing in a right turn, a gust of wind caught its right wing, causing the left wingtip to contact the ground. The pilot vacated the aircraft without injury.

ACCIDENT

Aircraft Type and Registration:	Pegasus Quantum 15, G-CCYL
No & Type of Engines:	1 Rotax 582-48 piston engine
Year of Manufacture:	2004
Date & Time (UTC):	19 May 2011 at 1755 hrs
Location:	Harringe Court Airfield, Kent
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Engine and wing damaged
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	58 years
Commander's Flying Experience:	59 hours (of which 19 were on type) Last 90 days - 13 hours Last 28 days - 6 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

After an uneventful takeoff, at approximately 500 ft agl, the engine began to run roughly and lost power. There was sufficient altitude available for the pilot to return to the airfield where he carried out a landing on the reciprocal runway. An inspection of the engine revealed damage to the bottom of the spark plugs fitted in the rear cylinder. After replacing all of the spark plugs the engine ran smoothly and the pilot, believing the fault had been corrected, prepared to takeoff again.

No problems were observed during the second takeoff, but at a height of 90 ft above the runway, the engine began to run roughly once again. With insufficient height to land in the next field, the pilot attempted to land on the remaining length of the runway. The aircraft landed hard and came to a halt resting on its left wingtip. The pilot was uninjured.

A detailed examination of the engine revealed damage to the crown and underside of the rear piston. The evidence suggested that this had been caused by foreign object debris, passing from the crankcase, through the rear cylinder inlet valve, into the cylinder. No defects were observed within the crankcase and no further foreign objects were found. It could not be determined when the foreign object debris had entered the crankcase.

ACCIDENT

Aircraft Type and Registration:	Rotorsport UK Calidus, G-HTBT
No & Type of Engines:	1 Rotax 914-UL piston engine
Year of Manufacture:	2010
Date & Time (UTC):	17 April 2011 at 1645 hrs
Location:	Perth Airport, Scotland
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to rotors, propeller, empinage, mast, canopy, front section and right wheel
Commander's Licence:	Private Pilot's Licence
Commander's Age:	59 years
Commander's Flying Experience:	56 hours (of which 16 were on type) Last 90 days - 14 hours Last 28 days - 14 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

During the landing ground roll, the pilot moved the cyclic control forward and leant forward to apply the rotor brake. The gyroplane rolled onto its right side, skidded forward while rotating to the right, and came to rest after turning through 180°. After the pilot and passenger had established that they were both unhurt, the aircraft was removed from the runway and associated debris was cleared away.

The normal landing technique is to hold the control column aft until the gyroplane stops. In this event, moving the control column forward appears to have induced a rolling moment to the right which caused the rollover.

Regulations applicable to this accident state that pending the arrival of safety investigators or consultation with the AAIB, no person shall move the aircraft except where such action may be required for safety reasons or to bring assistance to injured persons. These regulations can be viewed via the AAIB website at www.aaib.gov.uk under '*Guidance and regulations*'. The AAIB will provide guidance to individuals reporting an occurrence.

ACCIDENT

Aircraft Type and Registration:	Thruster T600N 450, G-CCUZ
No & Type of Engines:	1 Jabiru Aircraft Pty 2200A piston engine
Year of Manufacture:	2004
Date & Time (UTC):	20 March 2011 at 1515 hrs
Location:	Wickenby Airfield, Lincolnshire
Type of Flight:	Training
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Failure of screws attaching the propeller flange to the crankshaft, leading to propeller detachment
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	25 years
Commander's Flying Experience:	508 hours (of which 477 were on type) Last 90 days - 55 hours Last 28 days - 17 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and subsequent AAIB enquiries

The propeller and hub assembly separated from the aircraft shortly after takeoff. The pilot completed a successful forced landing in an adjacent field. Examination revealed that all of the propeller flange mounting screws had failed. Some of the screws showed evidence of having fractured some time before the propeller finally separated.

Two previous, similar propeller attachment failures on this aircraft type were reported on in AAIB bulletins; both had resulted from fatigue failures of the corresponding screws. These were on aircraft G-EVEY on 26 October 2009 and G-CBWJ on 2 August 2010.

On 20 May 2011 the UK Civil Aviation Authority published an Emergency Mandatory Permit Directive applicable to all Thruster T600 aircraft having Jabiru 2200A engines driving two-bladed ground-adjustable Warp Drive propellers of 64-inch nominal diameter. This required replacement of the flange-to-crankshaft screws on reaching 500 hours operating life, or within 5 flight hours for those having lives between 500 and 1,000 hours, and before further flight on those having exceeded 1,000 hrs life.

BULLETIN ADDENDUM

AAIB File:	EW/G2008/07/10
Aircraft Type and Registration:	North American P-51D-20 Mustang, G-BIXL
Date & Time (UTC):	13 July 2008 at 1600 hrs
Location:	Duxford Airlfield, Cambridgeshire
Information Source:	Aircraft Accident Report Form

AAIB Bulletin December 2008, page 45 refers

The cause of the rough running and power loss, which occurred during this accident and had occurred before intermittently, had not been determined when the report was published. Subsequent investigation showed faults in both magnetos such that when the generator windings became hot an electrical short developed. During testing, the left magneto failed completely after 20 minutes and the output from the right magneto became intermittent after 90 minutes. Both magnetos operated normally after cooling.

FORMAL AIRCRAFT ACCIDENT REPORTS ISSUED BY THE AIR ACCIDENTS INVESTIGATION BRANCH

2009

3/2009 Boeing 737-3Q8, G-THOF
on approach to Runway 26
Bournemouth Airport, Hampshire
on 23 September 2007.

Published May 2009.

4/2009 Airbus A319-111, G-EZAC
near Nantes, France
on 15 September 2006.

Published August 2009.

5/2009 BAe 146-200, EI-CZO
at London City Airport
on 20 February 2007.

Published September 2009.

6/2009 Hawker Hurricane Mk XII (IIB), G-HURR
1nm north-west of Shoreham Airport, West Sussex
on 15 September 2007.

Published October 2009.

2010

1/2010 Boeing 777-236ER, G-YMMM
at London Heathrow Airport
on 28 January 2008.

Published February 2010.

2/2010 Beech 200C Super King Air, VQ-TIU
at 1 nm south-east of North Caicos Airport, Turks and Caicos Islands, British West Indies
on 6 February 2007.

Published May 2010.

3/2010 Cessna Citation 500, VP-BGE
2 nm NNE of Biggin Hill Airport
on 30 March 2008.

Published May 2010.

4/2010 Boeing 777-236, G-VIIR
at Robert L Bradshaw Int Airport
St Kitts, West Indies
on 26 September 2009.

Published September 2010.

5/2010 Grob G115E (Tutor), G-BYXR
and Standard Cirrus Glider, G-CKHT
Drayton, Oxfordshire
on 14 June 2009.

Published September 2010.

6/2010 Grob G115E Tutor, G-BYUT
and Grob G115E Tutor, G-BYVN
near Porthcawl, South Wales
on 11 February 2009.

Published November 2010.

7/2010 Aerospatiale (Eurocopter) AS 332L Super Puma, G-PUMI
at Aberdeen Airport, Scotland
on 13 October 2006.

Published November 2010.

8/2010 Cessna 402C, G-EYES and
Rand KR-2, G-BOLZ
near Coventry Airport
on 17 August 2008.

Published December 2010.

AAIB Reports are available on the Internet
http://www.aaib.gov.uk