ACCIDENT

Aircraft Type and Registration:	Cessna U206F Stationair, G-BGED
No & Type of Engines:	1 Continental Motors Corp IO-520-F piston engine
Category:	1.3
Year of Manufacture:	1974
Date & Time (UTC):	27 June 2004 at 1800 hrs
Location:	Beacon Village, near Honiton, Devon
Type of Flight:	Aerial Work
Persons on Board:	Crew - 1 Passengers-5
Injuries:	Crew - 1 (Fatal) Passengers - 3 (Fatal), 2 (Serious)
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Private Pilot's Licence
Commander's Age:	52 years
Commander's Flying Experience:	628 hours (of which in excess of 172 were on type) Last 90 days - 6 hours 42 minutes Last 28 days - 4 hours
Information Source:	AAIB Field Investigation
	All times in this report are local (UTC+1)

Synopsis

Shortly after takeoff, with the pilot and five parachutists on board (including one 'tandem' pair), the aircraft's engine began to lose power. The pilot flew to the east away from the airfield for a distance of some 6 nm, achieving a maximum height of approximately 1,100 ft agl, before turning back. As the engine lost power the pilot was unable to maintain height and, in attempting a forced landing, the aircraft clipped the tops of several tall trees and crashed steeply nose down into a sloping grass field.

Nine Safety Recommendations are made.

Background

The aircraft involved in the accident was operating from a parachuting school located at Dunkeswell Airfield, near Honiton in Devon. The school owned and operated a Cessna 206 (G-ATLT) but, early in 2004, they leased an additional Cessna 206 (G-BGED) to be used at times when the demand for parachute jumping was sufficiently high. Both aircraft were kept at the school and each had been modified for use in parachuting operations.

History of the flight

On the morning of the accident the pilot arrived at the parachuting school in time to conduct his first flight of the day, taking off at about 1000 hrs. This flight was on the leased aircraft G-BGED and involved taking five parachutists (four static line parachute students and a jump master) to 3,500 ft. The aircraft made several passes over the airfield in order to drop the four students before returning to land. The jumpmaster remained onboard throughout the flight and reported that, on the descent back to the airfield, the pilot pointed out that the alternator warning light had illuminated. The aircraft made an otherwise uneventful landing and taxied back to the clubhouse apron where it was shut down; the whole flight took about 35 minutes.

Witnesses report seeing the aircraft outside the clubhouse at some point during the day with its engine cowling removed. A member of the school also reported being told by the jumpmaster, who subsequently received fatal injuries in the accident, that there was a problem with the alternator belt.

The pilot then conducted a second flight in G-BGED, taking off just before midday. This time there were three qualified parachutists on board and the aircraft climbed to 10,000 ft for a jump over the airfield. The aircraft then landed before again shutting down outside the clubhouse. The duration of this flight was about 31 minutes.

The pilot then flew the club's own aircraft, G-ATLT, for a further parachuting flight over the airfield. This aircraft had, up to that point, been flown by another of the club's pilots during the day and, from his records, the flight was conducted by the accident pilot with the right fuel tank selected.

Late in the afternoon it was decided that both club aircraft would depart together to make a parachute drop over the airfield at 10,000 ft. Five parachutists boarded G-BGED, two single parachutists, a tandem pair and the jumpmaster, with the aircraft being flown by the same pilot who had conducted the two earlier flights on the aircraft that day. Both aircraft lined up on Runway 23 at about 1752 hrs at which time the surface wind was westerly approximately 10 kt. The wind at 1,000 ft amsl was also westerly at between 15 and 20 kt and at 2,000 ft amsl remained westerly at between 20 and 25 kt. The area had been subject to showers in the afternoon and cloud cover remained broken with some slight to moderate showers still reported. Visibility was reported as being 15 to 20 km, but deteriorating to between 4,500 m and 12 km in showers. An aftercast showed that some eight minutes after G-BGED took off, Dunkeswell Airfield was subject to slight showers with a reportes cloudbase of 2,400 ft amsl (1,600 ft aal). This weather was moving in an easterly direction at approximately 20 to 25 kt. The temperature was +14°C and mean sea level pressure 1020 hPa.

G-ATLT took off first, making a climbing turn to the east after departure. G-BGED took off shortly afterwards and was seen by one of the parachutists in G-ATLT to get airborne and continue its initial climb out, apparently as normal. G-ATLT continued its climb to 10,000 ft, initially climbing to the east before turning back to drop the parachutists over the airfield.

Reports from the two parachutists on G-BGED, who survived the accident, indicated that soon after taking off they were aware of a problem with the aircraft. Their memories of exactly what happened are unclear. However, it was apparent that the pilot had initially informed the jumpmaster that they were losing power and, later, that he was attempting to return to Dunkeswell but they might have to land in a field. As the problem continued, one of the survivors recalls asking the jumpmaster whether they should jump, but being told the aircraft was too low.

At 1800 hrs the radio operator at Dunkeswell Airfield received a distress call from the pilot of G-BGED informing him that the aircraft was losing power. The operator requested the aircraft's position and whether the pilot thought the aircraft would be able to make it back to the airfield. The pilot replied he was to the east and that he would not be able to make it back. Unable to get replies to further calls to the aircraft, the Dunkeswell radio operator notified the police at 1802 hrs that an aircraft accident might have occurred.

One of the survivors recalled checking to see whether the rear door was open during the latter stages of the flight, which it was. The other survivor remembers the pilot telling everyone to 'brace' and being shown the position to adopt by one of the other parachutists; this being hands on head with the chest bent over towards the knees. The parachutists were now sat on the floor facing rearwards. The last recollection of the flight by this survivor was of seeing trees seconds after the 'brace' call.

Witnesses on the ground report seeing the aircraft flying low over trees close to the site of the accident. They describe hearing the "engine coughing and spluttering", which one witness described as sounding as if it was misfiring. Another witness described hearing the engine "revving loudly, cutting out and misfiring". The aircraft disappeared from view and was then heard to crash. One of the last witnesses to see the aircraft still airborne reported that the sky was clear and sunny at that time.

Two witnesses close to the accident site made their way quickly to the field where the aircraft had come down. The first person at the scene described seeing the aircraft lying in the field with fuel leaking from the right wing and a person staggering around nearby. Other witnesses also reported seeing fuel leaking from the wings but subsequent enquires were unable to establish the rate of leakage and whether the fuel was leaking from the right or left wing, or both. There was no fire.

The first witness at the scene managed to contact the emergency services using her mobile phone and was instructed not to approach the aircraft due to the danger of fire posed by the leaking fuel. She remained clear of the aircraft and managed to get the nearby survivor to come over to her. She remained on the telephone guiding the emergency services to the site whilst at the same time re-assuring the survivor. The other witness arrived shortly afterwards and made his way to a nearby road to meet the emergency services. Using his four wheel drive vehicle he was able to lead them along a track through an adjacent wood to get them to the crash scene. Both witnesses demonstrated considerable resource in dealing with the situation and there is no doubt that their actions enabled a quicker response than would otherwise have been possible.

An air ambulance and police helicopter were quickly at the scene followed later by the local fire service who had the problem of locating the site by road. It was then established that two further survivors remained in the aircraft. The survivors were the tandem pair and one of the single parachutists. The pilot, jumpmaster and the other single parachutist received fatal injuries in the impact.

Immediate treatment was given at the scene before the two most critically injured survivors were transferred to hospital by helicopter. The third survivor was transported by road ambulance. The most seriously injured parachutist, the tandem pair instructor, died later that night from his injuries.

Pathological information

Only one of the six occupants, the pilot, was seated and restrained and his injuries were consistent with high longitudinal and vertical impact forces. The base of his seat had failed during the impact, allowing him to move forward and strike the instrument panel. The post-mortem examination of the pilot showed that he died from multiple injuries.

Figure 1 illustrates the probable locations of those parachutists aboard G-BGED at the time of the impact, all of whom were seated on the floor and unrestrained. The 'tandem' instructor and student were seated beside the pilot leaning against the wooden box and facing

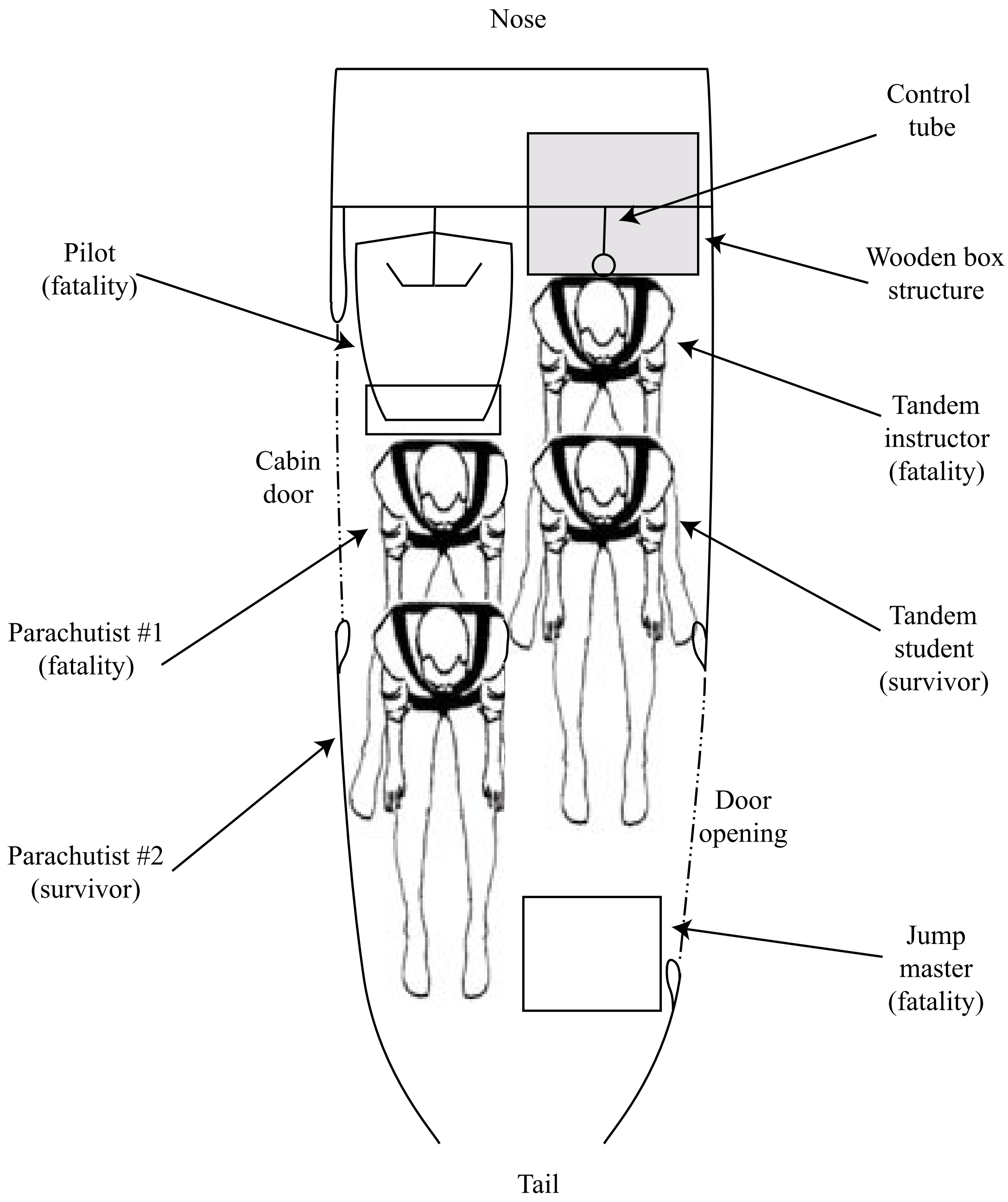


Figure 1

Seating layout for G-BGED

rearwards. The two single parachutists, identified as Parachutist No 1 and 2, were facing rearwards, with No 1 leaning against the back of the pilot's seat. Parachutist No 1 was fatally injured and had sustained a fracture of the pelvis and been struck in the face. Parachutist No 2, seated against Parachutist No 1, survived and, although he had sustained spinal injuries, his pelvis was intact. He was able to exit the aircraft after the impact and subsequently was treated by the emergency services. The tandem parachutists both sustained pelvic fractures. The fatally injured instructor had a deep laceration to the back of his head, indicative of striking his head on the right side control wheel tube. There was evidence to suggest that the harness of the surviving tandem student attaching him to his instructor, had been cut, although it was not established whether this occurred pre- or post impact or by whom. The injuries to these four parachutists were consistent with high longitudinal and vertical forces resulting from the aircraft's impact with the ground.

The injuries sustained by the fifth parachutist, the jumpmaster, were significantly different and the pathologist concluded that he most likely sustained these by falling to the ground separately from the aircraft. This conclusion was substantiated by the fact that he was found approximately two metres to the left of the main wreckage.

Accident site and wreckage examination

The aircraft had crashed into an up-sloping narrow grass field, immediately beyond an area of woodland. There was evidence of contact between the leading edge of the right tailplane and the tops of trees, approximately 15 m tall, bordering the field, with freshly broken branches being found around their bases over a track distance of some 100 m. At this point, the aircraft had been on a track of 280ºM, following which it had descended at a steep angle to the horizontal. The impact with the trees appeared to have yawed the aircraft to the right, and it struck the ground with a high rate of descent, in a 30º nose down and right wing low attitude whilst on a heading of 010ºM. The right wing tip had impacted first, followed by the underside of the forward fuselage and the left wing. The aircraft wreckage was substantially intact, although the right wing front spar attachment had failed and the nose wheel had detached. This was found some 15 m from the main wreckage.

Lack of significant damage to the propeller blades indicated that the engine had been producing low power at impact. The auxiliary fuel pump START switch was found in the ON position, the spring loaded EMERG switch was found OFF. Approximately 15 litres of fuel were recovered from the right wing, but none was recovered from the left wing. There was little evidence on site of staining from fuel spillage on the ground.

Aircraft description

General

G-BGED, a Cessna U206, was a single engined, six passenger, all metal high wing aircraft. It was powered by a fuel injected Continental Model IO-520-F horizontally opposed, six cylinder, overhead valve, air cooled, fuel injected engine with a wet sump oil system. This drove a metal, three bladed, constant speed propeller, controlled by a constant speed unit (CSU) attached at the front of the engine. Dual magnetos, an electrical engine starter, a belt driven alternator and a vacuum pump were located at the rear. The aircraft had an entry door on the left side of the cabin at the pilot's seat position and a double cargo door on the right side of the cabin, but for parachuting operations, the cargo doors had been removed.

Modifications for use in parachuting operations

In 1982, G-BGED was approved for parachuting by the CAA. The conditions of the CAA Flight Manual supplement included; removal of all seats with the exception of the pilot's, removal of the cargo doors for ease of egress during parachuting operations and the installation of a spoiler attached to the hinges of the forward cargo door jamb. All loose equipment was required to be removed or secured before flight.

A later modification to fit a perspex roller door in the cargo door opening, for occupant comfort in flight, had also been approved by the CAA. This door was required to remain open for takeoff and landing.

On 2 March 2004 a plywood board floor covering the cabin area was fitted, and the right control wheel and front right seat were removed by the aircraft's maintenance organisation. Additional modifications were made in that the tube to which the control wheel attached was capped with a tennis ball, and a wooden box shaped framework had been placed in the right side leg space below the instrument panel, providing a back rest for the forwardmost parachutist.

Fuel system

A diagram of the aircraft fuel system is shown in Figure 2. This type of aircraft has two bag tanks, one in each inner wing with a capacity of 119 litres each. Fuel is gravity fed through two reservoir tanks (left and right) to the fuel selector valve, all of which are located beneath the cabin floor. This valve is operated manually through a linkage from a handle positioned on the cockpit floor between the front seats. Depending upon the setting of the selector valve, fuel from the left or right tank flows via an electric auxiliary fuel pump and a fuel strainer to the engine-driven fuel pump. A pressurised supply of fuel is sent to the fuel metering unit which then regulates the fuel to the distribution manifold and finally to the engine fuel injector nozzles. The fuel/air mixture is controlled by means of the throttle and mixture control knobs. Excess fuel from the metering unit is returned by way of the selector valve to the reservoir tank of the wing tank being used. There is an additional filter within the fuel metering unit.

The engine-driven fuel pump provides sufficient fuel flow/pressure for normal engine operation with the electric auxiliary fuel pump acting as a back-up in the event of an engine-driven pump failure. The electric auxiliary pump is manually selected by means of a yellow and red split rocker switch on the lower left side of the instrument panel. The yellow right half of the switch is labeled START, and its upper ON position is used for normal starting and minor vapour purging during taxi. The red left half of the switch is labeled EMERG and its upper HI position is used in the event of an engine driven pump failure during takeoff or high power operation. The HI position may also be used for extreme vapour purging. With the right half of the switch in the ON position, the pump operates at one of two flow rates dependant on throttle setting. Maximum fuel flow is produced when the left half of the switch is held in the spring loaded HI position. When this is selected, an interlock automatically trips the right half of the switch to the ON position. The auxiliary pump is also required to assist in restarting the engine should fuel exhaustion from the selected tank occur. However, if the engine-driven pump is functioning normally, with a good supply of fuel, and the auxiliary pump 'START' switch is placed in the ON position, an excessively rich fuel/air ratio can result and lead to a loss of power and/or a 'rich cut'.

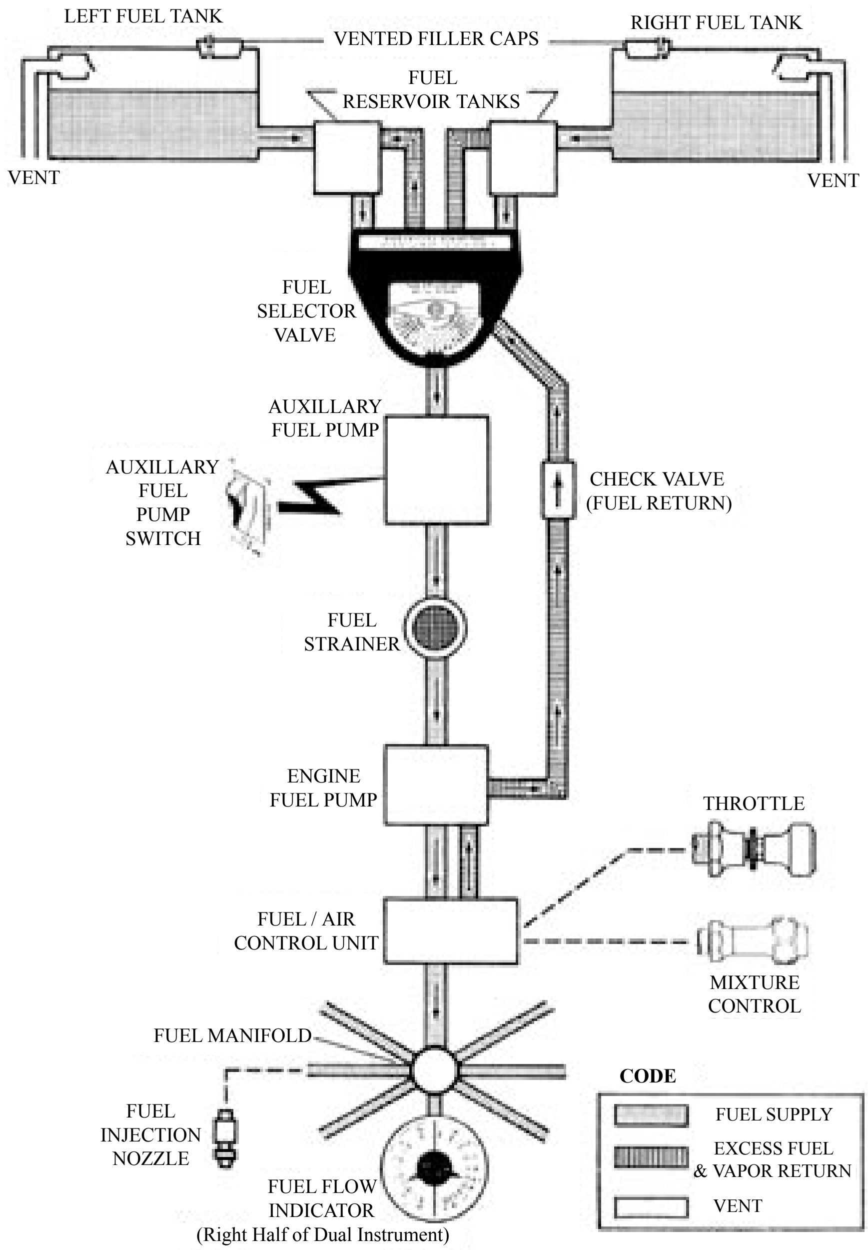


Figure 2

C206 Fuel system

Aircraft and maintenance history

G-BGED was constructed in 1974 since when it had accumulated 4,785 hours. The propeller had been completely overhauled to zero time condition and fitted to G-BGED in March 1999, since when it had completed 1,172 hours. A new engine, Serial Number 818871-R, was fitted in September 1999 and, at the time of the accident, had completed 988 hours. The last annual check had been carried out on 5 March 2004 and the most recent maintenance, a 50 hour check, 1 hour 10 minutes prior to the accident. The aircraft was certificated in the private category.

A week before the accident another pilot had been flying G-BGED and had completed a 'high lift', which involved climbing to 10,000 ft followed by a prolonged descent. The pilot recalled that it had been a very cold day and he had set a high manifold pressure during the descent in order to minimise the cooling rate of the cylinders. At about 2,000 ft in a high left hand downwind position, he opened the throttle but there was no immediate power increase and the engine began to run roughly. Realising the engine was not running at full power he expedited his approach and the aircraft landed safely. A ground run was subsequently carried out but the engine ran smoothly and there were no symptoms of the rough running encountered in flight. The aircraft was due for a 50 hour check and was subsequently flown to its maintenance organisation at Exeter Airport. On 21 June 2004, an engine run carried out prior to any maintenance activity revealed that, at the end of the run, the engine was slow to shut down after the mixture lever was pulled to the fully lean position. The mixture control was adjusted and the engine shut down normally following a further ground run the following day. The 50 hour check, which included an oil change, was completed on 24 June 2004 and the aircraft was flown back to Dunkeswell.

Prior to this, a defect had been reported to the maintenance organisation on 27 May 2004, after the alternator belt was reported as having been found '*adrift*' with the ammeter indicating a discharge from the battery. A new belt was fitted and tensioned, and a ground run conducted to confirm that the battery was charging satisfactorily. Also, on the 30 April 2004, there was a report of the '*alternator belt loose*', when the belt was re-tensioned and the alternator locked, and before that, on 20 February 2004, a report of the '*alt belt worn and out of adjustment*', following which a new belt was fitted.

Following the first flight on the day of the accident, during which the low voltage warning light had illuminated (indicating that the battery was not charging), it is probable that the alternator belt had been tightened, but there was no record of this having been done.

Maintenance requirements

The CAA publication, CAP 660 '*Parachuting*', sets out the minimum standards the CAA requires to be met, prior to the grant or renewal of parachuting Permissions and Exemptions, together with requirements for the conduct of parachuting operations. This states:

> *'……all maintenance work and modifications must be certified by an appropriately licensed aircraft maintenance engineer, or an authorised person employed by an approved aircraft maintenance organisation.'*

Detailed wreckage examination

Flying controls

The wreckage was recovered to the AAIB's facility at Farnborough where a detailed examination was carried out, in conjunction with the manufacturer's representative. Continuity of the flight control system, which consists of conventional aileron, elevator and rudder control surfaces manually operated through mechanical linkages, was confirmed. The extension of an electric actuator, which operated the elevator trim tab to provide electric trim in addition the manual system, was measured as 1.5 inches, equating to 5º tab down, full travel being 25º up and 5º down. (This tab position may not represent the pre-accident setting as both trim cables had been pulled as the tail section deformed in the impact.) Both flap surfaces were found at full travel (40º) and this was confirmed by measurement of the electric flap actuator extension.

Alternator belt

The alternator belt was found to be correctly tensioned, but the quality of the wire locking through the securing bolt on the mounting arm was not to aviation standard and appeared to be reused wire.

Engine

The engine was returned to engine manufacturer for detailed examination and possible testing, under the supervision of the AAIB. However, the crankshaft propeller flange showed evidence of torsional cracking and therefore the engine could not be test run. A detailed strip examination was carried out and this showed that the basic engine had been mechanically sound before the accident and that it had been in good condition, given its time-since-new and operational usage.

The accessory gearbox was intact; the various gear teeth were undamaged and exhibited normal operating wear. The engine oil sump had been ruptured with the result that only approximately one pint of oil was recovered. The sump contained a small amount carbon but no metal or other debris was observed.

Both magnetos, the ignition switch and harnesses were tested satisfactorily and all the spark plugs were in a serviceable condition; their electrodes were clean and exhibited only light deposits.

The vacuum pump was intact; however, the drive coupling was broken and the pump could not be rotated by hand. The pump was disassembled and the rotor and one vane were found to have broken; the five remaining vanes were intact. It is considered that this damage occurred at impact.

The engine driven fuel pump was free to rotate and its drive was intact. The pump was tested and functioned satisfactorily through its full range of operation.

Propeller

The propeller showed very little evidence of rotation at impact, or any damage usually associated with an engine producing high power. One blade exhibited a nick on its leading edge and, generally, some chordwise scoring was present. The propeller assembly was removed from the engine and sent for a detailed strip examination at an approved maintenance facility, under the supervision of the AAIB. No failures were identified and internal witness marks in the hub from all three blades showed the blade pitch angles had been at approximately 11º at the time of impact with the ground. This is the minimum, 'fully fine', blade angle. The CSU was tested satisfactorily.

The most recent maintenance on the propeller had been carried out in 2002 when, in accordance with Airworthiness Notice 75, the propeller was disassembled for a bare blade inspection. During assembly of the blades into the hub, each blade retention nut is torqued tightened to an appropriate value and then locked into position by drilling a 'staking' hole across the blade nut and hub interface. These holes are then filled with an expansion plug in order to lock the two together and prevent any loss of blade nut torque loading. It was noted during the examination that two previous 'staking' holes on the hub were closer than the minimum specified spacing of 3/16 inches between holes and, as such, the hub should not have been returned to service.

Fuel system

The fuel tank selector handle linkage had separated at the selector valve; the valve was found in the left tank position but with the handle set to the right tank position. Examination of the linkage failure showed this to have been occasioned in the impact.

The two reservoir tanks beneath the cabin floor were cut open and each found to contain approximately 40 to 60 ml of fuel. The fuel strainer was removed and approximately 70 ml of fuel was recovered. Its internal filter was found to be clear of debris.

Figure 3

Contaminated filter removed from G-GBED (left) and identical clean filter (right)

Each wing bag tank had a vented fuel cap installed and their gaskets, vents, and filler ports were intact. The bag tank in the left wing had a wrinkle on the lower surface below the outboard filler port. Tests were carried out on the left fuel tank to establish if fuel could have drained out either in-flight or post impact. With the left wing level and the bag tank filled with water, a small amount of water was observed dripping out of a vent hole in the bottom of the wing. The wing was then repositioned with the leading edge 30° down, to reproduce its attitude as found in the wreckage, and a slow drip was observed coming from an access panel opening near the external vent tube. No further leaks were found and no further water drained away from the tank.

The fuel metering unit filter was removed and was found to be 80% to 85% blocked with debris, as indicated in Figure 3.

The throttle arm and throttle plate were intact and moved freely through the full range of travel. The mixture arm had been bent into the throttle body but straightening the arm allowed it to move freely through its full range of travel. The inlet supply fuel hose nut was found to have been cross threaded on the inlet elbow fitting, causing damage to the elbow fitting threads. This nut, however, was found to be tight with no evidence of fuel leakage[1]. The fuel metering unit was bench tested with the contaminated filter installed, and then re-tested with a clean filter in its place. Although the unit did produce a flow of fuel, this was below the normal value. Disassembly of the unit revealed internal damage consistent with being occasioned during the impact and this damage had the effect of restricting the flow of fuel through the unit. The aircraft service information requires the fuel metering unit filter to be checked every 100 hours, but this check was not required to be done the during maintenance prior to the accident as it had been carried out during the Annual Check on 5 March 2004.

A fuel distribution manifold valve flow vs. fuel pressure test was conducted and found to be within the

Footnote

[1] In a response to this finding, the manufacturer advised that *'Cessna Service Bulletin, SE81-42 Fuel Vapour Owner Advisory, mentions loose connections, cracked or leaking flares at fuel line connections and minor leaks in fuel lines can produce conditions similar to fuel vapour.'*

manufacturer's specifications. The manifold valve was disassembled and its diaphragm found intact and filter screen clean of debris. The cylinder fuel nozzles were unrestricted and exhibited normal operating wear.

Further testing

A functional fuel metering unit, with the contaminated filter from G-BGED's unit installed, was mounted in a new engine which was then run on the manufacture's test bed. The engine was tested at various power settings, including full power, and the tests repeated with an uncontaminated filter. There was no discernable difference in the performance of the engine with either filter installed.

Fuel samples

A sample of the fuel recovered from the right wing tank of G-BGED was analysed by QinetiQ Fuels and Lubricants Laboratory and found to comply with the specification of Avgas 100LL. However, a small quantity of sediment was noted to be present.

The two most recent fuel samples taken from the bowser operated by the school were also analysed. The school's records indicate these samples were taken on 25 June 2004 and 27 June 2004; the day of the accident. The sample taken on 25 June failed to comply with specification for Avgas 100LL; the liquid had a green colouration. This can occur if the fuel has remained in a hose for a period of time and the hose has not been flushed prior to taking the sample. However, a high gum content is often associated with this but, in this case, the gum content of the sample was within specification. The sample also had low vapour pressure. However, these characteristics were unlikely to cause the engine to loose any significant power. The sample taken on 27 June did comply with the specification requirements apart from a small quantity of sediment being evident and it exhibited a slight haziness in its appearance. Haziness is often an indication of water contamination, but tests indicated less than 10 ppm free water and 45 ppm total water content, which is not excessive for aviation fuel.

Fuel system debris

Visual examination of the debris deposited on the outside of the fuel metering unit filter was also conducted by QinetiQ, and this showed that it comprised a dark, very fine compacted particulate within heavily matted fibres, as seen in Figure 4. An Energy Dispersive X-Ray (EDX) analysis indicated a predominantly carbon based composition of both the fibres and the particulate. Their report concluded that:

> *'the evidence suggested that the particulate on the blocked filter was typical of debris found in fuel systems. It is probable that the presence of the fibres effectively reduced the porosity of the filter, thus capturing particles that would normally have passed through and therefore increasing the concentration above a level that would normally be seen. The origin of the fibres could not be determined.'*

A scanning electron microscope was used to measure the mesh size of an identical filter as 191 x 183 μm (0.0075 x 0.0072 inches).

The fuel metering unit filter was removed from the parachute club's other similar aircraft and debris was also found, but the level of contamination was much less than that seen on G-BGED. Analysis by QinetiQ again showed that the debris consisted predominantly of fibres, with flakes and particulate matter also present. EDX analysis indicated a predominantly carbon based composition to the fibres and flakes although a few paint flakes and a single

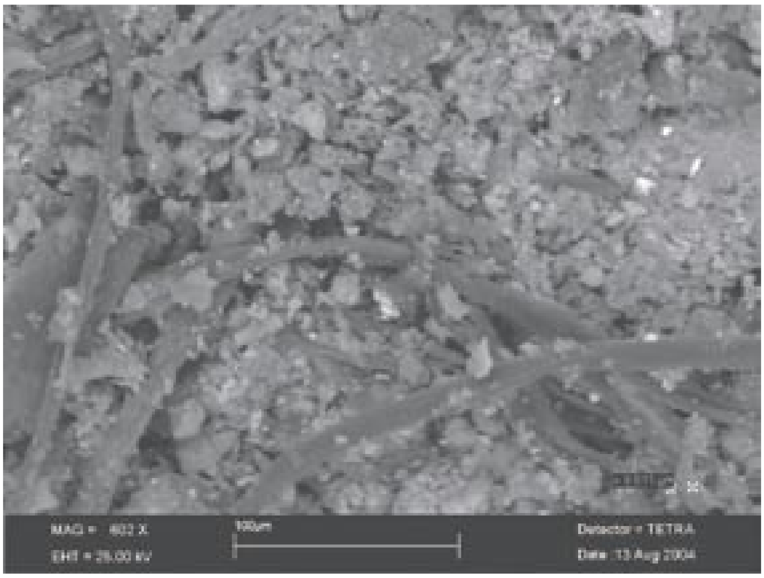


Figure 4

Magnified image of the fibres and debris removed from the filter

aluminium flake were also found. The particulate was predominantly composed of silicon with some magnesium and aluminium. Their report concluded that:

> *'the majority of the debris consisted of fibres and flakes, the appearance and composition of which suggest are organic in origin. The remaining chunky particulate is typical of dust, sand and grit. This debris is typical of external contaminants and is to be expected in a filter. The paint flakes and aluminium particle are likely to have originated from the aircraft, again are typical of what is found in a filtration system and are not cause for concern. The quantity of debris examined is very small compared to the amount present in the original filter examined from G-BGED and the lack of elements found in the original analysis suggests that this is a cleaner system.'*

Fuel storage

The school operated its own fuel bowser, a fuel sample from which was normally checked by the first person to use it each day that flying took place. Fuel samples were retained in five litre containers, numbered one to seven, which were used in consecutive order and were kept in the school's clubhouse. However, the fuel samples retrieved amounted to considerably less than five litres in each container and this low sample to container volume ratio may have led to the measured low vapour pressure.

A written record was maintained of each fuel check but the details were not necessarily entered into the record by the person doing the actual check. This was the case on the day of the accident. Thus, whilst it has been possible to identify the person entering the details of the fuel check into the log, it has not been possible to positively identify the person who actually carried out the check, although it is thought to have been one of the individuals subsequently fatally injured in the accident. There was an assumption by the school pilots interviewed that, if the bowser operating panel had been opened up, then the bowser had been checked.

The bowser was fitted with a counter mechanism which indicated the quantity of fuel dispensed, measured in litres. The gauge could be set to zero at any time but this was not routinely done either before or after use. The pilot of G-ATLT stated he did not zero the gauge before or after refuelling but he thought that the pilot of G-BGED did re-set the counter after each refuelling operation. The reading on the bowser at the time of the accident was 129 litres (about 30 US gallons).

No record was kept at the bowser of fuel dispensed, either during individual aircraft refuels, or on a daily basis, but the bowser contents were periodically monitored by use of a dipstick.

Aircraft fuel management

Prior to commencing operations, the first pilot to fly a particular aircraft should normally carry out a full walk round check, which would include a water drain check of the fuel tanks. Both aircraft were fitted with fuel strainers, located at the lowest point of the fuel system, and these should also normally have been checked for water prior to the first flight of each day. A fuel tank dipstick, used to enable the contents of the tanks to be established, was found within the wreckage of the aircraft.

The fuel tanks were located inboard in the wings on both aircraft and normal practice was to refuel G-ATLT to 22 US gallons a side, sufficient for three flights to 10,000 ft, plus a reserve of about 45 minutes. G-BGED had previously been modified for use as a floatplane and was slightly heavier. As a result, to retain acceptable operating performance, it was only refuelled to 60 litres (equivalent to about 16 US gallons) a side, sufficient for two parachutist dropping flights to 10,000 ft, plus a reserve of about 45 minutes.

The fuel selector valve in both aircraft allowed selection of either left or right tank, but not both tanks together. Normal operation of G-ATLT was to use one tank for the first flight and then to select the other tank for the second flight. A third flight was then possible by using one tank in the climb and until the parachutists were dropped, and then the other tank for the descent. Normal operation for G-BGED would be to use one tank for the first flight and then to select the other tank for the second flight before refuelling.

During the investigation, it was not possible to ascertain the amount of fuel on board G-BGED at the start of the day. Also, no witnesses were found who actually saw the aircraft being refuelled during the day, although the aircraft had been seen parked in front of the bowser. The pilot of G-ATLT stated that he had re-fuelled G-ATLT twice on the day of the accident. The first re-fuel was after the first three flights, at about midday, and the second was after the sixth flight of the day at about 1430 hrs.

As the aircraft fuel gauges on both aircraft were considered inaccurate, dip sticks were used to check the actual fuel quantity on board after refuelling. The recommended practice was for pilots to maintain their own written record of the fuel on board the aircraft during jumping operations, including a record of which tank had been used for which flight. The record maintained on the day of the accident by the pilot of G-ATLT showed the fuel required for a drop from 10,000 ft was about 10 US gallons. After the accident no such record could be found for G-BGED, although it is possible that it became mislaid during the emergency response.

Previous incidents

In the course of investigating this accident, information concerning two previous incidents of fuel mis-management which reportedly occurred on the same type of aircraft was given to the AAIB. On one of these occasions, the pilot, who was reportedly the pilot involved in this accident, changed fuel tank selection whilst accelerating along the runway. The engine 'coughed' and he then decided to abandon the takeoff.

On the second occasion, on 19 August 2000, aircraft G-ATLT suffered engine problems whilst in the climb to drop two tandem pairs of parachutists and a cameraman. It was reported that the engine suddenly lost power whilst in the climb at about 5,000 ft. A glide attitude was established and the aircraft was turned onto a heading towards a disused airfield. As the pilot was unable to quickly confirm to the jumpmaster that he could re-start the engine, the two tandem pairs and the cameraman made an emergency exit from the aircraft, as it was high enough for their parachutes to deploy safely. They landed from their jump at a motorway service station, this being the most suitable area they were able to reach. The pilot then switched fuel tank selection, and operated the fuel pump HI and LO switches. Shortly after making a MAYDAY call, the engine re-started, although it 'coughed' and continued to 'miss', but it provided enough power for level flight, and so the pilot was able to recover it to Dunkeswell and land safely. During the landing rollout, the throttle was retarded and the engine stopped. A short time later the engine was restarted and the pilot taxied to the parachute school. Subsequent investigation revealed that the left tank, which was initially used for the flight, was dry and that the right tank contained approximately 17 gallons of fuel. The pilot later reported that although it is his usual practice to keep a detailed log of time, fuel useage and tank selection, on this occasion he noted the tank selection change but failed to carry out the action.

Recorded data

G-BGED was fitted with two GPS receivers, a Garmin GPS 100 and a Bendix/King Skymap II version 4. The GPS 100 did not record track information and so provided no information useful to the investigation. The Skymap II recorded the GPS position, GPS altitude, track (ºT) and ground speed for the last 28 flights, including the accident flight. The data was recorded every 30 seconds. GPS altitude is subject to larger errors than GPS horizontal positioning but these errors tend to change slowly with time rather than being erratic. In this case the GPS recording included the take-off roll on the accident flight and indicated that the GPS altitude error was only 15 ft at the time. For the purpose of this investigation the GPS altitude was therefore be assumed to be relatively accurate.

The accident flight was recorded by Burrington radar and showed that, although secondary radar coverage of the flight was constant, primary radar coverage was intermittent. No altitude encoded Mode C returns were recorded.

The Meterological Office provided a weather aftercast for the region on the day of the accident. There was also a wind monitoring station just beside Dunkeswell Airfield which is used to record wind speeds at various altitudes and the Meterological Office were able to supply data from this monitoring station that covered all the flights stored in the Skymap II. The wind data was used with the recorded ground speed and altitude to calculate the aircraft's true airspeed (KTAS) during the recorded flights.

Data analysis

The radar data and GPS data correlated except for a very slight divergence in the last minute of flight. The radar head sweep rate was eight seconds and the track coverage was slightly less than that of the GPS data. However, since the aircraft was not transmitting Mode C altitude, the radar data only provided horizontal position information. Due to these limitations, other than for general GPS track location confirmation, the radar data was not used. The use of the GPS data for the analysis also provided a like-for-like comparison with the GPS recordings of the previous flights.

The GPS track times for the flights on the day of the accident were as follows:

Flight	GPS track Start time	GPS track Stop time	GPS track Duration
1	10:48:28	11:23:53	35m 25s
2	12:51:10	13:19:42	28m 32s
3	17:52:43	18:00:14	7m 31s

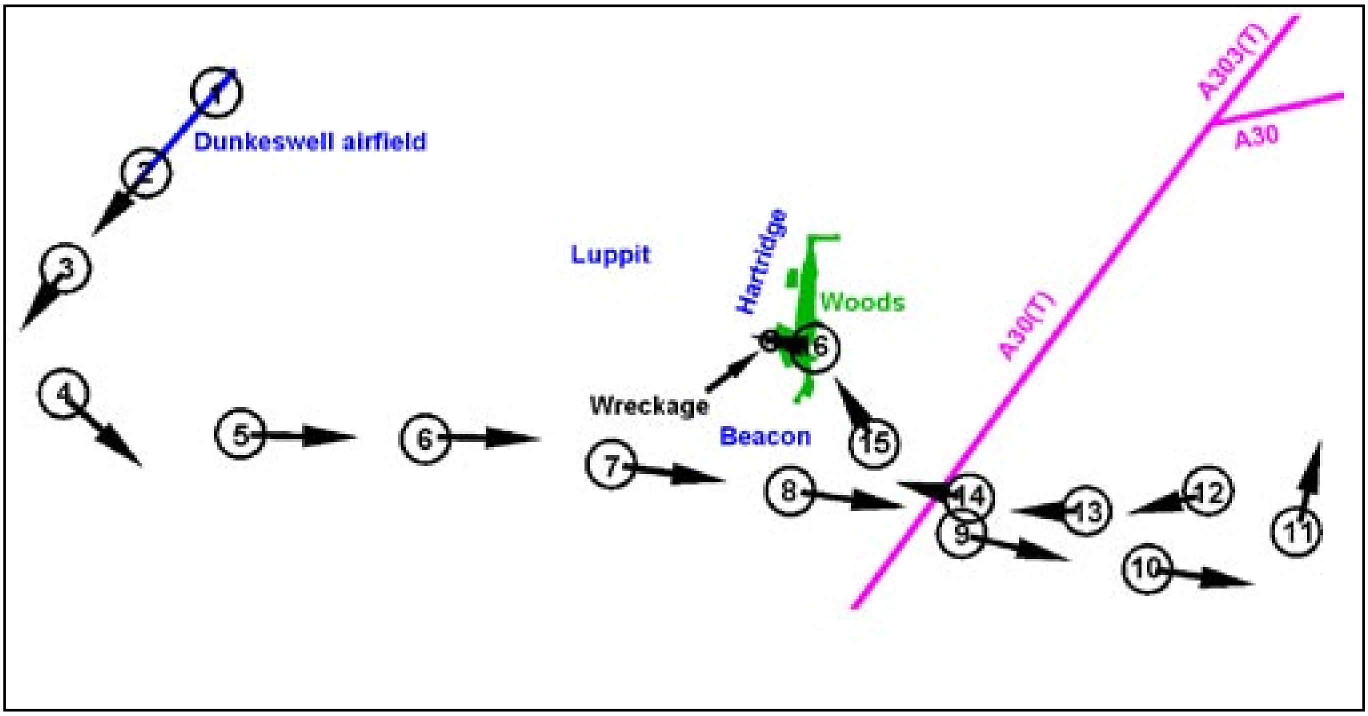
Table 1

GPS logged flights

The GPS recording on the accident flight started during the take-off roll from Dunkeswell on Runway 23 with a ground speed of 22 kt. The last recorded point in the log was seven and a half minutes later with a ground speed of 52 kt, a track of 282°T and a GPS altitude of 1,051ft amsl. Taking into account the wind conditions, this final airspeed was 69 KTAS. The approximate terrain elevation at the accident site was 750 ft.

Figure 5 shows the plan view of the accident flight which identifies the last GPS position before equipment power or antenna connectivity was lost. This location is consistent with the wreckage location. The recorded track shows that the aircraft turned away from an area of high ground near Dumpdon Hill. This track took the aircraft towards another area of high ground, Hartridge, upon which it crashed.

Figures 6, 7 and 8 show the altitude, altitude rate and true air speed parameters respectively, of the accident flight against the first 16 samples of the previous 27 recorded flights. These indicate that the rate of climb was apparently normal for the first 2.5 minutes (6 samples). After this, the climb rate reduced below that of all the previous flight profiles. Given that the airspeed was maintained during this period at approximately 80 KTAS, it would



Note: 16 GPS recorded track points sampled at 30 second intervals covering the period from 16:52:43 to 17:00:14 UTC. The recorded heading is indicated by arrow direction. The arrow length is proportional to recorded ground speed. The last fix point before satellite tracking was lost was at the same location as the wreckage as shown. Wind is from the West between 12 and 20 kt. Speed and heading are instantaneous non-smoothed values.

Figure 5

Plan view of the accident flight
Accident to G-BGED on 27 June 2004 at Beacon Village

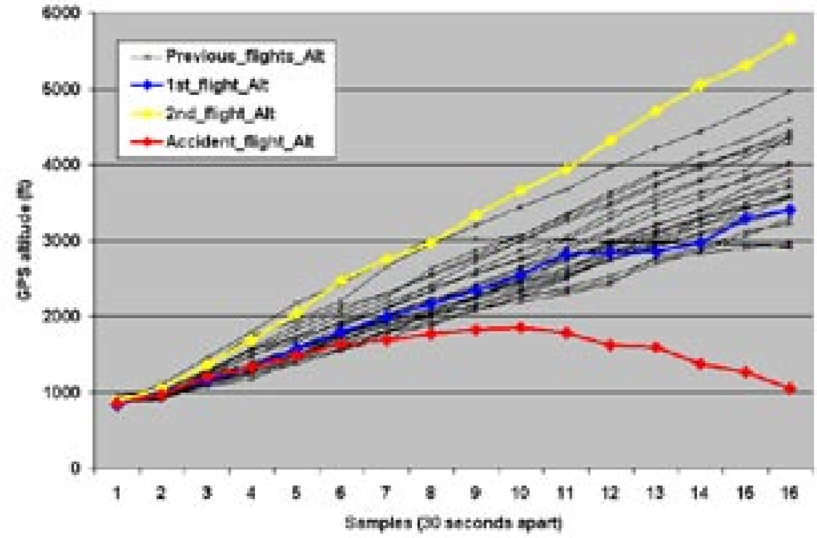


Figure 6

Take-off altitude profile of the 1st and 2nd flights of the day, the accident flight (3rd) and other previous flights.

Accident to G-BGED on 27 June 2004 at Beacon Village.

Note: The 1st flight had similar passsenger loading to the accident flight. The 2nd flight was with two less passengers. Fuel loading unknown.

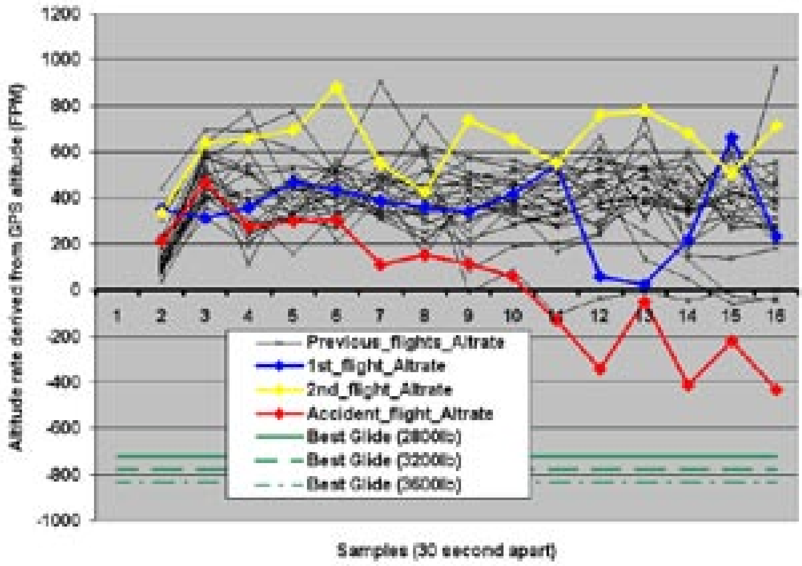


Figure 7

Take-off altitude rate profile of the 1st and 2nd flights of the day, the accident flight (3rd) and other previous flights.

Accident to G-BGED on 27 June 2004 at Beacon Village.

Note: The 1st flight had similar passsenger loading to the accident flight. The 2nd flight was with two less passengers. Fuel loading unknown.

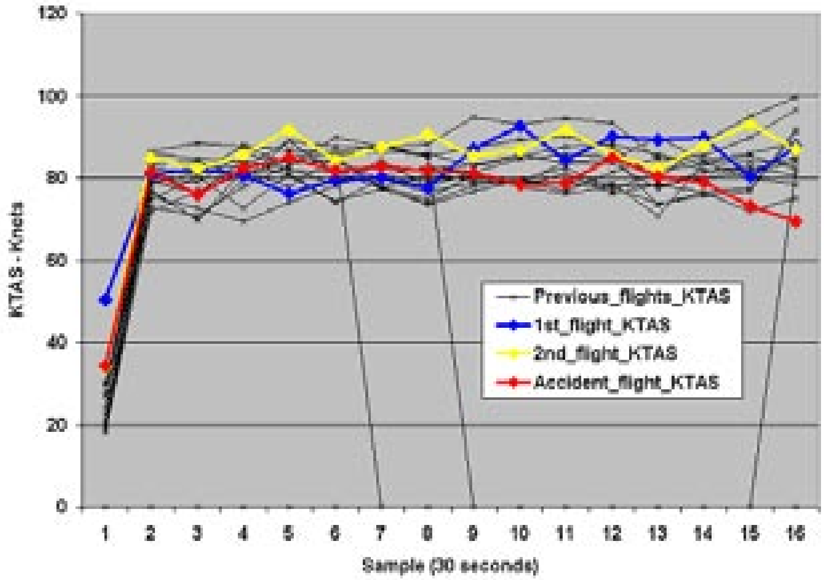


Figure 8

Take-off true airspeed profile of the 1st and 2nd flights of the day, the accident flight (3rd) and other previous flights.

Accident to G-BGED on 27 June 2004 at Beacon Village.

Note: The True Airspeed (KTAS) was derived from the GPS recorded ground speed and the wind data supplied by the Met Office.

appear that a reduction in power had occurred. In the last minute of flight the airspeed also reduced.

Figure 9 shows the altitude of the aircraft relative to the terrain beneath the aircraft. This shows that at the highest point of the flight, the aircraft had on average approximately 1,100 ft terrain clearance. During the last minute of recorded flight the terrain immediately below the aircraft was undulating such that the aircraft terrain clearance was never more than 900 ft.

Pilot history

The pilot of G-BGED held a private pilot's licence which was originally issued in 1984. He had flown aircraft engaged in parachuting operations for many years and was himself a qualified parachutist and had a current BPA parachute pilot's authorisation at the time of the accident.

Records of the pilot's BPA flight tests show that, in 1991, he successfully demonstrated a simulated forced landing in a Cessna 206 from a minimum height of 2,000 ft with the aircraft at a weight of at least 90% of its maximum all-up-weight. Further records show that in 1995 on another test he again successfully demonstrated a simulated forced landing, this time on a Cessna 180C. Both tests were to qualify him to fly these two aircraft types for parachute dropping.

Changes made to the currency requirements for private pilots lead to the BPA to change their test requirements for pilots in February 2000. It was considered that currency and training requirements now in place through the CAA were sufficient for the general handling requirements of a pilot taking part in parachuting operations. As a consequence training and testing in order to gain a BPA pilot's qualification was changed to include only those aspects directly related to the parachuting operation itself.

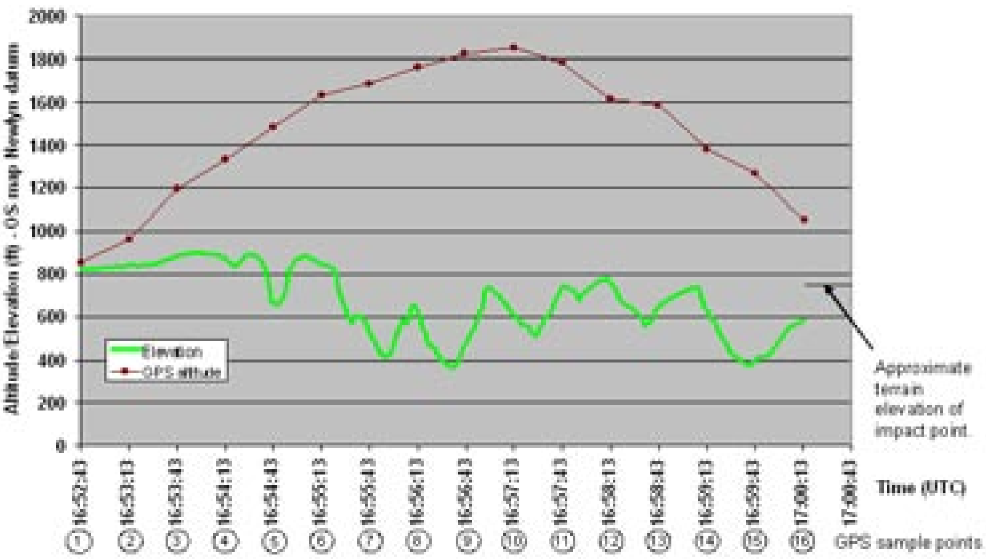


Figure 9

Aircraft altitude relative to terrain

Accident to G-BGED on 27 June 2004 at Beacon Village.

Note: GPS altitude is not as accurate as GPS horizontal position accuracy. Both the GPS altitude and the Terrain elevaion shown are with reference to the Newlyn altitude datum (as per OS maps) and so can be compared on the same scale.

Tests prior to February 2000 were conducted in accordance with BPA Form 108D. This detailed elements of flying tests to be completed, whether the pilot had successfully completed each section and any relevant remarks by the examiner. It also instructed that the test should be completed with the aircraft at 90% or more of its maximum all up weight. As a result of the changes to the test requirements this form was discontinued and the only records now retained are whether a pilot has passed or failed a test.

Records also exist of this pilot's various BPA authorisation renewals. However these provide no specific information on his achieved performance.

The pilot of G-BGED had flown on three other days in the six months prior to the accident, all of these being parachutist dropping flights, and all were flown on the same type of aircraft involved in the accident. His log book also shows that on 7 December 2003 he had flown for an hour's training with an instructor in a Piper Super Cub. There was no requirement to make detailed record of this training and so again it was not possible to substantiate the standard of his flying that particular training flight. The instructor however recalls no particular problems with the pilot's ability on that flight. There was a further 50 minute flight logged on 1 January 2004, again in a Super Cub, although the nature of the flight was not recorded. Of note, however, is that the performance of the aircraft flown on the training flight would have differed considerably from the heavily laden aircraft subsequently involved in the accident.

Parachute pilot qualifications

In order to qualify as a pilot of an aircraft engaged in parachuting operations, a pilot must meet certain experience and training requirements as laid down by the Civil Aviation Authority (CAA) and the British Parachute Association (BPA). The continuing validity of a parachute pilot's qualification is then reliant on him maintaining appropriate flying currency, as required by the CAA, for the maintenance of a licence, and carrying out sufficient parachuting flights, as required by the BPA. The pilot of G-BGED had complied with these requirements.

As part of the CAA's currency requirement, a private pilot with a single engine piston (SEP) rating is required to undertake a training flight of at least one hour's duration with a suitably qualified instructor in the 12 months prior to the rating expiring. Guidelines for the items to be covered during the training are covered in the CAA's Aeronautical Information Circular AIC 127/1999 (White 378). This includes the operation of the aircraft in an emergency, incorporating simulated precautionary landings. Whilst the flight is not considered a test, a log book entry is required by the instructor, only to be made if the pilot has demonstrated his ability to carry out a safe flight to an adequate standard. Should a pilot not meet the required standard, then his log book would simply not be signed by the instructor. Whether successful or not, there is no requirement to record any details of the training conducted or the standard achieved.

In order to maintain a parachute pilot's authorisation, the BPA requires that this is renewed annually. To achieve this, a pilot has to demonstrate that at least three parachutist dropping flights as pilot-in-command (PIC) have been conducted in the previous twelve months, or at least one flight made as PIC accompanied and supervised by a BPA Pilot Examiner or Chief Pilot. This flight is not a test and there are no laid down requirements for such a flight. No record need be made, other than an appropriate entry in the pilot's log book. However, the pilot must also demonstrate that he is current with parachute dropping techniques, emergency procedures and relevant BPA Operations Manual requirements.

Oversight of parachuting operations

All parachuting from civil aircraft over the United Kingdom is subject to a written permission from the CAA in accordance with Part V section 57 of the Air Navigation Order. Guidance is further given in CAP 660, which was originally based upon the BPA Operations Manual. Both documents detail the additional requirement for individual clubs to publish their own standard operating procedures in order to address the specific requirement of everyday operations not otherwise covered. An audit is carried out at least once every three years by the BPA, of member organisations, to comply with their delegated duties as agreed with the CAA.

At club level, the operation of aircraft used to drop parachutists is the responsibility of the appointed Club Chief Pilot (CCP). The areas of responsibility of such a pilot cover all aspects of the flying operation, including the aircraft, pilots and the provision of fuel. This task is not inconsiderable and this role may also be carried out by the same person acting as the Club Chief Instructor (CCI), who is responsible for ensuring that all the requirements, for both the parachuting and flying operations, as stipulated in the BPA Operations Manual, are met. The role of the CCP requires no stated qualification or training. Parachute pilot examiners form an additional part of the oversight process and they are required to have specific qualifications as listed under section 9, para. 1.4 of the BPA Operations Manual. However, their appointment relies upon experience and recommendation, but no specific training or test is required. Thus, whilst a system of oversight exists, the qualifications of those involved are not subject to any quantifiable standard.

Organisational documentation

The BPA Operations Manual and the Pilot's Information Manual were examined in the course of this investigation and elements of the contents were discovered which raised concerns in relation to the operation of parachuting aircraft. For example, there was a lack of differentiation between training requirements and elements required to be tested as part of gaining a qualification. Other information, particularly related to the Pilot's Information Manual, was mis-leading, out of date or incorrect. It was acknowledged by the BPA that this manual was out of date and they indicated it was in the process of being re-written. The manual was, however, at the time of the accident, still available to pilots, who had no way of knowing that its entire contents were anything other than correct.

Accident flight - nature of the operation

One of the surviving parachutists was a member of the public conducting a 'free fall' parachute jump for charity. He had no previous experience of parachuting and was jumping as a 'tandem pair', ie, attached to an experienced parachutist instructor and using a tandem parachute. In order to undertake the jump, this individual had to pay the charity involved £350. Of this, £100 was retained by the charity, with the remaining £250 being divided variously between the interested parties involved in organising or conducting the jump. These included an agent who organised such jumps for various charities, the parachuting club, and the tandem instructor. It could, therefore, be argued that the tandem jump was being undertaken as a commercial venture, with several parties profiting from the event. It transpired that the club concerned relied upon such jumps, together with short duration 'static line' jumping courses, to financially support its sport parachuting operation but, of note, their parachute pilots were not paid for their services. This meant that the flying operation was not subject to the standards that would otherwise apply to a commercial operation.

Analysis

This analysis concentrates on possible reasons for the loss of engine power, aircraft handling, operational oversight, survivability and recorded data issues, and leads to nine Safety Recommendations

The engine power loss

As a result of the examination of the wreckage, no conclusive cause for the engine power loss could be identified; the engine and propeller had both been mechanically sound prior to the accident and the ignition system components had been functional. There was very little evidence of fuel at the accident site and no fuel was recovered from the left wing tank, which was the selected tank at the time of impact. The later test indicated that it was unlikely that any significant volume of fuel had leaked out post impact from this tank. It was therefore considered that one possible cause for a power loss could be related to the operation of the aircraft's fuel system. Also, it could not be discounted that the (unidentified) cause of the loss of power on the flight prior to the most recent maintenance had reoccurred.

Operation of the fuel system

In the absence of detailed records there was no way of establishing how much fuel was onboard the aircraft at any point during the day and, in particular, prior to takeoff on the final flight. Had the pilot of G-BGED complied with the school's routine of refuelling with enough fuel for only two flights, plus a reserve, then the aircraft would have been refuelled after either the first or second flight of the day. Had it been after the second flight, then the aircraft should have departed with sufficient fuel in either tank to conduct the entire flight. However, had the aircraft been refuelled after the first flight of the day then it would still have departed with sufficient fuel for the flight, but this would have been contained in only one of the wing tanks. In this case, the opposite tank would contain some reserve fuel sufficient, theoretically, for about twenty minutes of flight. However, the actual endurance to be expected from this fuel would depend on the exact quantity contained in the tank after re-fuelling, and the actual fuel consumption rate of the engine. (Although the fuel gauges were considered to be inaccurate, the indication from a tank with a very low level of fuel should still have shown as a low quantity in this scenario.)

The refuelling records held by the parachuting school and the aircraft log, did not contain sufficient information on the precise fuel load and its distribution on G-BGED, prior to the accident flight. Whilst no witnesses could be identified who actually saw the aircraft being refuelled, circumstantial evidence suggests it was refuelled at least once during the day. Most notable was the reading on the bowser's fuel gauge which equated to a single uplift for G-ATLT after having completed three flights up to 10,000 ft, at approximately 10 US gallons (38 ltr) per lift. This indicates that the gauge had been zeroed in between the two refuels carried out to G-ATLT that day. As the pilot of G-BGED was reportedly in the habit of zeroing the gauge after refuelling, this also suggests that G-BGED was re-fuelled at some time between midday and about 1430 hrs.

The pilot involved in the accident was known to have operated G-ATLT on the sole flight he conducted on that aircraft that day, with the right fuel tank selected. This was established by the personal fuel record sheet for that aircraft compiled by the other pilot. It is possible, therefore, that when he flew G-BGED, he mentally decided to select the opposite tank on his next flight. If this was so, then he would have departed in G-BGED with the left tank selected, as the position of the tank selection valve found at the accident site would suggest. However, it is possible that the tank selection could have been changed in flight prior to the accident, possibly in an attempt by the pilot to sort out the problem.

The nature of the fuel tanks in this aircraft, being wide and long compared to their depth, means that, as such a tank becomes depleted, small 'packets' of air are initially drawn into the fuel supply as the fuel sloshes about due to turbulence and aircraft attitude changes, particularly if the aircraft were in level flight. This would cause the outlet pipe/stack to be intermittently uncovered. Initially, this is likely to have a minimal effect on the operation of the engine as the collector tanks are likely to remain fairly full but, as the level of fuel in the main tank diminishes further, more air and less fuel would be progressively drawn in, leading to increasing intermittent operation of the engine and finally to complete loss of power.

On the previous reported occasion where engine power was lost suddenly due to exhaustion of the fuel from the selected tank, the aircraft was in the climbing attitude, ie nose high, and this may have reduced the sloshing of the fuel and have led to a more sudden loss of power as the fuel became depleted. Subsequently, due to the height of the aircraft at the time, the engine was able to be re-started but it then ran roughly at reduced power 'missing' and 'coughing', probably due to air/fuel vapour having been introduced into the fuel supply to the engine. The symptoms, described by witnesses towards the end of the accident flight variously as "misfiring, spluttering, revving loudly and cutting out", are similar to those described above after the engine had been re-started. In the absence of any other defects being discovered during the investigation, these symptoms are consistent with the engine being starved of fuel but, on this occasion, after G-BGED turned back, the aircraft had insufficient height from which to glide to the airfield.

Witness evidence also indicated that fuel had been leaking from the right tank immediately after the impact and 15 litres were recovered from this tank. Witnesses were inconclusive as to whether fuel was leaking from the left tank but, as mentioned above, no fuel was recovered from this tank. However, as subsequent testing indicated that there was no significant path for any fuel that may have been contained to drain away, the possibility was raised that it was the left tank that contained little or no fuel at the time of the accident. If this were so then, when considered with fuel selector position as found and similarity of symptoms between this event and that which occurred on 19 August 2000 with G-ATLT, the possibility that the loss of engine power on the accident flight could have resulted from fuel starvation, following depletion of the contents of the left tank, could not be discounted.

Fuel system debris

The fuel system in G-BGED, was found to contain a significant amount of debris of unknown origin in the fuel metering unit filter which, during the previous 50 hour check, was not scheduled to be examined. Therefore, the debris, or a good proportion of it, was considered likely to have been present at the time of the power loss on the flight prior to the most recent maintenance, as the aircraft had only flown for some 1 hour 10 minutes since the check. Post that event, engine runs showed that full power could be obtained and, indeed, the aircraft had flown to and from Exeter Airport and preformed two parachutist dropping flights prior to the accident flight, without any reported engine power problems. Also, operating a new engine with this contaminated filter installed did not cause any performance loss. Therefore, debris in the filter would not appear at first sight to have been responsible for the earlier reported engine problem, and was unlikely to have caused the engine to fail on the accident flight, unless it had built up suddenly during the last flight.

The source of the debris was not established. However, engine test was conducted some weeks after the accident and after the filter had been disturbed by the very act of removal and transportation to the test facility. Thus, the debris might have somehow subsequently changed in nature, or possibly have become redistributed within the filter, changing its flow characteristics. The possibility, therefore, that it was a causal factor in the loss of engine power on the accident flight could not be dismissed.

Auxiliary fuel pump

The auxiliary pump START switch was found in the ON position, although it was possible that it could have moved to this position in the impact. If this were a valid pre-impact setting, then operation of the engine with this selection would result in an excessive fuel/air ratio, resulting in 'rich' running, with a consequent loss of power, or possibly a 'rich cut'. However, it is also possible that the pilot could have intentionally operated this switch when the engine problem first manifested itself, either in an attempt to restart the engine, or to overcome what he could have suspected to be an engine driven fuel pump failure. Operation of this switch could also help to purge air/vapour from the fuel system, should the selected fuel tank have become depleted[2].

Alternator belt

The adjustment of the alternator belt that was believed to have been made following the first flight of the day, was thought to have been carried out by an unqualified person; however, the belt was found to be correctly tensioned and a slack belt would not have caused a loss of engine power.

Aircraft handling

On the day of the accident, the pilot had previously climbed to altitude to the north of the airfield whilst flying G-BGED, and the pilot of G-ATLT expected him to do so again on the accident flight. The weather was such that visibility was good and the pilot of G-ATLT, who was flying just ahead of G-BGED, reported no difficulty with cloud in climbing to altitude. During this period, G-BGED was subject to a reasonably strong tail wind, which increased its relative groundspeed whilst flying towards the east, away from the airfield. It is difficult to determine exactly at which point the engine problem first became apparent to the pilot, although the aircraft's rate of climb was normal for the first 2.5 minutes of the flight. It is possible that the pilot had begun to level off due to the presence of localised cloud, but reports from the pilot of 'LT and witnesses at the accident site indicated that, in the area in which he was flying, cloud cover should not have impeded his ability to climb. Also, data from the GPS receiver showed that at no time, within the resolution of the data, did the aircraft fly level, which might be expected had the aircraft been transitioning under cloud to a clear area in which to continue the climb. The progressive nature of the change in the climb rate to a rate of descent, all of which occurred at around 80 kt, in addition, suggests that a reduction in power had occurred early in the flight, at about the 2.5 minute point.

If indeed the reduction in the climb rate at this point was due to the onset of a problem with the aircraft, rather than a problem with cloud, then the aircraft was

Footnote

[2] Partial or complete interruption of the fuel flow can also be caused, in certain types of aircraft, by the formation of 'vapour lock' in the fuel system, after the aircraft has been parked following a period of operation. Vapour is the result of the more volatile fractions of the fuel boiling off due to heat soak whilst the aircraft is parked, either from the airframe being exposed to warm sunshine, and/or from proximity of the fuel lines to the hot engine. It is more common in aircraft with low set wings (tanks) and with engines using Mogas. In this case, it is thought unlikely to have occurred as the C206 is a high winged aircraft, which results in the fuel lines always being under a positive pressure relative to atmosphere.

reasonably close to the airfield at this time and it should have been possible to complete a circuit and land back on the runway within the remaining time of the 7 min 31 seconds flight. However, the aircraft turned back for the airfield some five minutes into the flight, when it was 5.7 nm from the runway and by this time it was apparently having increasing difficulty maintaining altitude. The aircraft was also now having to fly into a headwind, increasing the time that would otherwise be required to return to Dunkeswell.

Towards the end of the flight, the recorded GPS track shows the aircraft turning away from an area of high ground (Dumpdon Hill) and on to a northwesterly track. This took the aircraft towards another area of high ground at Hartridge. The pilot's comments on the radio that he thought he wouldn't make it back to the airfield were probably made at about this time, as the aircraft was struggling to maintain altitude and terrain clearance from the rising ground. Hartridge runs approximately north-south and is quite flat on the top, and would probably have presented the best area in the immediate vicinity on which to make a forced landing. However, the aircraft was approaching from the east and the pilot would have been presented with quite a short distance in which to land without making a 90º turn. This may have been why the pilot selected full flap (40°) as he became concerned about the aircraft overshooting the chosen landing area ahead. This flap setting would normally only be used when a landing in the desired area is assured, as this degree of flap provides a large amount of drag[3]. It is possible that it was selected late in the flight and the combination of increased drag and rising terrain would likely have induced the pilot to continue to increase the pitch attitude of the aircraft in order to stay airborne. This view is supported by the fact that there was evidence of the aircraft having made contact with the tops of trees immediately before the field into which it crashed, over a distance of approximately 100 m. The impact attitude and final trajectory of the aircraft were both consistent with the aircraft having stalled just prior to striking the ground, probably at about the time the right tailplane made contact with a tree sufficiently hard for its leading edge to be dented.

Footnote

[3] The best glide distance is achieved with a 'clean' aircraft flying at the optimum speed. In this case, delaying the selection of (full) flap would have improved the pilot's chances of gliding to the likely selected landing area.

Operational oversight

It has been common practice over many years, in sporting aviation activities in the UK, that powered aircraft may be flown by pilots holding only a PPL, despite the fact the such operations may have a commercial aspect to them. Generally, this benefits the sports involved as they do not have to pay for the services of professional pilots; indeed it is possible that many sport aviation clubs would become financially unviable if they were required to do so.

The situation, however arises, where members of the public, ie, not regular club members, wish to experience a particular activity and pay to undertake, for example, a tandem-free-fall parachute jump with an instructor. Of importance is the expectation of the standard of operation being received by these members of the public paying for activities for which there is a clear profit motive attached by the provider. It is questionable whether those novices partaking in such activities are aware that, despite paying for their experience, it does not necessarily mean that either the pilot or aircraft are operating to the normal commercial requirements.

The imposition by the CAA of these requirements for commercial aviation activities is not reliant purely on the generation of profit. This might be considered to offer sporting organisations an advantage over other forms of aviation where such commercial activity requirements have been imposed. However, it is accepted that most aviation clubs exist primarily to provide the means of undertaking a sporting activity rather than to provide a business opportunity, but the definition is blurred as to where the boundary between the two lies. It is believed that this position is currently being examined by the European Aviation Safety Agency (EASA) although the outcome is currently unknown.

Both the CAA and BPA believe that, whilst a commercial licence is not required, the additional training required to become a qualified parachuting pilot compensates as the core skills required do not form part of normal commercial pilot training in the first place. This is accepted to a point but, as discussed in other parts of this report, anomalies in aspects of this training and oversight have been noted.

It is accepted by all parties that parachuting operations place a considerable strain on aircraft with frequent take offs, landings and climbs at maximum power followed by descents at reduced power. In more usual commercial operations where fare paying passengers are carried, certain standards are required by the CAA to be met by operators, and these are often embedded in the Air Operators Certificate (AOC). The standards set by an AOC would likely be quite onerous and a financial burden to sporting aviation organisations and, probably, would not be wholly appropriate. The oversight of civil sport parachuting by the CAA and BPA, where aircraft certificated in the Private category may be used, is meant to maintain acceptable standards of civil parachuting activities, an inherent part of which is the operation and maintenance of these aircraft. Whilst the circumstances relating to the maintenance/operation of G-BGED, ie, the absence of detailed fuel records, poor quality of fuel samples, contamination of the aircraft fuel system, and poor quality 'unapproved' maintenance of the alternator, were determined as not being causal factors in this accident, they are perhaps an indication that this aircraft, and possibly others in similar situations, may not be maintained/operated, to a high standard on a day-to-day basis.

Aircraft used in commercial operations, including light single-engine aircraft similar to that involved in this accident, are usually certificated in the Transport (Passenger) Category and hence subject to a more intensive maintenance schedule than aircraft in the Private Category. The parachuting school's own aircraft, G-ATLT was in fact certificated in the Transport (Passenger) Category. However, it should be noted that the basic requirement for maintenance to be managed, with defects being rectified and controlled, are the same for both private and public transport operations.

The circumstances of this accident illustrate an occasional scenario in the operation of light aircraft, where a reduction of available engine power, or complete engine failure, results in an accident instead of a successful forced landing. The particular terrain over which the aircraft might be flying being unsuitable for a successful forced landing, or the lack of experience of the pilot in the particular circumstances to conduct such a landing, are often contributory factors. When training for a PPL, pilots are taught to cope with an engine failure at different stages of flight, be it soon after takeoff (where options are usually limited to landing somewhere ahead), or at altitude (typically 2,000 ft) where sufficient time is usually available to plan a successful landing. However, after a licence is gained, only once in every 24 month period are private pilots required to fly with an instructor as a means of maintaining minimum flying standards, although this should include a review of various emergency situations that might reasonably be encountered.

To minimise the risks to student parachutists, whilst allowing clubs to operate with PPL rated pilots, the CAA and the BPA require, as part of their oversight procedure of parachuting clubs, that they appoint suitably qualified CCPs to specifically oversee the operation of the aircraft and its pilots. Such oversight is expected to ensure, as far as is reasonable, that new pilots are given adequate training and that the currency, abilities and specific knowledge of any pilot approved by the particular club to fly the dropping aircraft, is maintained at an acceptable level. This should, reasonably, include the ability to carry out a forced landing with minimum risk to the aircraft. In addition, CCPs are responsible for ensuring that the aircraft are kept airworthy in accordance with the normal CAA requirements. Maintenance of high standards with regard to fuel storage and refuelling operations is also required under this oversight. In practice, CCPs are not necessarily pilots with professional qualifications.

In the circumstances surrounding the accident to G-BGED, two factors stand out relating to the oversight of the operation of the aircraft, as distinct from the conduct of the parachuting operations. Firstly, there was a lack of positive control over the aircraft refuelling operation. The most direct effect of this was to hamper this investigation, in that the fuel load and distribution on G-BGED prior to the accident flight could not be precisely established from records. This, together with the lack of high quality fuel samples and the debris found in the filters of both aircraft operated by the school, raised questions about the oversight of the club's fuelling operation.

Secondly, given that the takeoff, left turn and initial climb were all apparently normal, the height gained, and hence time available to land the aircraft following the apparent onset of the problem some 2.5 minutes in to the flight, where the flight profile began to deviate from that expected, would have allowed the pilot to recover the aircraft back to the airfield within the time that it subsequently remained airborne. This would have been the most prudent course of action, particularly so as the hilly local terrain did not present many areas in which a forced landing might be made without undue risk. If the power loss had indeed occurred at the 2.5 minute point, it would seem that, in attempting to solve the problem, the pilot did not turn back until the aircraft was some miles downwind of the airfield, five minutes in to the flight and apparently unable to climb or maintain height. Although the pilot of G-BGED was current, within the CAA requirements in terms of flying hours, he had only flown on three other days in the previous six months, all flights being parachutist dropping flights, and before that, since 7 December 2003, only two flights in a Piper Super Cub totalling one hour fifty minutes. This is below the currency requirements of many flying clubs. Again, this raised questions concerning the abilities and recurrent training of pilots when faced with non-normal situations, and hence the oversight of flying operations.

Whilst it would be understandable that a low hours/experience private pilot on a recreational flight might, under similar circumstances, be working to capacity and possibly delay making a prudent decision to return, the oversight of pilots engaged in flying aircraft on parachuting operations should ensure that they make the most appropriate decisions when any flight does not proceed normally. This is particularly so as the pilot must assume total responsibility for the 'passengers', all of whom are paying either directly or indirectly for what is effectively a commercial service. As a result of the above findings, the following safety recommendation is made.

Safety Recommendation 2005-041

It is recommended that the Civil Aviation Authority, in consultation with the British Parachute Association, review their oversight of Parachute Schools, to ensure that the procedure currently in place adequately addresses its original intent, ie the establishment and maintenance of the highest reasonable standards of operation of such schools, including the operational standards for the aircraft and pilots engaged in parachuting operations.

Documentation

General concerns were raised during this investigation in relation to the documentation covering the operating of parachuting aircraft. In particular, the Operations Manual did not detail a training and test syllabus for initial qualification and renewal testing of parachute pilots. The BPA stated that the Pilot's Information Manual is in the process of being re-written, although this was suspended pending the outcome of this investigation. The following two safety recommendations are therefore made.

Safety Recommendation 2005-042

It is recommended that the British Parachute Association revise sections of the Operations Manual relating to the operation of parachuting aircraft, with the intention of clarifying the flying training syllabus and test syllabus required to qualify as a parachute pilot.

Safety Recommendation 2005-040

It is recommended that the British Parachute Association review the contents of the Pilot's Information Manual to ensure that all information contained is accurate, presented clearly in a professional manner and that a procedure is adopted to ensure that any future changes are promulgated expeditiously to all member clubs.

Survivability

The nature of the injuries sustained by the jumpmaster, who was positioned, unrestrained, next to the open door, suggests he was outside the aircraft when he hit the ground. His close proximity to the wreckage suggests that if he did exit the aircraft, it was at a late stage, possibly when the aircraft yawed following the impact with the trees. The yaw may have been sufficiently violent for him to have been thrown out of the open door on the right side of the aircraft. If so, then he would not have had the necessary height or time to deploy his parachute and, indeed, he was found with no apparent attempt having been made to initiate such a deployment.

With the possible exception of the jumpmaster, the parachutists in G-BGED were seated facing aft; this is generally accepted in parachuting operations as preferable to facing forwards, especially if the occupants are adjacent to a bulkhead which can react deceleration forces during any forced or crash landing. In this case, as is also normal in many parachuting operations, particularly those using smaller aircraft, the occupants had neither restraints nor seats and therefore their movement relative to the cabin during the impact was not controlled. Also, the lack of seats prevented any potential attenuation of the vertical impact loads although, in this case, the pilot's seat failed and he also suffered similar injuries to most of the parachutists in addition to striking the instrument panel. The only occupants not to sustain pelvic injuries were at the rear of the cabin and one of these was the jumpmaster whose injuries were consistent with falling to the ground separate from the aircraft. Had the occupants been on seats, it is possible that the severity of the internal injuries might have been reduced due to attenuation of energy and peak loading by the seat structure during the impact, although seats not specifically designed with crashworthiness in mind may themselves cause injuries.

However, the provision of seats for parachutists in a relatively small aircraft such as the Cessna 206 would be impractical and severely limit the freedom of movement within the cabin. This would also pose a threat to the safety of day-to-day parachuting operations, with risk of snagging and deployment of parachutes whilst in the aircraft. The cabin floor, however, has the potential in 'survivable' accidents, to offer a measure of protection if material with an ability to absorb energy were to form part of the floor. The following recommendation is therefore made.

Safety Recommendation 2005-043

It is recommended that the British Parachute Association, in consultation with the Civil Aviation Authority, consider issuing a requirement for appropriate energy attenuating material to be installed as flooring in aircraft engaged in parachuting operations, where the occupants are required to be seated on the floor.

The BPA Operations Manual does not provide guidance on whether tandem jumpers should remain attached during an emergency. If an emergency parachute descent from the aircraft has been discounted and a forced landing is imminent, it seems prudent to disconnect the two jumpers harnesses to aid egress from the aircraft, especially should one or other parachutist become incapacitated. On this occasion, whilst both tandem jumpers survived the immediate impact, it is still unclear if and how the student jumper managed to become free from his instructor. The following recommendation is therefore made.

Safety Recommendation 2005-044

It is recommended that the British Parachute Association include specific advice in their Manuals detailing emergency situations, in aircraft engaged in parachuting operations, concerning when conjoined tandem jumpers should separate from each other.

Although the impact was severe, this was a survivable accident, in that there were two survivors. The lack of any restraint system in the aircraft for the parachutists is an accepted practice as it allows safe and quick egress when jumping from the aircraft without, as mentioned above, the danger of tripping or snagging equipment on any seat structures or floor attachments. However, in the case of an emergency landing, the occupants are afforded little protection from any impact forces.

The BPA Operations Manual states that in an aircraft emergency the jumpmaster should follow the instructions from the pilot where practical. In the BPA's Jump Pilots' Manual it states that in case of an engine failure above 500 ft, the parachutists may decide to jump and, above 1,000-1,500 ft, they will almost certainly jump. This advice does not relate to tandem parachutists who would require significantly more height before jumping. Figure 9 shows that when the aircraft achieved its maximum altitude it was about 1,100 ft above the ground. This should have been sufficient for the three single parachutists to have been able to make an emergency jump from the aircraft. It must be understood, however, that the undulating nature of the ground below the aircraft and the attention being given to resolving the problem, might have affected the ability of both the pilot and jumpmaster to make a timely decision on whether or not the parachutists should jump. Once the aircraft could no longer maintain altitude and started to descend, little time remained for a decision to jump to be made before the aircraft was too low.

On larger aircraft such as the Cessna 208 Caravan, which can accommodate up to 14 passengers, restraint systems for use by parachutists when engaged in parachuting operations are required and fitted. The requirement for restraint is to prevent parachutists from sliding around the cabin floor during aircraft manoeuvring, and possibly causing control difficulties by shifting the aircraft's centre of gravity position. These systems are not necessarily designed to improve survivability in a crash situation. The cabin of the Cessna 206 is relatively small and there are no known control difficulties having arisen from the movement of parachutists. However, the use of a restraint system may have prevented the fall of the jumpmaster from the aircraft and, generally, might reduce injuries resulting from, for example, parachutists towards the rear of the cabin crushing those at the front. The following recommendation is therefore made.

Safety Recommendation 2005-045

It is recommended that the British Parachute Association, in consultation with the Civil Aviation Authority, consider the practicality of installing appropriate restraint systems for parachutists in all aircraft engaged in parachuting operations.

The student tandem parachutist who survived the accident could not recall any information that might have been given before takeoff on the brace position to adopt in case of emergency. It was one of the other parachutists on the aircraft who described the brace position he should adopt with his head on his knees. This would be a suitable brace position in a forward facing 'airline' seat with a lap belt where the occupant is likely to be thrown forward during an impact. Adopting a similar position whilst facing rearwards is probably the worst position to adopt, and is likely to result in the head and upper body being rotated backwards (towards the front of the aircraft) and being brought rapidly to a halt should they strike a fixed structure or the person behind. Ideally, rearward facing occupants should brace their backs against a fixed structure, such as a seat back or a bulkhead, but in this case no such structures were available for all the occupants. It was difficult in this investigation to determine whether the brace position described, and if adopted, adversely affected survivability. However, it would seem sensible to review the benefits of appropriate 'brace' positions for parachutists across the range of aircraft engaged in parachuting operations, and so the following recommendation is therefore made.

Safety Recommendation 2005-060

It is recommended that the British Parachute Association, in consultation with the Civil Aviation Authority, establish an appropriate 'brace' position for each seating position on aircraft engaged in parachuting operations.

G-BGED had been approved by the CAA in 1982 for use in parachuting operations. The CAA supplement to the Owner's manual provided details for the aircraft operation specific to parachute jumping. This included the removal of all seats, with the exception of the front left pilot's seat, and the securing of all loose equipment. Reconstruction of G-BGED's cabin interior, and examination of the other Cessna 206 used by the club, revealed that other further changes had been made; the presence of a wooden box beneath the right side of the instrument panel and a tennis ball fitted over the right control tube stub. Although these additions were intended to improve the cabin interior with regard to the accommodation of the parachutists, they were 'amateur' modifications and thus the aircraft was not configured to an approved standard. However, it should be possible to modify such aircraft interiors in a manner that improves the accommodation of parachutists without degrading its crashworthiness. Had the configuration been submitted to the CAA for approval, they state that the security and crashworthiness of the installations would have been considered. However, with the introduction of EC Regulation 1702/2003, the cabin configuration and the approval of any changes lies with the European Aviation Safety Agency and no longer with the CAA. The following recommendation is therefore made.

Safety Recommendation 2005-061

It is recommended that the British Parachute Association, in consultation with the Civil Aviation Authority and the European Aviation Safety Agency, conduct a review of cabin interiors on aircraft engaged in parachuting operations with regard to improving their crashworthiness.

Availability of recorded data

Witness statements, radar and wreckage analysis did not yield any definitive cause for this accident. Although there are no requirements for aircraft in the Private category, such as G-BGED, to carry any equipment for recording flight parameters or cockpit audio information, on this occasion data retrieval from the Skymap 11 GPS yielded altitude information that would otherwise have been unavailable. This enabled an understanding of the last flight, but not the reason for the aircraft's degraded performance. The investigation of this accident would have been greatly enhanced had audio and basic flight parameter recordings, such as attitude and propeller speed, been available. Thus, in accidents where there is extensive disruption of the aircraft, it may not be possible to determine the causal factors from wreckage analysis and witness evidence alone. This has proved to be the case in a number of investigations, including a recent one into a Hughes 369HS accident, G-CSPJ, the report on which was published in AAIB Bulletin 1/2005.

The circumstances of that accident were that a private pilot had hired the helicopter from a commercial organisation for a private flight. The helicopter was certified in the Transport (Passenger) category and as such would come under the heading of a Commercial Air Transport (CAT) aircraft, but was not required to carry flight recorders as it fell below the weight category where recorders are required. The AAIB has conducted or assisted with many investigations where flight recorders have provided invaluable information which has contributed to the understanding of CAT accidents. As technology now enables lighter, cheaper and more compact electronic devices including, potentially, basic flight recorders, to be made, consideration should be given to encouraging owners, operators and manufacturers to fit such recorders to as wide a range of aircraft, however small, with special emphasis, initially, on those that have a Certificate of Airworthiness in the Transport (Passengers) category. This would increase the proportion of air accidents where the causal factors would be fully understood, thereby improving the aviation community's knowledge of how to minimise the number of future accidents.

Two safety recommendations were made in the report on the accident to G-CSPJ, both to the Department for Transport, one of which stated the following:

'Safety Recommendation 2004-84

The Department for Transport should urge the International Civil Aviation Organisation (ICAO) to promote research into the design and development of inexpensive, lightweight airborne flight data and voice recording equipment.'

In a letter to the AAIB, dated 14 October 2004, the Department for Transport gave its full support to this recommendation.

It will be the AAIB's intention to recommend the fitting of appropriate airborne recording equipment, initially most likely a miniature CVR once such equipment becomes available, initially to these smaller CAT aircraft. While recommending such a measure, it is appreciated that the arguments against doing so are financial, technical and operational, but it is envisaged that these arguments will diminish as technological progress reduces the financial burden of installing such recorders. However, in order to design lightweight inexpensive equipment, minimum standards of design will need to be set. The following recommendation is therefore made.

Safety Recommendation 2005-062

It is recommended that the European Aviation Safety Agency develop standards for appropriate recording equipment that can be practically implemented on small aircraft.