ACCIDENT

Aircraft Type and Registration:	Slingsby T67C Firefly, G-FORS
No & Type of Engines:	1 Lycoming O-320-D2A piston engine
Year of Manufacture:	1990
Date & Time (UTC):	25 May 2005 at 1607 hrs
Location:	Near Potterspury, 6 miles northwest of Milton Keynes
Type of Flight:	Training
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - 2 (Fatal) Passengers - N/A
Nature of Damage:	Aircraft destroyed
Commander's Licence:	JAA Airline Transport Pilot's Licence with FAA and CAA Instructor Ratings
Commander's Age:	59 years
Commander's Flying Experience:	6,000 hours (of which at least 25 were on type) Last 90 days - 18 hours Last 28 days - 8 hours
Information Source:	AAIB Field Investigation

Synopsis

An instructor and his student were conducting a training flight when the aircraft was seen to enter a spin. The aircraft was still in a spin when it impacted the ground. There was no evidence of a mechanical problem; however, it is possible that the engine might have stopped during the spin. Whilst it was not possible to establish what the instructor planned to do on this flight, the investigation concluded that the aircraft probably entered an unintentional spin during an exercise involving oscillatory stalling. This particular exercise is not part of the UK Private Pilot's Licence syllabus. As this exercise is considered inappropriate for ab initio flying training, a recommendation has been made to the CAA to ensure that flying instructors do not include oscillatory stalling during early flying training.

Background to the flight

The commander had been a member of the Turweston Aero Club since November 2003 and had agreed that he would provide flying lessons to an acquaintance on a commercial basis. The student had no previous flying experience and the instructor first flew with him in G-FORS on 22 February 2005. Since then they had flown together on 12 occasions prior to the accident flight; all but one of these flights were in G-FORS. No training records were found of the flights although the completed exercises had been noted in the student's logbook with the entries initialled by the instructor. On the two flights prior to the accident, the instructor had recorded in his own logbook that the student '*Did well*'.

History of the flight

Both pilots arrived together at Turweston Aerodrome at about 1530 hrs. There was no evidence available of any formal briefing at the airfield and therefore no information available on the proposed content of the flight. Records indicate that the aircraft took off at 1545 hrs from Runway 27. The surface wind was approximately 200°/13 kt. After takeoff the aircraft turned towards the north. There was no radio call to indicate that the pilots changed frequency and the Turweston Air/ Ground Operator stated that he had not heard any emergency call on his frequency.

There were various eye and ear witnesses to the accident. One witness saw the aircraft flying very slowly in a straight line. He subsequently assessed the height of the aircraft as being about 500 ft. The witness could not hear any engine noise and kept watching the aircraft. He then saw the right wing drop and the aircraft enter a steep dive. As it descended, it appeared to be "turning from side to side" and then started to "spin clockwise". As it went out of sight behind some trees, the witness ran to telephone the emergency services. His wife, who was also watching the aircraft, saw it spinning out of sight behind the trees. She could not hear any engine noise either. Both witnesses confirmed that there were no other aircraft in the area at the time of the accident. They could not be certain about the number of turns the aircraft performed before going out of sight but considered that it had been spinning clockwise. Another witness, in a car, saw the aircraft for a very short time before it went out of sight behind a hedge. When he first saw the aircraft, it was just above tree top level and was in a high rate of descent. A further witness saw the aircraft when it was "spiralling out of control". He estimated that the aircraft did about two to four spins before going out of view behind some trees. His recollection was that the aircraft was spinning anti-clockwise and had a constant descent and turn rate. He could not hear any engine noise and confirmed that there were no other aircraft in the area. Another individual, who was first on the scene of the accident, had been working at home when he was alerted by a neighbour that there had been an aircraft accident. He cycled immediately to the area and, as the first individual on the scene, checked the occupants of the aircraft but he could not detect any signs of life. The instructor was in the right seat and the student was in the left seat.

The police recorded the first call about the accident at 1614 hrs and by 1624 hrs the first ambulance was on the scene and had confirmed that the two occupants of the aircraft had received fatal injuries.

Recorded information

The Turweston radio frequency is not recorded and a check of other possible radio frequencies showed no evidence of any calls being made by the occupants of G-FORS.

Radar information had been recorded and was available from both the Heathrow and Debden radar sites. Only primary returns were detected and therefore, no height information was available. The first radar returns were detected at approximately 1551 hrs some 7 km to the north of Turweston. During the flight, radar returns indicated that the aircraft carried out a left turn through at least 360º and there were then some indications of manoeuvring for 2¼ minutes before the aircraft took up a heading of approximately 010ºM for about 1¼ minutes at an average groundspeed of 110 kt. The final radar returns were detected close to the accident site at approximately 1605 hrs.

To evaluate the altitude of G-FORS during the accident flight another T67C was flown on the same recorded route. This indicated that the minimum altitude for primary radar contact was about 2,000 ft agl over the area, showing that G-FORS was at a minimum height of 2,000 ft agl from 1551 hrs to 1605 hrs when contact was lost.

Weather information

An aftercast was obtained from the Met Office at Exeter. The synoptic situation at 1800 hrs on 25 May 2005, showed a broad warm sector covering the British Isles with warm temperatures and light to moderate surface winds. The surface wind was assessed as 200º/ 13 kt, the surface temperature was 21ºC with a dew point of 12ºC, visibility was between 20 and 40 km, mean sea level pressure was 1019 hPa. There was a possibility, sometime during the afternoon, of some cloud with a base between 3,000 and 3,500 ft amsl. At 2,000 ft amsl, the wind was assessed as 220º/ 30 to 35 kt with an air temperature of 12ºC and a dew point of 6ºC. At 5,000 ft amsl, the wind was assessed as 230º/ 35 kt with an air temperature of 10ºC and a dew point of minus 4ºC. Using the CAA carburettor icing prediction chart, serious icing could be expected at any power at 2,000 ft amsl and light icing at any power at 5,000 ft amsl.

Aircraft description

The Slingsby T67C is a fully aerobatic, low-wing monoplane aircraft constructed from glass reinforced plastic and is fitted with a fixed tricycle landing gear. It accommodates two people seated abreast in the cockpit, who are protected by a single piece canopy that slides aft from its latched position. Power is provided by a single Lycoming four cylinder, horizontally opposed, air cooled, carburettor equipped piston engine giving 160 BHP at 2,700 rpm, which drives a two-bladed fixed pitch propeller. To enable control of the engine two throttle levers are provided, one at the centre and the other to the left of the cockpit, thus allowing either pilot to operate the throttles. These are interconnected by a lay-shaft and move in sympathy with each other.

The flying controls are conventional. The ailerons and elevator are operated by two interconnected control columns, which are connected to the flight control surfaces via push rods, pivot points and quadrants. The rudder is controlled by cables running from torque shafts in the cockpit to a quadrant in the tail and is operated by foot pedal mechanisms. As the seats are fixed, each of the four rudder pedals is individually adjustable to one of four positions. The rudder pedals are also connected to the nose wheel steering, which operates in the same sense as the rudder. The nose wheel is self-centred by a spring and cam mechanism mounted on the rear of the nose wheel leg. Elevator trim is also cable operated from a manual trim wheel, situated between the two seats, to a trim tab on the left elevator. The flaps are manually operated by a three-position lever located between the seats. This lever locks in each position and is released by operating a spring loaded plunger on the end of the lever.

Fuel is contained in two separate wing tanks, and is supplied to the engine via a fuel tank selector valve, filter and electrical and engine driven mechanical fuel pumps. The fuel selector valve can be selected to OFF, LEFT or RIGHT.

Wreckage and impact information

The accident site was a firm, dry, level field containing a crop of wheat standing approximately 0.8 m high. The site was bounded by tall trees approximately 80 m to the south and hedgerows, containing isolated trees, approximately 50 m to the north and west. Five metre high, low voltage overhead electrical cables, running north-west to south-east, were positioned approximately 200 m to the east.

Impact marks indicate that the aircraft engine struck the ground at a nose down angle of 35º on a magnetic heading of 020º with little forward motion. The structure behind the engine bulkhead had broken and the main fuselage had rotated anti-clockwise before coming to rest on a magnetic heading of 005º. Flattening of the wheat indicated that the left wing struck the ground prior to the fuselage rotating approximately 15º in an anti-clockwise direction. The tail section, which remained partially connected to the fuselage, came to rest on a magnetic heading of 326º. There were two distinct wreckage trails leading from the aircraft. One trail extended 6 m in a straight line forward of the engine and consisted of fragments of the canopy, windscreen and engine cowling. The second trail extended 8 m on a magnetic heading of approximately 155º and consisted of fragments of the canopy and items from the cockpit.

Both wings had sustained impact damage on the lower surface sufficient to cause the fibreglass skin to break and disbond from the supporting structure, thereby allowing the fuel to leak out of the wing tanks. The left wing sustained slightly more damage than the right. Short, green coloured streak marks on the lower surface indicate that the aircraft had some forward motion; however, there was very little impact damage to the wing leading edges and to the rear fuselage and tail section, other than the area where the fuselage had broken. All three undercarriage legs had broken close to the aircraft structure. The aileron controls were still connected and operated in the correct sense. The elevator control rod in the rear fuselage was bent, consistent with the impact forces, and had failed at the connecting rod in the rear fuselage. Aft of this point, the control rod and elevator surface moved normally. The rudder cables, which had detached from the rudder pedals, were still connected to the rudder and operated freely and in the correct direction. The elevator trim cable had been pulled out of the fitting on the elevator trim tab; consequently it was not possible to establish the position of the trim. The flaps were in the up position.

One blade of the propeller had bent under the engine. On this blade there was a small dent on the leading edge, towards the tip, and light chord-wise scoring across the front face over the full length of the blade. There was also a large dent on the trailing edge caused when the blade made contact with the nose undercarriage casting. The second propeller blade was undamaged. The crankshaft flange, on which the propeller was mounted, had bent downwards and the fly wheel hub had fractured. The majority of the engine accessories, including the carburettor, had broken off the engine and the engine support frame had failed due to buckling. Whilst there was no fuel in the fuel tanks, there was clean blue fuel in the fuel pipe between the fuel selector valve and filter.

The fibreglass structure aft of the engine bulkhead had broken and the rudder pedal assemblies had broken from their mounting points. The canopy, which had shattered, was fully open with the handle in the open position. The left side of the windscreen frame had broken where it joined the fuselage. The right lug on the canopy securing latch was missing and the left lug was bent. There was also impact damage to the metal and plastic parts of the canopy securing latch. The distortion of the windscreen frame and the inertia from the rotation of the aircraft to the left, might have been sufficient to cause the canopy and latch to open; however the possibility that the canopy was open before the impact cannot be excluded. The area behind the pilot's seats was covered in a white powder from the ruptured dry powder fire extinguisher. In the cockpit the barometric pressure was set at 1016 hPa on the altimeter and the magneto switch was set to 'Both'. The throttle control rods and the structure supporting the engine controls in the cockpit had been damaged in the ground impact.

Both occupants were wearing five-point seat harnesses. The inertia shoulder harnesses remained locked and retracted in the inertia units; however the beam to which they were attached had broken away from the fuselage. The metal male connector on the left pilot's crotch strap had broken and the connector on the right pilot's crotch strap had distorted and come out of the Quick Release Fastener, which had also distorted. The waist belts were intact. The right occupant was sitting on the map and aircraft checklist. Neither pilot had been wearing a parachute.

Detailed examination of wreckage

Flying controls

The elevator, rudder and elevator control runs were all examined, as far as possible, and found to be in a good condition with no evidence that there had been a control restriction or pre-impact failure.

The rudder pedal mechanism had 'frozen' and the centering device on the nose wheel steering had punctured the engine bulkhead in a position consistent with full right rudder having been applied. Mud had also been forced into the left side of the nose wheel, which had been bent backwards and to the right. The lower edge of the hub on the right side of the nose wheel had bent outwards and the tyre in this area had split. This damage indicated that the left side of the nose wheel impacted the ground first.

Engine controls

The mixture control was fully IN (fully rich) and it was assessed that this position was not influenced by distortion of the structure. The position of the carburettor hot air-valve, and a kink in the control cable connected to the valve, indicated that when the hot airbox distorted in the impact, the carburettor heat had been selected to ON. In the cockpit there was a bend in the exposed portion of the carburettor heat control rod caused by the instrument panel during the impact. The bend corresponded with the carburettor heat control having been pulled out by approximately 23 mm towards the hot selection: the range of movement of the carburettor heat control on a similar aircraft was 34 mm. This also suggested that carburettor heat had been selected ON.

The left hand throttle was at idle and this position was corroborated by damage analysis on the throttle control rod in the cockpit and the connection to the carburettor.

Fuel system

It was established that the fuel selector valve was in the RIGHT TANK position and would allow the unrestricted flow of fuel between the right tank and fuel filter. The fuel filter was clean and contained a small quantity of clean fuel. Although the casing of the electrical fuel pump had been damaged, all the seals were intact and the filter, which contained a small quantity of fuel, was clean. The electrical pump selection switch in the cockpit was at ON and the electrical fuel pump operated normally when power was supplied. Whilst the casing of the engine driven fuel pump had been damaged, the diaphragm was intact, the pump contained clean fuel and when operated the pump provided a strong suction force at the inlet and pressure force at the outlet.

Engine

The flywheel was fractured and bent downwards. The crankshaft flange had also bent downwards and embedded itself in both halves of the engine casing. The damage to the flywheel and crankshaft flange was consistent with the propeller, at the 6 o'clock position, striking the ground with the engine producing very little power. Whilst most of the oil had leaked out of a hole in the sump, clean oil was found in the oil filter; there was no debris in the filter paper.

The engine was taken to an overhaul facility where it was stripped under AAIB supervision. Both magnetos were serviceable and the colour of the pistons and spark plugs indicated that the engine had been running normally. All the components were able to move freely once the bent crankshaft flange had been removed from the engine casing. The number 1 and 2 inlet tappet bodies were badly spalled, and spalling had just started on the number 1 exhaust tappet body. Spalling is the separation of flakes of metal resulting from sub-surface fatigue in the metal component. All the valves were found to be in good condition. The number 1 and 2 inlet valve lobe on the camshaft was found to be badly worn with the valve lift 33% less than the number 3 and 4 inlet valves; the camshaft was checked for trueness and found to be satisfactory.

The engine manufacturer stated that camshaft lobe and tappet body wear can develop in engines that are flown infrequently, or when engines are operated in cooler weather where the flight times are less than an hour.

Light bulb filaments

Stall warning, starter engaged and alternator warning lights were situated next to each other at the top of the instrument panel in front of the left seat pilot. The filament on the starter engaged warning light was intact and normal, whereas the filament on the stall warning and alternator warning lights were intact and extended. An intact and extended filament normally indicates that at the time of impact the filament was illuminated. On this aircraft the alternator warning light can normally expect to be illuminated when the engine speed drops below 800 rpm. Ground idle is normally between 600 and 800 rpm.

Maintenance and significant recent faults

The aircraft had been maintained in accordance with the Light Aircraft Maintenance Schedule. The last annual maintenance was completed on 20 December 2004, approximately 62 flying hours prior to the accident, and the most recent 50 hour inspection was completed on 12 May 2005, approximately 9 hours before the accident.

The recent fault history revealed that it was reported that:

> On 26 January 2005, approximately 51 hours prior to the accident, the elevator was stiff to operate. No fault could be found. Also the engine ran roughly at low rpm. The plugs were serviced and a ground run was carried out, which was satisfactory.
>
> On 20 April 2005, approximately 25 hours prior to the accident, the engine ran rough at low rpm. Three induction gaskets were replaced, the spark plugs were checked and 2 of them were replaced. No subsequent unserviceabilities were reported.

Medical information

A Post Mortem examination was carried out on both pilots. It was concluded that the accident had not been survivable and that both had died from multiple injuries consistent with an aircraft crash. There was no evidence of any natural disease, which could have either caused or contributed to death or the cause of the accident.

Toxicological examination was essentially negative; neither pilot was under the influence of alcohol or drugs at the time of the flight. The instructor weighed 86 kg and the student weighed 116 kg.

Operational information

The instructor and his student were conducting a training exercise as part of a course for a Private Pilot's Licence (PPL). Details of previous flights had been recorded in both the instructor's and student's logbook. The student had flown all his exercises with the same instructor and had completed 12 flights totalling 12 hours 15 mins prior to the accident flight; all the flights except one were in G-FORS. It was noted that the student had completed one session of aerobatics, and had recorded a stalling exercise on eight of the flights, including one with 'oscillatory stalling' on 22 April 2005.

An aerodynamic stall occurs when there is a substantial breakdown of the organised flow across the wing resulting in a large reduction in lift. No reference to 'oscillatory stalling' was found in publications related to flying training within UK. However, another student who had flown with this instructor described this manoeuvre as maintaining the aircraft in a stalled condition whilst controlling any wing drop with rudder.

The instructor was experienced and had worked in both the USA and UK as a flying instructor. His most recent renewal of his UK instructor rating was on a flight with a CAA examiner on 12 June 2003, which remained valid until 5 July 2006. The student had no flying experience prior to his PPL course.

Another of the instructor's students was interviewed as part of the investigation. He had flown 14 dual flights with the instructor and was also a friend of the student involved in the accident. During the interview he confirmed that he had completed two sessions of spinning with the instructor but knew that the student involved in the accident had not experienced any spinning. He also confirmed that the instructor included oscillatory stalling during the PPL course. Both students had experienced this exercise with the instructor. During these exercises, the instructor would keep his feet and hands on the controls to monitor the student. On one occasion a student recalled that the aircraft went into a spin and the instructor took control and recovered the aircraft. Prior to any aerobatics or stalling, the instructor would complete a standard '*HASELL*' check and would use a minimum altitude of 3,000 ft for entry to each stall and a minimum altitude of 3,500 ft for entry to each spin. This student's experience of spinning was that only one turn would be completed and the height loss would be about 500 ft.

There was no requirement to carry out spinning during a PPL course although it is not precluded. The emphasis during initial training is on spin and stall awareness to enable the student to recognise quickly the onset of a stall or spin and take early recovery action.

Calculations indicated the aircraft was at a weight of approximately 942 kg with a CG position of 28% mean aerodynamic chord (MAC) at the time of the accident. This was at the aft limit for the CG and some 11 kg below maximum allowable weight. Fuel calculations indicated the aircraft had approximately 12 Imperial Gallons on board at the time of the accident.

There were two parachutes available in the crewroom at Turweston. Inquiries indicated that these had never been worn in any flight involving G-FORS. Each parachute weighed 7.6 kg and if both pilots had worn them on the accident flight, the aircraft would have exceeded the maximum allowable weight.

The aircraft certificate of airworthiness had been renewed on 19 December 2002 and was valid until 18 December 2005. The renewal process had involved a flight test on 17 December 2002 when the CAA approved airworthiness check pilot had carried out a spin to the left and to the right; both were recorded as satisfactory.

The Pilot's Notes for the aircraft included the following information about spinning.

1. The height loss during an erect spin is about 400 ft per turn, with each turn taking about 2½ seconds and the recovery taking about 500 ft.
2. If full pro-spin control is not maintained throughout the spin, the aircraft could enter either a spiral dive or a high rotational spin.
3. A high rotational spin is recognised by a steeper nose down attitude and a higher rate of rotation.
4. The recovery for a high rotational spin referred to the procedures for an '*Incorrect recovery'* (see para 6 below).
5. The '*Standard Recovery Technique'* is as follows*:*
   - *a) 'Close the throttle.*
   - *b) Raise the flaps, if lowered.*
   - *c) Check direction of spin on the turn co-ordinator.*
   - *d) Apply full rudder to oppose the indicated direction of turn.*
   - *e) Hold ailerons firmly neutral.*
   - *f) Move control column progressively forward until spin stops.*
   - *g) Centralise rudder.*
   - *h) Level the wings with aileron.*
   - *i) Recover from the dive.*

   WARNING: WITH C OF G AT REARWARD LIMIT THE PILOT MUST BE PREPARED TO MOVE CONTROL COLUMN FULLY FORWARD TO RECOVER FROM SPIN'
6. The '*Incorrect Recovery'* was as follows:

   'A high rotation rate spin may occur if the correct recovery procedure is not followed, particularly if the control column is moved forward, partially or fully, BEFORE the application of full anti-spin rudder. Such out-of-sequence control actions will delay recovery and increase the height loss. If the aircraft has not recovered within 2 complete rotations after application of full anti-spin rudder and fully forward control column, the following procedure may be used to expedite recovery.
   - *a) Check that FULL anti-spin rudder is applied.*
   - *b) Move the control column FULLY AFT then SLOWLY FORWARD until the spin stops.*
   - *c) Centralise the controls and recover to level flight (observing the 'g' limitations).'*

A copy of Service Bulletin 43 Issue 2, warning of the possibility of the engine stopping during a spin, was enclosed in the Pilot's Notes for this aircraft. The Service Bulletin advised the pilot that if the engine was not correctly leaned and the slow running adjusted to between 700 and 750 rpm then there was a chance of it stopping during a spin.

On 26 November 2005, a CAA Test Pilot flew two flights in a similar T67C to confirm the spinning characteristics of the aircraft type and to evaluate the consequences of practising an oscillatory stall.

1. On the first flight, the aircraft was at a weight of 910 kg with a CG of 25% MAC. The stall speed was established as 57 kt. In a full stall, the rate of descent was about 500 ft/ min. The use of rudder was explored during the full stall and the aircraft was very susceptible to a wing drop. It was noted that a smooth application of increasing rudder resulted in a large and rapid wing drop of 90°. Even with immediate centralisation of controls, the resultant height loss was some 1,000 ft. It was considered that any attempt to maintain controlled flight at the point of stall was unwise in that it could lead to loss of control without further warning. Two incipient spins were flown with the controls centralised after ½ turn; the recovery was effective with a total height loss between 900 and 1,000 ft. Four spins, in both directions, were carried out, with between two and four turns each. This indicated that the height loss in each turn was just over 400 ft and it required about 500 ft for full recovery with the recovery taking an additional half to one turn of the spin. The rate of turn was close to three seconds per turn. For these spins, the engine mixture was set to fully rich and the carburettor heat was selected ON; the engine continued to run although it was noted that the rpm decreased to about 600.

2. For the second flight, the aircraft was at a weight of 872 kg and a CG of 27.5% MAC. Five spins were carried out with up to four turns and in both directions. In three of the spins, the control column back pressure was released and the turn rate increased to about two seconds per turn. The recovery from these high rotational spins took between 2½ and 3½ turns. Additionally, on three of the spins, the engine stopped but restarted during the recovery of the spin; the mixture was set to full rich for all spins. On two of the spin recoveries, the corrective rudder was maintained to establish if the aircraft would enter a spin in the opposite direction. On both of these occasions, the aircraft entered a spiral dive.

Analysis

General

Evidence from witnesses was that the aircraft was in a spinning manoeuvre as it approached the ground. Whilst there was some difference between witness accounts as to the direction of the spin, impact marks and damage to the aircraft confirmed that G-FORS struck the ground while it was spinning to the left (anti-clockwise) and with the correct rudder input applied to recover from this manoeuvre. Allowing for the slight differences in witness accounts, it was possible that the aircraft had been in a spin to the right from which it had been recovered only to re-enter a spin to the left. Radar evidence also indicated that the aircraft entered the final manoeuvre above a minimum height of 2,000 ft agl, which is at variance with one witness estimate of 500 ft. The investigation attempted to determine whether the spin had been caused by mechanical failure or by the pilots either intentionally or unintentionally entering a spin.

Engineering

Engineering analysis revealed no indication of structural failure, control restriction or any other onboard emergency that would either cause the aircraft to inadvertently enter, or fail to recover from a spin. Illumination of the alternator warning light and damage to the propeller blade indicated that when the aircraft crashed the engine was producing very little power and might possibly have just been windmilling very slowly. Whilst there was no fuel in the ruptured fuel tanks, the presence of fuel in the fuel filter, in both the electrical and mechanical fuel pumps and the extensive fuel spillage suggested that the aircraft had not run out of fuel. The position of the engine controls also indicated that whilst the engine had been throttled back, it had not been shut down. The carburettor heat control was selected ON. Either pilot might have made this selection as part of his routine checks, to clear carburettor icing or because he intended to operate the engine at a low power setting.

With the mixture control set at fully rich and the carburettor heat at ON, the engine would have been running on the rich side and would therefore have been susceptible to stopping during a spin. Whilst the engine stopping in flight would not directly cause the aircraft to enter a spin, or prevent it from recovering, it would have been distracting, particularly during such a critical phase of flight.

Since the aircraft had some history of a rough running engine, and evidence was found of a worn cam shaft, consideration was given to the possibility that the fault had returned and distracted the pilots. The engine manufacturer has stated that the reported rough running was most likely caused by an ignition or carburettor fault, or a leak in the induction system. The magnetos were found to be serviceable and given that the spark plugs and leads had recently been checked it is unlikely that they were the cause of any problem. The condition of the carburettor and induction system meant that it was not possible to prove the pre-accident integrity of these systems. The engine manufacturer also stated that worn camshaft lobes would have caused a gradual reduction in the maximum static power of the engine and would not have affected the slow running. There had been no previous reports that the engine was lacking in power, which suggested that any deterioration in engine performance would have been negligible.

Operational

There was no specific documentary or witness evidence to indicate what the instructor intended to do during the flight. There was a record in the student's logbook of the exercises undertaken during previous flights and it was apparent that he had completed a number involving stalling, but none involving spinning. Although it was not a required exercise, the instructor was known to include spinning during his training flights. The possibility that the flight was planned to include some spinning could not be excluded.

If the flight was to include spinning, it is likely that the instructor would first demonstrate a spin to the student. The radar recording showed a 360º turn, which could have been a clearing and positioning turn prior to some handling exercises. The aircraft's altitude could not be accurately determined but a trial indicated that the minimum height at this time would be at least 2,000 ft agl. Evidence from other students was that the instructor would use a minimum entry height of about 3,500 ft agl for any spinning manoeuvre. The flight time prior to the initial clearing turn was sufficient to achieve a height of at least 4,000 ft agl. It was not possible to determine the exact manoeuvres carried out after the 360º turn but it was possible that they included some aerobatics. Thereafter, there was a period of about 1¼ minutes when the aircraft maintained a constant northerly heading until loss of contact close to the accident site. Following such a period of relatively constant flight, it would be good airmanship to complete another clearing turn before further manoeuvring. Evidence from another student about the instructor's normal approach to flying was that he was conscientious and would normally have completed such a clearing turn. It was therefore considered unlikely that the final spin was an intentional manoeuvre.

The remaining possibility was that the spinning manoeuvre was unintentional and that the instructor was unable to recover the aircraft before it struck the ground. For the spin to be unintentional, the aircraft would have to be in a situation whereby a spin was possible. The essential components of a spin are that the aircraft's wing(s) are stalled and that yaw and/or roll is present. Prior to a fully developed spin, there is an incipient stage during which prompt centralisation of controls would normally prevent the development of a full spin. With close monitoring by the instructor, it is difficult to envisage a scenario whereby the student could inadvertently enter a full spin before the instructor could recover the situation. It would be possible for this to occur if there had also been some sort of distraction, such as an engine problem or some sort of control malfunction or restriction, including a loose article impeding the control(s).

However, the instructor was known to include oscillatory stalling during instruction and there was a record of this in the student's logbook. One other student of the instructor described the oscillatory stall as being in a deep stall with the pilot controlling any wing drop with applications of rudder. This manoeuvre contains all the requirements for a spin. Furthermore, the extent of any wing drop would be very dependent on the rate of speed decrease, lateral balance of the aircraft and aileron/rudder control position. Although the instructor was known to monitor the controls during student manoeuvring, it is possible that a violent wing drop during an oscillatory stall could have resulted in the student applying full or near full opposite rudder. The subsequent entry into a spin could have been rapid and potentially disorientating for someone with no previous experience of spinning. Furthermore, any appreciable forward movement of the control column at the same time could have resulted in an increased turn rate, increasing any disorientation. The instructor would be expected to have immediately attempted to take control but, if the student had applied inappropriate control inputs, some time might be required for the instructor to get the student to release the controls. During this time, any erratic control inputs could have resulted in a change in turn direction and/or a change in spin characteristics. Once he had taken control, the instructor would need to identify the turn direction and then take the appropriate recovery actions.

Another unknown factor is the altitude at which the aircraft entered the spin. It is possible that the instructor had used an entry height of about 3,000 ft agl for a stalling exercise, as was his normal procedure. This would have resulted in less time for recovery and the closer than normal proximity of the ground would have meant increased stress for the pilots. The aft CG position may also have delayed recovery. Another possible complicating factor during the spin could have been a distraction, such as an engine problem/ stoppage or a loose article impeding the controls.

For this scenario to be possible, the aircraft would have been involved in stalling during the final northerly track. An evaluation of this track indicated an average radar ground speed of 110 kt. With the known wind from approximately 220º to 230º at 30 to 35 kt, this would mean that the aircraft was travelling at an average airspeed of approximately 80 kt. This could have been the aircraft climbing at the normal climb speed of 77 kt but could also be consistent with a reducing airspeed prior to a stall (approximately 57 kt).

To evaluate the possibility of this scenario, a CAA test pilot flew in the same aircraft type on 26 November 2005. This indicated that the aircraft characteristics in a spin were in accordance with the Pilots Notes and that any deliberate delay in recovery from the stall was unwise. Use of rudder during a full stall could initiate a large and rapid wing drop and subsequent loss of control.

Therefore, although an unidentified control problem, loose article or other distraction could not be eliminated as a contributing factor, it is considered that the most likely scenario was that the aircraft entered an unintentional spin during an exercise involving oscillatory stalling. The instructor was unable to recover the aircraft from the spin before the aircraft struck the ground.

One aspect was considered to be highly relevant. The inclusion of oscillatory stalls during early flying training would appear to be unnecessary and inappropriate. While accepting that this is not a normal manoeuvre within UK flying training it is recommended that the CAA highlight the circumstances of this accident and issue guidance to all UK registered flying instructors to ensure that oscillatory stalling is not included in flying exercises during ab initio flying training.

It was also noted that neither pilot was wearing a parachute although they were available within the flying club. Following a spinning accident to G-BLTV on 3 November 2002, the AAIB made the following recommendation: *'The Civil Aviation Authority should conduct a review of the present advice regarding the use of parachutes in GA type aircraft, particularly those used for spinning training, with the aim of providing more comprehensive and rigorous advice to pilots.'* This was accepted by the CAA and an updated Safety Sense Leaflet 19A *Aerobatics* was published in LASORS containing the following information on parachutes:

> *'While there are no requirements to wear or use specific garments or equipment, the following options are strongly recommended:*
>
> *Parachutes are useful emergency equipment and in the event of failure to recover from a manoeuvre may be the only alternative to a fatal accident. However, for physical or weight and balance reasons their carriage may not be possible or practicable, the effort required and height lost while exiting the aircraft (and while the canopy opens) must be considered. If worn, the parachute should be comfortable and well fitting with surplus webbing tucked away before flight. It should be maintained in accordance with manufacturer's recommendations. Know how to use it, and regularly rehearse, how to use it, and remember the height required to abandon your aircraft when deciding the minimum recovery height for your manoeuvres.'*

It is possible that the use of parachutes would not have made any difference in the accident involving G-FORS because of the possibly limited altitude and time available. Furthermore, the use of parachutes on this occasion would not have been permissible because of weight considerations. Nevertheless, the evidence indicated that the use of parachutes, although readily available, was not a normal procedure at the Aero Club. The advice contained within CAA Safety Sense Leaflet 19A is still considered valid.

Safety Recommendation 2005-146

It is recommended that the United Kingdom Civil Aviation Authority highlight the circumstances of this accident and issue guidance to all UK registered flying instructors to ensure that oscillatory stalling is notincluded in flying exercises during ab initio flying training.