ACCIDENT

Aircraft Type and Registration:	Slingsby T67M MKII Firefly, G-BNSO
No & Type of Engines:	1 Lycoming AEIO-320-D1B piston engine
Year of Manufacture:	1987 (Serial no: 2021)
Date & Time (UTC):	30 April 2016 at 0938 hrs
Location:	Whitwell-on-the-Hill, North Yorkshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - 1 (Fatal) Passengers - 1 (Fatal)
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Private Pilot's Licence
Commander's Age:	25 years
Commander's Flying Experience:	215 hours (of which 3 were on type) Last 90 days - 34 hours Last 28 days - 14 hours
Information Source:	AAIB Field Investigation

Synopsis

The aircraft, operating in the vicinity of Castle Howard, North Yorkshire, was engaged in a general handling flight which included aerobatics. It was seen by witnesses in the area and recorded on radar. One witness saw the aircraft carry out a loop and, having passed the apex of the manoeuvre, enter what appeared to be a spin. The aircraft did not recover from the spin and struck the surface of a ploughed field, fatally injuring both persons on board.

History of the flight

The pilot and a friend arrived at Full Sutton airfield at about 0830 hrs. The pilot had booked G-BNSO for two flights that day; the first was for general handling and aerobatics and the second, later, was to take family members flying. The weather was good with a light westerly wind, good visibility in excess of 10 km and broken cloud at about 3,000 ft.

Both the pilot and his passenger were students on the Tucano phase of their RAF flying training and had flown the Grob Tutor, a light piston-engine aircraft, during their initial flying training.

With the assistance of other club members, they pulled the aircraft out of the hangar and then went into the club house and completed the booking-out form. The Chief Flying Instructor (CFI) joined them at the aircraft and checked the fuel and oil levels whilst the pilot carried out the pre-flight inspection, watched by his passenger. Whilst he did not look at the fuel gauges, the CFI estimated that there was 1.5 hours fuel in the left wing tank and 1.0 hours fuel in the right wing tank, based on the engine consuming 45 litres of fuel per hour whilst performing aerobatics.

Another pilot, who had met the G-BNSO pilot and passenger when they had first arrived at the club, was taxiing back to the parking area having flown two circuits when he heard them call for a radio check and airfield information. There was no reply, so he passed them the information he had received earlier. That pilot switched off his engine at 0915 hrs and by that time G-BNSO was at the holding point carrying out the power checks. Shortly after this, the aircraft was seen to backtrack Runway 22 and depart.

A full radar track and Mode C heights of the aircraft were recorded as it climbed through 200 ft after takeoff and, following a right turn, tracked towards Castle Howard. Witnesses in the vicinity of the southern part of Castle Howard estate heard or saw the aircraft. A couple, who were close to the scene in their garden, saw the aircraft perform a loop. On the downward half of the manoeuvre the aircraft appeared to enter a spin, during which the engine was initially heard to "cut out" but then it appeared to restart, before cutting out again. The witnesses lost sight of the aircraft as it descended behind the roof of an outbuilding but they then heard the sound of an impact. Other witnesses reported a similar "corkscrewing" motion before the aircraft struck the surface of a ploughed field, initially with the nose and right wing, in a steep nose-down attitude. The pilot and passenger, who were fatally injured were each found to be holding the top part of their respective control sticks, which had broken off in their hands. The pilot was holding the left stick with both hands and the passenger the right stick with just his right hand.

Previous flight

On 16 January 2016, the accident pilot and another colleague, also a student pilot, had flown together and recorded their manoeuvres and their return flight to the airfield on an action camera. It showed them sharing the flying and performing aerobatics. The colleague recalled that, following a reverse stall turn that was obviously not going to be completed, the accident pilot took the recovery action of 'throttle to idle and control column centralised'. He then put the throttle to full power and the engine returned to full power quickly, but not smoothly. After the flight, the pilot remarked that the reason he used full throttle was that he realised that for an incipient [spin] recovery he should have left the throttle at full power. Closing the throttle is part of the incipient spin recovery action for the Tucano.

Survivability - parachutes

The Civil Aviation Authority (CAA) Safety Sense Leaflet Number 19, '*Aerobatics*' contains valuable information on carrying out this activity. In Section 4, 'Personal Equipment and Clothing', it addresses the wearing of parachutes and contains the following guidance:

> *'In some aircraft for physical or weight and balance reasons it may not be possible or practicable to wear a parachute. However, in the event of the failure to recover from a manoeuvre a parachute may be the only alternative*

> *to a fatal accident, although the time and height lost while exiting the aircraft (and while the canopy opens) must be considered. A static line deployment system might save vital seconds. A parachute should be comfortable and well-fitting with surplus webbing tucked away before flight, and maintained in accordance with manufacturer's recommendations. Know and regularly rehearse how to get out of the aircraft and use it, and remember the height required to abandon your aircraft when deciding the minimum recovery height for your manoeuvres.'*

In this instance, neither pilot was wearing a parachute and the impact with the ground was not survivable. A representative of the flying club stated that parachutes were in general available at the club but there was no club requirement for them to be worn and they were not normally worn in the Slingsby Firefly at the club.

Weight and balance

A post-accident weight and balance calculation was carried out. The exact fuel in the aircraft tanks is not known but, based on an estimate of 40 kg, the calculation gave a total mass at impact of 939 kg and a centre of gravity (CG) of 905 mm aft of the CG datum (the forward face of the engine compartment firewall). The CG limits were 860 to 917 mm aft of the CG datum and the maximum permitted operating weight was 975 kg. The aircraft was therefore being operated within the permitted weight and CG envelope.

Aircraft performance

The Flight Manual for the Slingsby T67 aircraft covers spin recovery actions:

> *'<u>7.2.10 Erect Spin Characteristics</u>*
>
> *At entry, the aircraft pitches nose up slightly whilst rolling rapidly in the direction of applied rudder. The aircraft rolls almost to the inverted during the first half turn of the spin and then the spin progressively stabilizes over about 3 turns, ending up with about 50° of bank and the nose about 40° below the horizon. The rate of rotation is about 150° per second or 2.5 seconds per turn. The average load factor throughout is 1.2 G. The IAS stabilizes at about 75 kts to the right and 80 kts to the left. If full pro-spin control is not maintained throughout the spin, the aircraft may enter either a spiral dive or a high rotational spin. A spiral dive is recognized by a rapid increase in airspeed with the rate of rotation probably slowing down as the spin changes to a spiral dive. The wings can be levelled by using aileron with rudders central and the dive then recovered using elevator and the dive then recovered using elevator (whilst observing the 'g' limits). A high rotational spin is recognizable by a steeper nose down attitude and a higher rate of rotation than in a normal spin; airspeed will be higher than a normal spin but will not increase rapidly; recovery is as given in Section 3, Para. 3.7.2 Incorrect Recovery.'*

The standard erect spin recovery technique is described:

> *'3.7 ERECT SPIN RECOVERY*
>
> *3.7.1 Standard Recovery Technique*
>
> *a) Close the throttle.*
>
> *b) Raise the flaps.*
>
> *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.'*

The incorrect recovery action is described:

> *'3.7.2 Incorrect Recovery*
>
> *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).'*

When compared with the Spin Recovery action for the Grob Tutor and Tucano aircraft, the Slingsby T67 differs in that the control column must be moved progressively forward to effect spin recovery. Initially on moving the stick forward, the rate of spin rotation will increase before coming out of the spin. Application of the Tutor or Tucano spin recovery technique of placing the stick in a central position is not the correct recovery action for the Firefly. An instructor who has regularly carried out spin recovery training in the Slingsby T67 stated that providing the correct recovery action was taken, the aircraft recovers from the spin.

Pilot and passenger experience

The pilot commenced flying in November 2009, and flew the piston-engine Grob Tutor until November 2012. During this time he won an aerobatic trophy. He recommenced flying in July 2014 as a student pilot in the RAF, completing his basic course on the Grob Tutor in February 2015 and accumulating a total of 152 hours. During that time, specific flights, which involved spinning training, were carried out, the most recent of which were two sorties in September 2014. In November 2015, he commenced intermediate flying training on the Tucano aircraft and had completed 63 hours in the aircraft and an additional 21 hours in the flight simulator. He had carried out spinning training in the Tucano aircraft in the early stages of his course.

He held a civilian Private Pilot's Licence with aerobatic endorsement and a current civilian aircrew medical. The pilot had recorded four flights in the Slingsby T67; two were dual check flights and two were flights where he had been the Pilot in Command (PIC). The instructors who flew with him to clear him to fly the club Slingsby T67 had not carried out spin recovery training and so the pilot had not been taught type-specific spin recovery training in this aircraft type.

The passenger commenced flying training in August 2015 as a student pilot in the RAF, accumulating 59 hours during basic training on the Grob Tutor during which he would have carried out spinning and spin recovery training. He started his Tucano training on 4 April 2016, had accumulated 5.7 hours on type but had not yet carried out spinning training. He did not hold a civilian Private Pilot's Licence.

Engineering - aircraft description

The Slingsby T67M MkII is two-seat, dual-control fully aerobatic monoplane aircraft of fibreglass construction. It is fitted with a tricycle fixed landing gear and is powered by a Lycoming AEIO-320-D1B four-cylinder fuel-injected piston engine fitted with a Hoffman HO-V72L two-blade variable-pitch propeller.

Fuel is held in left and right fuel tanks within the inboard leading edge sections of the wing and within each tank there is a separate chamber fitted with flapper valves to maintain a positive supply of fuel for aerobatic or inverted flight. Fuel is picked up within these chambers by a weighted filter attached to a flexible tube, designed to stay immersed as the fuel moves around during flying manoeuvres. There is a valve in the cockpit to enable the pilot to select the left or right tank and fuel is drawn from the tanks by an electric pump, which provides a pressure supply to the engine-driven injection pump. The engine pump suction is sufficient to draw fuel throughout the flight envelope so it is not necessary to run the electric pump constantly.

The flying controls are conventional, consisting of ailerons, elevator and rudder operated via pushrods and cables. The elevator trim wheel is fitted in the centre panel between the seats, directly behind the flap lever and the trim wheel is connected to an elevator trim tab fitted to the right elevator.

The wing inboard trailing edges are fitted with twin-section flaps operated by a three-position lever in the cockpit. The lever locks into these positions as required and is released by a push button on the end of the lever.

The aircraft is fitted with mechanical, electro-mechanical and pneumatic analogue instruments. It has a conventional electrical system consisting of a battery and alternator, with the various system circuits protected by resettable breakers mounted on the instrument panel.

Maintenance and airworthiness

The aircraft was serial number 2021, built in 1987, with a valid Airworthiness Review Certificate and an EASA Part M Release to Service issued on 11 April 2016. The aircraft had been maintained in accordance with the manufacturer's recommendations and had a continuous and comprehensive set of maintenance records.

Accident site

The aircraft crashed into a ploughed field and came to rest upright, pointing north. The engine cowl had detached and the engine was partially buried, at an angle approximately 50º to the horizontal. Marks had been left in the ground by the wing leading edges and there was severe disruption to the aircraft structure. Both propeller blades had detached and were fractured at their roots. The blade surfaces and edges were lightly scuffed and dented. Both wings had sustained severe leading edge damage and the left and right integral fuel tanks had split open, with no fuel in either tank. The emergency services had noted a very strong smell of fuel around the aircraft and observed fuel seeping away into the ground.

The rear section of the fuselage had fractured midway between the trailing edge of the wing and the tailplane and was bent around to the right side of the aircraft. The tailplane, elevators and rudder were still attached and had sustained minor damage. There were large indentations on the fin leading edge. The flaps had been in the retracted position; the left flaps were in place and the right flaps had detached, with the inner flap section beneath the aircraft and the outer section approximately 12 metres behind the aircraft. The left and right ailerons had broken free from their pivots but were still attached to their control rods and were lying on the ground beneath the aircraft. The plastic windscreen and canopy had disintegrated and the fragments were scattered around the crash site. The canopy handle was in the closed position and the latches, although separated from the windscreen frame receptacle, were also in the shut position, consistent with the closed handle. The pilot and passenger were wearing the five-point safety straps, which were still fastened and attached to the integral airframe seat structure. The pilot and passenger were not wearing parachutes.

Within the cockpit all of the instruments, switches and controls had been severely damaged or displaced and the left and right control column hand grips, as described earlier, had detached. The flap lever was set in the fully retracted position and the trim wheel was undamaged.

Engineering examination

The aircraft wreckage was recovered to the AAIB at Farnborough for closer examination.

Aircraft structure

The aircraft was severely damaged in the impact, with the wings losing their structural integrity, split open along the leading edges. The upper and lower skin outboard sections of both wings had separated from the ribs and were severely distorted, with some ribs displaced by the wing distortion. The cockpit and seat area above the wing box was largely intact but the forward area of the cockpit and instrument panel was badly crushed.

Fuel system

The fuel system components had been severely disrupted in the accident and there was no fuel in the system. Both fuel caps were in place and the leading edge damage had exposed the fuel tank internal components. The tank chambers had been damaged but the flapper valves were clear of debris and free to move. The weighted filters and flexible pipes were correctly connected, free to move and clear of debris. There was no evidence of pre-accident leakage around the tank structures and there were no foreign objects or debris in either tank. The supply pipes leading to the tank selector valve had broken away from their tank outlet unions and the linkage from the fuel selector valve operating handle had sheared; examination of the valve showed that it was fully selected to the left tank, allowing an unrestricted fuel flow. A sample of fuel was taken from the airfield where the aircraft was last refuelled and analysis showed the fuel, AVGAS 100LL, to be uncontaminated and normal. The fuel pumps were only slightly damaged and testing showed that they were capable of fuel delivery.

Flying controls

The flying control surfaces had sustained varying degrees of damage in the accident. Both ailerons had detached from the wings at their pivot points but were still attached to their control input rods. Despite this, the aileron control rod and bellcranks were intact, had continuity and operated in the correct sense. The rudder was correctly attached, had sustained only minor damage and was free to move through its full range. The rudder control cables had dislocated from their fuselage support pulleys but were continuous and correctly attached to the damaged rudder pedal mechanisms. However, the left and right rudder pedal assemblies were severely disrupted in the accident and the 'pedal reach' set by the pilot and passenger could not be determined. The elevators were still attached and free to move through their full range. Despite the fracture of the fuselage, the elevator push rods and linkages were intact, had full continuity and operated in the correct sense. The trim wheel was found set slightly forward of its neutral setting and the elevator trim tab was found deflected 4 mm upwards.

Engine and propeller

The engine mountings had been crushed and the engine forced back against the firewall, with much of the ancillary equipment between the engine and firewall damaged. The propeller spinner was fragmented and the two blades had broken at their roots. Both pitch change counterbalance weights were still attached and the counterbalance weights, and the fractures in the blade roots, showed the propeller to have been in fine pitch at impact with the ground.

The engine and its equipment were removed. Both magnetos had been damaged but appeared to have been in good condition, with no pre-existent damage or wear. Examination of the spark plug electrodes indicated that the engine was in a good state of tune and examination of all four cylinders found no fault. The sump had cracked during the impact but the engine retained lubricating oil, the accessory gearbox was in good condition and the engine could be turned smoothly by hand, with all the components moving in the correct sense without restriction.

The four injector jets were in place and clear of blockage and the injector distributor and its internal components were undamaged. The throttle body was damaged but free of debris and very small quantities of clean fuel were found in the various pipes of the fuel injection system, though too small for analysis.

Cockpit instruments and equipment

All the instruments and switches had suffered damage. Several of the instrument needles had been trapped in position by the distortion of the impact. The altimeter was found set to 1019 hPa and an imprint left by the airspeed indicator (ASI) needle indicated a speed of 108 kt at impact - Figure 1 shows the needle strike in the ASI. The severity of the damage meant that none of the primary instruments could be tested. Examination of the pitot-static tubes found them severed in numerous places as a result of the impact but no pre-impact damage was found.

Figure 1

Needle strike on ASI face showing 108 kt

Some of the engine instruments and one of the two fuel gauges needles appeared to have been trapped at, or close to, the position they were at the point of impact (Figure 2). In particular the engine oil temperature was indicating in the green sector, the cylinder head temperature at 180ºC and the left fuel gauge was showing 12 imp gals. In contrast, less plausible were the oil pressure (at full deflection in the red sector), the right fuel gauge (showing zero) and the ammeter (at full deflection to the left).

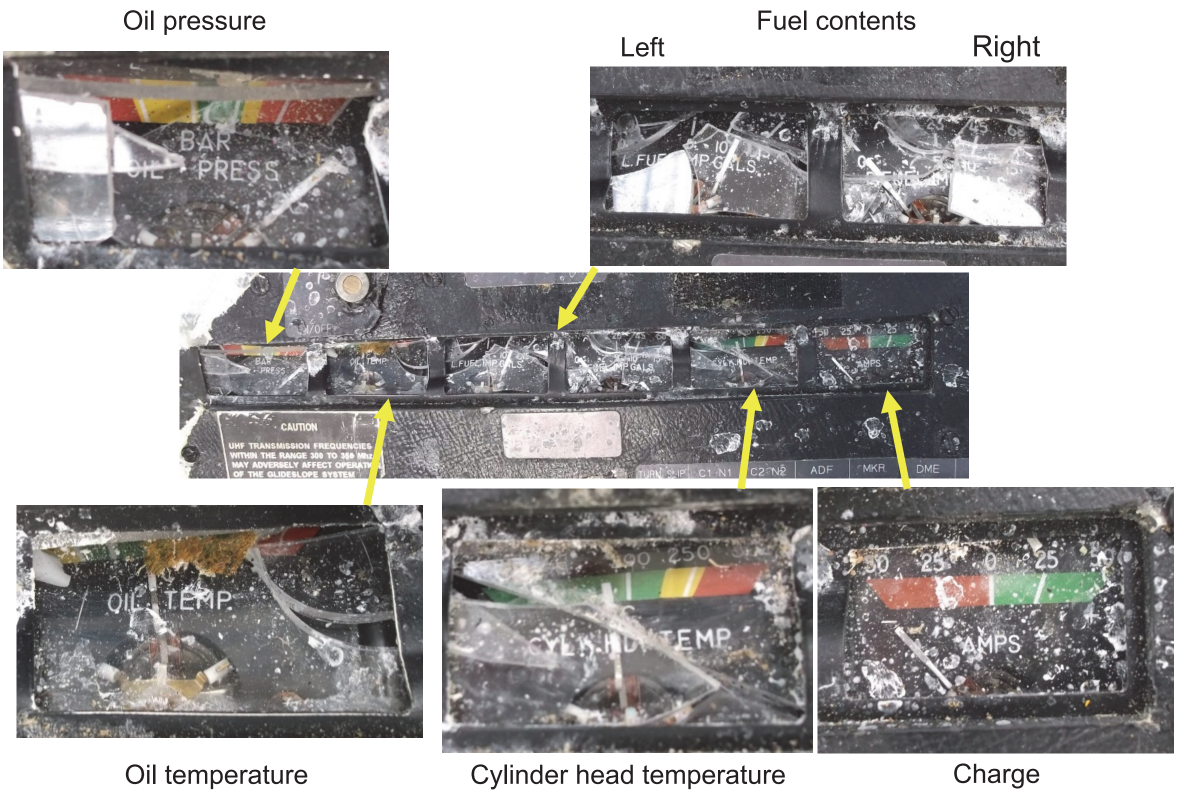

Figure 2

Engine and fuel gauges

The combined fuel and manifold pressure gauge was badly damaged, with no meaningful readings, and the position of the mixture, pitch and throttle controls at impact could not be determined. However, the mechanical rpm gauge, although damaged, showed a needle strike mark similar to that on the ASI, and its needle had bent and precisely matched the contour of a small area of distortion on the instrument face. The strike mark and the bend position indicated a reading of 1,150 rpm when the aircraft hit the ground.

Damage to the transponder selector panel meant that the transponder setting at the time of the accident could not be determined.

Electrical system

The aircraft electrical system could not be tested due to the severity of disruption. The battery was ruptured and the circuit breaker panel in the cockpit was badly damaged, with the majority of breakers fractured from their mountings or appearing to have tripped.

Analysis - engineering

Despite the extensive damage to the aircraft it can be determined that there had been no structural failure or loss of control surfaces in flight. Detachment of the ailerons and flaps was as a result of structural distortion of the wings during the impact sequence.

The ground marks and damage to the aircraft suggest the outer portion of the right wing leading edge hit the ground simultaneously with the propeller spinner, suggesting a slight left yaw to the aircraft. The clear imprint made by the right and left wing leading edges on the ground at impact showed no evidence of rolling or spinning of the aircraft at this point.

Examination has found that there was continuity and operation in the correct sense of the flying control system and that there was no pre-accident fault or control failure of the aileron, rudder or elevators. An unremarkable elevator trim setting had been made and is not relevant to the causes of the accident. The position of the flap lever, set to retracted, verified by the position of the remains of the linkages, was as would be expected in an aircraft configured for straight and level or aerobatic flight. The large indentation on the fin leading edge had been caused by the canopy frame as it derailed and travelled upwards, meeting the fin as the rear fuselage structure 'bent' during the impact and is also not relevant to the accident.

Despite the damage to the rest of the aircraft, the engine was largely undamaged. The bend in the throttle butterfly valve lever and fuel control unit linkage was caused during the impact and would only have occurred with the throttle in the near-closed position. This throttle position, along with the needle showing 1,150 rpm, would be reasonable in this situation. The engine instrument readings, and the condition of the engine's mechanical components, indicate the engine was operating normally up to the impact with the ground.

Testing could not be carried out on any of the primary instruments. The sub-scale setting on the altimeter of 1019 hPa was the QNH for the day and is likely to have been set by the pilot in preparation for the flight. The needle strike on the ASI shows an airspeed of around 108 kt at the impact, plausible considering the damage sustained by the aircraft.

Analysis - operations

The pilot was properly licensed to conduct the flight and the weather was suitable for the intended aerobatics.

From witness evidence, the aircraft appears to have inadvertently entered a spin from some form of looping manoeuvre shortly after the apex of that manoeuvre. From the recorded radar data, the altitude at that point was probably between 3,500 and 4,000 ft, which should have provided sufficient height for the spin to have been stopped and the aircraft pulled out of the dive if spin recovery action had been taken correctly and promptly. The same witness also described hearing the engine faltering during the descent but no physical evidence has been found to suggest an engine problem. It is possible the witness was hearing the effect of rapid opening or closing of the throttle, coupled with the masking effect on the engine sound as the aircraft rotated during the spin.

Both pilot and passenger had been taught spin recovery in the Grob Tutor. The pilot had undergone a Slingsby T67 check flight on 16 January 2016 with the club CFI which was a single circuit and did not cover aerobatics or spin recovery.

The spin recovery action in the Grob Tutor, and in the Tucano, requires that following the application of opposite rudder, the control stick is centralised. This is taught by using both hands in the Tucano and there is no requirement to move the control stick forward. In the Slingsby T67, the control stick should be moved progressively forward until the spin stops and with an aft CG the Flight Manual emphasises that the pilot must be prepared to move the control stick fully forward. As the stick is moved forward the spin's rate of rotation initially increases. The pilot in this accident had not received type-specific spin recovery training in the Slingsby T67 aircraft.

The aircraft appeared to have descended in a spin, however, the aircraft attitude and ground marks at impact suggest that it had started to recover, albeit too late to avoid hitting the ground. An instructor who regularly spins this aircraft type states that if the correct recovery action is taken, the aircraft will come out of the spin.

Conclusion

The extensive damage to the aircraft was wholly consistent with a high-energy impact with the ground. Examination of the aircraft and its systems found no evidence to suggest the aircraft had suffered a structural failure or technical malfunction which could have contributed to this accident. The investigation established that, when found, both occupants were holding their respective control column but it was not possible to establish which occupant was handling the aircraft at any point during the flight.

Given that the aircraft may have been in the process of recovering from the spin in the very last moments of the descent, it is possible that an incorrect spin recovery technique was used as the requirement to move the control stick progressively forward is a critical element of the spin recovery action in the Slingsby T67. This was not a requirement for spin recovery in the Tutor or Tucano; aircraft on which the pilot had previously received spin training. It is possible that if the pilot initially adopted the technique applicable to those aircraft, the spin recovery would have been delayed.