ACCIDENT

Aircraft Type and Registration:	Ikarus C42 FB100, G-CDNR
No & Type of Engines:	1 Rotax 912 ULS piston engine
Year of Manufacture:	2005 (Serial no: 0507-6696)
Date & Time (UTC):	20 March 2016 at 1600 hrs
Location:	Stoke Airfield, near Burrows Lane, Middle Stoke, Kent
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Fatal) Passengers - N/A
Nature of Damage:	Aircraft destroyed
Commander's Licence:	National Private Pilot's Licence (Aeroplanes)
Commander's Age:	61
Commander's Flying Experience:	117 hours (of which 17 were on type) Last 90 days - 2.5 hours Last 28 days - 1.5 hours
Information Source:	AAIB Field Investigation

Synopsis

The pilot, who was converting to three-axis microlights, was flying solo following three training flights that morning. The aircraft was seen to become airborne and then climb very steeply, achieving an extreme nose-up attitude. The left wing dropped and the aircraft descended, colliding with high tension power cables adjacent to the runway. It then struck the ground and an intense post-crash fire broke out. The pilot was fatally injured.

History of the flight

The pilot had qualified as a weight shift microlight pilot in August 2013 and decided to convert to three-axis microlights in 2015. His first solo flight in a three-axis aircraft was in the Ikarus on 12 February 2015, after 13.75 hours of training. He had made an appointment to take up three-axis flying again on 20 March 2016.

The instructor arrived at the airfield at approximately 1000 hrs and checked the weather. The forecast was for a 1,400 ft cloud base with a light wind down Runway 06, which was suitable for training and solo flights. He moved the aircraft out of the hangar, carried out the daily inspection and then washed it.

The pilot arrived at about 1130 hrs and discussed with the instructor the plan for the day, which was to make a number of 30-minute flights to continue his three-axis training. They conducted two training flights in the morning, covering takeoffs, climbing, emergencies in the circuit and use of flaps. As expected, after a year since his last three-axis flight, the pilot was a "little rusty" on the first couple of landings. Following a demonstration by the instructor and some further practice, the pilot improved measurably to a competent solo standard.

Following a debrief in the cockpit, the instructor took the pilot into the training room and gave him a presentation on the use and effects of different flap settings. He also talked about the importance of aircraft attitude during a go-around.

They carried out a third dual flight during which the instructor simulated an engine failure after takeoff, followed by a simulated engine failure downwind, from which the pilot landed. He flew competently on his second circuit and seemed calm and ready to go solo. The engine was shut down and the instructor briefed the pilot to fly out to the Isle of Sheppy, an area that he was familiar with, and practise some climbing and descending turns. The pilot seemed happy to be flying solo again and, after restarting the engine, taxied back to the threshold of Runway 06. The instructor observed the takeoff. He heard the pilot apply full power and saw the aircraft become airborne. It climbed very quickly and reached a very high nose-up attitude, which the instructor described as the aircraft "hanging on its prop".

The aircraft drifted left over the railway line that runs alongside the runway before dropping the left wing, descending and striking a set of high tension power cables. There was a bright flash and the aircraft fell to the ground. The instructor and club members ran to the accident site and attempted to extinguish the post-crash fire with handheld fire extinguishers. The pilot had sustained fatal injuries.

Accident site

The aircraft had come to rest in a field adjacent to the northern edge of the airfield, beneath power cables carried on pylons running in a southwest-northeast direction (Figure 1).

The airstrip is slightly curved and is bordered by marshy ground to the south and a railway line to the north. A line of pylons runs north of and roughly parallel to the railway and carries 400kV electricity cables. Each pylon has three arms, with the power supply cables attached to the end of each arm. A separate phase is carried on each arm, with four cables in each phase. The aircraft had struck the southern array of cables (ie the ones on the airfield side of the pylons), causing an electrical discharge across two phases.

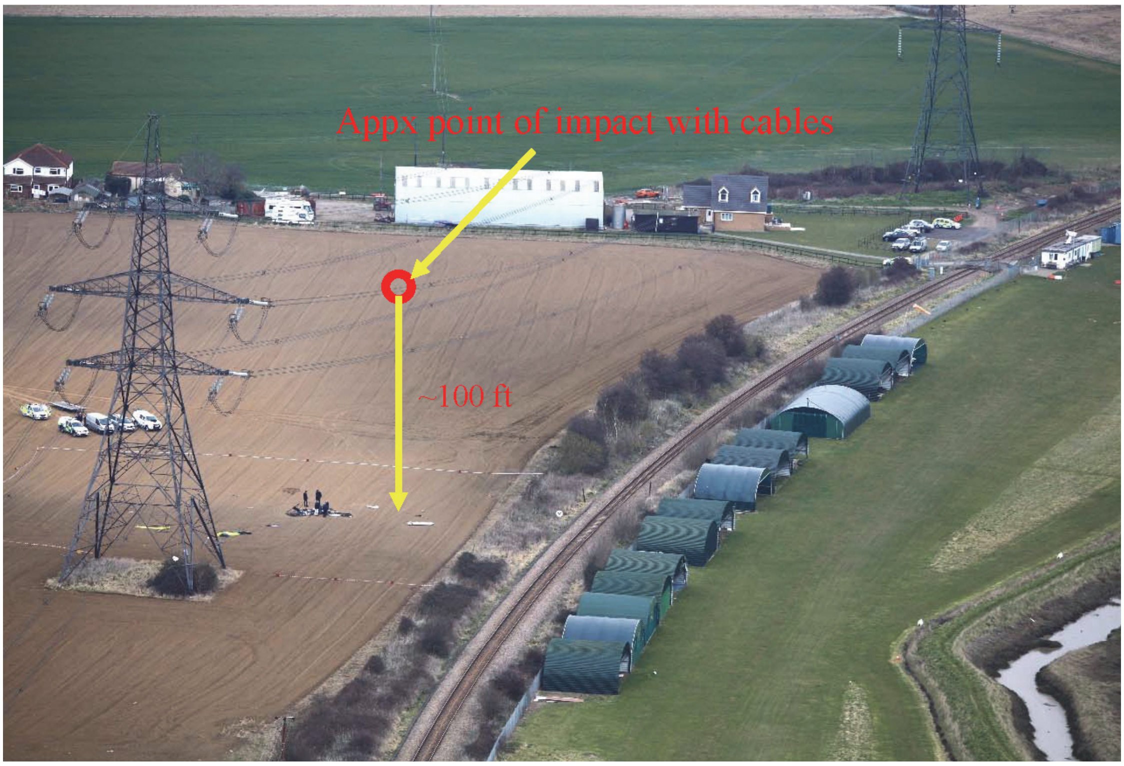

Figure 1

View of accident site, looking along Runway 06

The aircraft had come to rest in an inverted attitude, with the nose pointing roughly parallel to the runway heading, ie 060°. The wreckage had burnt out, with the fire in the forward fuselage having been particularly intense. It was apparent that the right wing had separated close to the root as a result of striking the cable group mounted on the centre arm on the south side, approximately 100 ft above the ground. The right wing was found approximately 13 m from the main wreckage. The cables had not been severed, but had sustained damage in the form of broken cable strands (Figure 2).

Photo: National Grid

Figure 2

Damage to power cables

The cable group below the damaged ones exhibited some slight scuffing, possibly as a result of a brushing contact with the underside of the left wing; this showed evidence of light scuff marks on the wing struts, with several holes resulting from severe electrical discharges that had caused localised vaporising of the aluminium alloy. Similar features were observed on the structural members of both wings and on flying control components, with some of the flying control tubes having melted. The positions of the discharge damage on the wing struts was consistent with the spacing of the cables within the group (Figure 3).

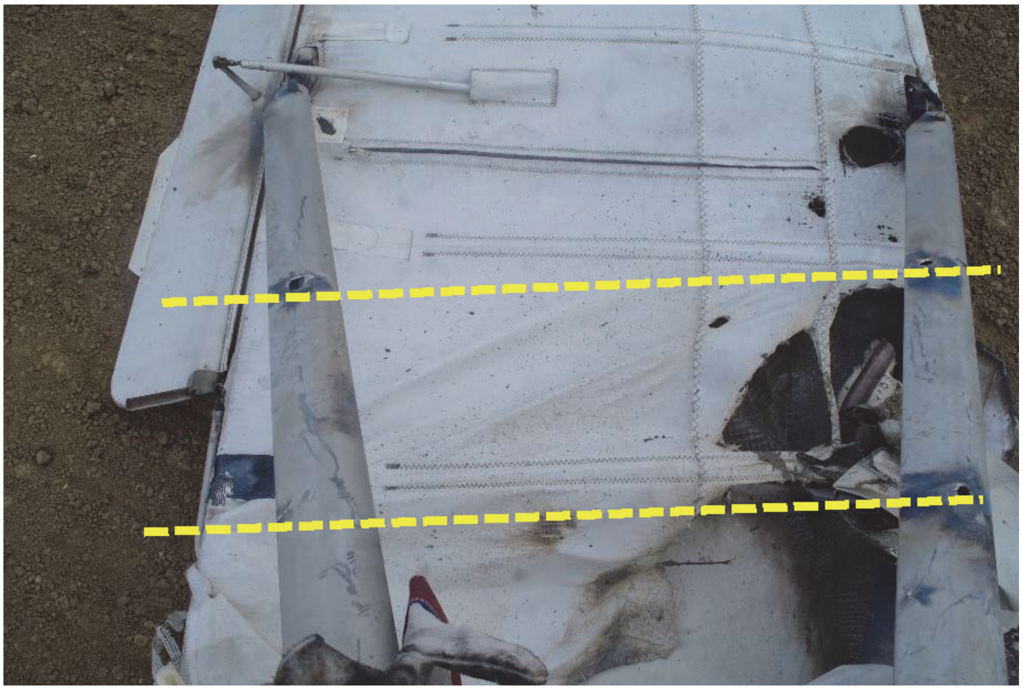

Figure 3

Underside of right wing showing electrical discharge damage and possible cable contact positions

The fabric covering of the left wing, which had remained attached to the fuselage, had burnt away, although there was little evidence of significant heat on the ground, leading to the conclusion that the fabric may have been ignited by the electrical discharge. The fuel tank, located behind the cockpit, had burst on impact and the burning fuel had consumed most of the forward fuselage. There was a shallow crater beneath the engine, but no other ground marks. The propeller blades had all broken at the approximately mid-span point, suggesting power at impact, although it was not possible to quantify this.

The right wing leading edge spar had been broken just inboard of its mid-span point, as a result of contacting the cables. A foam fillet had been bonded to the front face of the tube, giving an aerodynamic shape to the leading edge. An indentation was apparent in the foam, close to the spar fracture, which was consistent with being made by one of the cables (Figure 4). As can be seen, the cable would have been approximately vertical relative to the wing leading edge, suggesting the aircraft was in a near vertical nose-down attitude at the time.

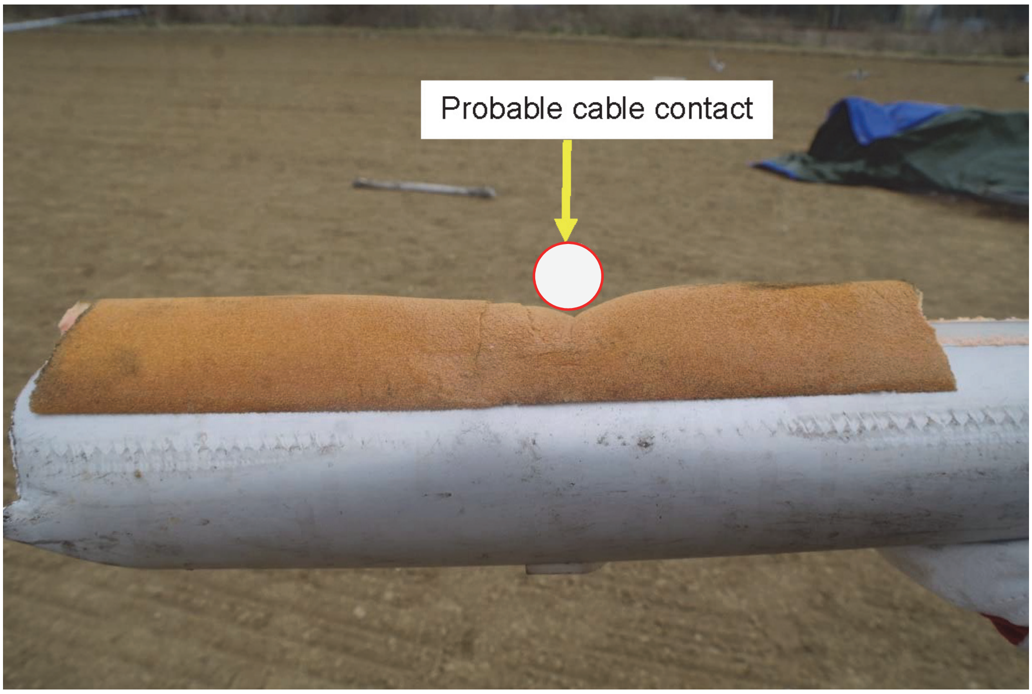

Figure 4
Likely cable contact on the right wing leading edge spar

It was concluded, from the available evidence, that the right wing had struck the middle set of cables on the south side of the pylons whilst the aircraft was in a steep, probably vertical, nose-down attitude. It is likely that this caused a yaw to the right, bringing the left wing into light contact with the lowest set of cables, resulting in the phase-to-phase discharge that in turn produced the bright flash and explosion reported by witnesses.

Following an inspection of the site, the wreckage was recovered to the AAIB's facility for a detailed examination.

Aircraft information

General

The Ikarus C42 is a two-seat high-wing aircraft with a tricycle landing gear. It is manufactured in kit form or as a complete aircraft. Factory-built examples are dealt with by the British Microlight Aircraft Association (BMAA), and are approved as microlights. The Light Aircraft Association (LAA) deals with the kit versions, which can be either a microlight or Group A aircraft. G-CDNR was a factory-built aircraft and was classed as a microlight.

The airframe primary structure is of bolted and riveted aluminium tube construction, the main structural member being a tubular boom that carries the empennage at the rear and the engine and nose landing gear at the front. The fuselage is given a conventional external shape by virtue of non-structural composite mouldings. The flying surfaces are covered with pre-stitched reinforced polyester envelopes. The engines approved for use in the Ikarus are the Rotax 912 UL (80 hp) and 912 ULS (100 hp).

The flight controls are operated by a 'side stick' mounted on a console between the front seats. The top of the stick incorporates two buttons that respectively apply nose-up and nose-down elevator trim, the electric trim actuator being mounted within the left tailplane and operating a trim tab attached to the trailing edge. The flaps are operated by control rods, with the position being controlled by a lever in centre of the cockpit roof; squeezing a calliper attached to the lever allows the flaps to be placed in one of three detented positions. Engine power is controlled by means of a throttle lever mounted between the pilot's legs.

Additional information

In-service structural problems

Two structural issues with the aircraft type were identified by the manufacturer subsequent to the accident; one related to cracking of the fuselage tube and the other to cracking of the A-strut, which links the fuselage tube to the wing leading edge.

The cracking of the fuselage tube resulted in an Owner's Service Bulletin (OSB) 29, which was issued on 16 June 2016. The Bulletin became the subject of a Civil Aviation Authority (CAA) Emergency Mandatory Permit Directive (MPD), issued on 28 June 2016. It required an inspection for cracking of the front of the fuselage tube; the affected area is shown in Figure 5a. The engine is supported, via a pylon, on the front of the tube. In addition, there are two square cut-outs in the tube; the front one carries the nose landing gear and the rear forms the attachment of the A-strut.

Cracks have been found emanating from the corners of the upper cut-outs which, if allowed to propagate, would compromise the structural integrity of the engine mountings, the nose landing gear leg and the A-strut. An extreme example is shown in Figure 5b. As far as is known, no crack has progressed to complete failure. The LAA covered the topic in an article in the August 2016 issue of their '*Light Aviation*' magazine.

The fuselage cracking appeared to primarily affect high flight hour, early examples of the aircraft, although the MPD applied to all C42 models, with inspections being required prior to the next flight on aircraft with over 2,000 hours of operation.

G-CDNR had achieved over 2,420 flight hours at the time of the accident but had never been inspected in accordance with the MPD, as the accident occurred prior to the discovery of the fuselage tube cracking problem. Two other C42 aircraft based at the same airfield, with slightly fewer flight hours, were inspected and found to have no cracks.

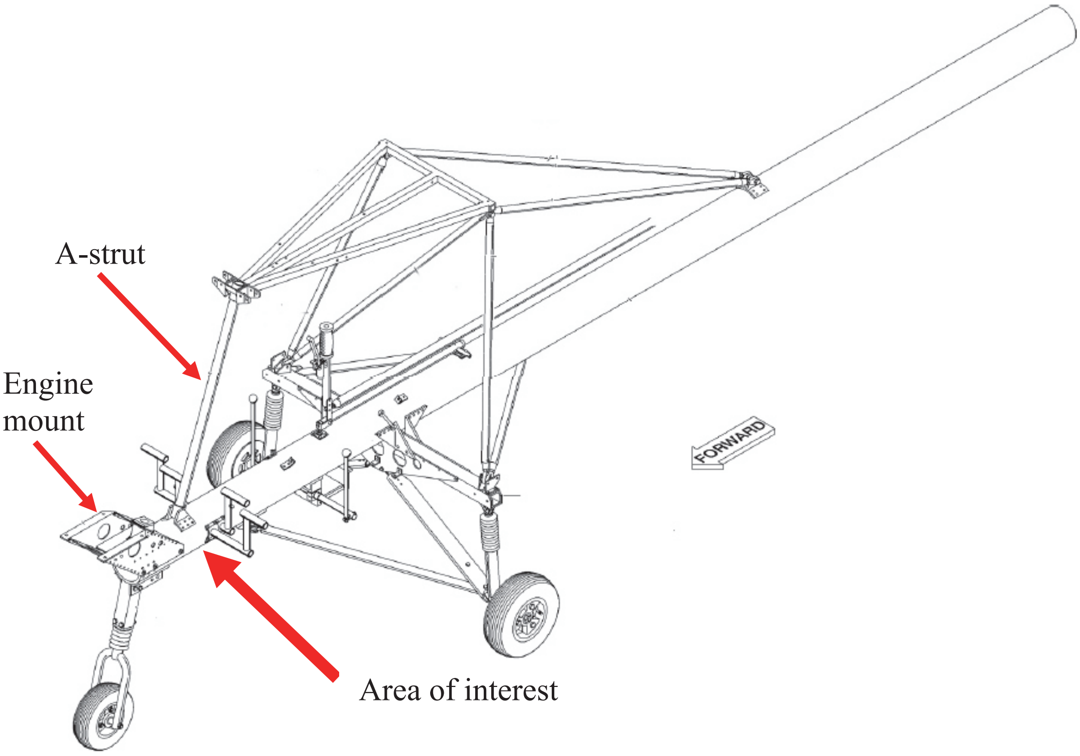

Figure 5a

View of fuselage structure

Figure 5b

Example of crack emanating from rear cut-out, as shown in OSB 29

In November 2016, cracking of the A-strut was identified on the same airframe that had suffered the fuselage tube cracking that led to the issue of OSB 29 and the subsequent MPD. It was found that the A-strut was cracked around its entire circumference within the outer collar at the connection between the strut and the upper surface of the main fuselage tube (Figures 6a and 6b). The failure was concealed by the collar and the upper part of the strut had been retained in position only by a single locating rivet (ie a manufacturing aid) that located the collar on the strut. The crack had emanated from the bolt hole in the strut.

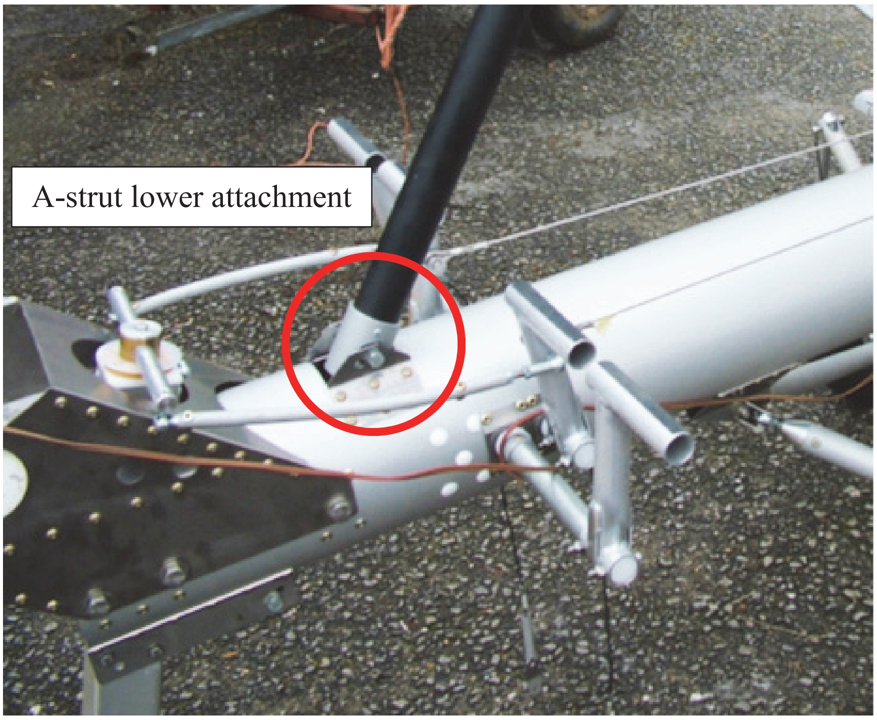

Photo: Red Aviation

Figure 6a

A-strut attachment to forward fuselage tube

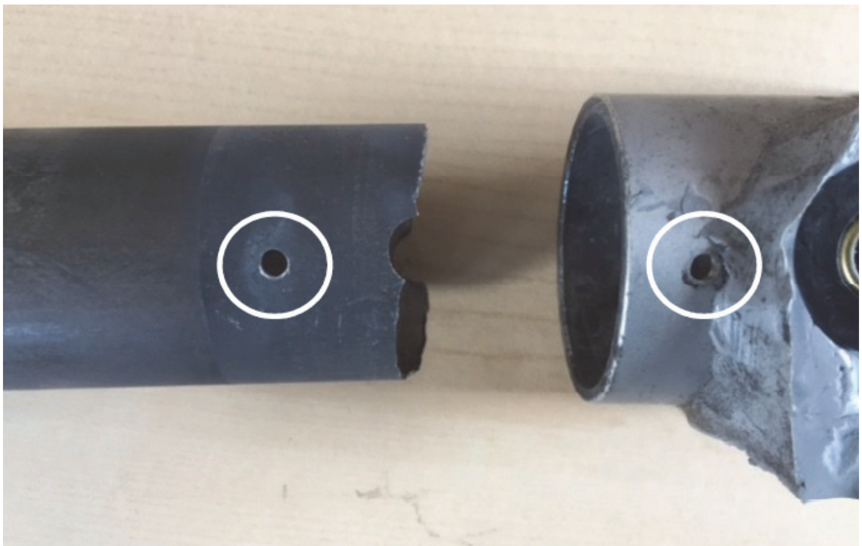

Photo: Red Aviation

Figure 6b

Failed A-strut after removal of collar, showing rivet hole

The UK agent for the aircraft, in conjunction with the German manufacturer, issued OSB 31 on 30 November 2016, applicable to all C42 A and B model aircraft, although later B models featuring a different design were exempted. The Bulletin stated that it was believed that the failure was the result of excessive loads placed on the A-strut due to near failure of the main fuselage tube. One other similar case was known to have occurred on an aircraft known to have sustained landing gear damage. However, it was also considered that the failure may have been related to fatigue due to flexing of the A-strut, thus introducing the requirement for an inspection of potentially vulnerable aircraft.

The OSB requires any aircraft which have previously suffered damage that could have affected the A-strut, such as nose gear or accident damage, to be inspected by means of a borescope inserted into the strut from its lower end. However there was no requirement to inspect aircraft with no history of damage and which had flown less than 2,000 hours. Aircraft with more than 2,000 flying hours were recommended to be inspected at the next Annual or 100-hour Inspection, whichever occurred first.

Subsequent to the accident, the manufacturer's design/certification engineer stated that his calculations indicated that, in the event of an A-strut failure, the rivet would withstand flight loads of 2 to 3g before failing. It was pointed out that the A-strut is also attached to the engine firewall structure, thus providing some additional strength.

Aircraft examination

The intense fire that developed after the aircraft came to rest had resulted in much of the structure being reduced to ash or solidified molten alloy. It was thus not possible to conduct a complete continuity check on some of the flying controls in the cockpit area. However, those parts of the system that remained bore no evidence of disconnect or failure prior to striking the ground. A bell crank assembly, in the right wing aileron circuit, had become disconnected as a result of being melted in the electrical discharge after the aircraft struck the power cables.

It was established that the flap operating lever, in the roof of the cockpit, had been in the flaps retracted detent and that the elevator trim electrical actuator was in the middle of its operating range, thus indicating that the elevator trim was approximately neutral.

The engine was dismantled and no evidence of failure or malfunction was found, with all the internal components being in good condition. However the carburettors, together with most other engine accessories, were burnt and could not be tested.

The fuselage boom was examined with particular regard to OSB 29. However, very little of the front end had survived the fire. An exception was the nose landing gear leg, which had remained attached to the lower half of a short length of the fuselage tube, including the cut-outs for the leg and the A-strut. The latter was severely fire affected, but contained a few centimetres of the lower end of the A-strut. It was not possible to draw any conclusions from the fracture surfaces due to the fire damage.

The A-strut upper and lower attachments to the fuselage tube were made with steel brackets. These had survived the post-impact fire, whereas much of the surrounding aluminium material had not. Figures 7 and 8 show the remains of the lower and upper attachments. The lower attachment was similar to the upper in that both used collars and locating rivets (the rivet is not visible in the image of the lower attachment).

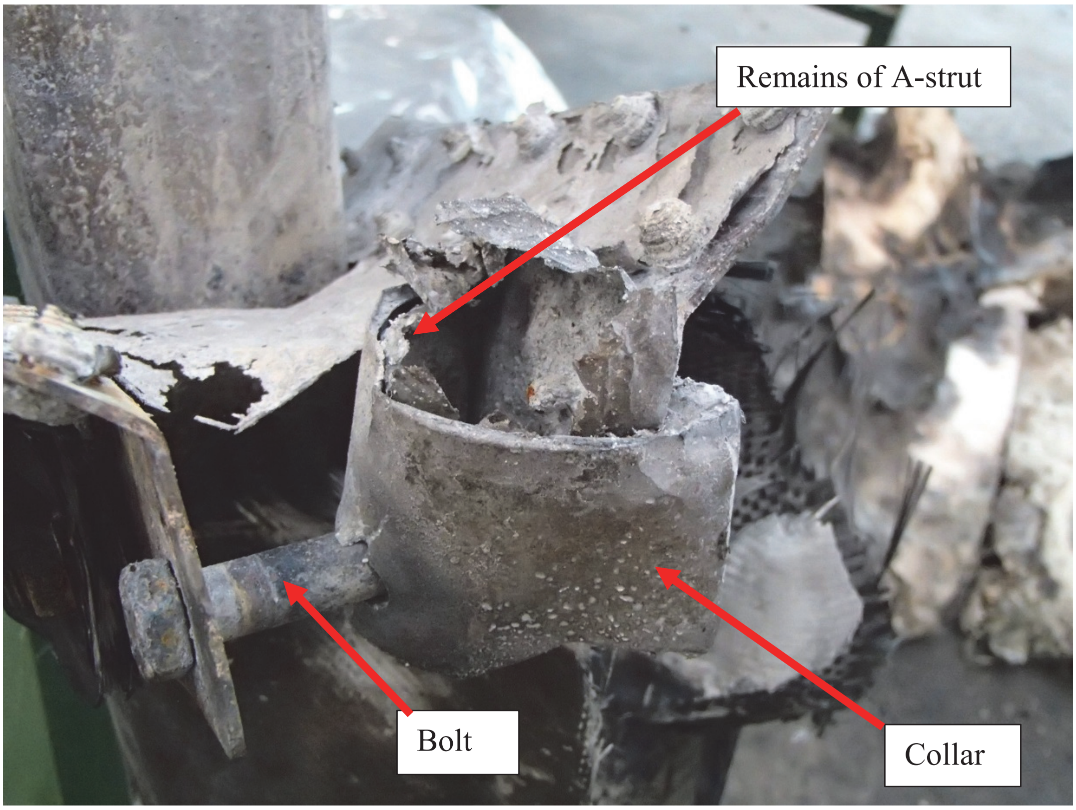

Figure 7
Lower attachment

The remains of the collar on the upper attachment were fragile and part of it was peeled aside to reveal the locating rivet; this appeared intact. However there was no evidence of any part of the A-strut, unlike the lower attachment, where a section of the strut, together with the rivet was found positioned concentrically within the collar.

Figure 8

Remains of A-strut upper attachment and (lower view) rivet

Recorded information

Security video recording

A video camera located on the clubhouse recorded both the takeoff with the instructor and the takeoff for the accident flight. Figure 9 shows three snapshots from each takeoff which illustrate differences in the respective flightpaths. The takeoff with the instructor was at a higher weight, but the aircraft tracked along the runway in a normal climb. On the accident takeoff the aircraft became airborne and climbed steeply, whilst drifting to the left (prior to dropping the left wing, descending and contacting the power lines).

Previous take off with the instructor

Solo accident take off

Figure 9

Comparison of normal and accident takeoffs

Weight and balance

The instructor estimated that the fuel on board at the commencement of the accident flight was 30 litres and the pilot's weight was 75 kg. Total weight at takeoff was calculated as 362 kg, with a maximum permitted takeoff weight of 450 kg. The Centre of Gravity (CG) range for the aircraft was 350 mm to 560 mm aft of the zero datum, which is defined as the wing leading edge root. The calculated CG at the time of the accident was 397.8 mm aft of the CG datum. The aircraft was therefore being operated within the maximum permitted takeoff weight and CG envelope.

Airfield information

Stoke Airfield has a single grass runway orientated 06/24, 400 m long by 20 m wide. Running along the west side of the runway is a railway line and to the west of that are a set of 200 ft high power cables. The active runway at the time of the accident was Runway 06, with a right hand circuit.

Personnel

Pilot's background and experience

The pilot had commenced his microlight flying on 28 March 2012, although his instructor thought he had undertaken some light aircraft training previously. He successfully passed his weight shift microlight General Skills Test (GST) on 2 August 2013. Thereafter, he mainly flew his Blade 912, which is a weight shift microlight, but also carried out three-axis microlight training on the Ikarus C42. His first three-axis solo flight was in G-CDNR on 12 February 2015. He continued to fly his Blade 912. On 20 February 2016, he recommenced his three-axis conversion.

Tests and research

Flight test

On 7 September 2016 flight testing, commissioned by the AAIB, was carried out at Old Sarum Airfield using an Ikarus C42 aircraft (registration G-CDOK) which closely matched the accident aircraft. The purpose of the flight test was to assess the aircraft's handling qualities, particularly with respect to takeoff profiles with full power applied. The weather conditions were good, with a surface wind of 160° at 8 kt, visibility in excess of 20 km, OAT +24° and light turbulence. The instructor from Stoke Airfield who had witnessed the accident was present for the test and was able to compare the accident flight profile with that of the test aircraft.

The testing was carried out by a qualified Experimental Test Pilot using standard CS-23[1] test techniques. The test aircraft was configured with the same weight, CG and elevator trim position as the accident aircraft. Flights were carried out with the test pilot flying the aircraft 'hands-on' (Closed Loop) and then 'hands-off' (Open Loop), to establish the forces needed to control the aircraft and its behaviour if not controlled, as would have been the case had the pilot become incapacitated.

The circuits were flown to Runway 06 at Old Sarum which has an 800 m grass (over chalk) runway. The following is quoted from the Flight Test Report:

> *'Take-off: "Closed Loop" and "Open Loop" take-offs were conducted with take-off flap. Closed Loop the stick was held aft to reduce loads on the nose-wheel. The aircraft flew itself off in this attitude and was allowed to accelerate to 60 KIAS to climb away. Directional control was easy with full power applied indicating an effective rudder. Open Loop the aircraft was trimmed as above and full power applied smoothly with subtle inputs to the rudder to ensure it ran straight along the ground. Without any joystick input the aircraft lifted off to approx. 5 ft, sank slightly as it continued to accelerate then pitched smartly nose up to approx. 30° at 55 KIAS before pitching back down to a stable climb attitude of approx. 25° nose-up. Without rudder input there was a subtle tendency for the aircraft to yaw and then roll to the left.*

Footnote

1 EASA Certification Specification 23.

Full Power caused the nose to pitch up – idle power caused it to pitch down. Application of full power caused the aircraft to yaw very slightly left which created sufficient sideslip to cause the aircraft to subsequently roll left.

With full power applied during the take-off condition assessments the aircraft had a subtle tendency to yaw to the left followed by a roll to the left. If the yaw was not prevented the aircraft continued to roll with the nose starting to drop as the AOB [angle of bank] exceeded 30°. If not corrected the AOB increased and the nose dropped below the horizon with the aircraft entering into a spiral dive.

Conclusions and Recommendations

The 100 hp C42 aircraft was a very benign aircraft with good handling qualities and stall characteristics. Take-offs and landings were easy to perform. The application of full power with neutral pitch trim created a nose up pitching moment but in all tested cases the aircraft eventually stabilised into a climb. The more flap that was applied the greater the nose up pitch (initial and stable) attitude and the slower the subsequent airspeed but even with full flap the aircraft did not slow down to the stall speed. It was possible to conduct Open Loop take-offs with one stage of flap with the aircraft eventually ending up in a 55 KIAS climb. Without small rudder inputs to prevent yaw to the left the aircraft with full power applied would roll to the left and subsequently enter a spiral dive.'

The instructor who had witnessed the accident observed the test flight takeoffs, but none had the extreme climb rate and nose-up attitude of the accident flight.

Medical and pathology

A post-mortem examination did not reveal the presence of any pre-existing disease or medical condition which might have contributed to the accident. The pilot was reported to have been in good health and toxicology showed no presence of drugs or alcohol.

Analysis

General

The investigation concluded that the accident resulted from an in-flight loss of control followed by a collision with the high tension power cables adjacent to the airstrip. The instructor described the aircraft as "hanging on the prop", which suggests a high angle of attack. It is probable that the aircraft entered a stall, with the left wing dropping such that the aircraft was pointing at the ground. This is supported by the angle of the cable impact mark on the right wing leading edge. None of the cables broke, although it is probable that they had the effect of reducing the aircraft's vertical speed. The shallow crater made by the engine and the lack of significant compression foreshortening of the fuselage suggested a relatively low ground impact speed.

Engineering aspects

While it was not possible to conduct a complete check of the flying controls due to the fire having consumed some components, there was limited scope for a disconnect or a malfunction in such a simple system. Regarding the secondary flying controls, the flaps were found to be retracted. The elevator trim, being in a central position, is unlikely to have resulted in control forces that were higher than the pilot was used to.

The engine components were found to be in good condition, although some of the accessories had been severely damaged by the fire. The aircraft had been climbing prior to the loss of control and the damage to the propeller blades indicated that at least a degree of power was applied at the time of the ground impact.

The witness and video evidence additionally indicated that the aircraft had climbed more steeply after takeoff than on the previous flight. Whilst this could be expected due to the reduced all-up weight of the aircraft after the instructor had disembarked, it appeared to happen immediately after the aircraft became airborne.

The possibility of cracking of the fuselage tube and A-strut was identified on C42 aircraft subsequent to the accident to G-CDNR. Neither had previously resulted in an accident but, of the two, the A-strut issue is considered more relevant to this accident, as the likely consequences of a failure would allow the wing leading edge to lift, thus increasing the angle of attack. This in turn would cause an uncommanded climb, which accords with the observed behaviour of the aircraft after takeoff.

Had a failure of the A-strut occurred, the upper section would have been held mostly by the locating rivet, which could have failed in shear under the action of flight loads. The rivet was found to be intact and undistorted, similar in appearance to the rivet in the lower attachment, which still retained the bottom of the A-strut. This suggested that there had not been an airborne failure, and this is supported by the statement from the manufacturer's design/certification engineer that the rivet would withstand flight loads of 2 to 3g. However, given the degree of damage sustained by the aircraft in the post-crash fire, the possibility of some other failure could not be discounted.

Operational aspects

The pilot was properly licensed to conduct the flight and had carried out three flights with the instructor that day to prepare him for the solo flight. During those flights he had demonstrated a satisfactory standard of ability in the operation of three-axis aircraft, sufficient to be allowed to fly solo. It appeared that either no attempt was made to correct the aircraft's extreme nose-up attitude or drift to the left prior to the accident, or the pilot had been unable to take corrective action. The post-mortem examination did not identify any medical reason for a lack of intervention by the pilot.

The flight testing demonstrated that:

> *'with full power applied during the take-off condition assessments, the aircraft had a subtle tendency to yaw to the left followed by a roll to the left. If the yaw was not prevented the aircraft continued to roll with the nose starting to drop as the AOB exceeded 30°. If not corrected the AOB increased and the nose dropped below the horizon with the aircraft entering into a spiral dive.'*

The witnesses' description of the final manoeuvre was more indicative of a wing drop at the stall resulting from the excessively nose-high pitch attitude.

The instructor had observed the flight tests at Old Sarum and in none of those takeoffs did the test aircraft climb as steeply as the accident aircraft. This suggests that either the pilot had applied an aft side stick control input, or the aircraft suffered a failure leading to a loss of control. If the pilot did not correct the yaw to the left, his ground track would have taken him towards the power cables, the location and height of which were known to him. With the high nose-up pitch attitude, the visibility forward would have been restricted by the nose of the aircraft. It is possible that, in trying to achieve the maximum angle of climb to avoid the power cables, the pilot may have made a large aft side stick control input and, with limited forward visibility, may not have been fully aware of his extreme nose-up pitch attitude.

Conclusion

The pilot had demonstrated that he was competent to fly the aircraft before undertaking the solo flight and yet the aircraft was seen to climb very steeply before control was lost.

The extreme angle of climb and wing drop were not reproduced in the 'Open Loop' (hands-off) takeoffs during flight testing and this suggests that either the accident pilot had made a deliberate and sustained aft side stick control input, or a failure of the aircraft occurred, resulting in the steep climb and a reduction in airspeed. The continued reduction in airspeed led to a stall, left wing drop and departure from controlled flight, with insufficient height to recover before striking the cables.

There was insufficient evidence available to determine which possibility was more likely.