AAIB
Air Accidents Investigation Branch

AAIB Bulletin 2/2022

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AAIB Special Bulletins and Interim Reports

This section contains Special Bulletins and Interim Reports that have been published since the last AAIB monthly bulletin.

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AAIB Air Accidents Investigation Branch

AAIB Bulletin S3/2021 *SPECIAL*

ACCIDENT

Aircraft Type and Registration:	Escapade, G-CGNV
No & Type of Engines:	1 Rotax 912-UL piston engine
Year of Manufacture:	2011 (Serial no: LAA 345-14901)
Date & Time (UTC):	14 November 2021 at 1204 hrs
Location:	Breighton Airfield, East Riding of Yorkshire
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:	Private Pilot's Licence (Aeroplanes)
Commander's Age:	66 years
Commander's Flying Experience:	945 hours (of which 4 were on type) Last 90 days - 9 hours Last 28 days - 3 hours
Information Source:	AAIB Field Investigation

Synopsis

The aircraft was seen to takeoff and climb steeply while appearing to sideslip and drift off the runway centreline. It climbed to approximately 180 ft agl at which point the left wing dropped, the aircraft departed from controlled flight and it descended rapidly to the ground. The pilot was fatally injured. The evidence indicates that the seat moved rearwards leading to the pilot losing control of the aircraft. The cause of the seat movement is under investigation. Three Safety Recommendations are made.

History of the flight

The pilot had flown the aircraft to Breighton Airfield from Rufforth (East) Airfield during the morning of Sunday 14 November 2021 to attend a remembrance service on the airfield. After the service he boarded G-CGNV for the return flight and started his takeoff from the Runway 10 threshold. Witnesses recalled that at some stage during the takeoff the pilot made a radio call on the Breighton Radio frequency indicating that he had a problem with the seat and was returning to the airfield to land. Eyewitnesses, including several pilots, reported that immediately after lifting off the aircraft began to climb at an uncharacteristically steep angle and in an unusual attitude. The aircraft climbed left wing low with right yaw which generated significant sideslip and led to its flightpath rapidly diverging to the right of the runway. CCTV imagery corroborated eyewitness accounts. The aircraft reached approximately 180 ft agl at which point the left wing dropped and the aircraft departed from controlled flight, descended rapidly and struck the runway abeam the control tower. The aircraft sustained major disruption during the impact, and a fire ensued. Airfield staff were quickly on scene and the fire was extinguished within one minute. The pilot was fatally injured. An image of the track of G-CGNV using PilotAware ATOM GRID Network data is contained in Figure 1.

Figure 1

Track of G-CGNV using PilotAware ATOM GRID Network data
(Satellite imagery courtesy of Google Earth)

Aircraft description

The Escapade is a homebuilt, single-engined, high wing, monoplane, taildragger aircraft of tubular steel, tubular aluminium and plywood construction with fabric covering. It is a two-seat side-by-side aircraft with dual controls, cable operated flaps and conventional flying controls. An image of G-CGNV is shown in Figure 2.

Figure 2

Image of G-CGNV (image used with permission)

The seats are also of tubular steel construction with tailored foam fabric-covered cushions. Both seats are adjustable for reach. They slide backwards and forwards on flat nylon runner strips on which the outer frame tubes of the seat pan rest. In G-CGNV, additional foam pads had recently been fitted by the pilot to raise and move him forward on the seat.

The seat is held in the selected position by a small spring-loaded pin centrally positioned at the front of the seat pan. The pin locates in equally spaced holes in a tube called an '*adjustment rail'* attached to the cockpit floor cross frame. Figure 3 shows the seat adjustment pin.

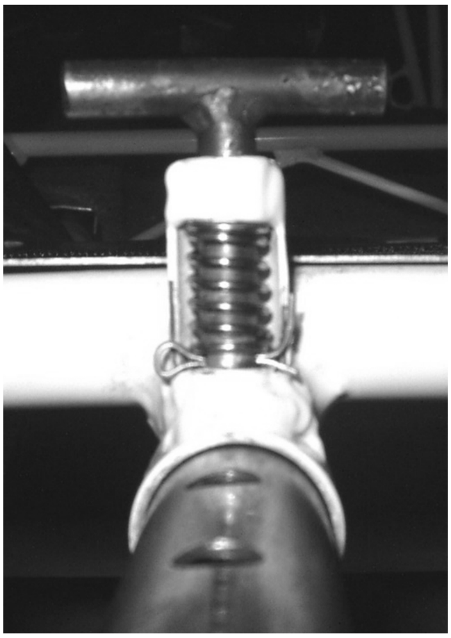

Figure 3

Image of seat pin from the aircraft assembly manual
(courtesy of the manufacturer)

The seat has 150 mm of travel and is fitted with a 25 mm wide webbing loop and cam buckle which is designed to be tightened after seat adjustment. These are known as '*seat adjuster backup straps*' (Figure 4). The installation manual states that these are '*a safety backup in case of seat pin failure*.' The straps should be tightened before flight, after the seat position has been finally adjusted.

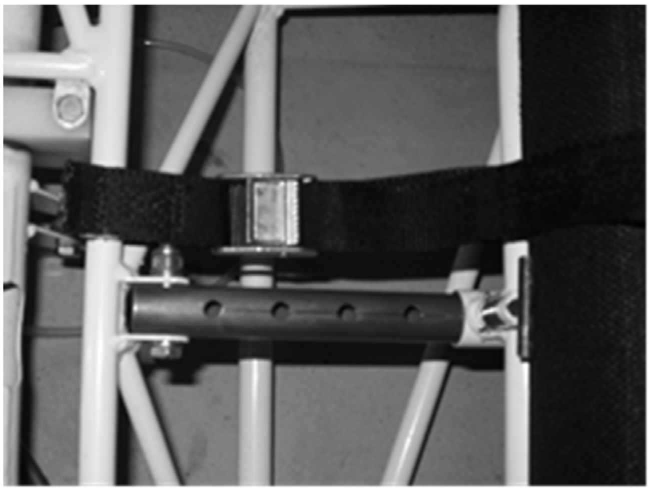

Figure 4

Image of the seat adjuster backup strap from the aircraft assembly manual (courtesy of the manufacturer)

On G-CGNV, four-point safety harnesses were fitted for each of the seat occupants. The shoulder straps were attached to a cross tube at the rear of the cockpit, and the lap straps were attached to the seat frame at the back of the seat pan. Therefore, if the occupant was correctly strapped in and the seat then moved rearwards, the two shoulder straps would slacken, however the lap strap would remain tight.

To enter and exit the cockpit, pilots and passengers generally move the seat fully rearwards to enable their knees to clear the instrument panel and control column.

Initial findings

Witnesses recalled that at some stage during the takeoff the pilot made a radio call indicating that he was having problems with his seat.

The stature of the pilot required him to have the seat fully forward. Evidence showed that the rudder control cables had recently been adjusted to the shortest limit in order to bring the rudder pedals rearwards to be nearer the pilot.

Witness evidence indicated that other users of the aircraft had previously experienced difficulty locating the pins for both left and right seats in an appropriate hole in the adjustment rail to lock the seats. Figure 5 shows a comparison between the correct and incorrect location of the seat adjustment pin. While sitting in the seat the occupant is not afforded the same view as in Figure 5.

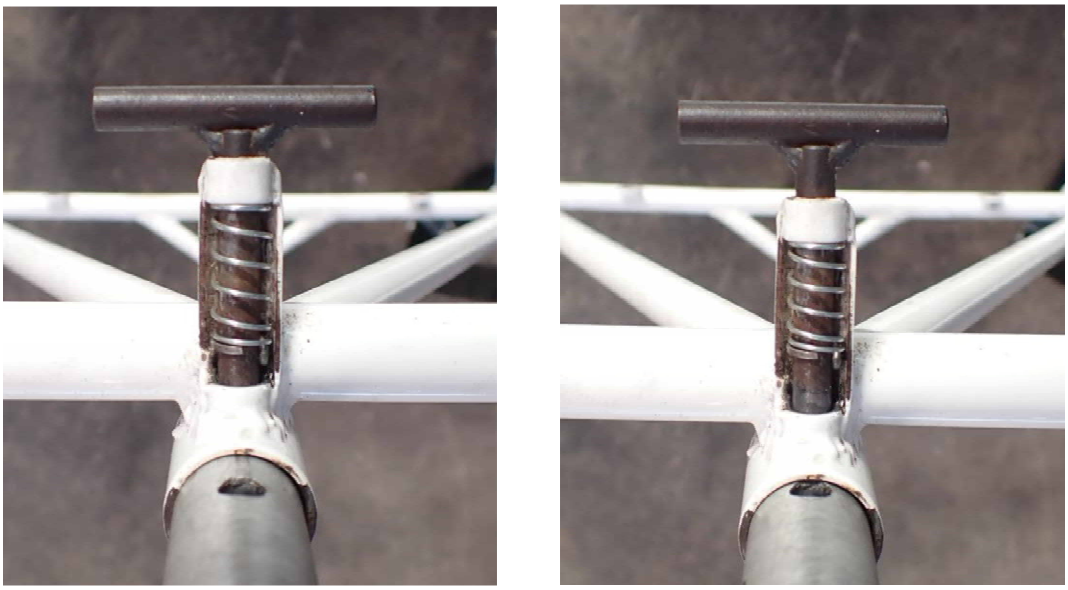

Figure 5

Seat adjustment pin correctly located in one of the holes in the adjustment rail (left) and incorrectly located sitting on top of the adjustment rail (right).
Note: seat cushion removed for clarity

Post-accident examination of the pilot's seat assembly showed that the seat pin was not correctly located in a hole in the adjustment rail. The damage and distortion to the adjustment rail was consistent with the seat being towards the rearmost extent of its travel when the aircraft struck the ground. Marks on the damaged adjustment rail showed that the seat adjustment pin and holes were slightly misaligned, with their centrelines offset (Figure 6), making it difficult for the pin to locate correctly.

Figure 6

Marks created on the pilot's seat adjustment rail by the pin

Witness evidence also indicated that the pilot had found the seat adjuster backup straps "fiddly" to use. The pilot's strap was found to be set at a length that would have allowed the seat to have travelled rearwards to around the full length of its travel, and therefore would not have secured the seat in the fully forward position as required by this pilot.

Conclusion

The evidence indicates that the seat adjustment pin was not correctly located in one of the holes in the adjustment rail and therefore the seat was not locked in the fully forward position required by the pilot. Additionally, the seat adjuster backup strap, intended to prevent rearwards seat movement in case of pin failure, appears not to have been tightened.

At an early stage in the takeoff, the pilot reported he was having problems with his seat.

The evidence indicates that the seat moved rearwards leading to the pilot losing control of the aircraft. The damage and distortion to the adjustment rail was consistent with the seat being towards the rearmost extent of its travel when the aircraft struck the ground.

Safety Recommendations

The inadvertent seat movement appears to have caused a loss of control with catastrophic consequences. The evidence shows that the pin was not correctly located in one of the holes in the adjustment rail and therefore the seat was not locked in place. Initial findings indicate that it is difficult to confirm correct pin location while occupying a seat, and for forward positions of the seat it might not be possible to vacate the seat to check the pin location. Additionally, the seat adjuster backup strap, designed to prevent rearwards seat movement in case of pin failure, appears not to have been tightened.

On the UK register there are 36 Escapade aircraft and 7 Sherwood Scout aircraft of similar design. These operate on Permits to Fly issued by the BMAA and LAA. Given the possibility for a seat to not be properly locked in place and the secondary locking to not be secure the following two Safety Recommendations are made:

Safety Recommendation 2021-049

It is recommended that the Light Aircraft Association remind owners of this aircraft type of the necessity, after every seat position adjustment, to:

- ensure that the seat pin is correctly locking the seat in position, and
- set the seat adjuster backup strap after the desired seat position has been selected.

Safety Recommendation 2021-050

It is recommended that the British Microlight Aircraft Association remind owners of this aircraft type of the necessity, after every seat position adjustment, to:

- ensure that the seat pin is correctly locking the seat in position, and
- set the seat adjuster backup strap after the desired seat position has been selected.

Some of the safety issues identified in this Special Bulletin apply to other aircraft types on the UK register. Therefore the following additional Safety Recommendation is made:

Safety Recommendation 2021-051

It is recommended that the Civil Aviation Authority in conjunction with the Light Aircraft Association and British Microlight Aircraft Association, remind pilots of the importance of ensuring that seats are correctly locked and any secondary locking mechanisms are correctly used, particularly after any seat position adjustment.

Further work

The investigation continues to examine all pertinent operational, technical, and human factors which might have contributed to this accident. A final report will be issued in due course.

Published: 14 December 2021.

AAIB Field Investigation Reports

A Field Investigation is an independent investigation in which AAIB investigators collect, record and analyse evidence.

The process may include, attending the scene of the accident or serious incident; interviewing witnesses; reviewing documents, procedures and practices; examining aircraft wreckage or components; and analysing recorded data.

The investigation, which can take a number of months to complete, will conclude with a published report.

SERIOUS INCIDENT

Aircraft Type and Registration:	Edge 540, G-EDGY
No & Type of Engines:	1 Lycoming AEIO-540-EXP piston engine
Year of Manufacture:	1997 (Serial no: 18)
Date & Time (UTC):	1 May 2021 at 1220 hrs
Location:	Overhead Tempsford Airfield (disused), Bedfordshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Loss of right aileron and damage to right wing skin
Commander's Licence:	Private Pilot's Licence
Commander's Age:	45 years
Commander's Flying Experience:	598 hours (of which 51 were on type) Last 90 days - 4 hours Last 28 days - 3 hours
Information Source:	AAIB Field Investigation

Synopsis

During an aerobatic flight, as the pilot applied a full left aileron control input, the centre hinge attachment for the right aileron failed. This allowed the right aileron to bend up in the centre and fail before detaching from the aircraft; only a small inboard section of the aileron remained attached. The pilot had sufficient control remaining to make a safe landing.

The investigation found that the centre hinge attachment for the right aileron failed due to fatigue cracks developing to such an extent that the parts were no longer able to carry the required load. These fatigue cracks had multiple origins indicating that they were not due to a material feature or flaw. The aircraft manufacturer has issued a Service Letter to all known owners recommending regular detailed inspections of similar aileron centre hinge attachments. The UK LAA has contacted all affected owners in the UK to ensure they are aware of this mandatory Service Letter.

History of the flight

The pilot planned to undertake a 30-minute aerobatic flight from Little Gransden Airfield, Cambridgeshire, during which he intended to practice two pre-planned display routines. The visibility was greater than 10 km and the surface wind was northerly at approximately 10 kt. Prior to the flight he added half a quart of oil to the engine, confirmed the wing fuel tanks were empty and checked the fuselage fuel tank was full (66 litres). The start-up, taxi-out, control checks and power checks were all normal. He took off from Runway 28 at approximately 1315 hrs and flew the short distance to his intended practice area overhead Tempsford disused airfield (approximately 4 nm west of Little Gransden Airfield). As he approached Tempsford he climbed to the base of the clouds to confirm the cloudbase, which was 3,700 ft aal, then completed two steep turns to visually confirm the area was clear of other aircraft.

The pilot commenced the first display routine with a 45° climb followed by a 540° left roll to put the aircraft in a 45° inverted climb. He then pushed the nose forward to a vertical climb and rolled 90° to the right. As the aircraft slowed, he performed a stall turn to the left followed by a two-and-a-half turn knife edge spin, then recovered to a vertical dive. He pulled out of the dive with approximately 5 to 6 g leaving the aircraft at approximately 160 kt and 1,100 ft aal. He then initiated an aileron roll to the left but almost immediately heard a loud bang. His initial thought was that he had collided with another aircraft. He gently rolled the aircraft back to wings level and looked for the other aircraft but, not seeing any other aircraft, concluded that no other aircraft had been involved. He saw that the right aileron had detached from the outer and central hinge but could not see if it was still attached and hanging below the aircraft. The aircraft was still flyable but it felt heavy in roll, and he was concerned the remaining aileron may jam. He mentally rehearsed his abandonment drill in case he lost control of the aircraft. He pointed the aircraft back towards Little Gransden Airfield and made a Mayday call on the airfield frequency stating he intended to land on Runway 10.

As the pilot flew the aircraft back towards the airfield, he reduced speed to confirm the low-speed handling was acceptable. He completed his normal landing checks and tightened his harness in case the loose aileron affected the ground roll. He made the approach at 100 kt rather than the normal 80 kt to account for the single aileron. He made a smooth landing with the crosswind from the left and was able to taxi back to the hanger. Figure 1 shows the aircraft after it had been parked. The total time from the failure to landing at Little Gransden was 2 minutes and 20 seconds.

Figure 1

G-EDGY after landing, showing inboard hinge with section of aileron still attached and the distorted outboard hinge

Recorded information

A camera was fitted to the left-wing tip which recorded the whole flight. There was no other recording device fitted to the aircraft.

The images in Figures 2, 3 and 4 were taken from the camera and show the aileron failure.

Figure 2

Aircraft entering the left roll showing the right aileron failing upwards (circled)

Figure 3

Right aileron failure continued (circled, behind canopy)

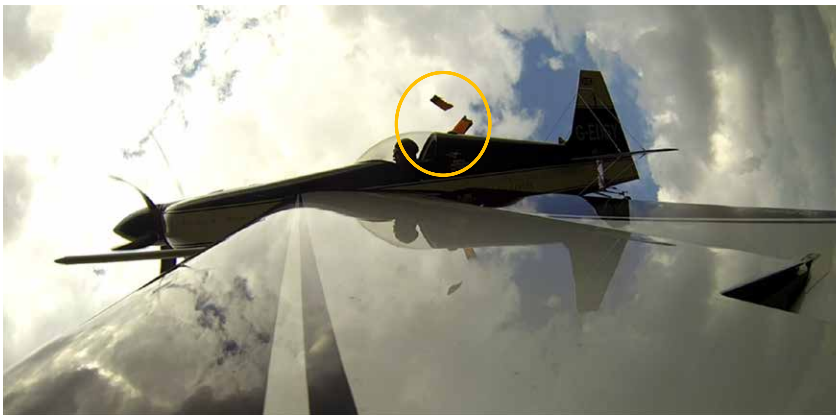

Figure 4

Parts of the right aileron departing the aircraft (circled)

Pilot information

The pilot held a private pilot's licence with a valid SEP rating and a Class 2 medical. He had accumulated 598 flying hours most of which were aerobatic flying. He regularly flew the aircraft in international aerobatic competitions at the advanced level.

The pilot reported that the routine he was flying was pre-planned to ensure that the aircraft remained within the limitations specified in the pilot's operating handbook for each manoeuvre. He was confident he had not exceeded any limitations during the accident flight. From his experience, he thought he would know if a manoeuvre had gone sufficiently wrong to exceed a limitation and that he would report this after landing. He was confident that the other people who flew G-EDGY would do likewise. So, he considered it was unlikely that the failure was caused by him or another pilot exceeding the aircraft limitations.

The pilot was asked what helped him manage the emergency when the aileron failed and how he was able to get the aircraft back on the ground safely. He reported that his aerobatic experience really helped as he was used to flying the aircraft into, and recovering from, unusual attitudes. He had also flown approximately 30 different aircraft types and he felt that this experience helped to reduce the startle effect when the failure occurred. He also recalled rehearsing his drill for abandoning the aircraft. It was useful to have a well-rehearsed drill to complete in the moments after the failure. He had previously experienced an engine failure and had needed to make a forced landing. He believed this previous experience helped him stay calm and manage the emergency.

Aircraft information

The Edge 540 is designed for unlimited aerobatics. The wings and full span ailerons are of composite construction. The ailerons are mass and aerodynamically balanced and are operated by push-pull rods. They are each attached by three hinge assemblies and a 'spade' is fitted to the inboard hinge attachment to assist control response.

There are three standards of aileron hinge attachment assembly fitted to Edge 540 aircraft.

There is an original standard of aileron hinge attachment assembly for which the manufacturer reported that there are no aircraft in service fitted with this design.

G-EDGY was fitted with aileron hinge attachment assemblies constructed from two aluminium, 2024-T3, 'L' shape brackets riveted to a flat distance piece containing a self-aligning bearing. These parts are anodised. The assembly is bolted to the rear spar of the wing and the aileron is attached by a bolt passing through the bearing (Figure 5). This standard of aileron hinge assembly has upgraded rivets compared to the original standard of aileron hinge assembly.

A new type of hinge, machined from a single piece of aluminium alloy, was introduced in 2010 when the aircraft underwent a design refinement and weight reduction review resulting in the Edge 540v3.

Figure 5

Image of centre hinge arrangement looking forward at wing rear spar

Maintenance information

The aircraft was built in 1997 and it had flown 1,270 hours. It was operated on a Permit to Fly which was valid until 31 March 2022. The last annual inspection was completed on 27 March 2021 and included an inspection of the aileron hinges in accordance with the manufacturer's service letter SB E54009. This required an annual inspection of the centre (and inboard) hinge mounting nuts and bolts, along with the rivets that hold the hinge attachment assembly together. This did not require the removal of the aileron. No anomalies were noted.

Aircraft limitations

The pilot's operating handbook specified a maximum manoeuvre speed (V_A) of 170 kt. The maximum speed for an aileron roll is also 170 kt.

Other operational information

The aircraft was primarily used for unlimited aerobatics during which roll inputs are often made aggressively to full deflection, up to V_A, to maximise the roll response of the aircraft. The aircraft is flown with the pilot's right hand on the control stick. Pilots of this aircraft type reported that they usually preferred to make rolls to the left as it is more natural to apply full stick to the left due to the position of their arm in the cockpit.

The owner was asked to make an estimate of the number of maximum control deflections used in left rolls that the aircraft had made, based on his experience in how the aircraft was used along with flying hours recorded in the aircraft log books. He estimated that around 23,000 cycles of rolls to the left with full control input had been completed.

Aircraft examination

The aircraft was initially examined at its home base along with the detached aileron parts, which had been recovered from the field in which they fell. The centre hinge attachment assembly for the right aileron had failed and the other two hinges, at either end of the aileron, had been bent upwards. The aileron had separated from the outboard hinge, but a small section of aileron remained attached to the inboard hinge along with the 'spade' (Figure 1). This part appeared to have been flailing in the slipstream and had caused some damage to the wing skin.

The right aileron inboard hinge was disassembled to release the remaining part of the aileron, and the centre hinge attachment was removed from the aircraft (Figures 6 and 7). The intact centre hinge from the left aileron was also removed. The centre hinge parts from both ailerons and the failed aileron were taken to a specialist laboratory for detailed metallurgical examination.

Figure 6

Parts of the failed centre hinge attachment for the right aileron before removal from wing

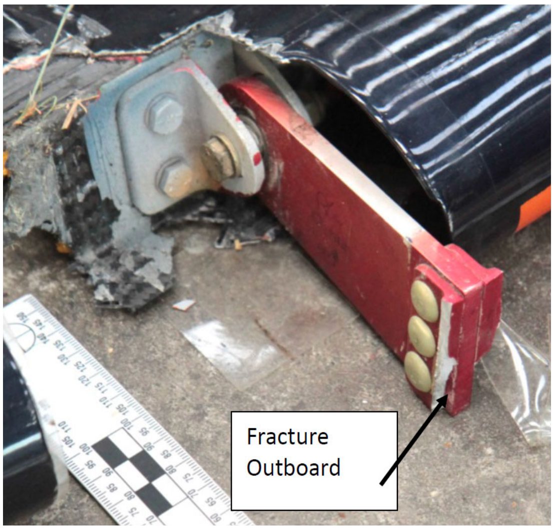

Figure 7

Remainder of the right aileron centre hinge attachment, still attached to the aileron

Detailed examination of the aileron centre hinge assemblies

Examination of centre hinges

A detailed examination of the failure surfaces was undertaken at a specialist laboratory using low and high magnification fractography techniques. This examination also included an assessment of the geometric and material conformity of the hinge parts and an estimate of the load cycles to failure using images obtained by scanning electron microscope.

The intact hinge assembly from the left wing was also examined. Evidence of cracking in the corner radii, in a similar area to those found on the failed right hinge assembly, was observed (Figure 8). To allow detailed examination, these parts were pulled open to failure using a machine. Once exposed, the failure surfaces were examined using the same methods as the failed parts.

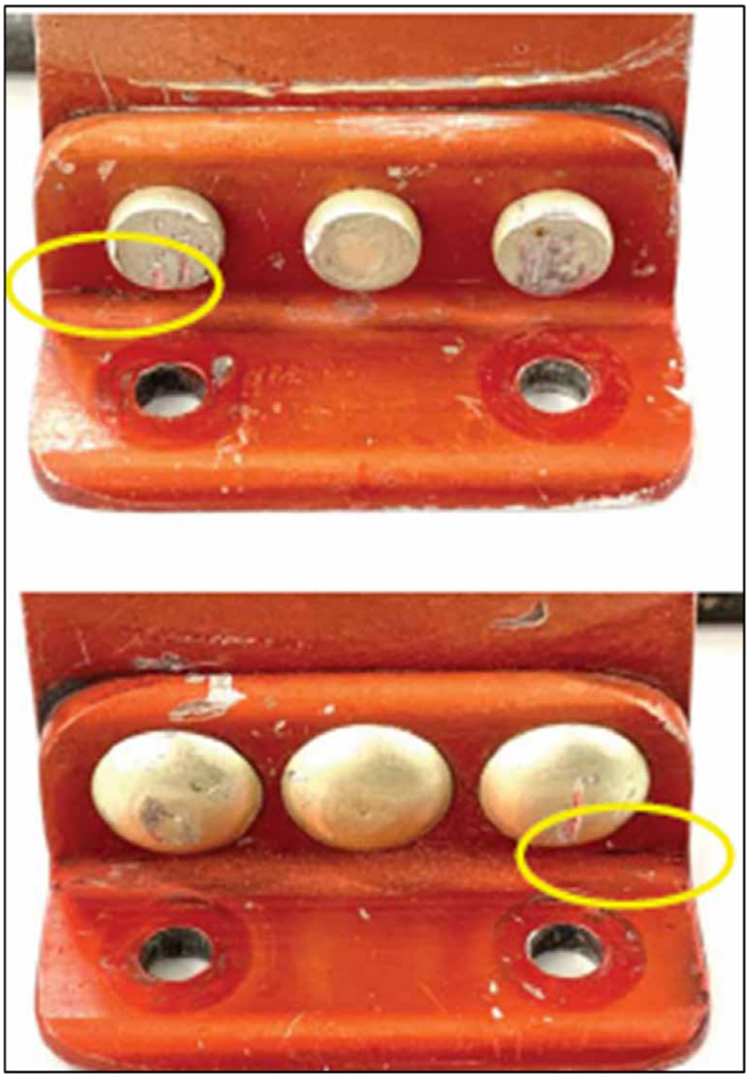

Figure 8

Evidence of cracking to left aileron centre hinge along corner radii

Examination findings summary

The following findings were made from the results of the detailed examination:

- The right aileron centre hinge attachment had failed through the corner radii of the two 'L' shaped brackets attaching the hinge assembly to the wing.
- Physical features of the right aileron centre hinge failure surfaces confirmed that both inboard and outboard sides had failed due to multi-origin fatigue.
- Checks of the microstructure and geometry confirmed that the part had been manufactured to, and still met, the specification.
- Pulling open and then examining the left aileron central hinge attachment revealed that the fractures present were very similar to those which resulted in the in-flight loss of the right aileron. These fractures had not yet grown to the same extent as seen on the right aileron hinge.
- On both the left and right aileron centre hinges, the cracks were multi-origin fatigue driven fractures. The right hinge had failed from the lower surface upwards and the left hinge from the upper edge downwards (Figure 9). This is consistent with control inputs to roll left.
- Striation counting of the failure surfaces suggested that the estimated number of load cycles to failure was approximately 14,000 cycles (Figure 10).

Analysis

As the pilot applied a full control deflection to roll left, the right aileron hinge attachment assembly failed. This allowed the right aileron to bend up in the centre and fail before detaching from the aircraft; only a small inboard section of the aileron remained attached. The pilot had sufficient control remaining to fly back to the airfield and make a safe landing.

The centre hinge attachment assembly of the right aileron failed due to fatigue cracks developing to such an extent that the parts were no longer able to carry the required load. These fatigue cracks were of multiple origin indicating that they were not due to a material feature or flaw.

The similar hinge attachment assembly on the left wing had not failed, but fatigue cracks like those on the right aileron hinge were found, although they had not developed so extensively.

From the striation marks, the metallurgy laboratory estimated that the hinge had been subjected to approximately 14,000 load cycles prior to failure. This is of the same order of magnitude as the owner's estimate of the number of full control deflections to roll quickly left which was 23,000.

The cracks on both the right and left centre hinge attachments had been developing over the life of the aircraft, but they had not been identified by routine inspections. The developing cracks were visible on the left hinge which had not yet failed. It is difficult to properly inspect the hinges without removing them and a service letter issued by the manufacturer (see safety action section below) addresses this issue.

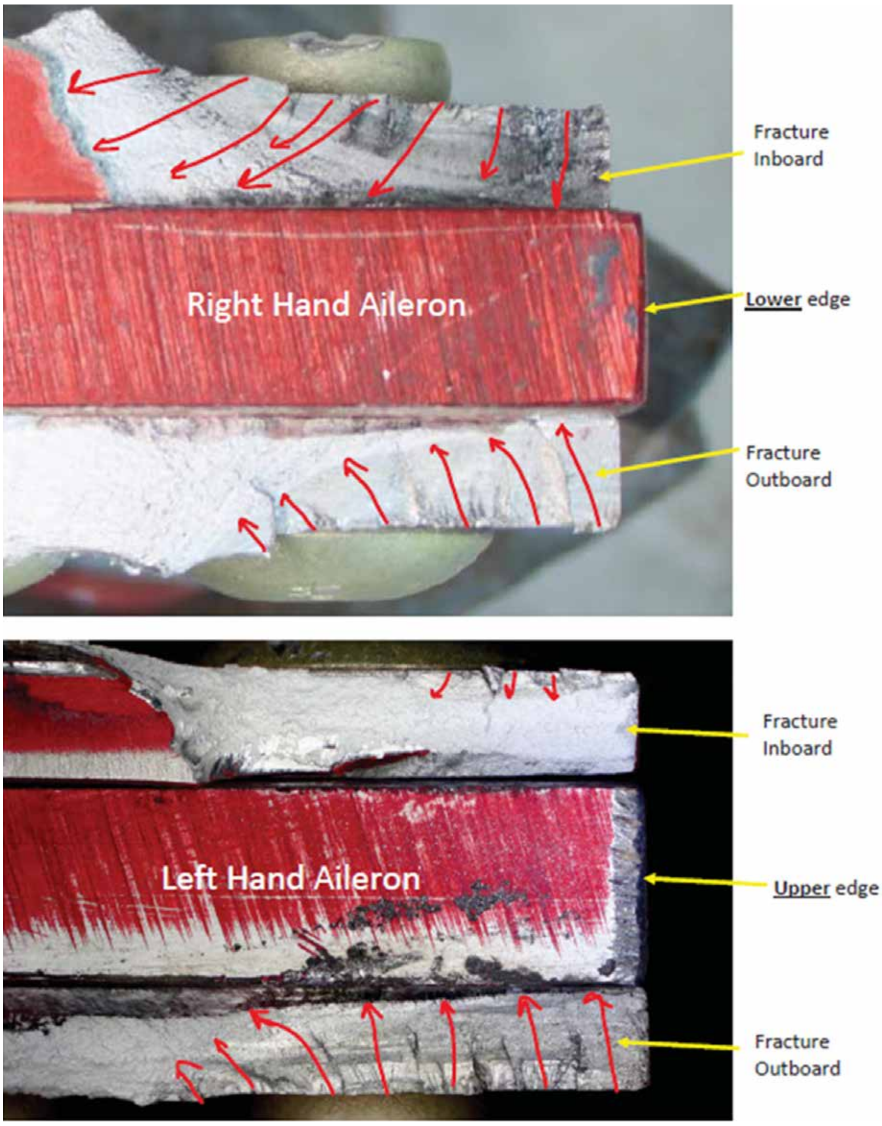

Figure 9

Fractographic summary of damage observed to centre aileron hinges (red arrows indicate direction and extent of fatigue crack growth)

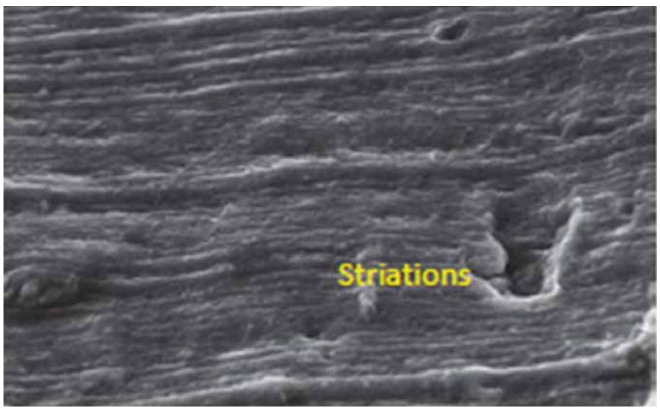

Figure 10

High magnification, scanning electron microscope image of fatigue striations on a fracture surface of the failed right hinge (each striation is the result of a load cycle)

Conclusions

Whilst performing aerobatics, the right aileron failed and detached from the aircraft. The pilot was able to fly the aircraft back to the airfield and make a safe landing.

The right aileron centre hinge attachment assembly failed due to fatigue cracks, similar cracks were found in the centre hinge attachment assembly on the left wing.

Safety actions

The aircraft manufacturer has issued Service Letter, SB E540015 to all known owners of affected aircraft. This letter is annotated 'MANDATORY' and recommends removal of the centre aileron hinge attachment assemblies at each 100 hour or annual inspection to allow inspection for cracks using a dye-penetrant method.

The UK LAA has contacted all affected owners in the UK to ensure they are aware of this mandatory Service Letter.

Published: 20 January 2022.

ACCIDENT

Aircraft Type and Registration:	Stampe SV4C(G), G-AWEF
No & Type of Engines:	1 De Havilland Gipsy Major 10 Mk.2 piston engine
Year of Manufacture:	1947 (Serial no: 549)
Date & Time (UTC):	9 May 2021 at 1521 hrs
Location:	Near Headcorn Aerodrome, Ashford, 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:	Private Pilot's Licence
Commander's Age:	57 years
Commander's Flying Experience:	753 hours (of which 517 were on type) Last 90 days - 8 hours Last 28 days - 5 hours
Information Source:	AAIB Field Investigation

Synopsis

The aircraft was taking part in a formation display practice with three other similar aircraft. Whilst practicing a new manoeuvre involving a synchronised line abreast stall turn, G-AWEF was seen to enter a spin. The aircraft did not fully recover from the spin before striking the ground fatally injuring the pilot.

No evidence was found of any pre-existing fault or damage to the aircraft which could have caused the spin or prevented the aircraft from recovering from the spin.

Flight tests conducted during the investigation showed that the most likely reason the aircraft entered a spin was that either too much aft stick was applied before the yawing turn was complete or that the rudder was not centralised when the pull-out was commenced. The investigation identified several reasons why this may have occurred.

The investigation highlighted the importance of obtaining guidance and mentoring from an experienced display authorisation evaluator when upgrading a display authorisation.

Incipient and developed spin recovery techniques vary between aircraft and may be different to those discussed in this report.

History of the flight

The pilot of G-AWEF was part of a Stampe aircraft display team. On the day of the accident, he was taking part in two formation display practice flights with three other pilots flying similar Stampe SV4C aircraft. Figure 1 shows the four aircraft during the accident flight. These were the team's first practice flights of the season with four aircraft, but G-AWEF's pilot had taken part in formation display practices with two and three aircraft earlier in the year.

Figure 1

The four Stampe SV4C aircraft photographed during the accident flight
(used with permission)
(G-AWEF is the red and yellow aircraft)

The four pilots met at Headcorn Aerodrome, where the aircraft were all based, at 1200 hrs and briefed for the intended flights. Their plan for both flights was to initially fly away from the aerodrome into the local area to practice some formation loops. They then planned to return to the aerodrome to practice one loop at 1,000 ft agl followed by their standard display routine which they had flown the previous season. At the end of the routine, they intended to practice a new manoeuvre which involved an opposition break[1] followed by a line abreast stall turn[2] with all four aircraft turning to the right. After this, the three 'following' aircraft would land and the formation leader would practice his solo display. Their briefing included several walkthroughs of the planned routine paying particular attention to the new elements.

Footnote

[1] An opposition break involves the aircraft on the left turning to the right and those on the right turn to the left so that they cross each other.

[2] A conventional stall turn involves pitching up into a vertical climb, then, as the airspeed is decreasing using the rudder to yaw the aircraft through 180° into a vertical downwards dive. A more detailed description of the stall turn the aircraft were flying is given in the section title 'stall turn'.

The four aircraft took off for the first flight at 1309 hrs and proceeded as planned. The three aircraft landed back at the aerodrome at 1335 hrs followed by the formation leader at 1355 hrs. After the flight the team discussed the first practice and how they could improve the display. They agreed that during the stall turn the four aircraft were positioned as two pairs with a larger gap in the middle when they intended them to be evenly spaced. They also felt that their airspeed had been “slightly slow, although not dangerously slow”, when they initiated the stall turn. They agreed that on the second practice they would aim to ensure the spacing was equal between the aircraft and the leader planned to initiate the pitch-up into the stall turn and the rudder input at slightly higher speeds.

The four aircraft took off for the second practice at 1510 hrs. They again departed from the aerodrome to practice the formation loops which the pilots later recalled were much better than the first flight. The four aircraft then returned to the aerodrome and completed their display routine which again concluded with the stall turn. The pilots also later recalled that the spacing between the aircraft was much better than the first flight. The formation leader recalled that they started the stall turn manoeuvre from approximately 500 - 600 ft agl flying away from the display line towards the north. He called “pull-up, pull-up, go” on the radio to initiate the climb at approximately 85 kt (about 10 kt faster than the earlier flight). He recalled looking along the line of four aircraft and seeing them all climbing together. He called “rudder, rudder, go” to initiate the stall turn at approximately 45 kt. Three of the aircraft completed the stall turn as planned. However, two of the pilots and numerous witnesses on the ground saw G-AWEF enter a spin. One of the pilots said he “saw G-AWEF entering a spin straight off the stall turn and rotated two-and-a-half to three times before briefly straightening just before hitting the ground”.

Several witnesses recall seeing the aircraft complete the stall turn before entering the spin and then rotating several times before disappearing below the treeline. One witness, who was familiar with the airfield, estimated the aircraft was at 300 – 400 ft agl when it entered the spin. Another witness said he saw the aircraft complete the stall turn but “very shortly after this but not immediately, entered a spin to the right, and descended in a spin completing between one and two turns before disappearing behind the trees with a high rate of descent”.

The airfield air/ground radio frequency is not recorded but the radio operator and the pilots of the other aircraft reported that they did not hear any radio transmission from G-AWEF.

Several witnesses were filming and photographing the aircraft during the display practices. However, none of the footage provided to the AAIB captured the stall turn. One witness, who was at the airfield, captured footage of G-AWEF in the spin, a still from which is shown in Figure 2. The aircraft was also captured by a CCTV camera, stills from which are shown in Figure 3.

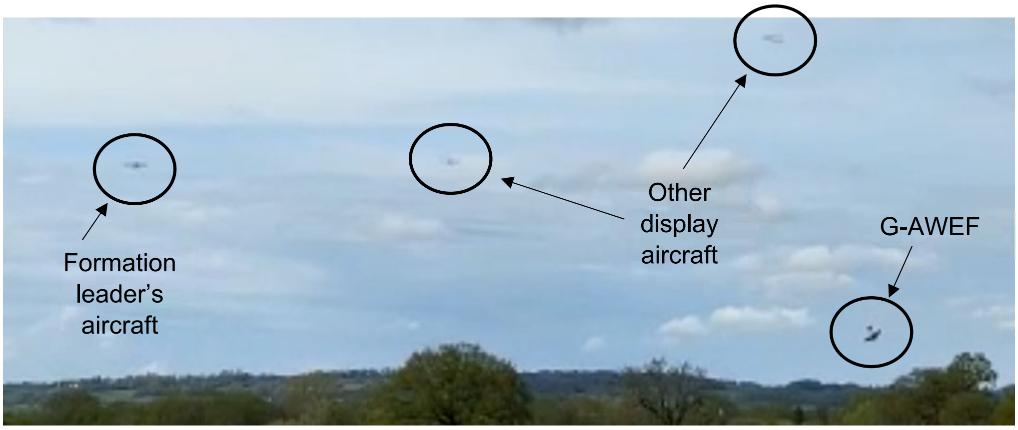

Figure 2

Mobile phone footage shot by a spectator at the airfield (used with permission)

Figure 3

Montage from CCTV (used with permission)

The aircraft struck the ground in a field approximately 1 nm north of the aerodrome (Figure 4), there were no signs of fire. An angler who was fishing in a nearby lake ran to the accident site to assist the pilot. He recalled that he arrived within a few seconds of the impact and managed to get to the pilot but there were no signs of life. The other three aircraft circled above the accident site and directed the aerodrome emergency services to the location. Once the emergency services had arrived, the three remaining aircraft returned to the aerodrome and landed normally. An air ambulance also attended the scene. However, the pilot could not be revived.

Figure 4

Accident location

Accident site

The aircraft hit the ground in a large open agricultural field and came to rest upright on a north-easterly heading. Initial examination of the wreckage indicated the aircraft was complete with no vital parts or control surfaces missing. The tail section, from the rear cockpit seat frame aft, was undamaged other than some distortion and splitting of the left tailplane tip structure. Both cockpit areas and the engine bay were extensively fragmented (Figure 5). The upper and lower wing leading edges had been compressed and distorted along the full length of both wings. The upper wing bracing struts and rods had been cut by the first responders and the wing had been moved forward to gain access to the pilot. After the aircraft was removed from the accident site, two distinct parallel marks had been left on the ground by the mainplane leading edges (Figure 6). Comparison of these ground marks with the aircraft's original structural dimensions suggest that the aircraft hit the ground with a 65° nose-down attitude.

Figure 5
Accident site showing tail and mainplane positions

Figure 6
Marks left by the mainplane leading edges

The control column and rudder pedal linkages and mechanisms were disrupted and there were multiple bends and fractures of the linkages. The rear cockpit rudder pedal foot pads had both detached from the rudder bar.

The throttle and mixture levers had become detached from their locations on the cockpit side structure. The rods, levers and cables of the throttle and mixture controls were distorted and detached. The rear cockpit pitch trim handwheel was dislocated but was correctly connected to its piano wire linkage which was within its guide conduit and was correctly attached to the elevator trim tab. A sharp bend had formed in the piano wire and conduit where it passed through the rear cockpit seat frame. The front cockpit elevator trim wheel had also detached and become disconnected from the rear cockpit trim wheel.

The fuel tank had a large split on the left corner of the front edge and contained no fuel. The engine was lying on its side within the wreckage and many of its ancillary external components were detached whilst being held loosely on and around the engine by wiring and linkages.

Despite the damage to the aircraft, an onsite examination of the aileron, rudder and elevator controls and linkages showed a continuity of those controls.

Figure 7

Propeller as found in the accident site (engine lifted clear)

One of the propeller blades had detached from its root, had fragmented, and was found lying beneath the aircraft. It was also split along its chord from tip to root on the largest fragment. The other blade was also detached at its root and had made a deep cut into the ground along its length. It had also bent forward and had started to break mid-way along its aerofoil section (Figure 7).

The engine lubricating oil tank was dislocated but attached by its supply and return pipes. Although it had split open it contained a small quantity of engine oil.

The carburettor had broken off the intake manifold and was only attached to the engine by the remains of its linkages and its fuel supply pipe.

The front and rear seats had separated from the airframe, both were distorted, and the front seat pan was compressed with its seat back bent forwards. The rear seat was misshapen with its small wooden seat pan oddments box in place. The box contained a variety of small hand tools, some spare gaskets and spark plugs. The small luggage cubby cover in the fuselage behind, and at the top of the rear seat had opened and the contents, a wind proof jacket and an aircraft cover, had fallen out.

The rear seat harness was found loose having been undone by the first responders. The front seat harness was still attached to the seat frame and was tightly fastened with its loose ends neatly tucked away. The front cockpit cover panel was present but had detached.

Recorded information

The aircraft was not fitted with any data logging or recording devices, nor were there any radar recordings of the accident flight.

Aircraft information

G-AWEF was built in 1934. The Stampe SV4C(G) is a biplane of wood and fabric construction and is fitted with conventional rod and cable operated flying controls. The ailerons are fitted to the upper and lower mainplanes. The lower ailerons are connected via cables and pulleys to the control column and the upper mainplane ailerons are linked to the lower ailerons by a pair of steel aerofoil section rods. The rudder pedals and control columns are fitted in the front and rear cockpit. The rudder pedals are adjustable for reach. The elevator is fitted with a trim tab on the right trailing edge. Pitch trim inputs can be made from the front and rear cockpit using a small rack and pinion handwheel fitted on the left side of each cockpit. The handwheels are linked by a tubular rod. Movement of either handwheel adjusts the trim tab via a piano wire within a conduit.

This aircraft was powered by a Gipsy[3] Major straight four-cylinder inverted piston engine which drove a fixed pitch laminated wooden propeller. Fuel/air mixture was supplied by a single choke Hobson carburettor. The aircraft was fitted with an inverted flight device which was part of the induction system, operated by a small lever included beneath the normal throttle and mixture levers on the throttle quadrant. Ignition was by two spark plugs per cylinder and supplied with energy from a pair of magnetos. The engine had a dry sump lubrication system. The front cockpit instruments included an engine rpm gauge. The rear cockpit was also fitted with an rpm gauge and included an oil pressure gauge.

Pneumatic/mechanical flight instruments were duplicated in each cockpit and consisted of a barometric altimeter, airspeed indicator and a compass. A turn and slip indicator were

Footnote

[3] This aircraft was originally fitted with a Renault 4PO series engine, but due to difficulties experienced in maintaining this engine type to an airworthy condition, many Stampe SV4 aircraft were fitted with Gipsy Major 10 Mk 2 engines and redesignated as Stampe SV4C(G). G-AWEF was approved with this engine type under a CAA Airworthiness Approval Note (ANN) 26819 issued in February 1999.

fitted to the rear cockpit and simple slip indicator fitted in the front cockpit. To comply with the aerobatic limitations issued by the CAA the aircraft was also fitted with a g-meter. An inverted slip indicator was fitted in the rear cockpit only.

A radio and transponder were also fitted in the rear cockpit only and were powered by a small, sealed lead acid battery fitted in the fuselage to the rear of the rear cockpit.

The front and rear cockpits were fitted with light alloy 'bucket seats'. The rear seat pan had a small wooden cubby box beneath the padded cushion. Five-point safety harnesses were fitted to the seats in the front and rear cockpits. An additional 'emergency lap strap' was attached to the airframe on each side next to the seat base.

Aircraft maintenance history

The aircraft had a valid Certificate of Airworthiness and an Airworthiness Review Certificate and its next annual maintenance was due on 30 March 2022.

Aircraft examination

The aircraft was recovered from the accident site and transported to the AAIB headquarters for further examination. Both wings were removed prior to moving the aircraft.

Fuselage

The nose section and engine bay and both cockpits were extensively damaged during the impact. Conversely, the rear fuselage and tail section aft of the rear pilot seat frame were relatively intact.

Flying controls

Ailerons

All four ailerons were damaged structurally and were restricted in their movement, having detached from their hinges and by distortion of the surrounding wing structure. The continuous loop aileron cable was correctly connected to the remains of the control column but had broken where it passed over the right lower wing spar. Evidence on the cable where it had broken showed that it was a tensile overload failure where it was forced to stretch over the displaced and bent wing spar when the aircraft hit the ground. The aileron pivot assemblies were examined and despite the damage sustained, they showed no signs of wear or pre-accident failure. All the damage to the aileron control, hinge assemblies and surrounding wing structure was attributable to fuselage and wing damage caused by the impact.

Elevator and pitch trim tab

The elevator control mechanisms at the base of the control columns were severely disrupted. Various breaks and separations were caused by fragmentation of the fuselage and cockpit floor. However, elevator cable was unbroken from under the rear seat area and throughout the relatively intact rear fuselage section. The elevator was correctly mounted on its hinges on the tailplane and had a full and free range of movement between its stops. There was no wear apparent on elevator hinges or the trim tab hinge. The elevator pitch trim tab was correctly attached and remained where it had been set, at 11° upwards, giving a nose-down trim. The bend in its piano wire linkage prevented any movement. When the wire linkage was disconnected from the tab it had a full and free range of movement within its limits of 17° up and down.

Rudder

The rudder bars were no longer connected to each other because the front to rear cockpit linkage rod had been broken during the impact. The front and rear rudder bar and pedal pivots were undamaged and showed no evidence of wear. The rudder was undamaged and correctly attached to the fin by its hinges, which showed no sign of any abnormal wear. The dual cables running either side of the aircraft from the seat frame back were also intact and rudder movement was full and free.

Engine

The engine block and cylinder were relatively intact. Despite the damage to the magnetos and cables it appeared that they had been correctly connected prior to the impact with no evidence of pre-existent faults or damage.

Examination of the carburettor indicated that it had detached from the intake manifold and had been pushed forward with considerable force. Two of the four mounting bolts had sheared and the rearmost section of the mounting flange, where the rear bolts were fitted, had broken away. The flange face had evidence of smearing showing how the carburettor had detached. The throttle butterfly valve was damaged by the lip of the carburettor attachment flange is it was pushed forwards (Figure 8).

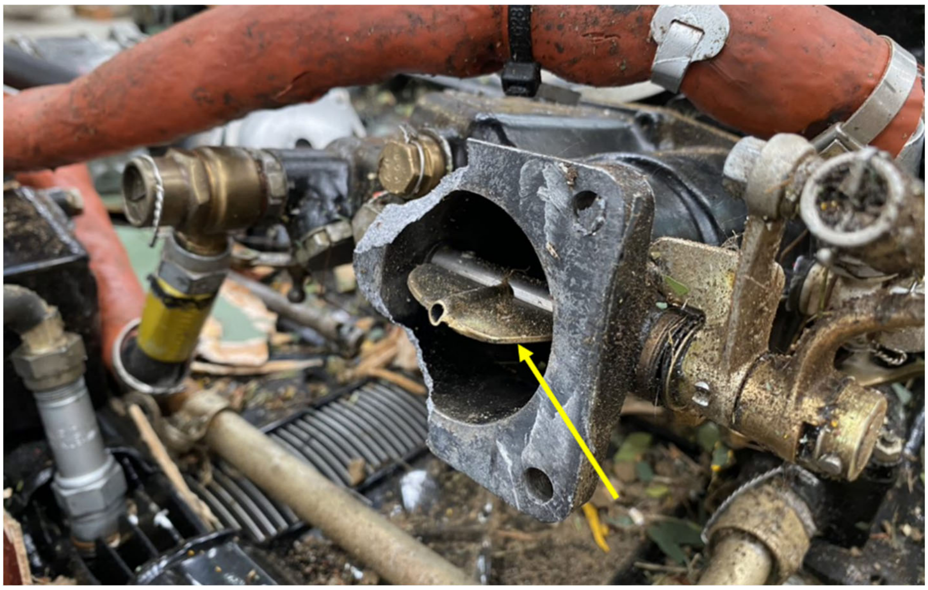

Figure 8

Damage to the edge of the carburettor butterfly valve

The magnetos were damaged, and the left magneto had been forced away from its drive assembly. All the high-tension cables were present and correctly connected within the heads of the magnetos. Examination of the spark plugs indicated the engine to have been running in a good state of tune with the correct mixture and no oil contamination. The damage to the propeller indicated that it was rotating, and the engine was producing power when the aircraft hit the ground.

Cockpit instruments

All the front and rear cockpit instruments were severely damaged during the accident and apart from the barometric setting on the rear altimeter of 996 hPa, no other useful information was found.

General condition

Although the damage caused to the aircraft during the accident was severe, the examination of its structural and mechanical components found the aircraft to have been in good condition. There was no corrosion on any of its metallic components and the wooden structural members were free from degradation. The fabric covering was also in very good condition. The general condition of the aircraft suggested that it had been stored in dry conditions and had been well maintained.

Survivability

A vintage aircraft constructed of light plywood over a wooden frame covered with a fabric covering does not afford much crashworthiness. In this case the structure fragmented and splintered into small pieces. The seats became dislodged, with their mountings still attached to small sections of framework. The same occurred to the additional emergency lap strap mountings which failed in overload caused by forces created by the occupant and seat during the rapid deceleration at impact.

Weight and balance

The most recent weight and balance schedule found in the aircraft records was dated 15 December 1995. This was used by the AAIB to calculate the aircraft's weight and balance after the accident. However, it could not be confirmed if this schedule was still accurate or if the weight had changed in the intervening years.

Tools and equipment found under the rear cockpit seat and the items found in the luggage cubby were weighed. The pilot's weight was obtained from his medical records. The resulting weight and balance calculation is shown in Table 1.

It could not be determined exactly how much fuel was onboard the aircraft when the accident occurred. The aircraft was refuelled prior to the first flight of the day with 25 litres of fuel, but it is not known how much fuel was onboard prior to this. The display leader reported that he would not normally fully fill the tank prior to display flying to minimise weight, typically he would have 50-55 litres onboard. The aircraft had flown approximately 36 minutes since refuelling and it was reported that the aircraft typically used 35 litres per hour. So, the estimated fuel load was 35 litres (56 lbs) although this could not be confirmed.

	Mass (lbs)	Arm (inches)	Moment (lbs - in)
Empty weight	1,198.0	10.52	12,603
Pilot (rear seat)	198.0	53.00	10,494
Under pilot seat	11.1	53.00	588
Luggage cubby	5.4	73.00	394
Fuel	56.0	-0.80	-45
Total	1,468.5	16.37	24,034

Table 1

G-AWEF Weight and Balance calculation

The aircraft's maximum takeoff weight for aerobatic flights was 1,700 lbs and the centre of gravity limits were 9.45" to 17.72". Regardless of the fuel load onboard the aircraft would have been within the maximum weight and centre of gravity limits.

The weight and centre of gravity of the accident aircraft was compared with two of the other aircraft in the display team (data was not available for the fourth aircraft). The weight was similar to the other aircraft (slightly less than one and slightly more than the other) but the centre of gravity was slightly further aft than the other two aircraft. All aircraft were within the approved limitations.

Meteorology

At the time of the flights there were a few scattered clouds above the height at which the aircraft were flying. There was a light south to south-westerly wind and a temperature of approximately 18°C.

The pilots of the other aircraft in the display team did not recall any significant turbulence during the flights.

The surface wind recorded at the airfield around the time of the accident is shown in Table 2.

Time (hrs)	Direction	Speed (kt)
1510	SSW	11.3
1515	SSW	8.7
1520	SSW	10.4
1525	SSW	12.2

Table 2

Wind data from Headcorn around the time of the accident *(accident time – 1521 hrs)*

The Met Office Balloon forecast issued at 1430 hrs predicted that at 1600 hrs the surface wind at Headcorn would be from 220° at 7 kt with possible gusts to 17 kt, the 500 ft wind would be from 220° at 13 kt and the 1,000 ft wind would be from 220° at 15 kt.

Airfield information

Headcorn is a licensed aerodrome with a main grass runway orientated 10/28 and provides an air/ground radio service. The hangars, club houses and area where people can watch the aircraft is located to the south of the runway.

The aerodrome has a CAA Long Term Permission (LTP) to allow aircraft to fly below 500 ft agl for the purpose of display practice or rehearsal whilst within the box shown in Figure 9. Outside the defined area all aircraft must comply with the SERA[4] minimum height rules. When within the box and to the south of the River Beult, aircraft may fly down to the minimum height specified in their DA. Within the box and to the north of the river, aircraft may fly to the higher of their DA minimum or 200 ft agl for normal flight or 500 ft agl for aerobatic flight.

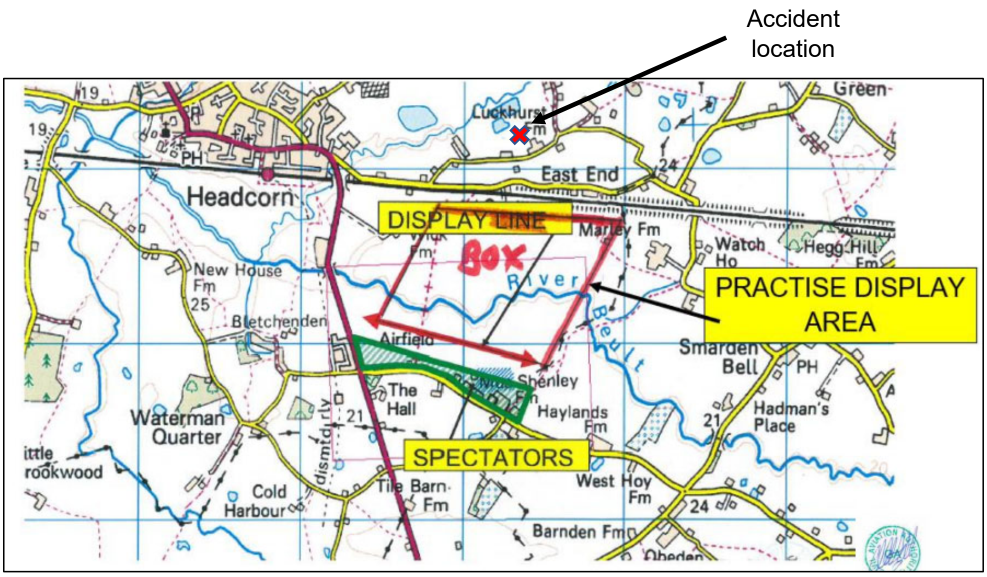

Figure 9

Extract from the CAA LTP issued to Headcorn Aerodrome with the accident location added (marked by a red cross)

The CAA specified the following conditions which must be met to use the permission:

- The pilot in command has been briefed by a Display Authorisation Evaluator (DAE).
- Each flight is authorised by the airfield manager or a deputy nominated.
- The airfield manager is to maintain records of each flight made pursuant to this Permission.

Footnote

4 Standardised European Rules of the Air.

The display leader confirmed that a display briefing was completed in September 2020 with a DAE to cover the in-season practice in 2021. The aerodrome records log included a record of the accident flight. Following this accident, the CAA conducted a review of the use of LTPs. This found that there was some ambiguity regarding how flights were authorised and highlighted the need for a formal record of display briefings. Since the accident the airfield manager has enhanced record keeping to make it clear when a pilot has requested permission to use the practice display area. The CAA intends to issue updated instructions to all LTP holders to clarify the requirements.

As shown in Figure 9 the accident location was to the north of the practice display area.

Pilot information

The pilot held a UK and EASA PPL(A) with a valid Single Engine Piston rating and aerobatic rating. His logbook recorded he had accumulated a total time of 753 hours with 517 hours in G-AWEF. His most recent revalidation, signed in August 2019, was by experience, as was his previous revalidation in 2017. In 2019, he had completed 2 hours and 20 minutes of differences training with an instructor to fly a Falco F8L which he had built. He had flown 7 hours and 40 minutes in 2021 prior to the day of the accident, partly in G-AWEF and partly in the Falco. These hours included two formation flights (with three aircraft) and an aerobatic flight.

He had initially qualified to fly in 1992 on a Grumman AA-5 at Prestwick Airport and flew from there for several years on the AA-5 and Piper Tomahawk. In 1997 he moved south and started to fly from Headcorn Aerodrome, converting to fly the Piper Cub and then the Tiger Moth. He first flew G-AWEF in December 1998 before he purchased the aircraft in 2004. His logbook also recorded that he had flown the Turbulent, Chipmunk and Harvard.

The pilot had been flying in the Stampe display team since 2005. The team's display had consisted primarily of a flat (non-aerobatic) display in various formations and tail chases. He held a valid display authorisation (DA) which authorised him to display a Category A aircraft[5], with a minimum flypast height of 30 ft agl, to be a member of an intermediate formation[6] with an unlimited number of aircraft, and to participate in tail chases with up to four aircraft. His DA did not authorise him to include aerobatic manoeuvres in his display routine. To fly the stall turn, which the team were practicing, in a public display the pilot would have needed to upgrade his DA[7]. However, this was not required for him to practice the manoeuvre. It was reported that the pilot intended to apply to upgrade his DA when the team were content with the manoeuvre.

Footnote

5 Category A means a single-engine piston aeroplane with less than 200 horsepower.

6 Intermediate means the formation manoeuvring must remain smooth and progressive and can entail increased pitch and roll rates. Bank and pitch angles must not exceed 60°. Flying formation aerobatics would require an Advanced Formation endorsement on the DA but this was not necessary for the synchronised stall turn as the aircraft were not in 'close formation' during the manoeuvre.

7 The process and requirements for upgrading a DA to add additional privileges is explained later in this report in the section *'Display authorisation'*.

The pilot's logbook contained detailed notes next to each flight. There were numerous references to aerobatic flights and particular manoeuvres which he had flown throughout his logbook. Stall turns were mentioned regularly.

The most recent reference to spinning practice was on 24 June 2005 during a solo flight in G-AWEF. Prior to this, spinning practice is mentioned during dual flights in April 2001, March 2000 and February 1999 in a Tiger Moth and in December 1998 in G-AWEF.

Medical and pathological information

The pilot held a valid class 2 medical. His last medical examination was two days before the accident and included an electrocardiogram. The aviation medical examiner who conducted the medical reported that the pilot was fit and well, and that he had no concerns about signing his medical. The pilot's family reported the pilot was fit and well and in good spirits on the day of the accident and that he had slept well the previous night. The other members of the display team also reported that he seemed to be his "normal cheerful" self and was looking forward to flying.

The post-mortem examination concluded that death was caused by multiple injuries. There was no evidence to suggest a medical cause of the accident.

Stall turn

A conventional stall turn involves pitching up into a vertical climb, then, before all forward momentum is lost, the aircraft is yawed through 180° into a vertical downwards dive. The name is misleading as, if the manoeuvre is flown correctly, the aircraft will not aerodynamically stall at any point.

The display team had modified their stall turn to climb at a 70°-80° angle rather than vertical. This was done to reduce the chance of the engine being starved of fuel which can occur in a Stampe if the aircraft experiences less than 1g. The aircraft were fitted with inverted fuel systems, but they were difficult to use in formation so was not used during this manoeuvre.

The aircraft started the manoeuvre flying in a box formation towards the display line. They then flew an opposition break where the two aircraft on the left of the box turned to the right and the two on the right turned to the left. The four aircraft turned through 180° to position in an equally spaced line flying away from the display line. When seen from the display line the formation leader would be on the far left of the line and G-AWEF would be on the far right, with the two other aircraft spaced in between. They estimated that there were 70-80 m between each aircraft. Once in position the formation leader called for the aircraft to pitch up together by calling 'pull-up, pull-up go' on the radio, intending that the aircraft should then climb together in a line. As the speed reduced the display leader called 'rudder, rudder, go' on the radio to initiate the stall turn. All the aircraft were to stall turn to the right. The pilots reported the team had not discussed whether they would recover in a vertical dive or if they would re-establish the 70°-80° angle but, following discussion after the accident, they all reported they had been diving vertically before recovering to level flight.

A diagrammatic representation of the stall turn is shown in Figure 10. The team reported that the whole manoeuvre was normally flown with full power applied. In Figure 10, depicting the intended manoeuvre:

- When in position 1, on the display leader's command, initiate the climb with an aft stick input and left rudder to keep the aircraft in balance.
- At position 2, on the display leader's command, apply full right rudder to rotate the aircraft through 180°. As the aircraft rotates around the lower wing, left aileron might be required to stop the aircraft rolling right due to the secondary effects of the rudder input.
- When the aircraft approaches position 4 and is pointing straight down, centralise the rudder to stop the yaw and allow the aircraft to accelerate in the dive. Once airspeed has built-up sufficiently, apply aft stick to recover to level flight.

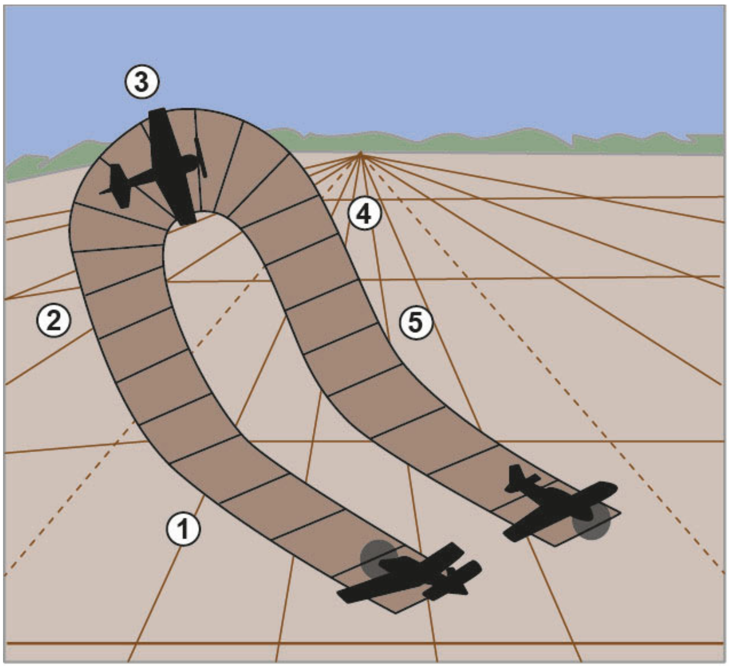

Figure 10

Diagram of a stall turn

(note, this diagram shows the aircraft flying a -70° pitch angle on the downline. It could not be determined if the accident pilot planned to fly this or a vertical downline)

Spinning

A spin is a condition of stalled flight in which the resultant aerodynamic force causes the aircraft to 'autorotate', where the aircraft is continuously rolling, yawing and pitching. In a fully developed spin, the aerodynamic forces on the aircraft are balanced by the inertia forces created by the rolling and yawing motion. The flight path will normally follow a helix whose axis is orientated vertically. For a spin to occur the wing must stall and the nose must yaw.

During a conventional stall turn, as the aircraft climbs the airspeed reduces but the angle of attack is low so the aircraft will not stall. However, the manoeuvre requires the pilot to yaw the aircraft by applying rudder, so if the angle of attack is allowed to increase beyond the critical angle, by applying aft stick, the conditions are set for the aircraft to spin.

The following quote, discussing the exit from a stall turn, is an extract from Neil William's book '*Aerobatics*'[8]. It highlights the potential to enter a spin as the aircraft exits the manoeuvre.

> *'Really, all we are doing is to use all the controls as necessary to point that nose absolutely straight down. At this point there is a great tendency to pull back hard on the stick; after all, are we not pointing straight at terra firma, and with full power on, at that? However, we must resist the temptation; first because* […] *it would be only too easy to stall and flick, and secondly because we want to preserve the shape of the manoeuvre.'*

This indicates that if, at the completion of the yaw element of the stall turn, the pilot moves the stick backwards there is a distinct possibility of initiating a 'flick'. A 'flick' describes a deliberate autorotative roll or an unintended autorotative departure preceding a full spin. Probably the word 'flick' was chosen to indicate that the reaction of the aircraft was much more sudden and quicker than that achievable using the controls conventionally.

If a pilot recognises the signs of an impending (or incipient) spin before it develops into a full spin, they can take prompt action to prevent it developing. The actions to recover from an incipient spin may differ between aircraft but are conventionally: Throttle - CLOSE and Controls - CENTRALISE. If this drill is taken immediately on recognising autorotation it should stop the aircraft transitioning into a developed spin. However, this requires experience, training and regular practice. If any pilots finds themselves in an unintentional incipient or full spin, especially at low altitude, it is likely they will experience a startle and surprise reaction. The rapid rolling, yawing and pitching motion of an aircraft in a spin can be very disorientating, particularly if it is not anticipated and if the pilot is not familiar with the motion. It could take several seconds to comprehend what has happened and determine what actions need to be taken.

Spin recovery techniques vary between aircraft and it is important for pilots to know the correct recovery technique for the aircraft they are flying. However, generically they involve the following actions[9]:

1. Throttle CLOSED
2. Aileron NEUTRAL
3. CHECK the direction of rotation
4. Rudder FULL against the indicated direction of spin

Footnote

8 Williams, N. (2003) '*Aerobatics*'.

9 *Air Pilot's Manual – Flying Training* (2017) Elstree: Pooleys Air Pilot Publishing - Standard Spin Recovery (page 196).

5. PAUSE allowing the rudder to take effect
6. Move the stick progressively FORWARD (elevator NOSE-DOWN) until rotation stops
7. When the rotation stops, CENTRALISE the rudder
8. EASE OUT of the ensuing dive

Correctly identifying the direction of spin is critical so that the rudder input at step (5) is in the opposite sense. Identifying the spin direction during an intended spin may be easy but this can be much harder with an unexpected spin. Applying the correct spin recovery for the specific aircraft type, in the correct order, is critical and any change in that order may delay the recovery or prevent it entirely.

High power tends to flatten the spin and, on some aircraft, can delay recovery.

If the pilot attempts to pitch-up too early or too aggressively the aircraft can enter a secondary stall or spin.

Flight tests

The AAIB commissioned a series of flight tests to help understand how and why the accident occurred. The flight test aims were:

1. To determine how a Stampe SV4C could enter a spin from the modified stall turn.
2. To assess the aircraft's spin characteristics to determine the height lost during a spin and during the recovery.
3. To assess the aircraft's longitudinal and lateral stability to determine if a pilot could move the elevator or rudder to an unintended position without any obvious tactile cues.

Four flights were conducted by a qualified test pilot in a similar Stampe SV4C aircraft. For safety an aircraft with an electric starter motor was used which meant the test aircraft was slightly heavier than the accident aircraft. The initial flights were flown dual and the final flight was flown solo to verify the results at a weight and centre of gravity closer to the accident flight.

A series of stall turn tests was conducted with the intention of investigating which aspects of the modified stall turn might have led to the unexpected departure into a spin. Various combinations of entry speed and rudder application speed were investigated. None of these resulted in any propensity to 'flick' or enter a spin after the yawing part of the turn was completed. The results showed that, so long as the rudder was centred before the stick was moved aft for the dive recovery there was no tendency to 'flick' or enter a full spin. For these uneventful stall turns the average height loss from pull-up to pull-out was 145 ft.

The only way the test pilot was able to get the aircraft to enter a spin was by either increasing the angle of attack with aft stick before centring the rudder or by not centring the rudder sufficiently before the pull-out was initiated. If either of these were done the aircraft would readily enter autorotation. If immediate recovery action was taken the rotation could be stopped within about one to one-and-a-half turns. An average of 130 ft was lost in stopping the autorotation and an average of about 460 ft was required to achieve a positive climb, a total of 590 ft.

To understand how the aircraft would behave if immediate recovery action was not taken, several four-turn spins were flown. The results show that during a four-turn spin the pitch attitude oscillated between 40° and 60° nose-down. The rate of turn was approximately 2 seconds per 360° turn. On average the height loss per turn started at 140 ft for the first full turn, 170 ft for the second and 200 ft for subsequent turns and the average height required to pull-out once the spin had stopped was about 450 ft. Therefore, the height loss from the initial departure through to the recovery to a positive climb would be in the region of 590 ft for a 1-turn spin, 760 ft for a 2-turn spin, 960 ft for a 3-turn spin and 1,160 ft for a 4-turn spin.

The longitudinal static stability of the test aircraft was assessed at 50 kt at full power and at idle power by measuring the stick displacement and stick force required to hold the aircraft ±15% off the trim speed. The results with full power showed that the stick had to move aft by 7 mm to hold 42 kt (approximately 4 kt above stall) and 7 mm forward to hold 58 kt. The stick force was one pound pull force at 42 kt and one pound push force at 58 kt. When repeated with idle power the results were 48 mm aft to hold the aircraft at 42 kt and 14 mm forward to hold 58 kt, the off-trim forces were a pull of 2 pounds force at 42 kt and a push of ½ pound force at 58 kt. The results showed that, particularly at full power, the aircraft has a low level of longitudinal stability. This indicates that very little stick movement or stick force is required to change pitch attitude or fly off-trim, therefore a pilot could easily move the elevator to an unintended position without any obvious feel cues.

The lateral stability was assessed to determine how easily a pilot could apply a rudder input or not fully centralise the rudder without realising. As typical for aircraft of this era the Stampe has a relatively small fin compared to the rudder. The fixed fin has a height of 0.62 m with a chord of 0.57 m and a total area of 0.3 m^2. The rudder is relatively large, with a height of 1.38 m, a chord of 0.54 m and a total area of 0.75 m^2.

When the fin and rudder are considered as a single stabilising surface the total area provides adequate directional static stability provided that the rudder is restrained in the central position by the pilot. However, as the rudder is considerably larger than the fin, the rudder is very effective. In addition, the range of rudder deflection is large (39° to the left and 44° to the right, a total of 83° of movement).

The rudder is moved by a foot-operated rudder bar which moves over an arc of 30°, meaning that every degree of rudder bar movement generates 2.7° of rudder movement. In linear measurement the rudder bar moves forward and aft about 55 mm each way, so the pilot's foot moves through about 110 mm from full rudder in one direction to full rudder in the other. This control gearing results in relatively small movements of the rudder bar generating significant rudder surface deflections and means there is potential for a pilot to move the rudder surface to an unintended position or, should a pilot misjudge centring the rudder bar by a relatively small error in foot position, a significant rudder surface deflection may still be present.

The rudder does not naturally self-centre so the pilot must hold their feet on the rudder to hold any selected position. The only reliable way to determine if the rudder is centralised is to look at the aircraft reaction.

Formation flying

The display team were attempting to fly the synchronised stall turn in a loose formation[10]. This adds an additional challenge for each pilot because whilst flying their own aircraft they must be constantly aware of the position of the leader and the other aircraft. To make the stall turn look good to a spectator they need to ensure their aircraft's movements are synchronised with the leader throughout the manoeuvre.

Discussions with other display pilots suggest that a synchronised stall turn is a difficult manoeuvre to fly accurately.

Civil Aviation Publication (CAP) 403 contains specific requirements and is intended as a code of best practice for flying displays. The document provides the following requirements for formation leaders:

> '*Formation leaders are responsible for ensuring the safe flight of a formation. The leader must ensure that the pilots in the formation are suitably qualified and that formation flying activity is comprehensively briefed.'*

The formation leader of the Stampe team had confirmed that all the pilots held the necessary qualifications and ensured that the flight was appropriately briefed. However, he had not confirmed when G-AWEF's pilot had last completed any spinning training. The formation leader had asked to fly with G-AWEF's pilot to confirm his competency and to provide some support and training with the new manoeuvres, but this had not taken place. G-AWEF's pilot had wanted to master the manoeuvres before flying with the formation leader.

Display authorisation

The Air Navigation Order defines a Flying Display as any flying activity deliberately performed for the purpose of providing an exhibition or entertainment at an advertised event open to the public. To participate at such an event civilian display pilots must hold a DA or a DA exemption.

G-AWEF's pilot held a valid DA which entitled him to fly displays in close formation and in tail chases but it did not include an aerobatic endorsement. To fly the stall turn, which the team were practicing, in a public display the pilot would have needed to upgrade his DA

Footnote

[10] The formation used in the early part of the team's routine was a 'close formation'. In this formation the following aircraft only use the leader as their flying reference – the formation manoeuvres as one large aircraft. In 'loose formation' the pilots use their own attitude references but position themselves with respect to the leader to synchronise the manoeuvre.

to include standard level aerobatics[11]. It was reported that the pilot intended to apply to upgrade his DA when the team were content with the manoeuvre.

CAP 1724 – *'Flying Display Standards Documents'* sets out the rules and procedures for obtaining, maintaining and upgrading a DA. The document states that:

> *'Where a pilot seeks to upgrade the privileges of a DA, they must engage with a suitably qualified Display Authorisation Evaluator (DAE) for mentoring and guidance in fulfilling the necessary requirements.'*

The document highlights the importance of establishing a good mentoring relationship between a display pilot and a DAE. A DAE can help and support a pilot who wishes to upgrade their DA and provide useful guidance to assist the pilot in expanding their skills safely.

Whilst all the display team held valid DAs and had renewed them with various DAEs at the appropriate time, there was no evidence that the display team had set up a mentoring relationship with a DAE for the required upgrade to a standard level aerobatic DA.

To apply for a DA which includes aerobatics, CAP 1724 states that:

> *'An initial application for a DA that includes an authorisation for display aerobatics must include evidence that the applicant has received appropriate spin training. Additionally, applications for the renewal or upgrade of an aerobatic DA must be able to demonstrate that they are current on spin entry and recovery techniques.'*

Analysis

The aircraft was practicing a synchronised stall turn in a loose line abreast formation with three other aircraft when it was seen to enter a spin from which it did not recover. The aircraft started the manoeuvre from approximately 500 – 600 ft.

Witnesses reported that the aircraft completed the 180° yawing turn at the top of the stall turn but then entered a spin. CCTV and witness video footage showed the aircraft spinning towards the ground. The last few frames of the CCTV footage suggest that the rotation had stopped before the aircraft hit the ground.

The parallel and distinct ground marks made by the wing leading edges indicated that the aircraft hit the ground with a 65° nose-down attitude and provided further evidence that the aircraft had stopped its spin rotation.

A post-mortem examination did not reveal any evidence to suggest that the accident was caused by a medical issue. Therefore, the investigation considered whether the spin may have been caused by a technical failure of the aircraft.

Footnote

[11] The definition of 'standard level' aerobatics is given in CAA CAP 1724.

Aircraft

The flying control linkages within the cockpit were severely disrupted by the impact. Despite this, an examination of the flying controls showed how each component had been damaged during the impact sequence. No evidence was found of a pre-existing fault or malfunction that could have led to the loss of control of the aircraft.

The possibility of a loose article or foreign object affecting the flying controls was also considered. Nothing unusual was found within the wreckage and the items that were being carried in the seat box and the luggage cubby were still in place. The front and unoccupied seat straps and harness were found still attached to the seat, tightly fastened and neatly stowed. It is therefore unlikely a loose article interfered with the flying controls.

The engine ancillary equipment was severely damaged by the impact, but the block and cylinder heads were intact. However, fragmentation of one of the propeller blades and the forward bend of the other blade, indicated the engine was rotating and producing power when the aircraft hit the ground.

Despite the damage sustained in the accident the aircraft was found to be in good overall condition with no pre-existing faults. There was no evidence to suggest a fault or malfunction during the final manoeuvre that could have led to the accident.

As no evidence was found of a technical failure of the aircraft the investigation considered if the spin was caused by the way the aircraft was flown and how this might have occurred.

Aircraft handling

The AAIB commissioned flight tests to determine how a Stampe could enter a spin from a stall turn and to determine if the way it was being flown made a spin more likely. The display team were flying the entry into the stall turn at a 70°-80° climb angle rather than a more conventional vertical climb. They had also increased the speed at which they pitched-up into the manoeuvre and the speed at which they applied the rudder from the earlier flight. The flight tests showed that neither the pitch angle nor the entry speeds increased the likelihood of a spin after the manoeuvre.

The flight tests progressed to try to understand what control inputs would cause the aircraft to enter a spin as seen by the witnesses. The tests showed that the aircraft would enter a spin from the stall turn manoeuvre if either:

- aft stick was applied too early before the turn was complete (when the rudder was still applied) sufficient to stall the wing, or if,
- after completion of the turn, the rudder was not fully centralised when the aft stick was applied to start the pull-out from the dive.

There are several reasons why this may have occurred as listed below. It is likely that several of these factors combined to cause the pilot to start to pull back on the stick too early before the turn was complete or to still have the rudder deflected when the pull-out was commenced.

- *Low altitude* – The manoeuvre was started from 500 – 600 ft agl, so after completion of the yawing turn at the top of the turn the aircraft was probably no higher than 800 – 900 ft above the ground. When pointing vertically down at this altitude there may be a temptation to pull-up prematurely. The pilot's logbook records that he had practiced stall turns many times but it is not clear if he had practiced them at low altitude. However, he had completed the manoeuvre at this height during the earlier flight the same day without any reported problem.

- *Synchronised flying* – when a pilot is flying a stall turn on their own, they can select the optimum moment to pitch up into the manoeuvre and the optimum moment to apply the rudder, based on what their aircraft is doing and when it feels 'right'. However, in this case the moment at which the pilot pitched-up and applied the rudder was determined by commands from the formation leader. This could mean the aircraft was at a non-optimum speed or attitude at the point the pilot initiated the manoeuvre. This may have required slightly different control inputs to fly the aircraft round the manoeuvre and could have resulted in the pilot having more aft stick applied at the end of the yawing turn. For example, if the stall turn is entered slightly slowly the aircraft can start to 'fall out' of the manoeuvre (pitch forward) part way round the turn. If a pilot tries to prevent the aircraft falling forward by apply aft stick, they would be setup for a spin.

- *Small stick movements and low stick forces* – the flight tests demonstrated that the Stampe has quite low longitudinal stability. Relatively small movements of the stick and relatively small stick forces are required to change the pitch attitude or to fly offtrim. This means there would be no strong tactile cues to the pilot if he had inadvertently applied too much aft stick.

- *Rudder power and rudder bar sensitivity* – The rudder on the Stampe does not self-centre, so the pilot can only tell the rudder is centralised by the reaction of the aircraft. In normal aircraft attitudes it is easy for a pilot to see and feel if the rudder is in the correct position. The rudder bar movement is 110 mm from full rudder deflection one side to full deflection on the other, so only small foot movements are required to generate quite large rudder deflections. It is possible that the pilot thought the rudder was centralised when in fact it was still deflected, and inadvertently left some rudder applied when he started to pull out of the dive.

- *Aft centre of gravity* – Whilst the centre of gravity of the aircraft was within the approved limits, it was closer to the aft limit and further aft than the other aircraft in the display team. This would have the effect of reducing the longitudinal stability of the aircraft, further reducing the stick forces (as discussed above) and increasing the aircraft propensity to enter a spin if mishandled and could make spin recovery more difficult.

- *70°-80° or vertical downline* – The display team had planned to climb at a 70°-80° climb angle as they entered the stall turn. However, they had not discussed whether they would descend with a standard vertical descent or if they would try to fly a matching 70°-80° descent. Following discussion after the accident the other pilots agreed that they had flown a vertical descent. However, it is possible that the accident pilot was trying to fly a 70°-80° descent. If this was the case, it may have caused the pilot to pull back on the stick as he exited the turn to achieve the descent angle. If the rudder was not fully centralised and the airspeed was still low as he started to pitch for the descent angle the conditions would be set for a spin.

- *Distraction* – It is also possible that the pilot was distracted as the aircraft was completing the turn. There are several possible reasons. It is possible that he was looking for the other aircraft in the formation to assure himself that he had safe separation, that he was distracted by the rapidly approaching ground, that he was distracted by trying to synchronise with the leader or by trying to fly the manoeuvre accurately to ensure the display looked good. Another possible source of distraction could be a minor engine issue. When not using the inverted fuel system the carburettor relies on gravity to ensure a continuous supply of fuel to the engine. The display team were intentionally avoiding climbing vertically, keeping positive G during the climb to ensure the engine was not starved of fuel. However, it is possible that during the manoeuvre the fuel supply was briefly interrupted, which might cause the engine to run intermittently. Whilst this would not cause the accident directly, if it had occurred, it may have distracted the pilot during the completion of the turn.

Any of these factors, or a combination of them, could have caused the pilot to pull out of the manoeuvre too early or not to have fully centralised the rudder prior to starting to pull out of the dive.

Incipient spin

The flight tests demonstrated that if the rudder was still applied when the pull-out was commenced the aircraft would 'flick' into a spin. Experienced aerobatic pilots are often able to detect the first signs of uncommanded roll or the start of autorotation that indicates the aircraft is starting to enter a spin. The flight tests showed that if immediate recovery action was taken the rotation could be stopped in one to one-and-a-half turns with a total height loss to return to level flight of about 590 ft. However, the test pilot was expecting the aircraft to enter a spin and was ready to take the correct recovery action. It is likely to be a different experience for a pilot who was not expecting it, particularly if that pilot had not recently practiced spin recognition and recovery.

The accident pilot's logbook recorded that the last time he practiced spinning was on a flight in 2005. No evidence was found of any more recent spin training. Whilst even recent training does not guarantee that a pilot will detect the possibly subtle cues of an unanticipated incipient spin, training and current practice increase the likelihood they will perceive and react appropriately.

Developed spin

The flight tests demonstrated that if the spin was allowed to continue and complete two full turns it would take approximately 760 ft from the start of the departure to recover to level flight. Each further rotation added an additional 200 ft of lost altitude.

The flight tests recorded that in the spin the aircraft rotated at a rate of one revolution every two seconds. Descending rapidly towards the ground and rotating at this rate can be disorientating. A pilot who is not experienced and in current practice at flying spins might take a significant time to comprehend what is happening and react appropriately. Evidence from the CCTV and from the ground impact marks suggest that the aircraft had stopped rotating when it struck the ground. This suggests the aircraft had recovered from the spin but with insufficient height to recover to level flight.

Noting that the correct technique varies between aircraft, a standard spin recovery involves closing the throttle. The aircraft will recover from the spin with the throttle open but it may delay the recovery and therefore more height may be lost. During examination of the carburettor, after the accident, damage was found to the throttle butterfly valve. As the carburettor was forced forwards and dislodged by the aircraft structure and surrounding components compressing during the impact, the lip of the carburettor mounting flange struck and bent the edge of butterfly valve. The nature and position of the bend on the valve could only have occurred with the valve in the open condition. This suggests the throttle was open at the point of impact. This on its own could not be considered conclusive, as the rapid disruption of the cockpit and nose structure of the aircraft may have moved the rods and linkages and changed the throttle position. However, the additional evidence shown by the propeller supports that it was at a high power setting when the aircraft hit the ground. This suggests the throttle was not closed during the spin recovery, which could have delayed the recovery.

Oversight of display flying

The analysis above shows that it would be possible to practice at a higher altitude with sufficient height to recover from the spin. It also highlights the importance of spin recognition and recovery training when practicing aerobatic manoeuvres.

To fly a stall turn during a public display the pilot would have needed to upgrade his DA to include a standard level aerobatic endorsement. It was reported that he intended to do this with a DAE once he had mastered the manoeuvre. However, the process for upgrading a DA, as set out in CAP 1724, states that a pilot must engage with a suitably qualified DAE for mentoring and guidance. It is intended a pilot will engage with a DAE at the start of the process so that they can provide the mentoring and guidance. It is possible that, if this had taken place, the DAE may have encouraged the pilot to fly this manoeuvre at a high altitude, to undertake spin training or make other changes to enhance the safety of the manoeuvre. The display practice at Headcorn was taking place using a CAA exemption which allowed aircraft to fly below 500 ft. The exemption required that a briefing takes place with a DAE prior to flight. The formation leader confirmed that a briefing with a DAE had taken place in September 2020 to cover the practice flying in 2021. However, it is not known if this briefing had discussed in detail the new elements that were being practiced and how this was to be done. As the team was practicing new manoeuvres it may have been helpful to involve a DAE in the preparation for each flight rather than a single briefing for the whole session.

The accident occurred to the north of the practice display area. There is no requirement for the aircraft to remain within the display area throughout the display, but whilst outside the area they must comply with the standard SERA minimum height rules. The formation leader reported that the south-south-westerly wind on the day of the accident caused the aircraft to drift further to the north than intended. Whilst the aircraft were not intending to be below 500 ft and were not over a congested area so were not in breach of the regulations, their location meant that the manoeuvre was being flown close to farmhouses to the north of the airfield. A more detailed briefing with a DAE may have identified this hazard and given the opportunity to modify the display.

The CAA provide guidance for formation leaders in CAP 403. This document states that the leader is responsible *for ensuring the 'safe flight of a formation'* and *'must ensure that the pilots in the formation are suitably qualified and that formation flying activity is comprehensively briefed'.* The leader had completed a briefing prior to the flights and had confirmed that each pilot had the necessary qualifications. He had not confirmed when the accident pilot had last undertaken any spin training, and there was no formal requirement for him to do so. He had offered to fly with the accident pilot to confirm his competency and to provide some support and training with the new manoeuvres, but this had not taken place. It was not possible to determine whether, had this training flight had taken place, it would have revealed and rectified any issues that could have prevented the accident.

Survivability

The ground marks made by the wings showed that the aircraft hit the ground at 65° to the horizontal. The aircraft was predominantly constructed of lightweight plywood, over a wooden frame with a fabric covering. It therefore offered little inherent crashworthiness. When the aircraft hit the ground at this angle, most of the energy was transferred longitudinally through the airframe. The nature of the materials meant that they splintered and fragmented rather than absorbing energy by attenuation. This left no survivable space, affording no protection to the pilot and, although he was wearing his harness correctly, the seat and emergency lap strap attachment points failed early in the impact sequence. He was then unrestrained.

Conclusion

Prior to the accident the aircraft was in a well maintained and airworthy condition. All the damage to the aircraft was attributable to the impact and no evidence was found of a pre-existing fault or malfunction that could have led to the spin or prevented recovery from it.

Flight tests demonstrated that the most likely reason that the aircraft entered a spin was that either the pilot applied too much aft stick before the completion of the yawing turn or that the rudder was not centralised when the pull-out was commenced. The investigation suggested several reasons why this may have occurred including the low height at which the manoeuvre took place, the challenge of co-ordinating the manoeuvre in formation, distraction, and the low control forces.

The flight tests showed that it might have been possible to recover the aircraft if the pilot had reacted immediately to the early signs of an incipient spin. However, this may have been challenging for a pilot who might not have practiced spin recognition and recovery for 16 years. Once the spin had developed it was unlikely there was sufficient altitude to recover to level flight.

The display flying regulations require pilots who are upgrading their DA to engage with a DAE early in the process, to obtain guidance and mentoring. Had this happened in this case it may have provided an opportunity for the DAE to suggest the pilot undertook some spin training and practiced the synchronised stall turn manoeuvre at a height from which recovery was achievable. A DAE might also have suggested changing or modifying the manoeuvre to increase safety.

Published: 20 January 2022.

AAIB Correspondence Reports

These are reports on accidents and incidents which were not subject to a Field Investigation.

They are wholly, or largely, based on information provided by the aircraft commander in an Aircraft Accident Report Form (AARF) and in some cases additional information from other sources.

The accuracy of the information provided cannot be assured.

SERIOUS INCIDENT

Aircraft Type and Registration:	ATR 72-211, G-CLNK
No & Type of Engines:	2 Pratt & Whitney Canada PW121 turboprop engines
Year of Manufacture:	1989 (Serial no: 147)
Date & Time (UTC):	16 April 2021 at 0630 hrs
Location:	Guernsey Airport
Type of Flight:	Commercial Air Transport (Cargo)
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to cargo rail, rollers and locks.
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	59 years
Commander's Flying Experience:	10,500 hours (of which 155 were on type) Last 90 days - 78 hours Last 28 days - 28 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and further enquiries by the AAIB

Synopsis

As the cargo aircraft took off, a Unit Load Device (ULD) positioned in the centre of the aircraft slid rearwards into a vacant bay. After landing, as the aircraft braked, the ULD slid forward breaking through the forward locks and coming to rest in a vacant bay forward of its original position. An investigation by the ground handling organisation found that the locks to the rear of the ULD had not been raised and that there were no independent checks during the loading to verify that the locks had been correctly raised.

Safety action has been taken by the ground handling organisation to improve their loading procedures. The operator has also introduced 'void awareness' training on all their fleets during Operator Proficiency Checks to highlight the potential risks in operating with empty 'void' bays.

History of the flight

During the morning the aircraft had flown from East Midlands Airport to Guernsey with a full load of five freight containers (ULDs[1]). The ground handling team met the aircraft and two ULDs were unloaded. The remaining three ULDs were re-positioned within the aircraft in positions C1, C3 and C5 (Figure 1).

Footnote

[1] A ULD is a container or pallet used to load luggage and freight onto an aircraft.

Figure 1
ULD bay locations on G-CLNK

The pilots checked that the load tallied with the loading information report and closed the doors at 0610 hrs. As the aircraft accelerated during the takeoff for a flight to Jersey, the crew heard a 'slight thud', which they attributed to the movement of some water bottles in the cabin. During the 15-minute flight the pilots did not notice any change to the feel or control of the aircraft. The aircraft touched down normally and when the brakes were applied the pilots heard a sliding noise closely followed by a 'loud thud' which was felt through the airframe.

The aircraft cleared the runway and the co-pilot moved to the cabin to assess the load but could only see the ULD in C1[2] which was correctly positioned. Once on stand, the ground handlers inspected the load and discovered that the ULD initially loaded in bay C3 had moved to C2.

ULD loading and locking

ULDs are filled, weighed and their position in the aircraft determined by the loading planners prior to being delivered to the aircraft. They are then individually loaded onto the aircraft at the forward cargo door and pushed into position by hand. The ULD slide along rails that are attached to the cargo bay floor (Figure 2).

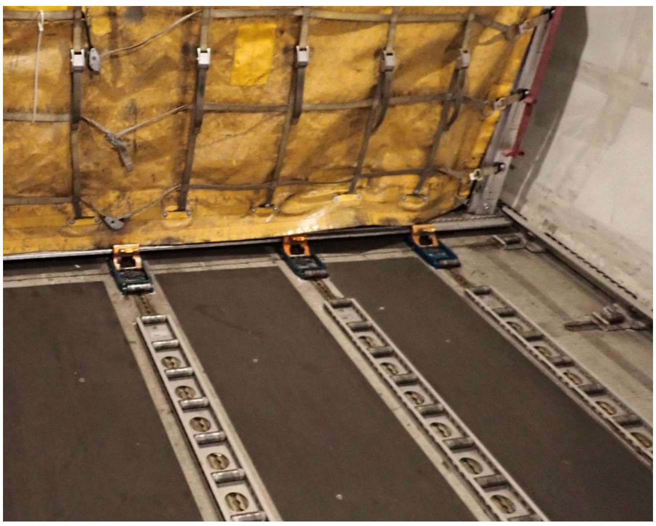

Figure 2
ULD rails and locking mechanisms

Footnote

2 There is insufficient gap between the ULD and the fuselage to allow the crew to view the load rear of the ULD in position C1.

Locks that secure the ULDs in position are located between the bays and like the rails are attached to the fittings on the floor. The position of each bay is indicated by green markers on the cargo bay walls. The locks can be positioned DOWN to allow ULDs to slide over them and UP to lock ULDs in position (Figure 3).

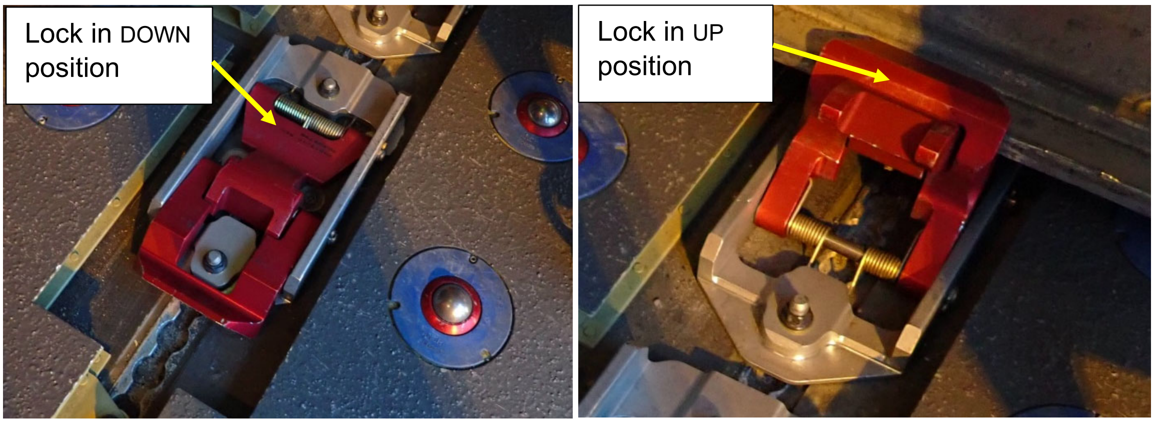

Figure 3
ULD lock positions

The locks can be used as a rear restraint, a forward restraint or when positioned between two ULDs as both a forward and rear restraint. When loading the aircraft, the locks at the rear of the bay in which the ULD is to be positioned should be in the UP position and the ULD is moved rearwards until it engages with these locks. Once in position, the forward locks are raised and engage with the front of the ULD preventing it from moving forward.

Examination of the aircraft

Examination of the aircraft by the operator found that the locks and rails between bays C2 and C3 were damaged and dislodged (Figure 4), and the locks to the rear of bay C3 were DOWN. The locks between bays C2 and C3 had been pulled out of the tracks in the cargo bay floor within which they were attached.

The ULD that moved in flight was found to be undamaged and there was no other damage to the aircraft.

Investigation by ground handling organisation

An investigation by the ground handling organisation identified that when the ULD in bay C3 was moved into location, the locks between bays C3 and C4 were not raised and remained in the DOWN position; however, the forward locks were raised. During the takeoff roll the slight thud heard by the crew was probably the ULD in bay C3 sliding rearwards to bay C4 and stopping against the forward locks which restrained the ULD in C5. During the landing the ULD would have slid forward as the aircraft decelerated, breaking the locks between bays C2 and C3 which were in the UP position. Its movement would then have been arrested when it hit the raised locks to the rear of the ULD in C1.

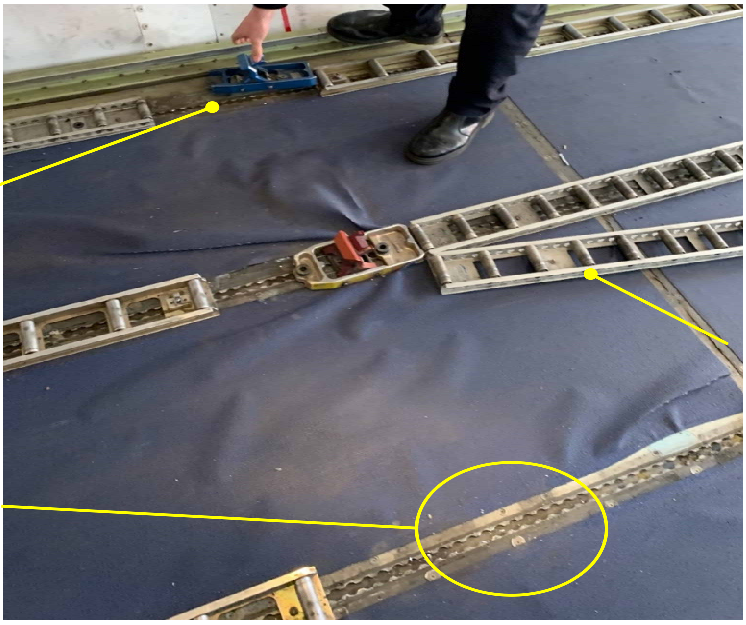

Figure 4

Damage to rails and locks between bays C2 and C3 (reproduced with permission)

Normally when loading ULDs into position, they are pushed until they contact the rear locks and the ULD cannot move any further rearward. The forward locks are then raised. In this event, with the rear locks in the DOWN position, the handling organisation was unable to determine how the ULD stopped in a position that would allow the forward locks to be raised and engage with the front of the ULD. It was considered that a combination of friction of the ULD as it was moved rearward on the rails, the visual cues of the green marker on the fuselage wall, and the forward locks becoming visible on the bay floor as the container moved over them probably resulted in the ULD being positioned so that the forward locks could be engaged without the rear locks being UP (raised).

Weight and balance

An assessment of the weight and balance of the aircraft, following the forward and rearward movement of the ULD loaded in bay C3, established that the aircraft remained within the forward and aft limits throughout the flight.

Safety action

The investigation by the ground handling organisation found that the loader may have been distracted during the loading; moreover, there was no requirement for an independent check of the locks to be carried out as the ULD were loaded. As a result of these findings the handling organisation undertook the following safety action:

> The ground handling organisation has revised their loading procedures to introduce an independent check to verify that all locks are positioned in the correct position when the aircraft is loaded.

To raise awareness of risks associated with void bays, such as the effects on trim if the aircraft is loaded incorrectly or the ULD moves into another bay, the operator has taken the following safety action:

> The operator has introduced 'void bay awareness' training as part of their Operator Proficiency Check on all fleets to highlight the risks when operating with void bays.

SERIOUS INCIDENT

Aircraft Type and Registration:	AW109SP, G-SCAP
No & Type of Engines:	2 Pratt & Whitney Canada PW207C turboshaft engines
Year of Manufacture:	2019 (Serial no: 22396)
Date & Time (UTC):	7 July 2021 at 0900 hrs
Location:	Wycombe Air Park, Buckinghamshire
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 1 Passengers - 4
Injuries:	Crew - None Passengers - None
Nature of Damage:	Shattered transparency
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	53 years
Commander's Flying Experience:	6,500 hours (of which 400 were on type) Last 90 days - 50 hours Last 28 days - 20 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The helicopter sustained a bird strike whilst climbing through approximately 1,900 ft at 150 kt. Bird remains entered the cockpit through the broken upper transparency, but the pilot and passengers were uninjured.

The Agusta Westland AW109 transparencies are not designed to withstand bird strikes and the design certification requirements do not require them to do so. Proposed amendments, specifically to the certification of Small Rotorcraft, were published in EASA NPA 2021-02 to change this for newly designed rotorcraft. An EASA rule making group is also considering retrospective application to existing fleets and/or to future production of already type certified rotorcraft.

The AAIB recently reported on another similar event involving an Agusta Westland 109SP, registration G-TAAS (AAIB Bulletin 8/2021).

ACCIDENT

Aircraft Type and Registration:	Beech Baron 95-B55, G-UROP
No & Type of Engines:	2 Continental Motors Corp IO-470-L piston engines
Year of Manufacture:	1982 (Serial no: TC-2452)
Date & Time (UTC):	27 March 2021 at 1215 hrs
Location:	Wellesbourne Mountford Airfield, Warwickshire
Type of Flight:	Private
Persons on Board:	Crew - 2 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to left outer wing, nose and landing gear components. Both propellers damaged and engines shock-loaded
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	65 years
Commander's Flying Experience:	12,129 hours (of which 19 were on type) Last 90 days - 5 hours Last 28 days - 5 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and further enquiries by the AAIB

Synopsis

The aircraft's landing gear retracted during a touch-and-go whilst the aircraft was on the runway. The cause of the landing gear retraction could not be conclusively identified.

History of the flight

The flight was the first since an annual maintenance check had been completed on 19 March 2021, and it was also planned to provide training for the aircraft's co-owner whose Multi Engine Piston (MEP) class rating had expired. The co-owner, acting as pilot flying, occupied the left cockpit seat and an instructor, acting as aircraft commander, occupied the right seat. The pilot flying and the instructor agreed that the pilot flying would fly the aircraft and manipulate the engine controls, and the instructor would move the flap and landing gear controls as required. A second co-owner was seated in the rear of the aircraft, as a passenger. The pilot flying stated that the takeoff weight was 2,215 kg, which is below the maximum landing weight of 2,272 kg, and that the centre of gravity was within approved limits.

The aircraft took off from Wellesbourne Airfield and after approximately 20 minutes of general handing, returned to the airfield for a number of touch-and-go circuits. The aircraft entered the circuit pattern for Runway 18 and the landing gear was extended as part of the pre-landing checks. The landing gear position indicator lights showed 'three-greens', indicating that the landing gear was down and locked. Full flap was selected on final approach and the aircraft touched down normally, however as the pilot flying increased engine power the aircraft was observed to settle onto its nose and left wingtip, and both propellers struck the runway surface. The right main landing gear leg remained locked in the down position. The aircraft slid to a halt slightly left of the runway centreline (Figure 1). The occupants were not injured and were able to vacate the aircraft without incident, using the cockpit door.

Figure 1

G-UROP following the landing accident

The instructor commented that during the landing, he had placed his hands in front of the dual control yoke bar[1] in anticipation of any excessive de-rotation of the aircraft onto the nose landing gear during the touch-and-go. In doing so, his left hand was close to the landing gear switch and it was possible it may have inadvertently contacted the switch. He stated that he had not selected the landing gear switch to UP on the ground roll.

Aircraft examination

The aircraft was recovered by lifting it beneath the wings and extending the nose and left main landing gear legs, which locked down allowing the aircraft to be towed from the runway. Examination of the aircraft revealed that the outboard end of the right main landing gear inner door was abraded due to contact with the runway during the accident (Figure 2). This door is mechanically sequenced to open when the landing gear is extended or retracted, and is closed when the landing gear is either fully up or down. The damage indicated that the right main landing gear had partially retracted and then extended during the ground roll.

Footnote

1 Beech Baron aircraft produced prior to approximately 1984 have a dual-control horizontal yoke bar, to which the left and right control yokes are attached. Later Baron aircraft have individual left and right control yokes mounted directly to the main instrument panel.

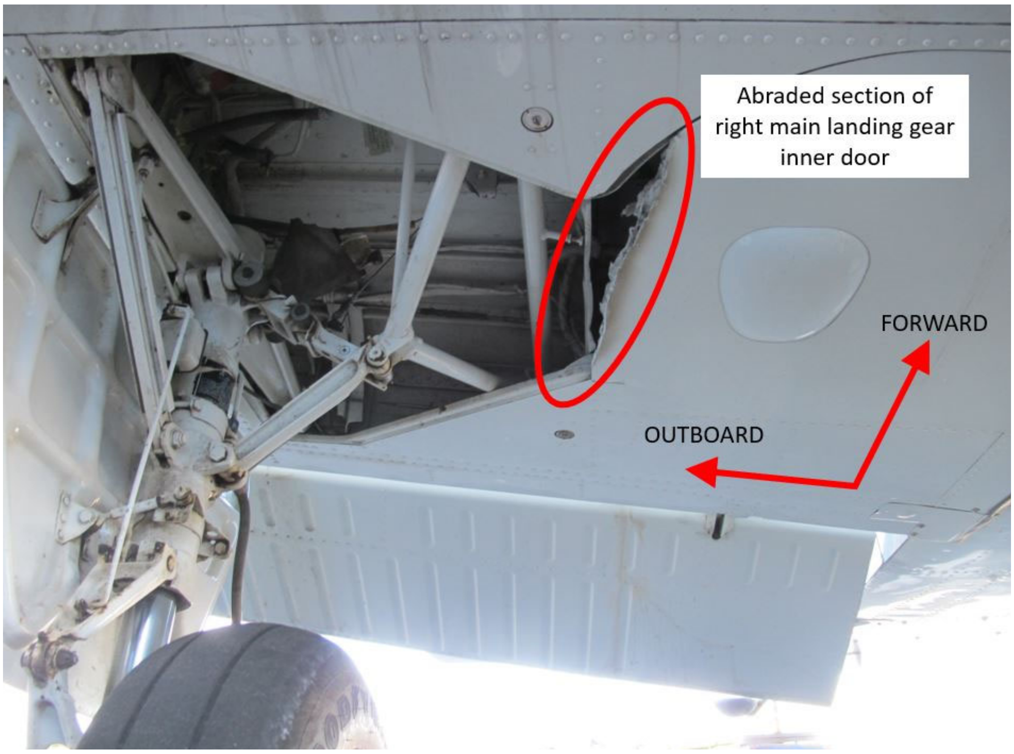

Figure 2
Abraded outer edge of right main landing gear inner door

The aircraft was supported on jacks and an attempt was made to raise and lower the landing gear, but accident damage to the weight-on-wheels switches prevented normal operation of the landing gear.

The aircraft was examined by the AAIB three weeks after the accident, including examination of the landing gear switch, which was found to be in an unserviceable condition. The switch's toggle teeth were misaligned by 90° and therefore the toggle function did not prevent operation of the switch when it was knocked either up or down. Following this examination, photographs were provided of the landing gear switch, taken two days after the accident, in which the switch appeared to be mechanically serviceable, with the toggle teeth aligned normally, indicating that the switch had been disturbed prior to the AAIB's examination. As the switch had been disturbed, it was not possible to accurately assess the mechanical or electrical state of the landing gear switch when the accident occurred.

Aircraft information

The maintenance organisation which performed the recent annual maintenance inspection and avionics upgrade stated that the landing gear switch had not been removed or otherwise disturbed during this activity. They stated that the switch is an 'on condition' component that does not require scheduled maintenance. The landing gear had been successfully cycled six times during the maintenance inspection and no abnormalities with the landing gear system had been apparent.

The aircraft was not fitted with an optional landing gear safety system, in which air pressure switches in the aircraft's pitot-static system prevent the landing gear being raised until an airspeed of 61 kt has been attained and the manifold pressure of one of the engines has exceeded 19 in-Hg. An additional guard for the landing gear switch, intended to prevent inadvertent operation of the switch, is also optionally available[2] but was not fitted to the aircraft.

Other information

The Air Safety Foundation of the American Bonanza Society (ABS), an owner's association for Beech Baron and Bonanza aircraft based in the United States, publishes safety information for its members. These include a *'Guide to Initial Pilot Checkout: Normally Aspirated Barons'*[3], which contains the following advice, Figure 3:

Flight Training

General Recommendations

These recommendations come from experience as techniques for avoiding the most common causes of Baron accidents:

- *Do not perform touch and goes. There is a high correlation between touch and goes and inadvertent landing gear retraction on the runway. A large number of loss-control crashes also occur during the high-workload on-runway phase of a touch and go. Make all landings to a full stop and take time to reconfigure for another takeoff and traffic pattern.*
- *Do not retract flaps during the landing rollout. Reconfigure the airplane only after coming to a stop on the taxiway after clearing the runway.*

Figure 3

General Recommendations from ABS's *'Guide to Initial Pilot Checkout: Normally Aspirated Barons'*

The aircraft's Pilot Operating Handbook does not contain any limitation prohibiting touch-and-go landings.

Discussion

The abrasion damage to the right main landing gear inner door indicates that the landing gear had partially retracted before then extending again during the ground roll, whilst the aircraft was below flying speed. The nose and left main landing gear legs collapsed under the weight of the aircraft, but the right main landing gear remained extended, possibly due to it experiencing an outward side-load during the accident.

This was the first flight following an annual maintenance inspection, during which the landing gear retraction and extension was successfully tested six times, with no faults identified. Both pilots observed that the landing gear lowered normally during the approach to the

Footnote

2 Beechcraft Class II Service Instruction 1215.

3 The American Bonanza Society's Beechcraft Pilot Proficiency Program (BPPP) Guide to Initial Pilot Checkout: Normally Aspirated Barons, Models 95-55, A55, B55, C55, D55, E55, 58, G58, December 2012.

runway, with three green lights indicating that the landing gear was locked in the down position.

The evidence available to the investigation was insufficient to conclusively determine the cause of the accident.

SERIOUS INCIDENT

Aircraft Type and Registration:	Piper PA-31, G-UKCS
No & Type of Engines:	2 Lycoming TIO-540-A2C piston engines
Year of Manufacture:	1974 (Serial no: 31-7400984)
Date & Time (UTC):	23 July 2021 at 0933 hrs
Location:	Doncaster Sheffield Airport
Type of Flight:	Aerial survey
Persons on Board:	Crew - 1 Passengers - 2
Injuries:	Crew - None Passengers - None
Nature of Damage:	Lower cabin door damaged
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	26 years
Commander's Flying Experience:	1,513 hours (of which 66 were on type) Last 90 days - 37 hours Last 28 days - 15 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and further enquiries by the AAIB

Synopsis

The aircraft's lower cabin door came open in flight when a screw forming part of the door's forward latching mechanism fractured. The aircraft landed safely and the investigation determined that the cabin door's rear latch was probably not locked when the cabin door was closed, allowing the door to open when the screw fractured. The screw had not been securely fastened and was loose, which contributed to a fatigue failure of the screw. The operator has taken a number of safety actions intended to detect unsafe conditions of the cabin doors on its PA-31 fleet.

History of the flight

The aircraft was operating an aerial survey flight, with a crew of one pilot and two systems operators onboard. The lead systems operator confirmed that prior to departure the cabin doors had been closed without difficulty, with the cabin door ajar warning light extinguished and the cabin door indicator showing SAFE. The doors were confirmed closed and locked by the application of gentle physical pressure to the doors, which is part of the normal pre-departure checklist.

After departing from Doncaster Sheffield Airport at 0920 hrs, the aircraft routed towards Hull at an altitude of 2,000 ft in IMC when, at 0933 hrs, the crew heard a 'loud bang' as the lower cabin door opened. The commander transmitted a PAN call to Humberside Radar informing them that the cabin door had come open and requesting radar vectors to the

Runway 02 ILS at Doncaster Sheffield Airport. The pilot informed the systems operators that he would fly a faster than normal approach, using full flap, to minimise the aircraft's pitch attitude during approach and landing.

The aircraft was transferred to Doncaster Radar who vectored the aircraft for the Runway 20 ILS, as this was a more direct return route and the surface wind was light. The aircraft landed uneventfully at 1000 hrs.

Aircraft information

The main cabin door is a clamshell design (Figure 1) with upper and lower outward-opening doors. The lower door is fitted with two folding steps and when open is supported by two cable-stays.

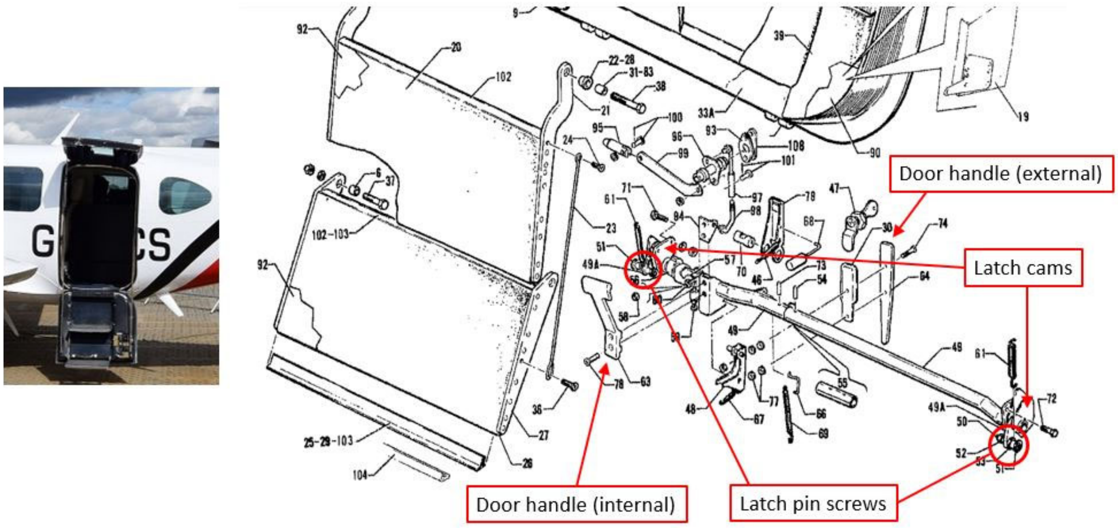

Figure 1

PA-31 cabin door and latching mechanism (illustration courtesy of Piper)

The upper door is held closed by overlap with the lower door when it is closed and locked. On G-UKCS the upper door is also fitted with an internal sliding latch[1], to additionally secure the cabin upper door.

The lower door is locked by means of two cams, mounted at either end of a rotating torque tube that is operated by movement of either the internal or external door handles. Latch pins, composed of a bushing sleeved over a latch screw that rotates with the latch cam, engage in hook lock plates fixed to the cabin door frame when the lower door is locked closed (Figure 2).

Footnote

[1] Embodied in accordance with Piper Service Letter 739.

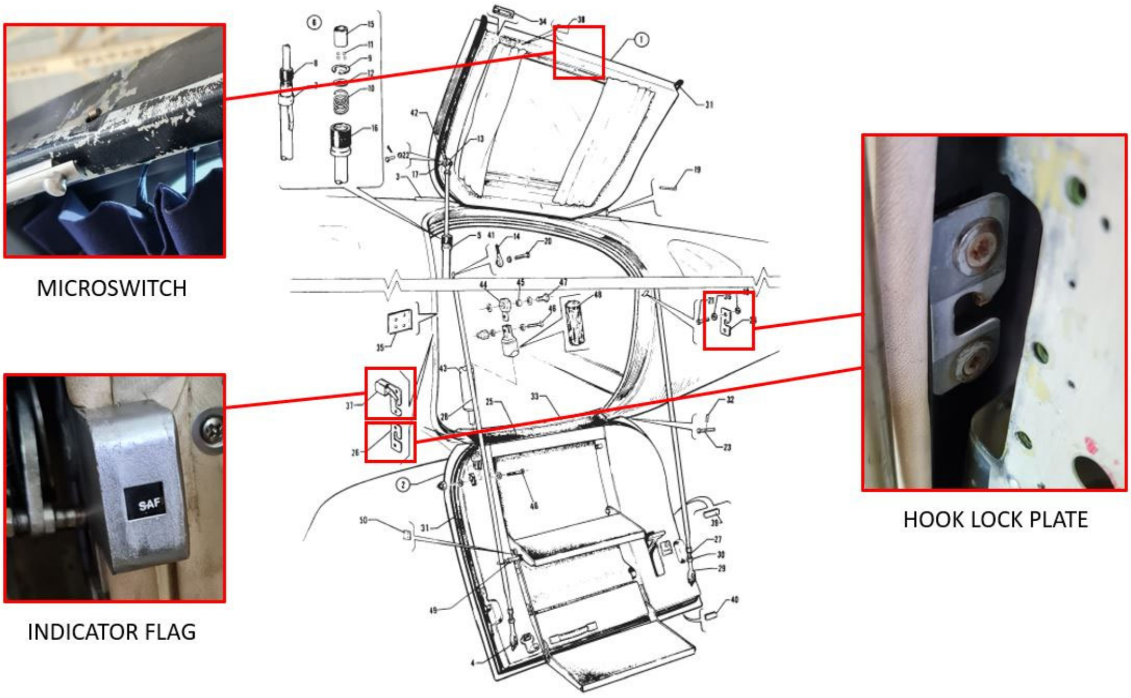

Figure 2

PA-31 cabin door components (illustration courtesy of Piper)

In addition to the two cam assemblies, G-UKCS also has a visual indicator flag incorporated into the cabin door forward latch assembly, which displays the word SAFE when the forward latch is engaged. This feature was introduced by the manufacturer to prevent inadvertent opening of the cabin door in flight and was mandated by a FAA Airworthiness Directive[2].

A single microswitch is fitted to the upper cabin door that contacts a striker plate in the lower cabin door when the doors are closed. Closure of the microswitch causes a door ajar warning light on the upper console of the flight deck instrument panel to extinguish.

Aircraft examination

The aircraft's upper and lower cabin doors remained attached to the aircraft, however the forward cable-stay had broken at its attachment point to the lower door and the rear cable-stay mounting structure was damaged.

The cabin door latch mechanism was disassembled, revealing that the forward door latch pin screw had broken (Figure 3), and the door latch return spring was bent, with one end fractured.

Footnote

[2] Piper Service Letter 803A and FAA AD 78-05-05, effective 8 March 1978.

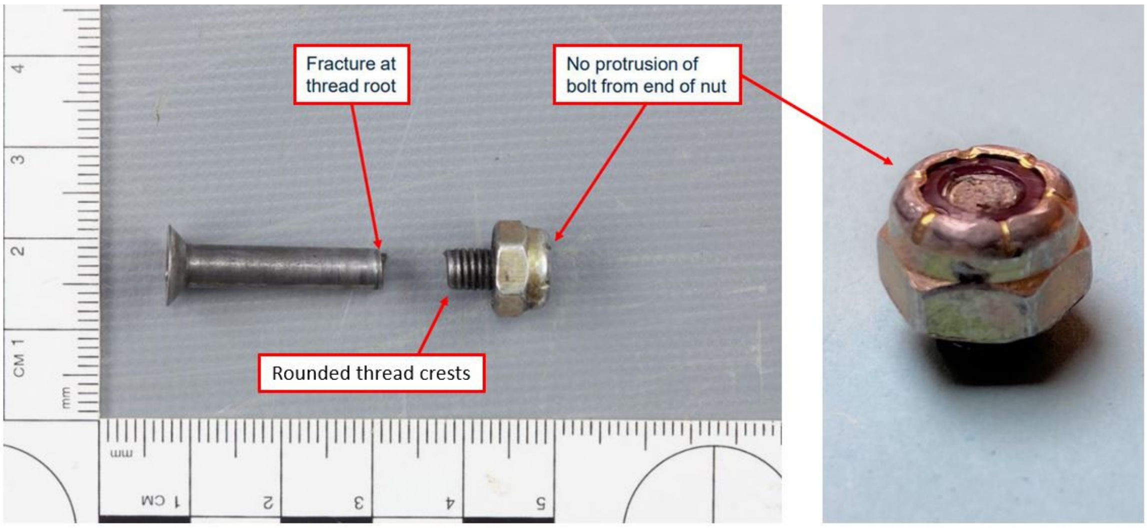

Figure 3

Fractured door latch pin screw (image courtesy of QinetiQ)

The latch pin screw had fractured at the thread root, close to the shank of the screw, and the thread crests in this area were rounded and worn around the circumference. The self-locking nut was observed to be insufficiently engaged on the screw threads, with no projection of the screw thread beyond the end of the nut. The screw was measured and confirmed, with reference to the aircraft's Illustrated Parts Catalogue, to be the correct screw for the latch assembly[3].

The screw's fracture surface exhibited fatigue beachmarks around the circumference of the fracture surrounding a smaller area of relatively rough, dull fracture characteristic of overload (Figure 4). A number of ratchet marks[4] were also visible within the fatigue region of the fracture surface, which encompassed approximately 60% of the screw's cross-section.

The propagation of fatigue cracking around the periphery of the screw thread root, surrounding the overload region, is characteristic of the screw being loose in the door latch assembly and rotating between load cycles. The worn and rounded thread crests at the fracture location on the screw also indicate a similar wear mechanism.

Operator's testing

The operator conducted testing of the cabin door following the incident and noted that when closing the doors from the inside, the rear latch pin was observed to not always fully engage in its latch hook when the door handle was in the closed position. This condition could only be seen from inside the cabin when conducting a visual inspection using a torch and would not be immediately visible or apparent to the crew members.

Footnote

3 Part number MS24694-S63 (#10-32 UNF-3A thread, 7/8" grip).

4 Ratchet marks are lines on a fatigue fracture surface that result from the intersection and connection of fatigue fractures propagating from multiple origins.

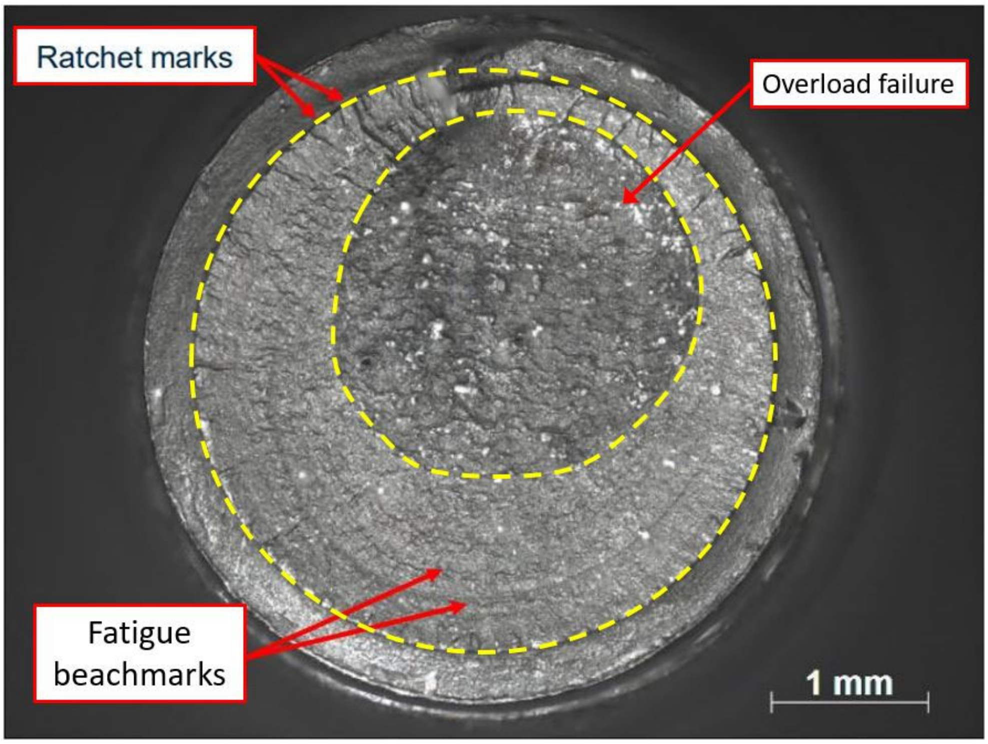

Figure 4

End view of screw fracture surface showing regions of fatigue and overload crack propagation (image courtesy of QinetiQ)

The forward latch pin screw was replaced and the testing was repeated. Whilst the repaired forward latch locked reliably, the unlocked condition of the rear latch could be reproduced. In this condition the door ajar cockpit indication extinguished and the lower door appeared to be flush but both the internal and external door handles were not in their fully closed positions, with the external handle protruding outwards (Figure 5).

Figure 5

Protruding state of the lower cabin door handle observed during testing (image courtesy of 2Excel)

Other information

The aircraft manufacturer stated that no similar occurrences of a broken latch pin screw were listed in the FAA's Service Difficulty Reporting System database.

The operator checked the aircraft's maintenance records and could not identify when the forward latch pin screw had last been disturbed. They stated that the screw had not been subject to any maintenance input since they had acquired the aircraft in June 2016.

Analysis

It is probable that when the cabin doors were closed and locked by the lead systems operator, the rear latch pin did not fully engage in its hook lock plate whilst the forward latch pin did, and that the door therefore appeared to be securely locked closed. The visual presentation of SAFE on the forward latch indicator, combined with the extinguishing of the door ajar cockpit warning light and the apparent security of the cabin door when pressure was applied to it would have all contributed to confirmation that the cabin door was properly closed and locked. The contrary indications of the internal door handle not being fully in the closed position and the rear latch pin not being safely engaged in its hook plate were not sufficiently prominent to have caused the crew to question the security of the cabin door prior to departure.

The forward latch pin screw fractured during flight due to propagation of a fatigue crack, through the threaded portion of the screw, which reached sufficient length that the remaining section of the screw could no longer withstand the loads applied to it. The screw was loose within the latch pin assembly because its self-locking nut had not been tightened at an unidentified previous maintenance event. The looseness of the screw contributed to the propagation of the fatigue crack as the screw had been subject to bending loads in service and rotation of the screw had caused fatigue to propagate from multiple initiation sites around the screw thread root.

The investigation did not determine whether the loose forward latch pin screw possibly contributed to the lack of engagement of the rear latch pin in its hook plate.

The upper cabin door remained closed when the lower door opened, due to its separate sliding latch, which contributed to the safe outcome of the event.

Safety action

The operator plans to conduct a fleet check on its PA-31 aircraft to ensure that the latch pin screws are not loose and are correctly mechanically fastened. It also plans to issue the following amplification statements:

- In its PA-31 Aircraft Maintenance Programme daily inspection instructions to ensure that the internal and external door handles are flush when the door is in the locked closed.

- In its PA-31 Check 1 (50-hour) inspection to include specific visual inspections for correct engagement of the cabin door latch pins and hook plates when the door is locked closed, and also that the latch pin screws are correctly mechanically fastened. Correct rigging of the internal and external cabin door handles is also to be highlighted in the Check 1 instructions.
- In its PA-31 Operations Manual pre-flight checklist to include a specific visual inspection to ensure that the cabin door internal handle is flush to the door inner skin when the door is locked closed.

The operator also plans to disseminate its internal occurrence report for this event to its engineers and flight crews and will include related safety information in recurrent continuation training.

ACCIDENT

Aircraft Type and Registration:	Agusta AB206B, G-WIZZ
No & Type of Engines:	1 Allison 250-C20 turboshaft engine
Year of Manufacture:	1977 (Serial no: 8540)
Date & Time (UTC):	15 October 2021 at 1330 hrs
Location:	Humberston Fitties Beach, Lincolnshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 2
Injuries:	Crew - None Passengers - None
Nature of Damage:	Tail boom damaged by rotor blade
Commander's Licence:	Private Pilot's Licence
Commander's Age:	56 years
Commander's Flying Experience:	1,700 hours (of which 194 were on type) Last 90 days - 36 hours Last 28 days - 15 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The pilot reported that the low main rotor speed warning light illuminated when he pulled on the collective lever at a height of approximately 800 ft. The helicopter was flying over a beach and he "*immediately entered autorotation*" leading to a run-on landing at approximately 15 kt. The helicopter came to rest upright on its skids, but the main rotor blades were found to have struck the tail boom causing substantial damage. There were no injuries.

ACCIDENT

Aircraft Type and Registration:	Druine D.31 Turbulent (modified), G-AREZ
No & Type of Engines:	1 Volkswagen 1834 piston engine
Year of Manufacture:	1960 (Serial no: PFA 561)
Date & Time (UTC):	8 July 2021 at 1730 hrs
Location:	Easterton Airfield, Birnie, Elgin
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Serious) Passengers - N/A
Nature of Damage:	Engine separated from aircraft and aircraft broken in two. Damaged beyond economic repair
Commander's Licence:	Private Pilot's Licence
Commander's Age:	55 years
Commander's Flying Experience:	1,614 hours (of which 64 were on type) Last 90 days - 45 hours Last 28 days - 19 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The engine failed shortly after takeoff. The pilot began a left turn to avoid trees ahead, but the aircraft stalled in the turn and struck the ground. During the touchdown the aircraft broke up and the pilot sustained serious injuries.

Although not positively determined, it appeared likely that a magnet detached from the propellor spinner back plate during takeoff, and this combined with incorrect wiring within the ignition system to stop the engine.

History of the flight

The aircraft had flown earlier in the day for approximately 55 minutes and that flight was routine with no evidence of any issues with the engine. For the accident flight a witness saw the aircraft start up, conduct engine run up checks and taxi out. All of these appeared and sounded normal. The pilot reported that the engine started easily and that oil pressure registered immediately. The pilot allowed the engine to warm up for between five and eight minutes before conducting the power checks. He stated that during the warm-up and power checks all indications were normal and he noticed no issues with the aircraft. The chocks were then removed, and the pilot taxied to the threshold of Runway 26 with the carburettor heat on. He stated that his routine was to taxi with carburettor heat on and turn it off during the pre-takeoff checks.

After completing the takeoff checks the pilot selected full power and during the acceleration checked that the engine and airspeed indications were all normal. The witness saw the aircraft start its takeoff roll but it was soon lost to sight behind a building. At that point the witness left the airfield in his car.

The aircraft lifted off at 48 mph but the pilot held the aircraft close to the ground to accelerate to 64 mph to improve the subsequent climb rate. At approximately 150 ft agl and with the aircraft approaching the airfield boundary the pilot reported that the engine suddenly stopped. He immediately lowered the nose to maintain flying speed. The terrain ahead was undulating, planted with trees and, in the pilot's view, unsuitable for any forced landing. The pilot began a left turn, using 20º to 30º angle of bank, but was concerned that the manoeuvre carried an increased risk of stalling. As he commenced the turn, he switched off the ignition and fuel supply to the engine.

The pilot stated that, during the turn, the aircraft stalled at approximately 50 ft agl and there was a significant left wing drop. The pilot applied full right rudder to attempt to control the roll attitude. The aircraft then struck the ground in an approximately wings level and nose-down attitude. The pilot estimated the time from the engine failure to touch down was 8 to 10 seconds. After the aircraft struck the ground, the pilot believes he was unconscious for a number of seconds. When he regained consciousness, he recognised the severity of the situation. The fuselage had broken at the front of the cockpit, though the pilot had remained secure in his five-point harness. He managed to release his harness and was then able to crawl clear of the wreckage and telephone the witness who had seen his departure.

As the witness was driving home, the pilot of the aircraft phoned to say that he had been in an accident and was on the ground at the end of the runway. The witness, who is a doctor, returned to the airfield and went to the site of the accident to assist the pilot. He called the emergency services.

Ground ambulances arrived approximately 10 minutes after the 999 call and then, due to the extent of the pilot's injuries, an air ambulance was called, arriving 35 minutes after the initial call. The pilot was transferred by air to the major trauma unit at Aberdeen Royal Infirmary.

Aircraft information

G-AREZ (Figure 1) was originally built by Rollason Aircraft and Engines Ltd in 1960. The aircraft was badly damaged in a heavy landing circa 1980, and after a long period out of service it was repaired, refurbished and returned to flying in August 2018. It was sold to the current operator in November 2019.

Figure 1
G-AREZ

Accident site

The aircraft struck the ground at the western end of Easterton airfield close to the threshold for Runway 08 (Figure 2).

Figure 2
Easterton airfield showing accident location

During the accident sequence the forward fuselage separated from the rest of the airframe just forward of the cockpit. There was extensive damage (Figure 3).

Figure 3
Aircraft at accident site

Aircraft examination

The aircraft and engine were examined by an Inspector from the Light Aircraft Association (LAA). He concluded that there was no evidence of a mechanical failure prior to impact, the engine controls were operating normally and the fuel system was operating correctly. The issue of carburettor icing was considered. However, as the pilot reported he had taxied out with carb heat on, selecting it off just prior to takeoff, it was considered unlikely to have caused the engine failure.

The aircraft's ignition system was extensively examined and, while some loose connections were found, both Leburg ignition controllers passed bench tests. The Leburg controllers receive timing information from sensors which detect the passage of magnets fitted to the propellor spinner back plate. The spinner backplate was damaged and one of these magnets was missing. There was evidence it had not been effectively glued in position. The wires connecting the controller to the magnet sensors should be arranged so that the connector responding to north magnet pole in one wiring harness is connected to the sensor for a south magnet pole in the opposite controller wiring harness. The controllers require an alternating sequence of poles passing the sensors, ie north–south-north-south, to operate correctly. If this sequence is not apparent the controller will not initiate the ignition spark.

In G-AREZ the wiring harness for both controllers were wired so the north magnet pole sensors were on identical connectors, so if a magnet was lost the engine would stop. The LAA Inspector made the following statement in his report: '*I believe that in-flight loss of one magnet during take-off, together with the unfortunate alignment of the aircraft's wiring between the controllers and their coils, is the most likely cause of the engine stop on Turbulent G-AREZ.*'

Survivability

The pilot was wearing an RAF pattern "Bone Dome" flying helmet. Despite impact to the head sufficient to cause concussion, he quickly regained consciousness and was able to extract himself from the aircraft and move clear of the accident. Despite the separation of the aircraft nose from the rest of the fuselage, the pilot's harness remained secure and attached to its mounting points.

Meteorology

The pilot had obtained a weather report from RAF Lossiemouth, which is approximately 10 miles north of Easterton. The forecast for the time of the accident showed light northerly winds, visibility greater than 10 km, broken cloud at 4,000 ft amsl and a temperature of 17 ºC.

Analysis

The aircraft had flown earlier in the day with no evidence of engine issues. During the checks for the accident flight departure, all indications were normal and there was no indication of any engine issue. The takeoff was normal and the initial performance of the aircraft was as expected by the pilot. At approximately 150 ft agl the engine suffered a sudden and total power loss, perhaps because of an interruption of electrical power to the ignition system. The pilot adopted a glide attitude but was faced with terrain ahead which he felt presented no opportunity for a safe touchdown.

The pilot began a turn to the left to avoid obstacles and switched off both the ignition and fuel supply. However, during the turn the aircraft stalled and control was lost. The pilot applied right rudder to control the wing drop and the aircraft struck the ground in an approximately level attitude. The fuselage broke just in front of the cockpit, the pilot suffered serious injuries and was briefly unconscious. There was no post touchdown fire and the pilot's harness remained secure and attached to its mountings. It is likely that the pilot's decision to wear an RAF flying helmet reduced the severity of his head injuries and thus allowed him to remove himself from the wreckage and telephone for assistance.

Conclusion

The engine suffered a total loss of power at low altitude, the most likely cause of which was a loss of a magnet from a timing sensor, combined with incorrect wiring within the ignition system. During a manoeuvre to avoid obstacles, the aircraft stalled and control was lost. The pilot suffered serious injuries during the touchdown and the aircraft was damaged beyond economic repair.

Bulletin Correction

Following publication of AAIB Bulletin 2/2022, the Light Aircraft Association (LAA) amended its report into this accident to reflect its updated view on the cause of the engine failure. Since the AAIB report was based on the LAA report, the above report has been amended to reflect the change. Full details of the change can be found on the AAIB website and will also be published in AAIB Bulletin 5/2022. The online version of the report was amended on 17 March 2022.

ACCIDENT

Aircraft Type and Registration:	Rebel, G-BZFT
No & Type of Engines:	1 Lycoming O-320-C2A piston engine
Year of Manufacture:	2001 (Serial no: PFA 232-13224)
Date & Time (UTC):	4 June 2021 at 1330 hrs
Location:	Clench Common Airfield, Wiltshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Deformed tail section, propeller and engine shock loaded
Commander's Licence:	Private Pilot's Licence
Commander's Age:	57 years
Commander's Flying Experience:	360 hours (of which 6 were on type) Last 90 days - 21 hours Last 28 days - 5 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The pilot reported that during the landing roll on grass Runway 33 at Clench Common, the aircraft started to turn left when at a low speed. He applied right rudder and differential braking, using the toe brakes, but with little effect, so he positively applied both brakes. As the aircraft came to a stop it nosed over momentarily causing the propeller to strike the ground. The aircraft then settled back onto its tailwheel, coming to rest in a grass field that bordered the runway.

The aircraft's tail section side panel was deformed when it settled back onto its tailwheel. The propeller was damaged, and the engine was shock loaded.

The pilot attributed the accident to his lack of experience on type, highlighting that he should not brake hard at low speed if there is no danger present, and must continue to 'fly the aircraft' until the engine is shutdown.

ACCIDENT

Aircraft Type and Registration:	Rolland-Schneider LS8-18, G-CJNB
No & Type of Engines:	No engines
Year of Manufacture:	1998 (Serial no: 8227)
Date & Time (UTC):	5 September 2021 at 1240 hrs
Location:	Seighford Airfield, Staffordshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Serious) Passengers - N/A
Nature of Damage:	Extensive damage to the fuselage and wings
Commander's Licence:	UK Sailplane Pilot's Licence
Commander's Age:	62 years
Commander's Flying Experience:	113 hours (of which 20 were on type) Last 90 days - 19 hours Last 28 days - 1 hour
Information Source:	Aircraft Accident Report Form submitted by the pilot and additional information provided by others

Synopsis

The pilot was flying a circuit following a winch launch. As the glider approached the landing site the pilot thought the glider was too high to make a safe landing so decided to fly an orbit. However, there was insufficient height to complete the orbit and the glider collided with trees in an adjacent field.

After the accident the pilot reflected that her previous experience at a hillside landing site and on lower performance gilders may have caused her to misjudge the approach. This report considers how previous experience can influence perception and discusses the challenge of decision making in a time-limited and stressful situation.

History of the flight

The pilot was a member of the gliding club at Seighford Airfield in Staffordshire. On the day of the accident, she arrived at the club in the morning, attended the morning briefing and rigged G-CJNB. The weather was not particularly suitable for soaring so she planned to practice some winch launched circuits at the airfield. She was relatively new to flying G-CJNB and felt she would benefit from more practice flying circuits. Her last few flights had been aerotow launches and it was over 30 days since her last winch launch, so she undertook a winch launch check flight with an instructor in a Grob Twin Astir glider (G-CKRH). The check flight went well with the instructor commenting that the "circuit planning and approach and the landing were executed well".

Several hours after the check flight the pilot prepared for a solo flight in G-CJNB. The winch launch commenced at approximately 1237 hrs and witnesses commented that the takeoff and climb into the circuit appeared normal. Several witnesses watched the glider turning onto final and make its approach and all agreed that it appeared to be higher than they would normally expect. As it drew level with the launch point witnesses estimated it was about 150 – 200 ft above the ground, where they would normally expect a glider to be at about 50 ft. At this point the airbrakes were heard to retract and the glider started a turn to the left. Witnesses watched it continue in a descending left turn. As the glider turned back toward the airfield it disappeared behind the treeline. Several witnesses heard the glider collide with the trees and impact the ground. Some witnesses briefly saw the tail and wingtip above the treeline as it appeared to cartwheel across the adjacent field.

The glider was found inverted in a field approximately 100 m to the north-west of the launch point. The pilot was extracted from the glider and airlifted to hospital. She had suffered serious injuries to her lower legs and many broken bones but, after a long stay in hospital, returned home to continue her recovery.

Pilot's recollection

The pilot was interviewed several weeks after the accident when she had been released from hospital. She could remember the accident flight until starting to turn left into the orbit but had no recollection after this point.

She recalled that there had been a light north-easterly wind on the day, which she believed was sufficiently "east" to need a little extra speed above the minimum approach speed. She planned to fly a 55 kt approach (the minimum approach speed is 49 kt). She recalled that the "winch launch was all fine but there was no lift at the top". She remembered setting up a very similar circuit to the one she had flown in the Twin Astir earlier.

She thought that she had extended the diagonal leg as she was starting to feel the glider was high, which gave her a short base leg. As she turned onto the final approach, there were trees underneath on the approach which she thought may have affected her perspective. She thought she used full airbrake almost immediately and with 55 kt remembered thinking that it appeared that the glider would "massively overshoot". She remembered thinking "I can't get down before the far bushes". She reduced speed to 49 kt but still appeared to be overshooting; she recalled thinking "you're going to have to make a decision as you're going to go over the far road". She remembered retracting the airbrakes and turning left.

Meteorology

The day of the accident was a clear sky day with a temperature of approximately 21°C. The gliding club have a weather station which records surface wind speed and direction. It recorded that at 1230 hrs the average wind direction was from 103° with an average wind speed of 10.7 kt and a maximum of 11.9 kt. By 1250 hrs the wind was from 110°, with an average speed of 6 kt and maximum of 7 kt.

Airfield information

Seighford airfield has a grass landing area orientated approximately 070°/250° and is approximately 850 m long. There are trees in the undershoot and overshoot in both directions.

Recorded information

The glider was fitted with a Naviter Oudie flight logger and a "FLARM" collision avoidance system, both of which contained recordings of the accident flight. Figure 1 shows the profile flown with relevant heights added. The graph in Figure 2 shows the altitude, ground speed and heading during the approach.

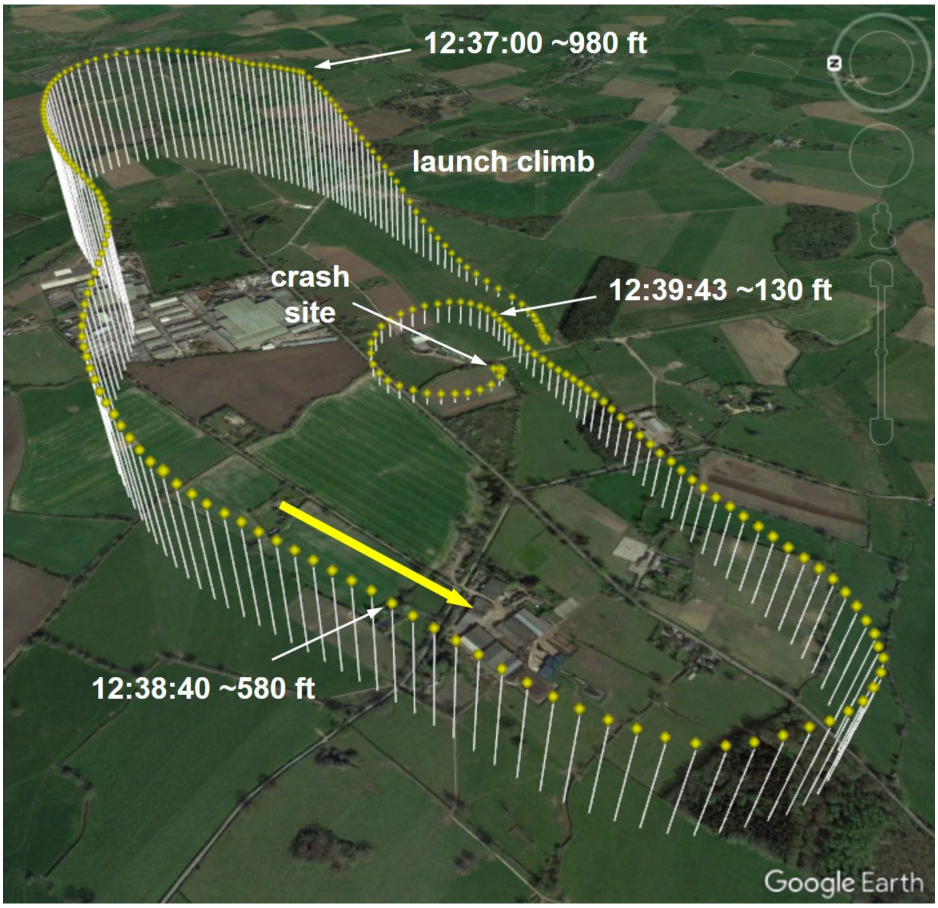

Figure 1

Accident flight profile showing the circuit, approach and orbit (heights are aal)

The flight logs show a normal winch launch and circuit up to the approach back to the airfield. The approach was flown at an average ground speed of approximately 55 kt[1]. After crossing the airfield boundary hedge, at a height of 130 ft above the ground, the glider

Footnote

1 Ground speed was calculated from the recorded GPS position data. There was a headwind on the approach so the airspeed seen by the pilot would have been slightly greater than the ground speed.

started a left turn. Just prior to commencing a left turn the ground speed reduced to 40 kt. The turn continued with a diameter of approximately 350 m. The ground speed increased during the turn to approximately 60 kt.

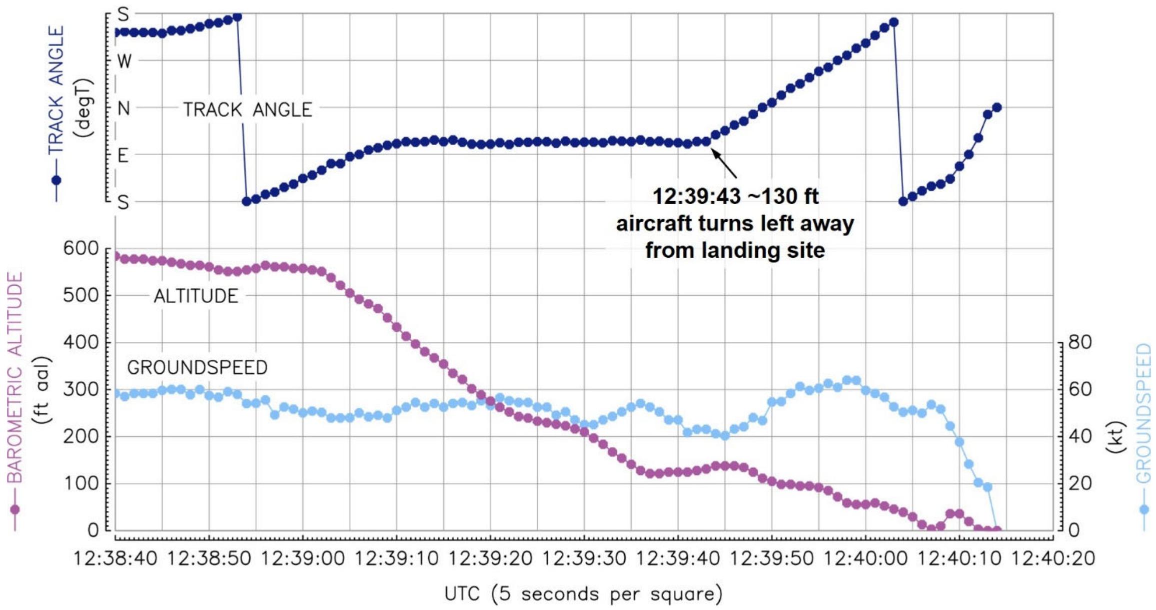

Figure 2

Chart showing the glider's altitude, ground speed and heading during the approach

Accident site and glider examination

Figure 3 shows the glider after the accident; the airfield is just beyond the trees in the background.

The accident site and glider were examined by several experienced members of the gliding club. They reported that the fuselage was very badly damaged forward of the wing and was also broken behind the wing. The right wing had a small diameter impact mark which penetrated the leading edge at about two-thirds span, and there were two large creases in the trailing edge inboard of the impact damage. It was thought this damage was caused by an impact with a tree branch. There was impact damage on the left wingtip but the wing itself was less damaged than the right one. On the underside of the left tip, there were marks showing it had dragged across the ground. The left wingtip extension was detached and closer inspection showed that it had torn the fitting from the main wing. The tail, fin and rudder were essentially undamaged.

There was a one to two-inch-deep ground mark just behind the eventual resting place of the glider. The shape of this and the surrounding debris, including multiple canopy fragments, suggested that this is where the nose struck in a very steep attitude and with little forward speed.

Figure 3
G-CJNB after the accident

All the damage appeared to be consistent with the glider colliding with trees and rotating across the field to its eventual resting point. There was no evidence of any pre-existing damage which could have contributed to the accident.

Glider circuit planning and managing the approach

The circuit flown by gliders needs to be more flexible than that used by powered aircraft to allow for the wind conditions, rising and sinking air, and the glider's performance. Glider pilots typically fly a 'diagonal' leg. When the glider is abeam the landing point the glider is turned onto a heading which 'cuts the corner' of the traditional circuit. This is followed by a short base leg then a turn onto finals. This technique ensures the landing point is continuously in sight and the pilot can judge the glide angle. If the glider is too high the diagonal leg can be widened, and the glider can track further downwind. If the glider is low, the pilot can turn into the landing site earlier. Most modern gliders are also fitted with airbrakes which can be extended to increase the rate of descent. Approaches are normally planned to use half airbrakes so that the amount of airbrake can be increased or decreased to make adjustments to the approach angle. An approach in a glider requires the continual assessment of the glide angle to ensure the glider is flying to the intended landing point. The pilot needs to make timely decisions to adjust the track flown and/or adjust the amount of airbrake to manage the glide angle.

Pilot's background and reflections

The pilot initially learnt to fly gliders at a hillside landing site in the late 1980s, but then stopped flying for several years due to family commitments. She returned to flying in 2019. In 2020 she started to fly from Seighford and began flying G-CJNB. She had accumulated a total of 113 hours and had achieved a BGA Silver Badge[2].

Reflecting on what happened, she thought that the circuit she flew, which was similar to the circuit she had flown earlier in the Twin Astir, was inappropriate for G-CJNB due to its higher performance. Once she realised she was high on the approach she thought it might have been better to retract the airbrakes and flying over the road, landing in the field beyond the airfield. She also thought that if she had waited very slightly longer after reducing speed on the approach the glider might have started descending satisfactorily.

After the accident, thinking about her previous flying, she realised that her previous flights in G-CJNB were all longer and had given her time to adjust to the higher performance and assess the conditions. She recalled that this flight was her first winch launch straight into a circuit in G-CJNB. She commented that she was never completely happy about the approaches and landings in G-CJNB and thought this was because she was not used to going wide enough and far enough downwind. Her previous flying had been predominantly at a hillside landing site where it was common to fly circuits close to the boundaries of the airfield due to downdrafts. She was aware that she was more familiar with flying tight circuits and was aware that she needed to practice wider circuits in G-CJNB.

Analysis

During the approach to land the pilot perceived that the glider was too high to make a safe landing on the airfield, so decided to fly an orbit to the left. There was insufficient height to complete the orbit and the aircraft collided with trees in an adjacent field.

After the accident the pilot provided helpful reflections on why she believed the accident occurred. She commented that her previous experience at a different gliding site and on lower performance gliders may have skewed her perception of the approach leading her to position the glider too high. Once in this position, she felt her only option was to fly an orbit. After the accident, without the pressure to make a quick decision, she considered that she could have continued ahead to land beyond the airfield or could have allowed more time for the reduced speed to translate into a steeper glide angle and use the airbrakes to land within the airfield boundary.

Human perception and specifically the challenge of judging a glide angle is discussed in CAP 737[3]. Past experience is a strong influencer in determining what 'looks right' to a pilot. Even when a pilot knows that their past experience may not be correct for the situation it can be difficult not to revert to what looks and feels right.

Footnote

2 To be awarded a Silver Badge a pilot must have completed: A duration flight of not less than 5 hours from release to landing, a distance flight of not less than 50 km made as either a flight of at least 50 km in a straight line or a flight round a course flight where one leg is of 50 km or more, and a height gain of at least 1,000 m.

3 CAP 737 is the CAA publication titled '*Flightcrew Human Factors Handbook*' - available from www.caa.co.uk

Once the pilot found herself high on the approach, she was faced with deciding what to do in a stressful and time limited situation. In quick decision making situations humans tend to accept the first solution which appears to offer an acceptable outcome. This is known as recognition primed decision making and is described in detail in CAP737. With limited time humans tend not to be good at evaluating all the available options and making a rational decision on the best option. In this accident the pilot decided to fly an orbit. Without the pressure to make a quick decision she may have considered that continuing ahead was a better option. Pilots may mitigate these situations by trying to think though different scenarios on the ground so that, if they find themselves in that position, they have already considered what they would do.

Conclusion

It is likely that the pilot's previous experience at another airfield and flying lower performance gliders led her to position the glider too high. Once in this position she decided to fly an orbit to lose the height but there was insufficient height to complete the orbit. The accident demonstrates the challenge of judging glide angle and how previous experience can skew a pilot's perception. It also shows the difficulty of making decisions in a time limited and stressful situation.

ACCIDENT

Aircraft Type and Registration:	Rollason Druine D.31 Turbulent, G-ARGZ
No & Type of Engines:	1 Volkswagen 1600 piston engine
Year of Manufacture:	1961 (Serial no: PFA 562)
Date & Time (UTC):	16 October 2021 at 1245 hrs
Location:	Damyns Hall Aerodrome, Upminster, Essex
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Serious) Passengers - N/A
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Private Pilot's Licence[1]
Commander's Age:	44 years
Commander's Flying Experience:	7,496 hours (of which 10 were on type)[2] Last 90 days - 154 hours Last 28 days - 53 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and further evidence obtained by the AAIB

Synopsis

A display team were training some new pilots to fly a 'limbo' manoeuvre which involved the aircraft flying under a string of bunting suspended between two poles. As one of the new pilots flew the aircraft through the limbo gate the aircraft pitched nose-down and struck the ground with sufficient force to break the main spar. The wings folded upwards and the remains of the aircraft came to rest inverted on the grass. The pilot was taken to hospital having sustained serious injuries.

It is likely that the pilot thought he was slightly high as he approached the limbo gate and instinctively pitched down. The aircraft probably struck the ground before he had time to realise the effect of the pitch input.

History of the flight

The display team were conducting a regular training session at Damyns Hall Aerodrome. Three pilots, who were new to the display team, were completing their introductory training. As the weather was benign, as well as practicing some formation elements, the display leader decided to introduce the new pilots to the 'limbo' element of the display. The limbo

Footnote

[1] The commander also held a Helicopter Airline Transport Pilot's Licence.
[2] These hours are a combination for rotary and fixed-wing experience.

manoeuvre involves flying the aircraft below a string of bunting suspended approximately 20 ft above the ground between two poles[3].

In addition to the normal display briefing and walk through, the display leader separately briefed each pilot on how to fly the limbo manoeuvre. He described that, for this first practice, the aircraft should descend from at least 500 ft aal flying in a straight line towards the limbo gate aiming to achieve approximately 90 kt as the aircraft reaches the gate. Full power should be applied just prior to the gate, if not already applied, ready for the climb. It was emphasised that pilots should not approach the limbo gate at low level over an extended distance. The minimum height of 5 ft should be achieved just short of the gate with sufficient lead-in to achieve stable level flight. Once through the gate, a straight climb was to be initiated back to 500 ft prior to entering the circuit. Guidance on the lateral positioning was given, the aim being to locate the aircraft centrally using an inverted triangle suspended from the limbo cable whilst maintaining 5 ft above the ground. This would ensure there would still be at least 5 ft between the aircraft and the limbo cable. The limbo cable was fitted with a weak link in case an aircraft struck the cable. The practice was conducted parallel to the main runway with the limbo gate set up approximately 50 ft to one side.

To enable the new pilots to experience the limbo procedure each of them observed three existing pilots flying the manoeuvre from the ground. On the first pass they watched from the side of the poles and on the second pass they held the poles. During these passes the display leader re-emphasised how the manoeuvre was flown. Rain then delayed the practice for just over an hour and one of the new pilots had to leave for a prior engagement. The two remaining pilots, the display leaders and a fourth experienced pilot then took off in the four Turbulent aircraft for a practice formation flight away from the airfield. As briefed, when they returned to the airfield, they practiced the limbo manoeuvre. The aircraft were positioned with approximately 200 m between each aircraft to approach the limbo gate. The four aircraft completed two passes through the limbo gate without incident before landing normally.

As planned, they kept the engines running on the four aircraft whilst the fourth pilot swapped with another experienced pilot before they embarked on another flight. The two new pilots switched their formation positions for the second flight. The display leader reported that the weather conditions were settled with a light and variable wind and overcast skies. None of the pilots flying that day reported any significant turbulence.

The second flight commenced with formation practice away from the airfield as before. On return to the airfield the team planned to conduct two passes through the limbo gate as they had done on the first flight. The first two aircraft passed through the limbo gate without incident. However, as the third aircraft approached the gate it was seen to pitch down and hit the ground. As the aircraft hit the ground the wings folded upwards and the aircraft came to rest inverted approximately 80 m past the limbo poles (Figure 1 and 2). The pilot was

Footnote

[3] The flights were conducted under a CAA Long Term Permission (LTP) issued to Damyns Hall Aerodrome which allowed aircraft to fly below the minimum SERA height for the purpose of display practice (whilst complying with the conditions specified in the LTP).

assisted from the aircraft and taken to hospital. He had suffered a serious head injury and other injuries. He was released from hospital after 72 hours.

Figure 1
G-ARGZ after the accident

After the accident, the pilot remembered setting himself up to fly through the limbo gate. He recalled that he gave himself enough space behind the preceding aircraft and positioned the aircraft centrally, wings level as he approached the poles at approximately 5 ft. However, as he approached the bunting, he had the impression that he was a little too high. He commented that everything happened very quickly and he was not certain what happened but he thought he pitched the nose forward for an instant and then centralised the controls intending to reduce height slightly. He was expecting to see the aircraft in level flight but it struck the ground. He recalled seeing the right wing folding and the landing gear coming into view. He realised he was no longer flying, braced himself and waited for the aircraft to come to rest.

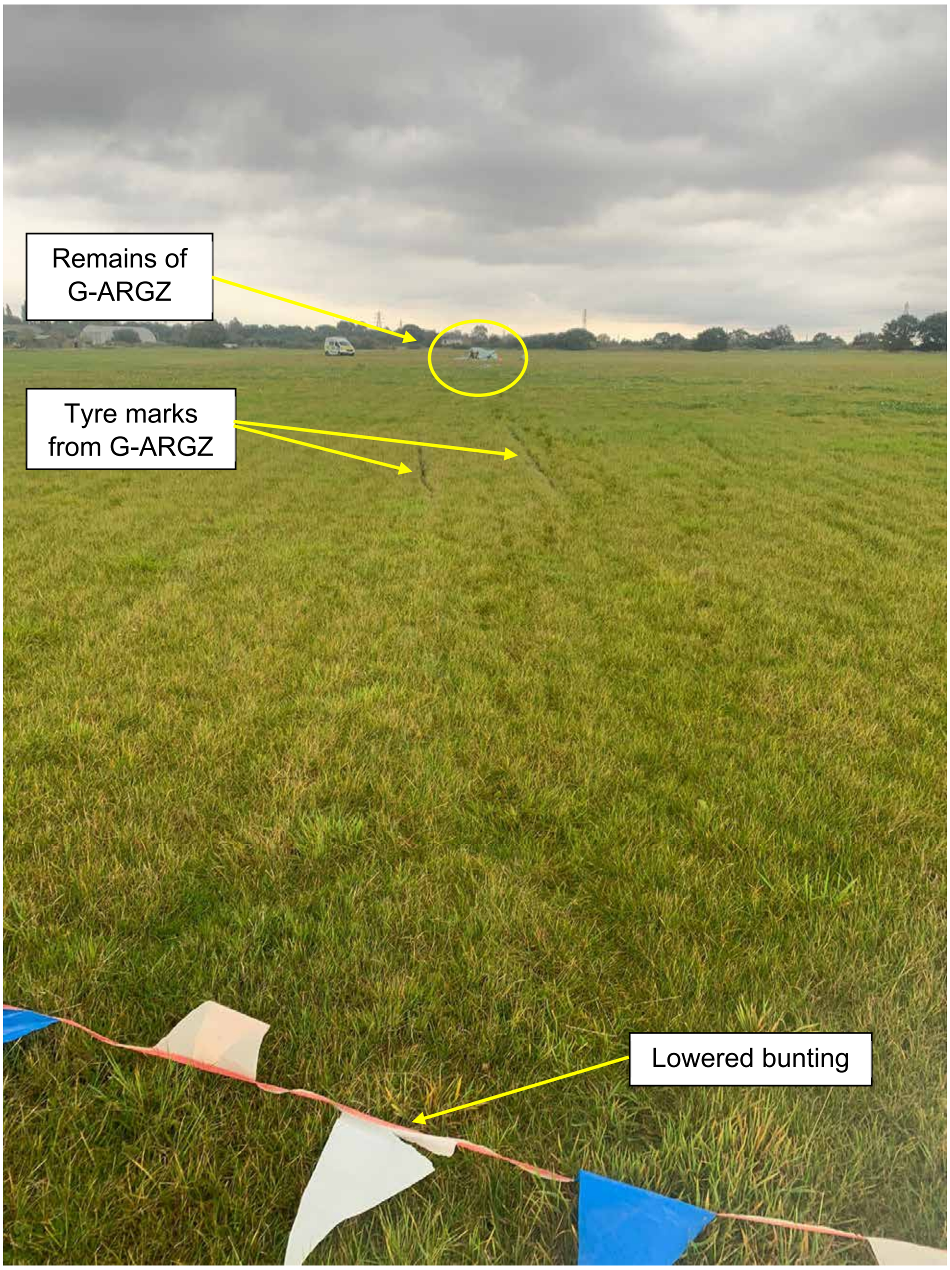

Figure 2

Accident site with the bunting in the fore ground and tyre marks for the accident aircraft

Recorded information

The aircraft was fitted with a cockpit mounted camera but the recording stopped just prior to the accident. The accident was filmed from the ground from two camera positions. The footage shows the aircraft approached the poles with the wings level and in level flight (Figure 3). The video showed that just before it reached the pole the aircraft pitched nose-down (Figure 4). There was no roll or yaw with the pitch change. The aircraft struck the ground on its main wheels in a wings level attitude. As it struck the ground both wings folded upwards (Figure 5). There was less than one second between the pitch change and the aircraft striking the ground.

Figure 3
Accident aircraft approaching the limbo gate

Figure 4
Accident aircraft pitched nose-down

Figure 5
Accident aircraft as it struck the ground and the wings folded upwards

Pilot's background and reflections

The pilot obtained his fixed wing private pilot's licence in 1997. After this he switched to helicopter flying and became a commercial helicopter pilot; he did not fly fixed wing aircraft again for several years. In 2011 he renewed his fixed wing licence and in the following years learnt to fly the de Havilland Chipmunk and obtained a sea plane rating. In 2021 he completed a Tiger Moth conversion course. Following this he was offered the opportunity to fly the Turbulent and undertook a formation flying course in the aircraft. He was then asked if he would like to join the display team. The accident occurred on the pilot's second training day with the display team.

The pilot had approximately 7,200 hours of helicopter flying time and approximately 300 hours of fixed wing flying.

The pilot reported that he was fit and well rested on the day of the accident. He stated that the formation flying had been a good challenge, and that he did not feel any external pressure on the day to complete the task.

After the accident the pilot felt there were three factors which contributed to the accident:

- He thought he made an instinctive decision to attempt to reduce height as the aircraft approached the bunting. However, afterwards he realised his height was probably acceptable and even if the aircraft was too high it would have been better to accept it as the bunting had a weak link and would break if the aircraft caught it.
- The controls are light and effective, meaning that only a small movement generates a significant pitch change.
- He had more experience flying helicopters than fixed wing aircraft. He thought that perhaps in that instant he had made a control input that would have made a small height change in a helicopter, returning it to a level attitude, but in the Turbulent resulted in a significant rate of descent.

Aircraft information

The Druine Turbulent is a light-weight low-wing single-seat aircraft constructed from wood with a fabric covering. The maximum authorised weight is 620 lbs. The maximum authorised airspeed (V_{NE}) is 109 kt. Typically approach and landing is made at 55 – 60 kt.

Aircraft examination

A pilot who flew G-ARGZ earlier in the day reported that the aircraft had been flying well with no problems. Members of the flying club examined the aircraft after the accident, paying particular attention to the flying controls, but did not find any evidence of any pre-existing defects. It was evident from the wreckage that the main wing spar had broken as the aircraft struck the ground.

Previous accident

The AAIB reported on a similar accident which occurred in the same aircraft type at Headcorn Aerodrome on 15 March 2008[4]. On that occasion it was concluded that the aircraft probably encountered a disturbed air mass that resulted in an uncommanded change of flight path.

Analysis

Whilst flying under the limbo gate the aircraft pitched nose-down and collided with the ground. The aircraft struck the ground with sufficient force to break the wing spar, causing both wings to fold up.

There was no evidence to suggest there was any defect with the aircraft which could have contributed to the accident.

The video showed the aircraft was in stable flight as it approached the limbo gate and there was no roll or yaw as the pitch changed. This suggests the aircraft was not affected by turbulence or wake from another aircraft. The other pilots flying at the same time also did not report any turbulence.

The flying club reported that they conducted an extensive briefing before the flight, including allowing the trainees to watch the manoeuvre flown by experience pilots prior to their own flights. The club reported that the weather conditions were suitable for conducting the flights.

The pilot reported that he was fit and well on the day and felt well prepared and briefed for the flight.

Whilst the pilot was not certain what happened during the accident, he thought that as he approached the limbo gate, he had felt the aircraft was too high and had instinctively pitched forward. The video recording showed that the aircraft struck the ground less than one second after the pitch change. It is unlikely the pilot had sufficient time to realise the effect of the pitch change prior to the impact. He considered that his considerable experience on helicopters may have caused him to make a control input more suitable for a helicopter rather than the Turbulent.

The flying club conducted an internal review following the accident and decided that in future new pilots will be required to practice flying along the runway at 5 ft and 90 kt to become familiar with flying the aircraft at low level and high speed prior to flying under the limbo gate. It intends to place an additional marker on the ground immediately beneath the central triangle to give pilots an additional reference point to help position the aircraft. It also intends to film all future limbo transits to inform pilots about their positioning. The flying club considered these measures would help to prevent a similar accident occurring again.

Footnote

[4] G-APTZ reported in AAIB Bulletin 11/2008, available at https://www.gov.uk/aaib-reports/durine-d-31-turbulent-g-aptz-15-march-2008 [accessed December 2021].

Conclusion

Whilst learning to fly a limbo manoeuvre, it is likely that the pilot thought he was slightly too high when passing under the cable and made an instinctive nose-down pitch input. The aircraft struck the ground before he had time to realise the effect of the pitch input.

The flying club have added some additional training which they intend will prevent a similar accident occurred again.

ACCIDENT

Aircraft Type and Registration:	Supermarine Aircraft Spitfire Mk 26, G-CIEN
No & Type of Engines:	1 Isuzu V6 piston engine
Year of Manufacture:	2014 (Serial no: PFA 324-14492)
Date & Time (UTC):	12 August 2021 at 2010 hrs
Location:	Newtownards Airport, County Down
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to landing gear, left wingtip, propeller, and engine cowlings
Commander's Licence:	Private Pilot's Licence
Commander's Age:	47 years
Commander's Flying Experience:	712 hours (of which 1 was on type) Last 90 days - 42 hours Last 28 days - 8 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and further enquiries by the AAIB

Synopsis

After landing, the aircraft suddenly veered to the right causing the left wingtip, propeller, and engine cowl to scrape the runway. Examination of the left landing gear leg revealed a failed weld that had allowed the lower part of the leg to rotate and consequently affect the wheel alignment. It is possible that the weld was damaged during a previous heavy landing, but due to the design of the leg it had not been possible to inspect the weld. The LAA has issued a warning to owners and is reviewing the design of the landing gear.

History of the flight

The pilot had recently purchased the aircraft and conducted a Permit to Fly revalidation check flight after various modifications had been embodied. The flight passed without incident and the pilot landed on Runway 21 at Newtownards Airport. The aircraft was slowing down on the runway centreline when it suddenly veered to the right. The pilot first applied left rudder and then full left brake but could not prevent the left wingtip, propeller and lower engine cowl scraping the runway. The aircraft came to rest off the runway with damage to both landing gear legs (Figure 1).

Figure 1

Landing gear damage
(Photograph used with permission)

Aircraft information

The Supermarine Spitfire Mk 26 is a kit build, 80% scale replica of the classic warbird, and is powered by an Isuzu V6 engine and a three-bladed propeller. There are fifteen Mk 26 aircraft registered in the UK with the oldest being 15 years old.

The landing gear consists of two retractable main gear legs and a steerable tail wheel. Each leg is sprung without any damping and is fitted with a disc brake and an aerodynamic fairing. The main gear legs are raised and lowered by an electrically powered actuator and locked in position by manually operated locking pins. Lights in the cockpit indicate to the pilot when the undercarriage is UNLOCKED, IN TRANSIT and LOCKED.

Each main gear leg has a large diameter upper steel tube (Figure 2 - A1) fitted with a pintle pin (A2), an attachment for the extension / retraction actuator (C3), and a locator for the locking pin (A3 & A9). Inside the upper tube, underneath the pintle pin, is a thick washer (A11) welded to the tube, and a splined shaft (A12) that is welded (shown) to the top surface of the washer. A thin metal disc (A5) is welded to the top of the upper tube to close it. A smaller diameter steel lower tube (B1) slides inside the upper tube, and a coil spring (B6) supports the weight of the aircraft. Another thick washer (B2), which has an internal spline that matches the splined shaft, is welded to the top of the lower tube. This arrangement allows the lower tube to slide and compress the spring but not rotate relative to the upper tube. A nut (B5) on the end of the splined shaft retains the lower leg. The brake and wheel axle are attached to the bottom of the lower leg.

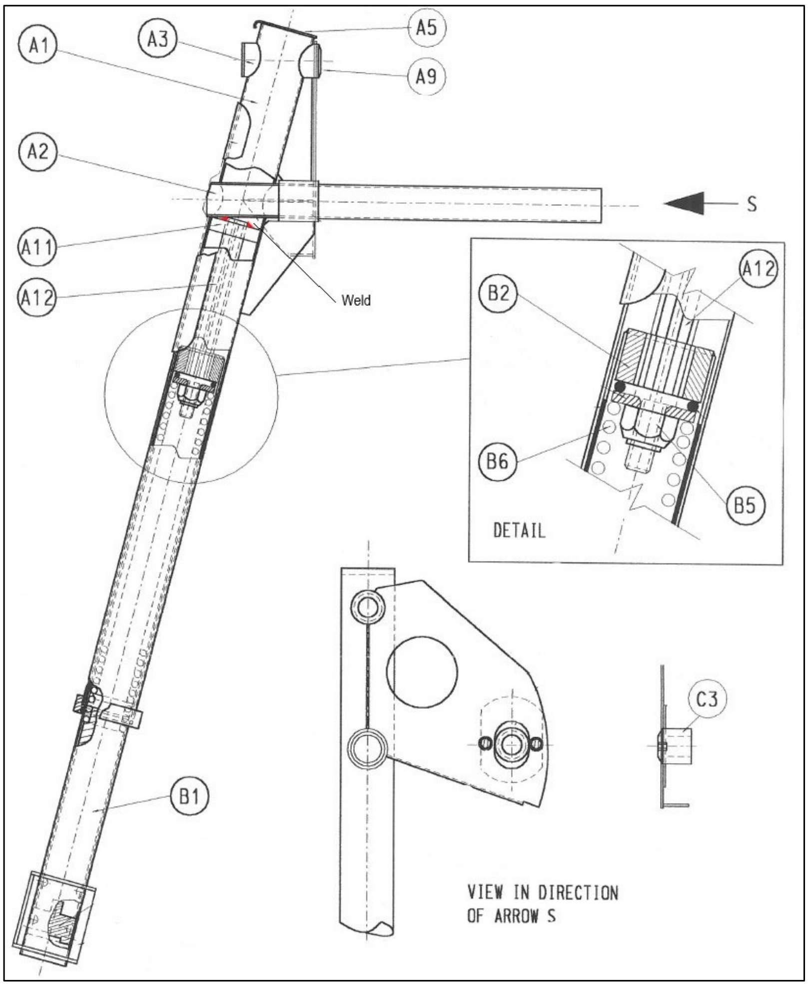

Figure 2
Section views of undercarriage leg

Aircraft examination

The left main gear leg was removed from the aircraft, and the upper tube was cut between the pintle pin and the thick washer (Figure 3). This enabled the fillet weld between the splined shaft and the thick washer to be inspected. It was evident that the weld had broken, and the splined shaft had rotated. The fillet weld was measured to be approximately 2 mm (Figure 4) with minimal weld penetration on the splined shaft.

Other information

In July 2017 the aircraft suffered a heavy landing after which both main gear legs were removed for inspection. This did not include an inspection of the weld that failed as access is only possible if the gear leg is cut as shown in Figure 3. The aircraft was reassembled and completed one flight in May 2018 before being sold to the current owner. The next flight was the accident flight.

Weld penetration

The LAA and an experienced independent engineer obtained another pair of gear legs from a Spitfire Mk 26 which had also been involved in a heavy landing. They were cut at the same location and the splined shaft to thick washer welds were examined. In their opinion, there was better weld penetration on both legs when compared to the accident aircraft leg. They concluded that manufacturing variability could have been a causal factor in the failure of the welded joint.

Manufacturing

All Spitfire Mk 26 landing gear legs were manufactured in Australia when the manufacturer was located there. The company is now based in Texas, USA and no longer makes the Mk 26. The later Mk 26B is a 90% scale replica and uses a different design of landing gear legs with a scissor link between the upper and lower tubes to react torsional loads instead of the splined shaft. This is the only standard currently available.

Figure 3
The left main gear leg removed and cut

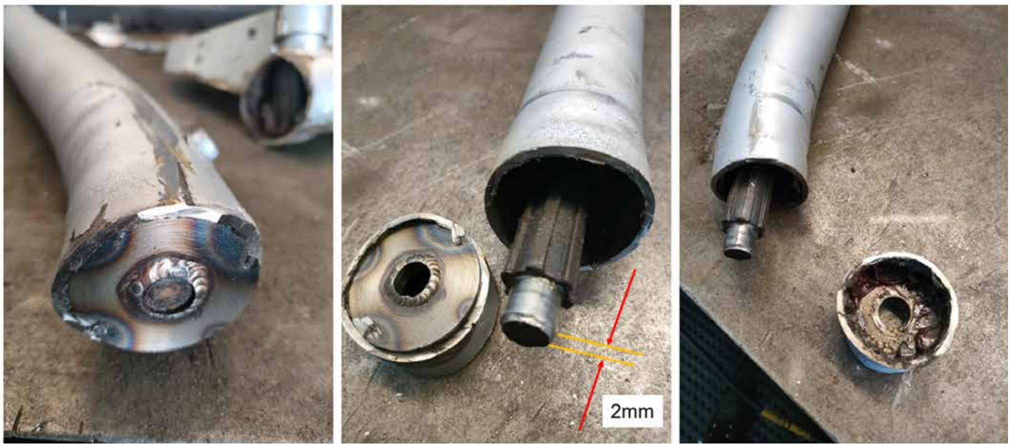

Figure 4
The left main gear leg with the thick washer removed

Analysis

During the landing roll, the weld between the thick washer and the splined shaft on the left main gear leg failed, allowing the lower leg, and consequently the wheel assembly, to rotate. This resulted in the aircraft veering to the right, despite the pilot applying full left rudder and left braking. The left leg was bent as the right wing lifted and the left wingtip, propeller and engine cowl scraped the runway.

The aircraft had not been flown since 2018 when, under previous ownership, it had suffered a heavy landing. The landing gear had been stripped, however the weld that failed could not be inspected. The aircraft had flown once between the heavy landing and the accident flight.

Comparison of the failed weld from G-CIEN and another pair of Mk 26 gear legs revealed poor weld penetration. This may have been the result of manufacturing variability and would have reduced the strength of the welded joint. The heavy landing may have damaged the weld, such that it failed after a further two landings.

The Spitfire Mk 26 landing gear is no longer manufactured, having been replaced with a different design for the heavier Mk 26B. The LAA are reviewing the design and the access restrictions to inspect the weld that failed to determine if further action is needed. The LAA have also issued a warning to all owners of UK registered Mk 26 aircraft about the possibility of hidden damage to the weld following a hard landing. No similar failures have been experienced by any of the 15 UK registered Spitfire Mk 26 aircraft since the first one flew in 2006.

Conclusion

A weld in the left landing gear leg failed during the landing, which allowed the left main wheel to rotate and the aircraft to veer to the right. Two landings prior to the accident flight, the aircraft landed heavily however, due to the design of the landing gear leg the subsequent inspection could not have detected any damage to the weld. Manufacturing variability could have resulted in poor weld penetration and therefore a reduction in strength. The LAA are reviewing the design of the undercarriage of the Mk 26 and have issued a warning to UK owners of the potential for hidden damage following a heavy landing.

Safety actions/Recommendations

As a result of this accident the following safety action has been taken:

> The Light Aircraft Association has issued a warning to all UK owners of Spitfire Mk 26 aircraft that there is potential for hidden damage to a weld following a heavy landing.
>
> The Light Aircraft Association is reviewing of the design of the Spitfire Mk 26 undercarriage leg, including the access restriction to inspect the weld that failed.

ACCIDENT

Aircraft Type and Registration:	DJI Matrice 300 RTK
No & Type of Engines:	4 electric motors
Year of Manufacture:	2021 (Serial no: 1ZNBJ1G00C00ED)
Date & Time (UTC):	3 August 2021 at 2337 hrs
Location:	Seymour Grove, Old Trafford, Manchester
Type of Flight:	Commercial Operations (UAS)
Persons on Board:	Crew - None Passengers - None
Injuries:	Crew - N/A Passengers - N/A
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Other
Commander's Age:	44 years
Commander's Flying Experience:	18 hours (of which 18 were on type) Last 90 days - 4 hours Last 28 days - 1 hour
Information Source:	Aircraft Accident Report Form submitted by the pilot

The DJI Matrice 300 RTK was being operated at night in support of RFFS operations to locate a missing person. After approximately nine minutes and 28 seconds of flight, when at a height of 63 metres, the pilot and observer heard an audible "bang or pop." The UA initiated a three-rotor emergency landing sequence, flying in a rapidly descending arc until it struck the ground. The aircraft was destroyed. Examination of the UA and review of the log file by the UAS manufacturer identified that the left rear frame arm folded back during the flight and struck the motor. This resulted in failure of the rotor, triggering the emergency landing mode. The UAS manufacturer considered there was a high likelihood that the locking collar at the junction of the frame arm had not been fully tightened, causing the rotor arm to fold back in flight.

AAIB Record-Only Investigations

This section provides details of accidents and incidents which were not subject to a Field or full Correspondence Investigation.

They are wholly, or largely, based on information provided by the aircraft commander at the time of reporting and in some cases additional information from other sources.

The accuracy of the information provided cannot be assured.

Record-only investigations reviewed: November - December 2021

22 Jul 2020 **Luscombe 8E** **G-BUKU** Old Hay Airfield, Kent

As the aircraft slowed through approximately 20-30 kt on landing, a gust of wind from the left caused the aircraft to yaw left and head towards the edge of the runway. The pilot applied right brake, which caused the aircraft to "snatch" to the right, so he applied left brake to try and regain control. With both brakes applied, the aircraft tipped forward onto its propeller and then over onto its back just off the side of the runway.

28 Sep 2020 **Pioneer 300 Hawk** **G-ISBD** Cranfield Airport, Bedfordshire

Shortly after a firm touchdown during a crosswind landing, the aircraft started veering right and came to a halt before leaving the asphalt surface. The pilot initially suspected a flat tyre but, after disembarking, found the right landing gear assembly to be buckled and partly collapsed. This reportable event was not notified to the AAIB until September 2021.

15 Jun 2021 **Jabiru UL-450** **G-ENRE** Newton Peveril Airfield, Dorset

The pilot conducted two go-arounds due to being too fast in variable winds on the first approach and because of a gust of wind during the second. The third approach was fast; the aircraft bounced on landing and the nose gear collapsed.

2 Jul 2021 **Eurofox 912(IS)** **G-TTUG** Saltby Airfield, Lincolnshire

After a normal landing on grass and during the roll out at slow speed, the nosewheel strut failed. Microscopic examination of the fracture surface revealed signs of corrosion fatigue which initiated from a crack, probably induced from a previous hard landing.

8 Sep 2021 **Escapade** **G-LEEK** Old Park Farm, Neath Port Talbot

On short final, the aircraft's landing gear contacted a hedge which caused the aircraft to pitch down and land heavily, resulting in substantial damage.

4 Oct 2021 **Pegasus Quantum 15-912** **G-NAPO** East Fortune Airfield, East Lothian

The pilot was carrying out a glide approach to land on Runway 25. The approach was slightly fast at 60 mph to penetrate the 11 kt headwind and was "noticeably steeper" than earlier crosswind approaches to Runway 29. As the aircraft rounded out to land at the start of the runway, it clipped a 5 ft high perimeter fence post with the trike gear, causing the aircraft to yaw right and roll left onto the concrete start of the runway. It slid to a stop on its side, having sustained damage to the wing.

Record-only investigations reviewed: November - December 2021 cont

5 Nov 2021 **Reims Cessna F152** **G-BFOE** Shoreham Airport, West Sussex

On landing, the solo student pilot lost directional control of the aircraft which departed onto adjacent grass, damaging a runway edge light. The pilot carried out a go-around and landed successfully.

5 Nov 2021 **Piper PA-28-180** **G-AVRK** Teesside Airport, County Durham

Following a normal approach, the aircraft bounced several times on the runway during which the nose gear leg failed. The aircraft veered to the left and came to a halt on the the grass at the side of the runway.

24 Nov 2021 **TL 2000UK Sting Carbon** **G-STIN** Godshill, Isle of Wight

During a fourth practice landing, the aircraft floated further along the runway and overran into a hedge. The aircraft was extensively damaged but the pilot was uninjured.

28 Nov 2021 **Bolkow Bo 209 Monsun** **G-AYPE** Bembridge Airport, Isle of Wight

Shortly after an uneventful touchdown at Bembridge Airport on the Isle of Wight, the nose gear collapsed.

9 Dec 2021 **Ikarus C42 FB80** **G-CKGS** Cotswold Airport, Gloucestershire

Shortly before touchdown while landing, the aircraft stalled and landed heavily. The left landing gear collapsed and the aircraft veered to left, stopping on grass south of runway.

Miscellaneous

This section contains Addenda, Corrections and a list of the ten most recent Aircraft Accident ('Formal') Reports published by the AAIB.

The complete reports can be downloaded from the AAIB website (www.aaib.gov.uk).

BULLETIN CORRECTION

Aircraft Type and Registration:	Grob G102 Astir CS, G-CJSK
Date & Time (UTC):	23 June 2021 at 1337 hrs
Location:	Gibett Hill, Brentor, near Tavistock, Devon
Information Source:	Aircraft Accident Report Form submitted by the pilot

AAIB Bulletin No 12/2021, page 40 refers

Following publication it was noted that in the first and fourth paragraphs on the second page of this report the airfield was named as Bodmin. This should have read Brentor.

The text should read:

> The pilot launched by winch from ***Brentor Airfield*** at 1250 hrs and climbed to an altitude of 4,100 ft for local soaring.

And:

> The glider came to rest in an area of open ground approximately 1 nm NNE from ***Brentor Airfield*** in an inverted attitude (Figure 1).

The online version of this report was corrected on 15 December 2021.

BULLETIN CORRECTION

Aircraft Type and Registration:	Jodel D120, G-BKAE
Date & Time (UTC):	23 June 2021 at 1055 hrs
Location:	Shacklewell Airfield, Stamford, Lincolnshire
Information Source:	Aircraft Accident Report Form

AAIB Bulletin No 10/2021, page 75 refers

Following publication it was noted that the location stated in this report was incorrect.

The original report stated the location of the accident was Shacklewell Airfied, Kent. The actual location of the accident was **Shacklewell Airfield, Stamford, Lincolnshire**.

The online version of the report was corrected on 9 December 2021.

TEN MOST RECENTLY PUBLISHED FORMAL REPORTS ISSUED BY THE AIR ACCIDENTS INVESTIGATION BRANCH

1/2015 Airbus A319-131, G-EUOE
London Heathrow Airport
on 24 May 2013.

Published July 2015.

2/2015 Boeing B787-8, ET-AOP
London Heathrow Airport
on 12 July 2013.

Published August 2015.

3/2015 Eurocopter (Deutschland) EC135 T2+, G-SPAO
Glasgow City Centre, Scotland
on 29 November 2013.

Published October 2015.

1/2016 AS332 L2 Super Puma, G-WNSB
on approach to Sumburgh Airport
on 23 August 2013.

Published March 2016.

2/2016 Saab 2000, G-LGNO
approximately 7 nm east of Sumburgh Airport, Shetland
on 15 December 2014.

Published September 2016.

1/2017 Hawker Hunter T7, G-BXFI
near Shoreham Airport
on 22 August 2015.

Published March 2017.

1/2018 Sikorsky S-92A, G-WNSR
West Franklin wellhead platform, North Sea
on 28 December 2016.

Published March 2018.

2/2018 Boeing 737-86J, C-FWGH
Belfast International Airport
on 21 July 2017.

Published November 2018.

1/2020 Piper PA-46-310P Malibu, N264DB
22 nm north-north-west of Guernsey
on 21 January 2019.

Published March 2020.

1/2021 Airbus A321-211, G-POWN
London Gatwick Airport
on 26 February 2020.

Published May 2021.

Unabridged versions of all AAIB Formal Reports, published back to and including 1971, are available in full on the AAIB Website

http://www.aaib.gov.uk

GLOSSARY OF ABBREVIATIONS

aal	above airfield level
ACAS	Airborne Collision Avoidance System
ACARS	Automatic Communications And Reporting System
ADF	Automatic Direction Finding equipment
AFIS(O)	Aerodrome Flight Information Service (Officer)
agl	above ground level
AIC	Aeronautical Information Circular
amsl	above mean sea level
AOM	Aerodrome Operating Minima
APU	Auxiliary Power Unit
ASI	airspeed indicator
ATC(C)(O)	Air Traffic Control (Centre)(Officer)
ATIS	Automatic Terminal Information Service
ATPL	Airline Transport Pilot's Licence
BMAA	British Microlight Aircraft Association
BGA	British Gliding Association
BBAC	British Balloon and Airship Club
BHPA	British Hang Gliding & Paragliding Association
CAA	Civil Aviation Authority
CAVOK	Ceiling And Visibility OK (for VFR flight)
CAS	calibrated airspeed
cc	cubic centimetres
CG	Centre of Gravity
cm	centimetre(s)
CPL	Commercial Pilot's Licence
°C,F,M,T	Celsius, Fahrenheit, magnetic, true
CVR	Cockpit Voice Recorder
DFDR	Digital Flight Data Recorder
DME	Distance Measuring Equipment
EAS	equivalent airspeed
EASA	European Union Aviation Safety Agency
ECAM	Electronic Centralised Aircraft Monitoring
EGPWS	Enhanced GPWS
EGT	Exhaust Gas Temperature
EICAS	Engine Indication and Crew Alerting System
EPR	Engine Pressure Ratio
ETA	Estimated Time of Arrival
ETD	Estimated Time of Departure
FAA	Federal Aviation Administration (USA)
FIR	Flight Information Region
FL	Flight Level
ft	feet
ft/min	feet per minute
g	acceleration due to Earth's gravity
GPS	Global Positioning System
GPWS	Ground Proximity Warning System
hrs	hours (clock time as in 1200 hrs)
HP	high pressure
hPa	hectopascal (equivalent unit to mb)
IAS	indicated airspeed
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
IP	Intermediate Pressure
IR	Instrument Rating
ISA	International Standard Atmosphere
kg	kilogram(s)
KCAS	knots calibrated airspeed
KIAS	knots indicated airspeed
KTAS	knots true airspeed
km	kilometre(s)
kt	knot(s)
lb	pound(s)
LP	low pressure
LAA	Light Aircraft Association
LDA	Landing Distance Available
LPC	Licence Proficiency Check
m	metre(s)
mb	millibar(s)
MDA	Minimum Descent Altitude
METAR	a timed aerodrome meteorological report
min	minutes
mm	millimetre(s)
mph	miles per hour
MTWA	Maximum Total Weight Authorised
N	Newtons
N_R	Main rotor rotation speed (rotorcraft)
N_g	Gas generator rotation speed (rotorcraft)
N_1	engine fan or LP compressor speed
NDB	Non-Directional radio Beacon
nm	nautical mile(s)
NOTAM	Notice to Airmen
OAT	Outside Air Temperature
OPC	Operator Proficiency Check
PAPI	Precision Approach Path Indicator
PF	Pilot Flying
PIC	Pilot in Command
PM	Pilot Monitoring
POH	Pilot's Operating Handbook
PPL	Private Pilot's Licence
psi	pounds per square inch
QFE	altimeter pressure setting to indicate height above aerodrome
QNH	altimeter pressure setting to indicate elevation amsl
RA	Resolution Advisory
RFFS	Rescue and Fire Fighting Service
rpm	revolutions per minute
RTF	radiotelephony
RVR	Runway Visual Range
SAR	Search and Rescue
SB	Service Bulletin
SSR	Secondary Surveillance Radar
TA	Traffic Advisory
TAF	Terminal Aerodrome Forecast
TAS	true airspeed
TAWS	Terrain Awareness and Warning System
TCAS	Traffic Collision Avoidance System
TODA	Takeoff Distance Available
UA	Unmanned Aircraft
UAS	Unmanned Aircraft System
USG	US gallons
UTC	Co-ordinated Universal Time (GMT)
V	Volt(s)
V_1	Takeoff decision speed
V_2	Takeoff safety speed
V_R	Rotation speed
V_{REF}	Reference airspeed (approach)
V_{NE}	Never Exceed airspeed
VASI	Visual Approach Slope Indicator
VFR	Visual Flight Rules
VHF	Very High Frequency
VMC	Visual Meteorological Conditions
VOR	VHF Omnidirectional radio Range

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