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.

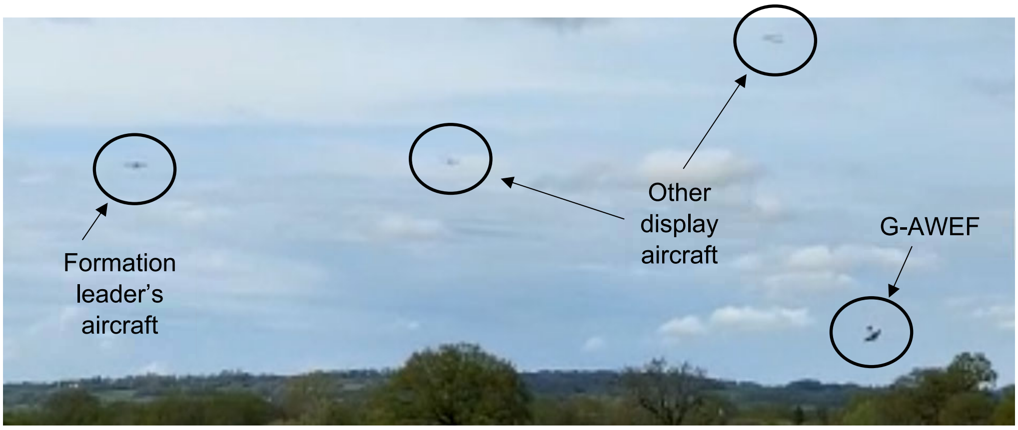

Figure 2

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).

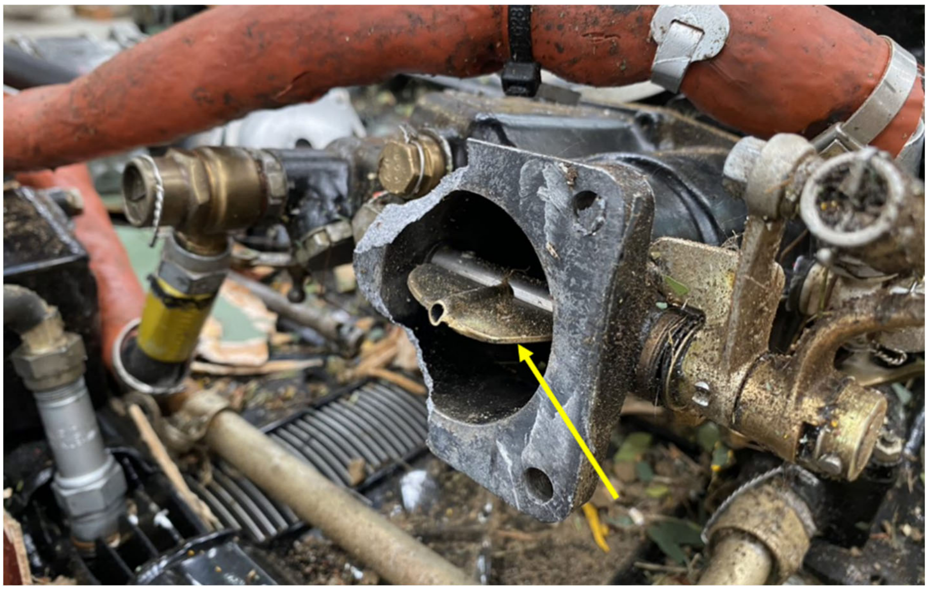

Figure 8

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.

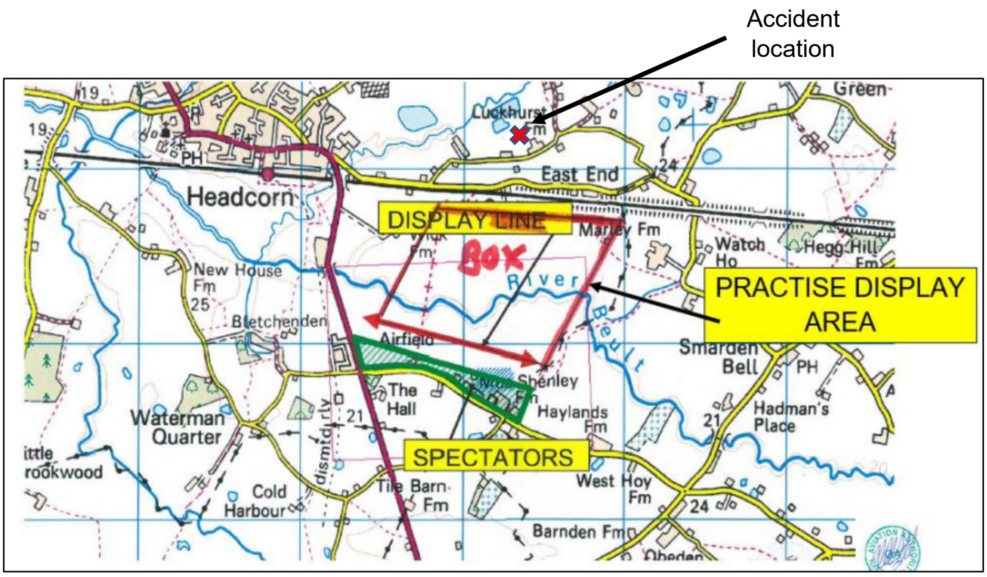

Figure 9

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.

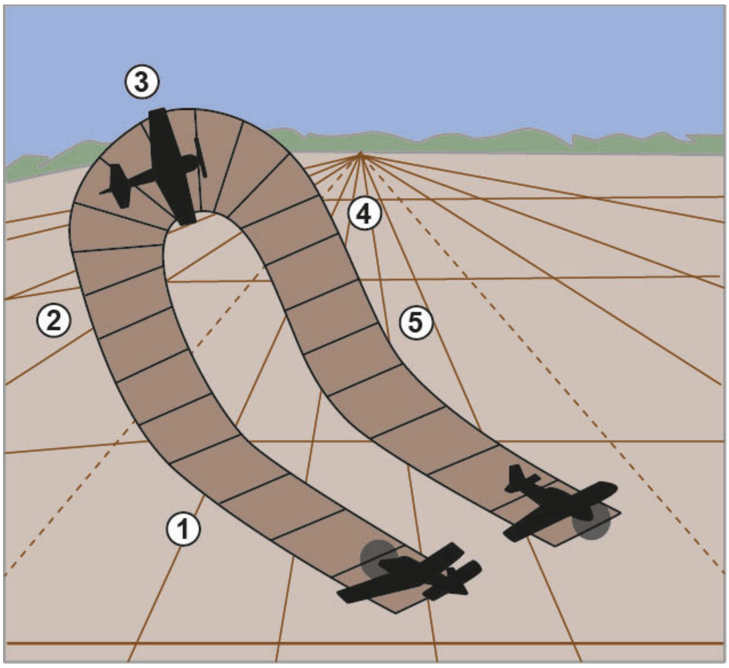

Figure 10

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.

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