Accident

Aircraft Type and Registration:	Spitfire Mk 26B, G-ENAA
No & Type of Engines:	1 Isuzu V6 piston engine
Year of Manufacture:	2013 (Serial no: LAA 324-15097)
Date & Time (UTC):	28 July 2024 at 1258 hrs
Location:	Enstone Airfield, West Oxfordshire
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:	Airline Transport Pilot's Licence
Commander's Age:	71 years
Commander's Flying Experience:	21,740 hours (of which 19 were on type) Last 90 days - 2 hours Last 28 days - 1 hours
Information Source:	AAIB Field Investigation

Synopsis

The aircraft yawed left during the takeoff roll, pitched up rapidly and once airborne rolled rapidly to the left. The left wingtip struck the ground and the aircraft came to rest inverted and caught fire. The pilot was fatally injured. The investigation found that the aircraft most probably stalled during the rapid pitch up and that the ensuing left roll and yaw occurred as a result of a post-stall autorotation.

Examination of the aircraft, while limited to some extent by the disruption caused by the impact and fire, did not reveal any technical defects which may have adversely affected the controllability of the aircraft.

No definitive cause was established for the loss of control.

History of the flight

Two members of the syndicate that owned the aircraft drove to Enstone Airfield together on the morning of the accident. They arrived at approximately 1000 hrs and moved the aircraft out of its hangar. The surviving syndicate member described the pre-flight checks as "all good." That pilot boarded the aircraft and taxied out at approximately 1200 hrs. He conducted a general handling flight in the local area for 30 minutes, during which there were no technical issues with the aircraft. He parked the aircraft near point B (Figure 1) for the crew change.

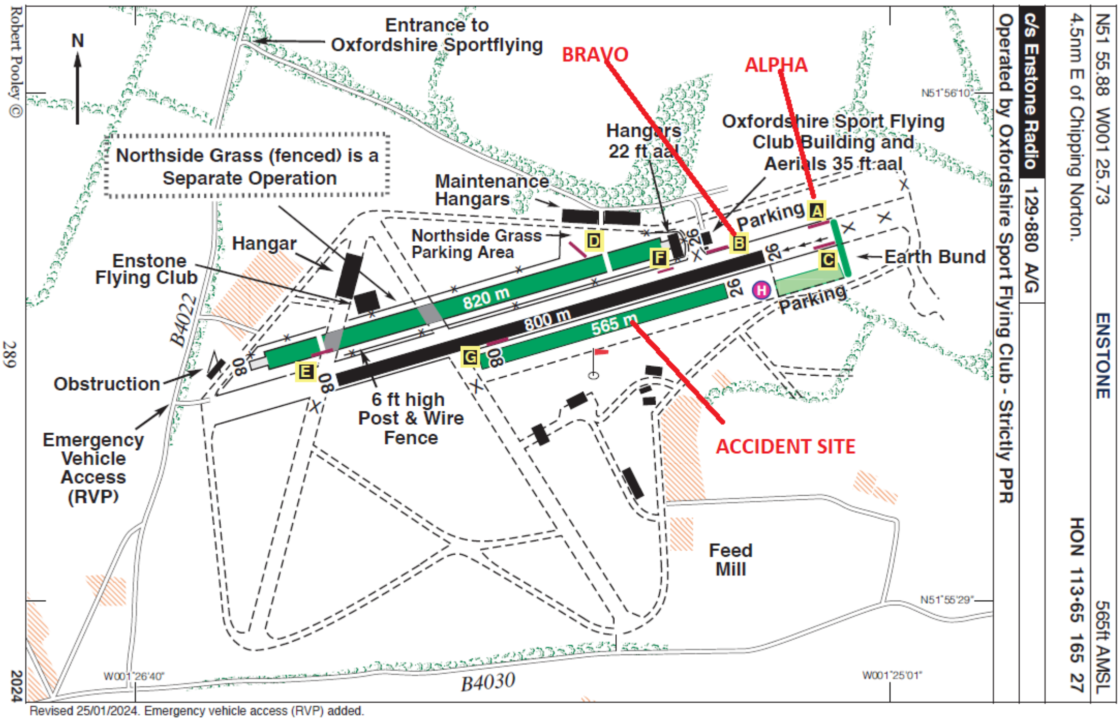

Figure 1
Enstone Airfield Chart

The first pilot had flown with the aircraft seat in its most aft position. During the crew change the pilots worked together to move the seat to the middle position of the three available. The seat was secured in that position with pip pins. The first pilot opened the engine cowling to check for leaks and stated that none were found. He then helped the second pilot strap into the seat's four-point harness. The second pilot then started the aircraft and taxied to position A (Figure 1) where he was seen to do the engine run up checks. He then lined up for takeoff on tarmac Runway 26 (shown in black in Figure 1).

The initial part of the takeoff roll seemed normal and the aircraft tailwheel lifted as expected. The tail then lowered to the ground and the aircraft yawed left towards the edge of the tarmac runway. As it approached the edge of the tarmac, the aircraft pitched up sharply and then rolled rapidly to the left. The left wingtip struck the ground, with approximately 120° of bank angle, followed by the nose. Immediately after the nose struck the ground a large fire broke out causing extensive further damage to the aircraft. The pilot was fatally injured.

Accident site

The aircraft came to rest at the southern edge of the south side grass Runway 26, approximately 45 m from the edge of tarmac Runway 26. The ground marks showed that the left wingtip struck the ground first, followed by the propeller and engine. Distinct propeller strikes on the ground indicated propeller rotation at the time of impact. The impact sequence was dynamic, with the right wing then striking the ground before the aircraft came to rest inverted. An intense post-crash fire, centred on the cockpit, caused extensive damage to the central part of the aircraft and engine bay.

Recorded information

Recorded information included closed-circuit television (CCTV) footage from two cameras located on the airfield's control tower and a video recording made by a witness using a mobile phone (Figure 2). The combined footage captured the aircraft as it taxied to the runway, the takeoff run, and subsequent takeoff through to the aircraft striking the ground. A recording of the radio communications between the pilot and airfield radio operator was also available.

Photogrammetry in conjunction with laser scan data of the accident site and of another Spitfire 26B was used to extrapolate G-ENAA's approximate speed, heading, pitch and roll angle during the accident takeoff. Smoothing algorithms were applied to the derived speed of the aircraft due to the varying quality of the recorded images. Because of this, values for speed are only an approximate indication.

Other potential sources of data, such as the pilot's mobile phone and the aircraft's MoTeC SDL3 instrument logger fitted in the cockpit were destroyed in the fire.

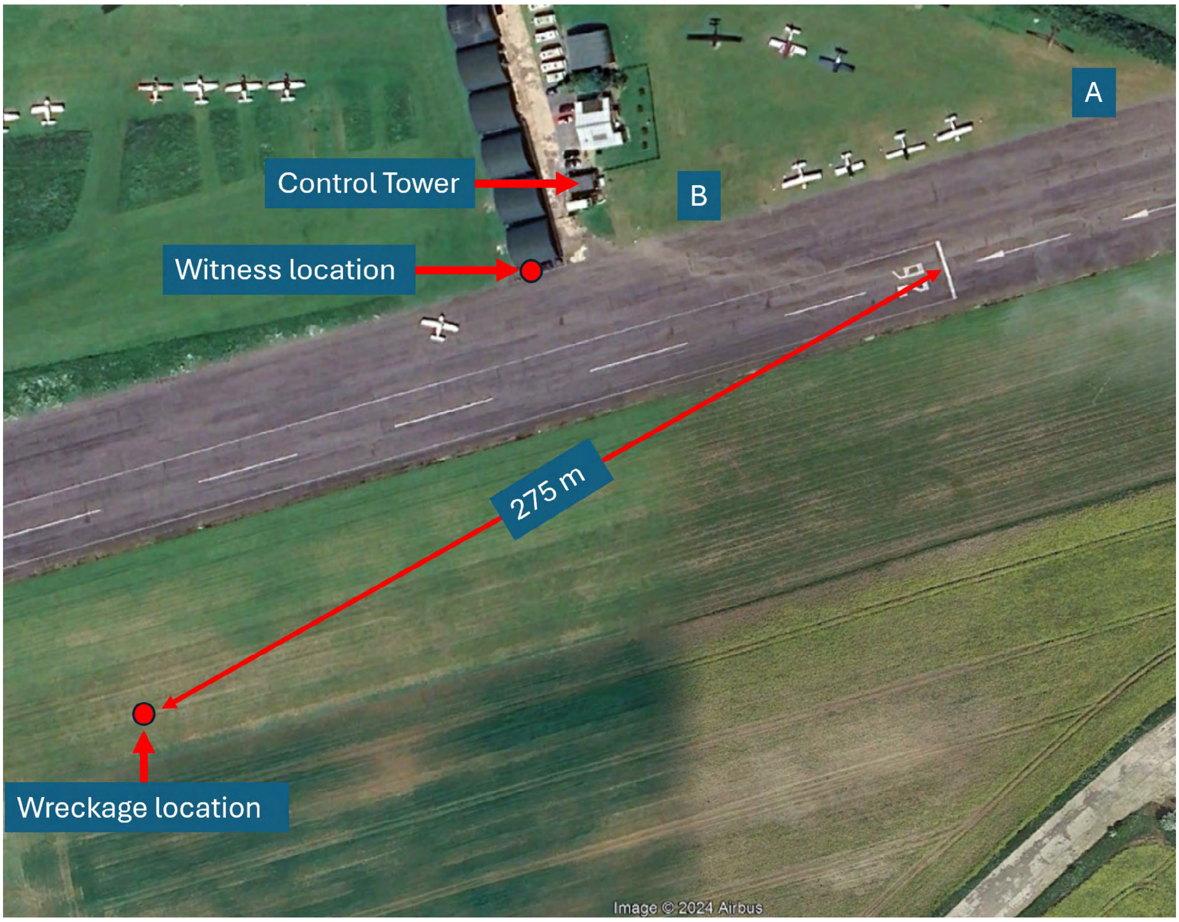

Figure 2

Relative position of control tower, taxi points A and B, witness and wreckage

Taxi and takeoff

The aircraft commenced taxiing towards Runway 26 at 1251:25 hrs from its parked position adjacent to the control tower. It taxied along the grass parking area to taxi point A, where it stopped short of the runway. The aircraft then remained stationary, consistent with pre-takeoff checks being performed, before the pilot transmitted at 1256:37 hrs that he was ready for departure. The flaps could be seen to be deployed but it was not possible at this point in the recordings to confirm their position. The radio operator advised that the surface wind was from 220° at 5 kt, which the pilot acknowledged; no further radio transmissions were received from the pilot. The wind direction and speed were consistent with the recorded footage of the airfield's windsock captured by the CCTV and witness video recordings. The aircraft then taxied to the runway where it was aligned to the right of the runway's centre line (Figure 3). At 1257:23 hrs the pilot commenced the takeoff run and the aircraft started to accelerate.

Figure 3
Aircraft at start of takeoff run

When the aircraft's airspeed reached approximately 45 kt, the tail of the aircraft lifted to an almost horizontal attitude (Figure 4), which coincided with a brief left rudder input, and the aircraft yawed to the left. The elevator could then be observed to move to a pitch up (control surface up) position, which was near to its full travel position, and the tail of the aircraft quickly lowered back towards the runway (Figure 5). The elevator remained in a pitch-up position, whilst the tailwheel tyre bounced on and off the runway surface several times. The aircraft's weight then settled on the tail wheel, which was almost coincident with the main landing gear tyres leaving the runway surface (Figure 6).

As the aircraft passed the witness's position, the pilot's head could be seen to be in an upright position and facing forward. At this point in the recording it was also possible to see that the flaps had been extended to about 10° and the elevator trim tab was set to approximately its mid-travel nose-up (surface down) position[1].

The aircraft continued to head towards the left side of the runway with the main wheels just clear of the runway surface whilst the tailwheel remained in contact (Figure 7). The aircraft's pitch attitude was about 12° nose-up. As the aircraft reached the side of the runway its airspeed was approximately 63 kt and it pitched up quickly at a rate of about 12°/s and started to climb (Figure 8). The elevators could then be seen to move quickly to a more neutral position. The pitch attitude reached just over 20° and the data indicated that the aircraft's airspeed reduced to approximately 58 kt. The aircraft then started rolling left, with a slight reduction in its pitch attitude to about 18° nose-up (Figure 9).

The aircraft's ailerons were then observed to move to a right roll position (left aileron surface down / right aileron surface up) (Figure 10) but the aircraft continued rolling left. The footage of the aircraft captured by the witness ended shortly after this point but the continuing flight path of the aircraft was recorded by one of the CCTV cameras (Figure 11). When the aircraft's bank angle reached about 30°, its pitch attitude briefly stabilised at about 15° nose-up but as the bank angle reached about 40° the roll rate increased quickly to about 70°/s. The aircraft's nose started to drop and the aircraft descended, with the bank angle reaching about 120° before the aircraft struck the ground, left wingtip first, at 1257:40 hrs.

The time interval from the start of the takeoff run to the aircraft striking the ground was about 17 seconds with the aircraft reaching a maximum height of approximately 30 ft agl. The rudder, elevators and ailerons could all be seen to have been moving during periods of the video footage and both flaps appeared symmetrically deployed.

Engine and propellor speed

The mobile phone recording contained sounds consistent with the operation of the aircraft's engine. This showed that at the start of the takeoff run the engine speed was about 2,000 rpm, and that the engine rpm was then progressively increased to a maximum of about 4,300 rpm; this equated to a propellor speed[2] of about 2,360 rpm. The recording indicated that this engine speed was maintained as the aircraft took off through to the aircraft subsequently striking the ground. There was no audible evidence of a problem with the engine, such as it backfiring.

Separate analysis using photogrammetry was also consistent with the propellor speed of about 2,360 rpm.

Footnote

1 The position of the flaps and pitch trim tab were established by comparing the images from the witness video recording with another Spitfire 26B with its flaps and trim tab set at known positions.

2 A reduction ratio of 1.82 between the engine speed and propellor speed is applied through gearing (ie an engine speed of 1,820 rpm = propellor speed of 1,000 rpm).

Figure 4
Tail initially lifts towards horizontal position

Figure 5
Tail wheel touches back down

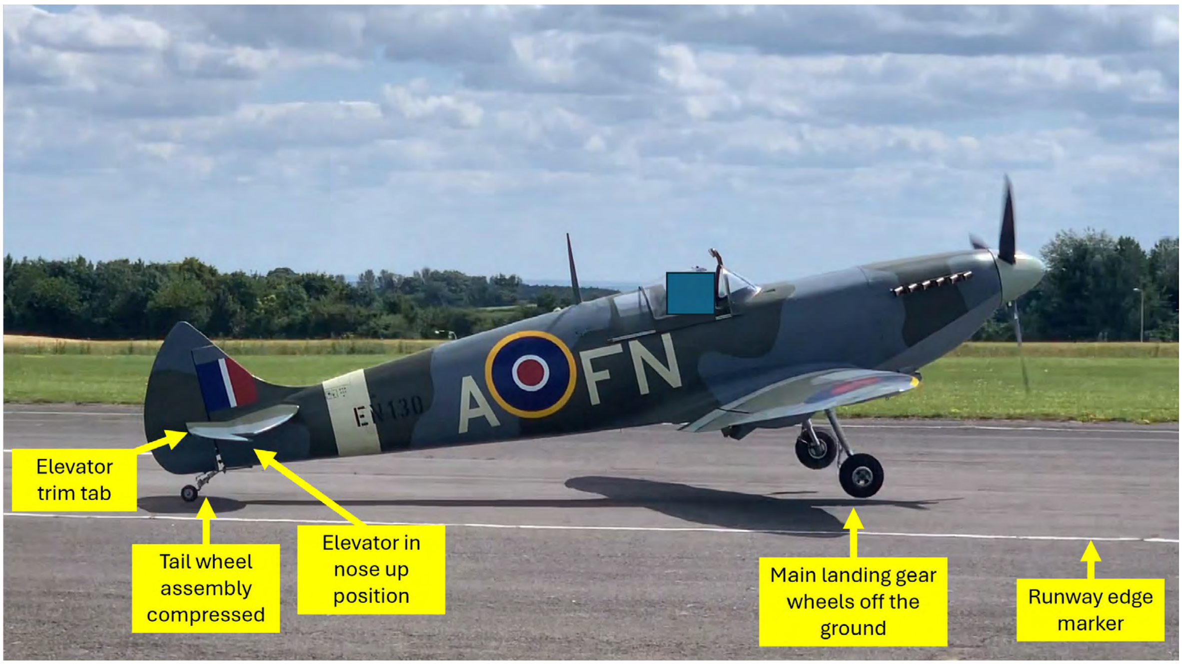

Figure 6
Aircraft attitude as it passed the witness position

Figure 7
Aircraft approaching the left side of the runway

Figure 8
Aircraft pitches up at 12°/s

Figure 9
Aircraft rolls left

Figure 10

Aircraft continues to roll left with counter (right roll) ailerons applied

Figure 11
CCTV image sequence

Previous video recordings

Several previous video recordings were obtained of G-ENAA taking off. These included the accident pilot taking off from Enstone Runway 26 in December 2017, recorded from an almost identical position as the accident video recording made by the witness. During the takeoff run, the tail of the aircraft had lifted to a near horizontal position which was maintained as the aircraft took off. Audio analysis of the video indicated that the engine speed reached about 4,400 rpm during the takeoff, which was about 100 rpm more than during the accident flight.

The previous videos of G-ENAA also showed a more gradual pitch up rotation at liftoff and lower pitch attitudes. Videos of other Mk 26B Spitfires also showed a similar tail-up takeoff technique, rotation rates and pitch attitudes.

Figure 12 shows the difference between G-ENAA's pitch attitude during the accident takeoff and that in December 2017, and Figure 13 shows the difference in the initial climb attitudes adopted.

Figure 12

Difference in pitch attitude prior to takeoff

Figure 13
Difference in pitch attitude during initial climb

Aircraft description

The Spitfire Mk 26B[3] is a kit-built scale replica based on the original Spitfire. The aircraft is supplied in kit form from a US based manufacturer. It is predominantly constructed from aluminium alloy skins riveted onto pre-formed frames, ribs and longerons. Although of a smaller scale, the profile of the wings and empennage mirrors that of the original Spitfire types.

Footnote

[3] The manufacturer introduced a series of scale replica Spitfires identified by their Mark (Mk). The Mk 25 is a 75% scale single seat aircraft. The Mk 26 is a 80% scale replica twin seat and the Mk 26B is a 90% scale replica twin seat. The Mk 26 and 26B fuselage dimensions differ from the Mk 25 but retain the 75% scale wing form.

The aircraft's flying control system is predominantly mechanical, relying on push-pull rods, torque tubes, bell cranks and levers to move the aileron, elevator and flap control surfaces. An electric motor operated by a switch in the cockpit, drives a common torque tube to move the flaps. There are no specific flap detents, but white marker lines painted on the inboard edge of the right aileron allow the pilot to judge flap position.

A trim tab on the right elevator is operated by a lever and Bowden cable[4] mechanism. The rudder control system consists of steel cables running from the rudder along the left and right side of the fuselage to the rudder pedals in the cockpit. A second cable runs forward from the rudder pedals, to form a continuous cable loop. This cable includes a turnbuckle at its midpoint and is routed through two pulleys on the left and right side of the footwell. The pulleys are mounted on a steel plate, on the aft face of the firewall. The rudder pedal position can be adjusted fore and aft in one of seven positions, but this can only be accomplished on the ground.

The pilot's seat has three positions to allow fore and aft adjustment of the seat on the ground by means of a pip-pin. A four-point harness, incorporating a quick release fitting (QRF) was fitted, with the shoulder straps attached to the rear cockpit bulkhead. G-ENAA had provision for a second seat behind the pilot, and this was also equipped with a four-point harness.

G-ENAA was powered by an Isuzu V6 fuel injected, normally aspirated, piston engine driving a three-blade variable pitch propeller. It was equipped with an electrically operated main landing gear and a fixed tail wheel and had a maximum takeoff weight of 860 kg.

An electrical stall warning tab was fitted to the right wing. In addition to modern analogue instruments, the cockpit instrument panel was equipped with several avionic devices including a digital MoTec SDL3 engine and electrical power monitoring display, and digital radio and transponder.

Aircraft information

G-ENAA was built and based at Enstone Airfield. The aircraft was constructed during 2013 and 2014 by a small team which included the accident pilot. This was followed by a period of test flying between October 2014 and March 2016. Since then, the aircraft had operated on an LAA Permit to Fly, for which the most recent certificate of validity was issued on 8 July 2024.

The aircraft was not flown between June 2019 and June 2021, nor between March 2022 and May 2023, when it was awaiting a replacement propeller following a propeller strike. For the purpose of renewing the Permit to Fly, two flights were flown on 11 May 2024, one on 14 July and another on 28 July, immediately prior to the accident flight. The most recent

Footnote

4 A type of flexible cable used to transmit mechanical push-pull forces by the movement of an inner cable relative to a hollow outer cable housing. Typically, the arrangement consists of a solid inner cable core, an inner plastic friction-reducing sleeve, a steel sheath / hollow cable housing and a protective outer plastic covering.

annual inspection was completed on 30 June 2024 and, among other things, involved an engine oil change, replacement of the oil and fuel filters, cleaning of the air filter and replacement of the No.2 fuel pump. The aircraft had accrued a total flight time of 181 hours.

At the time of the accident G-ENAA was one of three Mk 26B's on the UK register. Another Mk 26B, G-CLHJ, was previously destroyed in a fatal accident near Enstone on 22 August 2023.

Aircraft Handling Notes

After it was built, the aircraft was flown by an LAA test pilot who made the following comments in his written report:

> *'a. The takeoff was spritely with rapid acceleration. The tail was lifted at 50 kt and a marked swing to the left was experienced.*
>
> *b. On earlier flights this swing could hardly be contained even with full application of right rudder. Full rudder deflection was found to be less than the factory recommendation but, following adjustment, the rudder deflection was adequate to retain directional control.*
>
> *c. Though the manufacturer indicated a CG envelope of 600 to 875 mm aft of datum, the aircraft was found to be longitudinally unstable at CG position 849 mm aft of datum. A limit of 745 mm aft of datum was suggested.*
>
> *d. In the aft CG condition, stick force per g gradient was found to be low so care was advised to avoid exceeding maximum g.*
>
> *e. Initially a marked left wing drop (> 60°) at the stall was exhibited in all configurations. Stall strips were fitted to the inboard leading edge of the wing which resulted in satisfactory stalling qualities.*
>
> *f. There was an audio stall warner fitted which activated 5 to 10 kt prior to all stalls. There was little or no buffet and no tendency to spin.*
>
> *g. The stalling speed wings level, with idle power was 48 kt flaps up and 43 kt with 10° of flap.*
>
> *h. In a 30° banked left turn at 75% power the stalling speed flaps up was 50 kt and with 10° flap 44 kt.*
>
> *i. The aircraft was found to have adequate pitch trimming at all speeds, except in the full flap, gear down, idle power configuration. In this condition nose up trim "ran out" but the control forces were light (of the order two to three pounds) and hardly noticeable.'*

The pilot's notes for the aircraft, given to the investigation by the syndicate, gave the following guidance for takeoff:

> *'Expect a tendency to swing to the left, gradually increase to full power, keep tailwheel in contact until 50 kt, unstick at 65 kt. Accelerate to 100 kt whilst raising the undercarriage and flaps.'*

A tendency to yaw left with increased power is normal for propeller driven aircraft of this configuration. The yaw results from the increasing slipstream from the propeller impinging on the left side of the vertical fin. Syndicate members told the investigation that they did not try to keep the tailwheel on the ground until 50 kt during the takeoff roll. Their usual practice was to allow the aircraft tail to rise naturally as the speed increased and they estimated this would be at around 35 kt.

In the accident video it appeared that the elevator trim tab was set to approximately its mid-travel nose-up trim condition for the takeoff.

Stalling in manoeuvre

The speed at which an aircraft suffers an aerodynamic stall varies as a consequence of manoeuvres and the variation of applied acceleration (measured in multiples of g, the acceleration due to gravity). The stalling speed will vary in proportion to the square root of the applied g. So, if an aircraft experiences a force due to an acceleration of 4 g then the stalling speed will be twice that in unaccelerated flight. From an analysis of the accident video an estimation of the applied g and, from this, the stalling speed was made to give an indication of this effect during this accident. During the rapid pitch up after takeoff it was estimated that the acceleration would be 1.7 g and, therefore, the stalling speed would need to be factored by 1.3. The aircraft had approximately Flap 10 deployed and power applied, so from the test pilot's notes the unaccelerated stall speed would have been approximately 44 kt. Factored by 1.3, this would give a stall speed in the manoeuvre of approximately 57 kt.

Post Stall Autorotation

When an aircraft rolls, the relative airflow (RAF) over each wing is formed from components of forward speed and roll as shown in Figure 14.

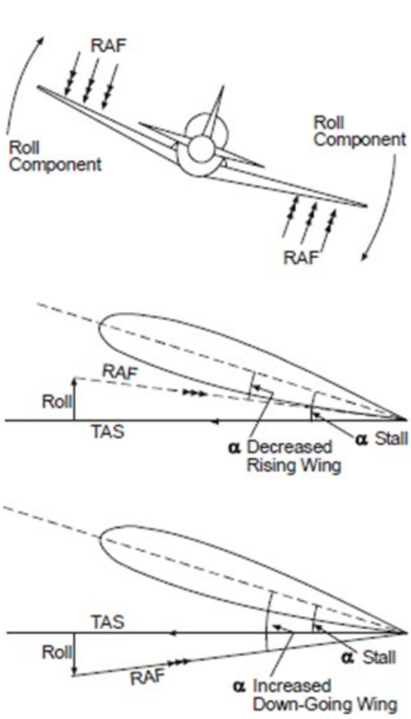

Figure 14

Change of angle of attack with roll

As an aircraft rolls, the angle of attack on the down going wing is increased. The lift produced by a wing will increase with angle of attack up until the point of a stall. If angle of attack continues to increase beyond the stalling angle then the coefficient of lift (C_L) on the wing will decrease and so exacerbate the roll. Deflecting ailerons downward increases the angle of attack of a wing, so any attempt to use them in the usual sense post stall will increase rather than correct any roll. As angle of attack increases, the coefficient of drag (C_D) produced by a wing also increases. So, if an aircraft rolls left post stall, the lift from the left wing will continue to reduce while the drag increases. The result of these two effects is the roll will increase, and the aircraft will yaw to the left. These effects are illustrated in Figure 15.

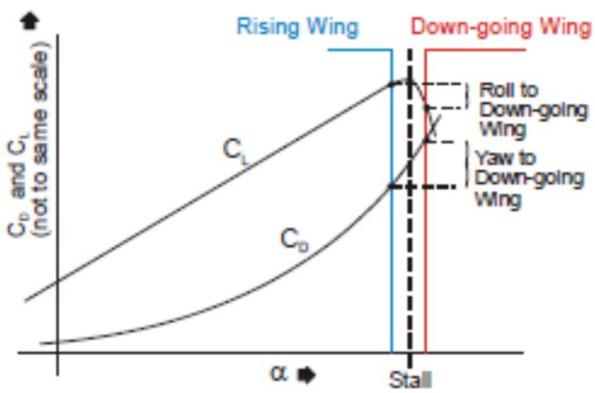

Figure 15

Variation of lift and drag with angle of attack

Aircraft examination

A preliminary examination of the aircraft was carried out at the accident site with further detailed examination conducted at the AAIB facilities.

General

The aircraft had suffered substantial impact damage, forcing the engine into the cockpit space. The intense post-crash fire was focused on the cockpit and centre section of aircraft and the majority of components in this area were totally consumed or rendered unrecognisable. The main spar had broken just outboard of the transportation joint, such that the left wing was completely detached from the aircraft. The main landing gear legs remained attached to the spar and were extended.

All but the outer third of the left wing had been consumed by the fire and the remainder had suffered extensive fire damage. Nothing remained of the stall warning system that could be tested. The right wing was intact and did not sustain any fire damage. The right wingtip was bent and the damage consistent with it having struck the ground as the aircraft was inverted. There was evidence that a stall strip had been glued to the right wing leading edge but it was not present and may have been dislodged in the impact.

Flying controls

Flying control continuity checks were conducted to the extent possible given the high level of disruption to the control systems from impact and fire damage. Flap and aileron control continuity was established on the right wing. The right wing flaps were found in the approximately 30° position but the inboard flap was damaged and the flaps may have moved during the impact sequence.

The horizontal stabiliser, elevators and trim tab on the right elevator appeared undamaged. The elevator moved freely and control continuity was established to just aft of the cockpit. Forward of this point, the control rod and linkage to the control column had been consumed by the fire.

The elevator trim tab was deflected approximately 20° down[5] (nose-up trim) and could not be moved from this position. The solid end fitting of the elevator trim cable was bent where it attached to the trim tab. The elevator trim cable had suffered varying degrees of heat damage along its length and the solid core could not be moved. In the areas where the fire had been most intense the outer plastic sleeve was completely absent and in other areas it had shrunk and formed around the steel sleeve. The inner anti-friction liner had melted and subsequently solidified in places, preventing movement of the cable. The trim tab moved freely once the cable was disconnected.

Footnote

[5] The elevator trim tab on the Mk 26B provides only nose-up trim (surface down). Examination of another Mk 26B showed that setting the trim lever to the full aft position corresponded to maximum nose-up trim (24° downwards surface deflection of the trim tab). When the trim lever was in the fully forward position, the trim tab was in the neutral position.

The routing of trim cable did not precisely follow the cable routing described in the Mk 26B constructor's manual. The outer plastic cover exhibited surface abrasion damage in several locations, and in one place was snagged where the cable passed through lightning holes in the fuselage frames.

The rear rudder cable loop was intact and continuity with the rudder surface was established by manually operating the cables, but the range of movement could not be checked because the top of the rudder was bent. Only the right rudder pedal assembly survived the fire. All that remained of the left rudder pedal was the brake cylinder.

Part of the forward rudder cable loop survived. The cable had failed in tension at the left side and the cable had been pulled to the right, such that the turnbuckle was jammed in the right pulley. This would have occurred when the engine firewall structure, on which the cable pulleys were mounted, was severely deformed during the impact sequence.

The AAIB investigation into the fatal accident to Spitfire Mk 26B, registration G-CLHJ, in August 2023 identified that the aircraft had been built with a misaligned rudder. This finding resulted in the LAA issuing a Mandatory Technical Directive to inspect the geometry, symmetry and rigging of the fin and rudder on all Mk 26 and Mk 26B Spitfires. G-ENAA was subject to that check in May 2024 and no anomalies were noted.

Seat

While the pilot's seat and much of its support structure were destroyed in the fire, the parts of the seat mounting structure which contained the seat adjustment mechanism were located in the wreckage and the pip pins were located in the middle position. This ruled out the possibility of the seat having moved during the takeoff.

Survivability

After the left wingtip struck the ground the aircraft continued to roll and came to rest inverted. Immediately after the aircraft struck the ground there was an intense fire which engulfed the cockpit area. The combination of accident and post-impact fire was not survivable.

The safety harness straps and seat furnishings had been destroyed by the fire, so limited assessment was possible. Two QRFs were identified in the wreckage; one, believed to be from the pilot's seat harness, had all four strap end fittings inserted into it and the other had only the fixed end fitting inserted.

Weight and balance

The pilot's weight was estimated at 70 kg and the fuel load remaining after the first sortie was approximately 85 litres. There was no baggage aboard the aircraft. Using those figures gave an aircraft mass of 781 kg and a CG position 690 mm aft of the datum. The aircraft was therefore within its mass and CG envelope.

Meteorology

The weather was good with only a light crosswind from the left. It was not considered to be a factor in the accident.

Post mortem report

Following the accident, the pilot's heart was examined by a consultant histopathologist. The results of that examination indicated that the pilot had coronary artery disease (ischaemic heart disease), and *'in the absence of other post-mortem findings, the severity of his coronary artery disease would be sufficient to account for a sudden cardiac death'.* In response to a request for clarification, the pathologist indicated that a *'sudden cardiac arrhythmia … would likely have rendered him incapacitated very quickly'*. He also said that *'he may have had an obstruction to a coronary artery resulting in chest pain that would have impaired his ability to control the aircraft'.*

The pilot had last undergone an aviation medical ECG in December 2022 which was assessed as normal. The pathologist stated that between 15 and 20% of sudden deaths due to ischaemic heart disease occur in patients with no previous history of the condition.

A summary of the report produced by the consultant histopathologist was included in the post mortem (PM) report written by a forensic pathologist. The PM report referred to the specialist examination of the pilot's heart and stated:

> *'There was no evidence of an acute blockage … that would have meant [the pilot] had been subject to sudden cardiac deterioration. However, the absence of acute blockage does not exclude a sudden cardiac deterioration (noting, of course that the level of disease would have been the same the preceding day, week and likely months with no (known) ill-effect)'.*

The PM report referred to the section of the consultant histopathologist's report that stated:

> *'There are contraction bands within the myocardium which may be associated with acute ischaemia but may be seen in resuscitation and correlation with the clinical history is required'.*

The PM report stated:

> *'Whilst this observation may suggest that the deceased was suffering from "acute ischaemia" – a reduction in blood flow to the heart muscle – and thus could be of potential relevance, it is suggested [in a referenced work] that this may arise as an artefact including in fatal air crashes'.*

The PM report stated that soot staining of the main airways *'indicated that [the pilot] was alive during the course of a fire'* (which occurred after the aircraft struck the ground). It went on to state that *'The medical cause of death can best be attributed to: Effects of Fire (principally inhalation of products of combustion)'.*

Comments from the CAA

The CAA was consulted on how the medical evidence should be interpreted in relation to the accident sequence and commented that 'there is evidence of control input which would not have occurred with an incapacitated individual'. This was in reference to the right roll input that was seen in response to the left roll. The CAA also considered that the observation that the pilot's head was upright during the first part of the takeoff indicated that he was not incapacitated at that point.

The CAA pointed out that coronary artery disease is *'extremely common, with a prevalence of almost 70% in males of this age'.*

Analysis

Technical aspects

Analysis of the audio signature from the witness video and separate photogrammetry analysis indicated that the engine achieved a maximum speed of approximately 4,300 rpm and this speed was maintained throughout the takeoff until the impact with the ground. There was no audible evidence in the recordings of any engine problems. Additionally, the condition of the propeller and the ground marks indicate that the engine was delivering substantial power at impact.

Examination of the aircraft, while limited to some extent by the disruption caused by the impact and fire, did not reveal any technical defects which may have adversely affected the controllability of the aircraft. Continuity of the flying control runs was established for the portions of the control runs which remained.

The as-found deflection of the trim tab was greater than that observed in the witness video. Fire and impact damage prevented the elevator trim cable from operating after the accident. The cable routing differed from that described in the constructor's manual and minor damage was observed on the outer plastic sleeve. This damage could have resulted from tensile forces imparted on the cable during the impact sequence, which would also have changed the trim tab position. Had the damage existed prior to the accident, neither it nor the cable routing are likely to have adversely affected operation of the trim cable, as the solid core moves independently of the outer cover. Additionally, another pilot who flew G-ENAA reported that the trim tab was not particularly effective and could easily be overcome by pilot force if it became jammed.

Given the extent of the fire damage, the possibility of a flying control restriction could not be completely eliminated based on the wreckage examination. However, the rudder, elevators and ailerons could all be seen to be moving during periods of the CCTV and witness video footage and both flaps appeared symmetrically deployed. This suggested that a control restriction or other control anomaly was highly unlikely.

The loss of control

The video obtained by the investigation showed the aircraft accelerate and the tail initially rise as expected. The aircraft tail then lowered back to the runway and the aircraft yawed left toward the edge of the paved surface. The aircraft would tend to yaw left with takeoff power applied, and to maintain a constant heading would require active correction by the pilot using the rudder pedals. As the aircraft approached the edge of the paved surface it lifted off, pitched up rapidly, then rolled and yawed left before striking the ground. In the video the aircraft ailerons were seen to be deflected in a right-roll position.

As the aircraft pitched up, the applied g and hence the stalling speed would have increased. It is probable that the aircraft speed was below the increased stalling speed in the manoeuvre and so the wing stalled. As there was power applied, once the wing stalled the torque reaction from the propellor would cause the aircraft to roll left, which was the motion observed. This was followed by a right-roll aileron input, but as this action deflected the left aileron downwards it would have increased the angle of attack on the left wing. Post stall, this increase in angle of attack would have further reduced lift on the left wing, exacerbating the roll to the left, and would have increased drag causing the aircraft to yaw left.

The roll to the left would have induced a sideslip which would also have caused the aircraft to yaw left. As the outside, right wing's speed would have been increased by the yaw, the lift on the right wing would also have increased further exacerbating the left roll. The aircraft rolled rapidly, and the left wingtip touched the ground causing the aircraft to continue to roll and yaw left before it came to rest. A large fire ensued around the forward fuselage area and the pilot sustained fatal injuries.

Reasons for the loss of control

The accident sequence began when the natural tendency of the aircraft to yaw left during takeoff was not contained, leaving the aircraft heading towards the left side of the runway. One explanation of subsequent events was that, given the marked pitch up control input, the pilot was trying to lift off as he approached the edge of the paved surface. The pilot may have suffered a startle response that caused his actions in the rapid pitch-up to be instinctive and – given the outcome – inappropriate. The nose-up trim setting would have reduced the control forces required to initiate the rapid pitch-up and so the pilot may have over-estimated the control input required to lift off. Once the aircraft began to roll left, the right-roll deflection of the ailerons observed in the video might have been an instinctive response from the pilot to attempt a correction of the roll attitude.

Another possible explanation for the loss of control was that the pilot became incapacitated at some point during the takeoff. Post-mortem examination revealed that he was suffering from coronary artery disease to an extent that could account for a sudden cardiac death or severe chest pain impairing his ability to control the aircraft. The conclusions of the PM report were more equivocal, however, and the CAA's view was that the fact that control inputs were observed suggested that the pilot did not become completely incapacitated. Nevertheless, some level of incapacitation short of collapse could not be excluded.

Conclusion

Immediately after takeoff the aircraft stalled during a rapid pitch up. Control was lost and the aircraft rolled and yawed left as a result of a post-stall autorotation. The left wing struck the ground, the aircraft came to rest inverted and caught fire, and the pilot was fatally injured. Despite the extensive damage sustained during the impact and ensuing fire, there was no evidence of a malfunction or failure of any of the aircraft's flying control systems that would explain a loss of control. It was possible that the pilot did not control the yaw during the takeoff run, initiated a rapid pitch up to lift off before running off the side of the runway and, in so doing, began the sequence of events. Although the medical evidence did not permit a definitive conclusion, it was also possible that the reason for the loss of control was that the pilot became incapacitated to some extent during the takeoff.

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