Accident

Aircraft Type and Registration:	Spitfire Mk 26B, G-CLHJ
No & Type of Engines:	1 Isuzu V6 Piston Engine
Year of Manufacture:	2019 (Serial no: LAA 324-15249)
Date & Time (UTC):	22 August 2023 at 1403 hrs
Location:	Near Enstone, 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:	Private Pilot's Licence
Commander's Age:	68 years
Commander's Flying Experience:	1,164 hours (of which 26 were on type) Last 90 days - 18 hours Last 28 days - 8 hours
Information Source:	AAIB Field Investigation

Synopsis

During a test flight towards obtaining a Permit to Fly, control of the aircraft was lost. The flight was testing the effects of leading edge stall strips as part of the Light Aircraft Association (LAA) approved test programme. The pilot was fatally injured when the aircraft struck the ground.

The aircraft was found to have been built with a misaligned fin and rudder. This misalignment made a wing drop at the stall more likely, but it did not prevent or restrict the ability of the pilot to recover from the stall nor any subsequent spin or spiral dive that might develop. Although the pilot's medical history indicated the possibility of an incapacitation this could not be confirmed or dismissed by the pathologist. The possibility of a control restriction preventing recovery could also not be excluded due to the extensive fire damage to the aircraft.

The LAA took action to alert owners regarding the possibility of a fin and rudder misalignment by issuing a Mandatory Technical Directive[1] (MTD) applicable to all Spitfire Mk 26 and Mk 26B aircraft.

History of the flight

The pilot was conducting the 20th test flight on the aircraft as part of the process for obtaining a Permit to Fly. All the test flying was being conducted at Enstone Airfield where the

Footnote

[1] https://mar2013.lightaircraftassociation.co.uk/engineering/TADs/324/MTD_01-2024_issue_1.pdf [accessed March 2024].

aircraft had been built and where it was based. The aim of the flight was to assess the stall characteristics after the repositioning of stall strips on the inner leading edges of both wings. The pilot completed his usual pre-flight preparation and started the engine at 1344 hrs. At 1350 hrs the pilot began to taxi towards Runway 26 and took off at 1356 hrs. Witnesses reported the aircraft turning right into the circuit whilst continuing to climb to what they estimated to be between 3,000 to 4,000 ft aal. After a few minutes the aircraft was to the south of the airfield and although some distance away, the witnesses could see the aircraft undergoing what appeared to be a series of stall manoeuvres during which the right wing was seen to drop followed by recovery to straight and level flight. After the third manoeuvre the right wing dropped and the aircraft entered a clockwise spin or rotation.

The aircraft struck the ground in an open field near the village of Enstone in Oxfordshire. The aircraft was severely damaged in the impact and caught fire. The pilot was fatally injured.

Accident site

The aircraft came to rest in a field approximately 100 m from a road opposite houses. The initial impact point was directly below 11kV power lines that crossed the field in a north/south direction; there was no evidence the aircraft touched any of the power lines during the accident (Figure 1). The ground marks showed the right wingtip hit the ground first with significant force. The impact mark and trail of debris suggested the aircraft was travelling in a westerly direction. Three propeller blades and a substantial part of the spinner were found together a short distance from the first impact point. Gouging and disruption to the soil from there on showed the aircraft to have carried on forwards until the left radiator fairing on the underside of the left wing ploughed into the soil causing the aircraft to rotate to the left before coming to a stop. The aircraft remained upright throughout the accident sequence. A fire, centred on the cockpit area, caused extensive damage to the centre of the aircraft.

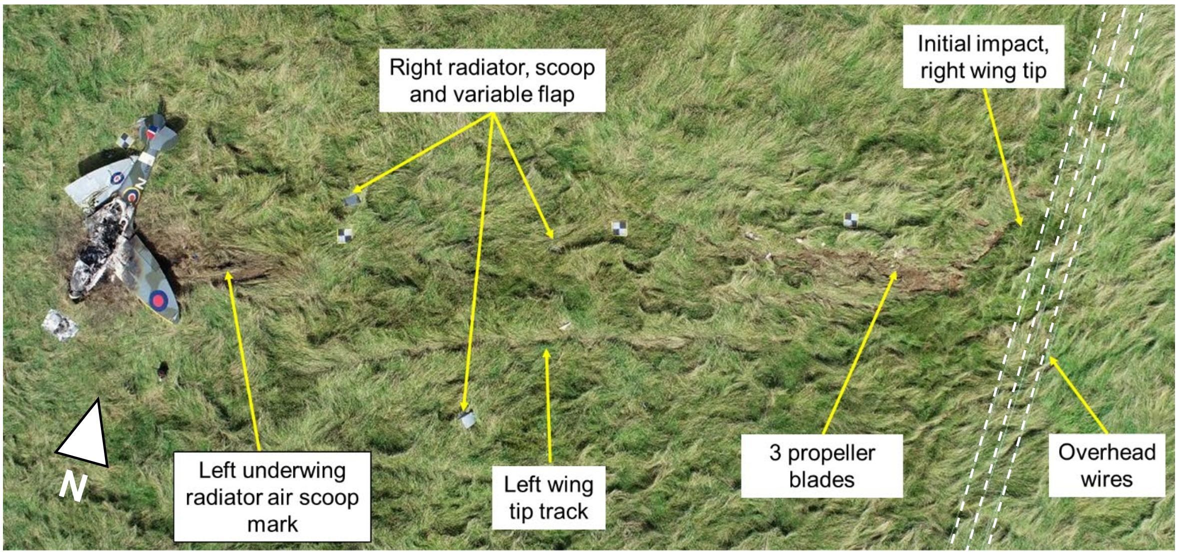

Figure 1

Accident sight overview

Recorded information

Sources of information

The aircraft was fitted with a PilotAware® system[2] and an engine control unit. Any recordings that may have been stored on these items, or any personal devices, were lost in the post-accident fire.

The aircraft was fitted with a transponder but there was no secondary radar detection of the aircraft. There was also no track recorded by the ground network associated with the electronic conspicuity device. The flight was detected and recorded by NATS primary radar. This provided the approximate flight path over ground when the aircraft was high enough to be in view of the radar installations but does not provide altitude information (Figure 2).

CCTV cameras installed at the airfield recorded the taxi and part of the takeoff of the aircraft. Part of the takeoff was also recorded from the ground on a personal electronic device. The takeoff appeared normal to those who were familiar with the aircraft.

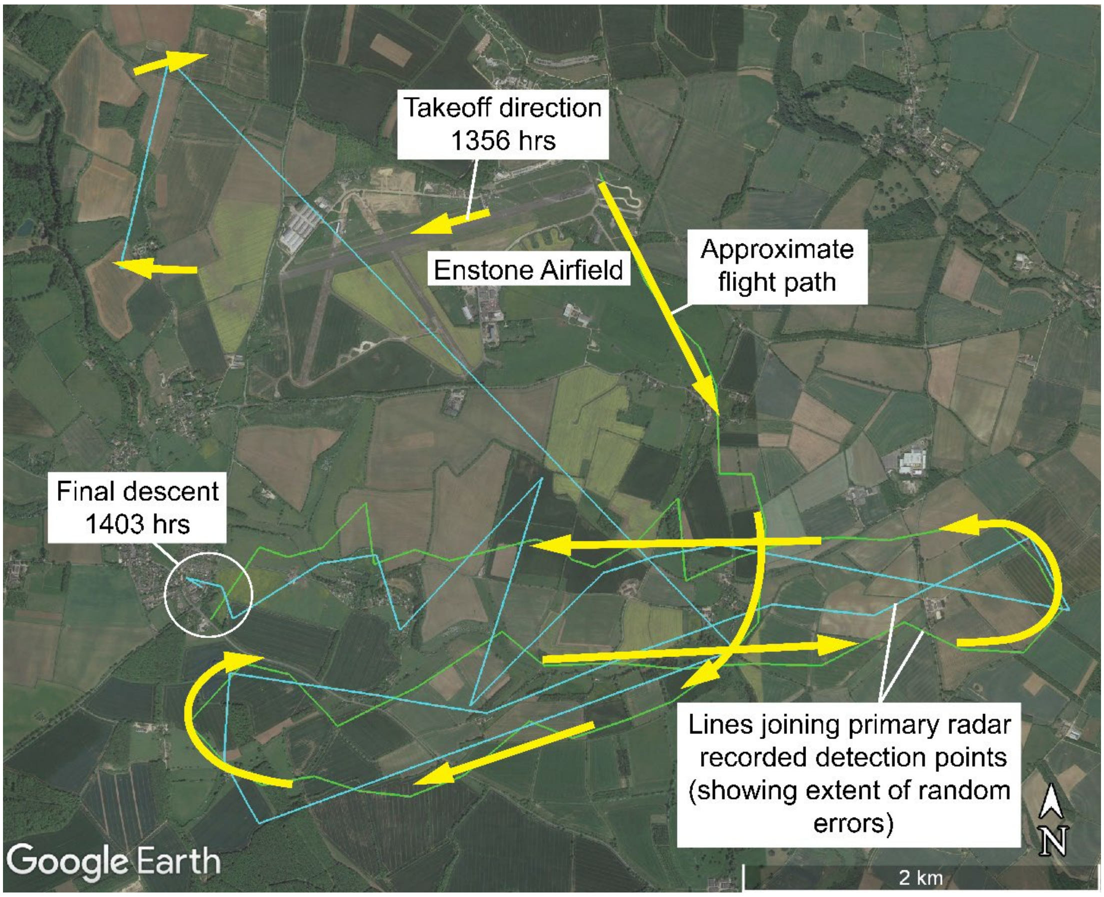

Figure 2

Approximate flight path

Footnote

2 Pilot Aware® is a commercially available self-contained interoperable conspicuity and warning device fitted to aircraft to enhance airspace safety. It has the capability to receive Mod-S, Mode-C and ADS-B and can up and downlink relevant data to and from ground stations.

CCTV Analysis

A south facing airfield CCTV camera recorded the last part of the final descent from approximately 2 km away. It did not show the aircraft at the entry to the descent which witnesses reported as being between 3,000 to 4,000 ft. Figure 3 shows a compounded image of the aircraft every 0.2 seconds extracted from a version of the recording that has been corrected for lens distortion and perspective. The aircraft size in the image is small compared to the image pixel size; however, rotation during the descent is still visible. The CCTV captured the descent which was generally from west to east ending with a flight path with an increasing component to the west. Combining the CCTV with the location of the accident site itself and the approximate ground track provided by the primary radar recording enabled calculation of the aircraft altitude profile. The derived data is shown in Figure 3. The errors associated with the calculations are shown as error bars. These are larger at high altitude due to distance uncertainty, but the resultant descent rate data is less sensitive to these errors.

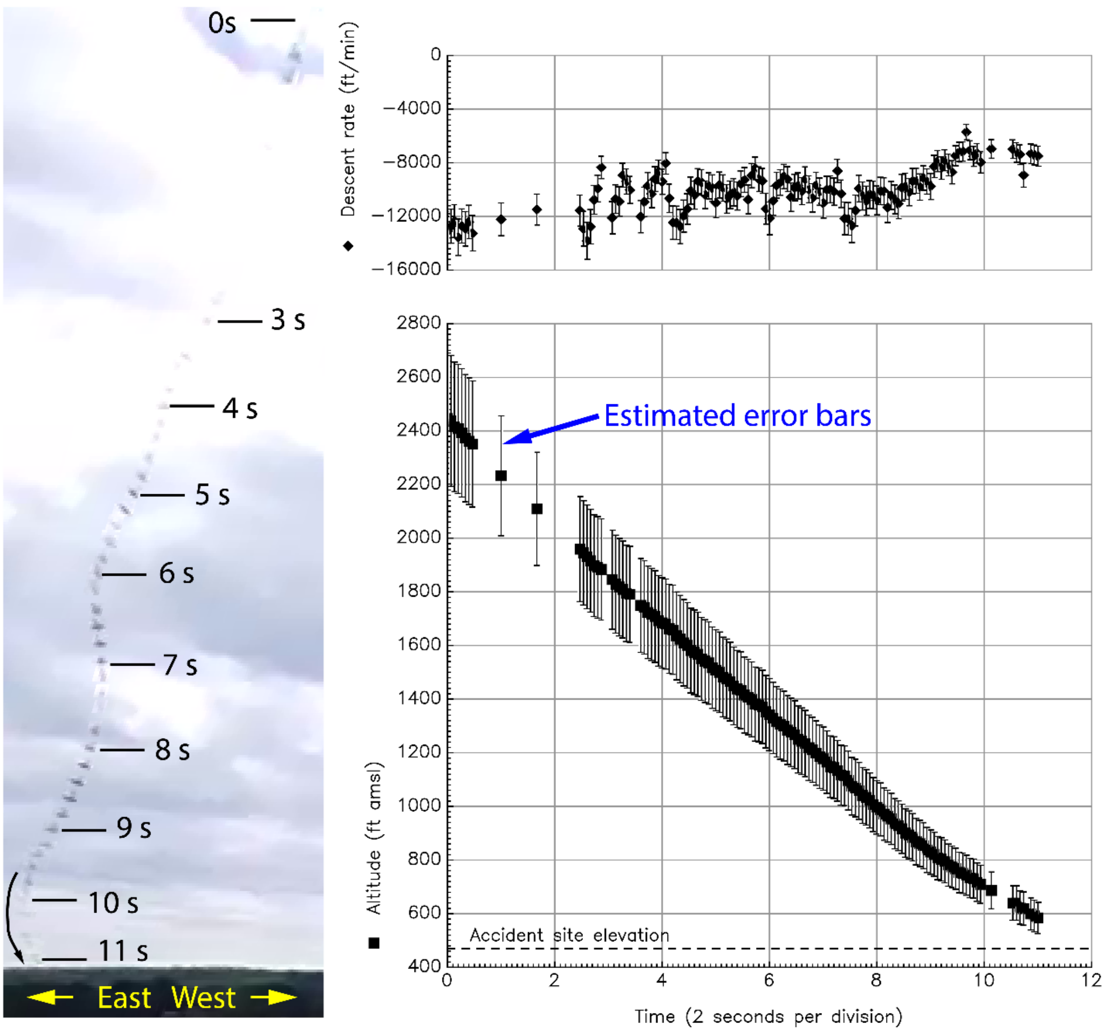

Figure 3

Compound undistorted CCTV image and analysis of the final descent

The aircraft was not visible in the CCTV recording when it was in front of a relatively bright area of the sky during the initial part of the captured portion of the descent. However, the available data points indicate that the flight path appears relatively consistent for approximately the first five seconds of the captured part of the descent. The shape of the descent during the final three seconds indicates a reduced descent rate. The final second of the captured descent indicated an increasingly westerly component to the direction of travel. The aircraft was not in view of the camera for approximately the last 100 ft of the descent.

Aircraft description

The Spitfire Mk 26B[3] is a kit-built scale replica based on the original Spitfire. The aircraft is supplied as a kit from a US based manufacturer. The aircraft structure is assembled by riveting aluminium alloy skins onto pre-formed frames, ribs and longerons. The wing form and empennage, other than overall dimensions, mirror the original Spitfire types. The completed aircraft is shown at Figure 4.

Figure 4

G-CLHJ undergoing engine runs (used with permission)

The flying control system on G-CLHJ was mechanical, using push-pull rods, bell cranks and levers to move the aileron, flap and elevator control surfaces. A trim tab was fitted to the right elevator which is set via a lever and Bowden cable mechanism. The rudder control system consisted of multistrand 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 was connected from the rudder pedals through pulleys on the left and right side of the footwell to form a continuous loop of cable to synchronise the rudder pedals (Figure 5). These pulleys were mounted on a steel pulley mounting plate which had holes drilled along its length to engage

Footnote

[3] The manufacturer introduced a series of scale replica Spitfires identified by their Mark (Mk). The Mk 25 was a 75% scale single seat aircraft. The Mk 26 was a 80% scale replica twin seat and the Mk 26B was 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.

on a pin, pivot and locking pin assembly to allow the rudder pedal position to be adjusted. Simple guide pins were located beside the outer edge of each pulley to prevent the cable derailing in use.

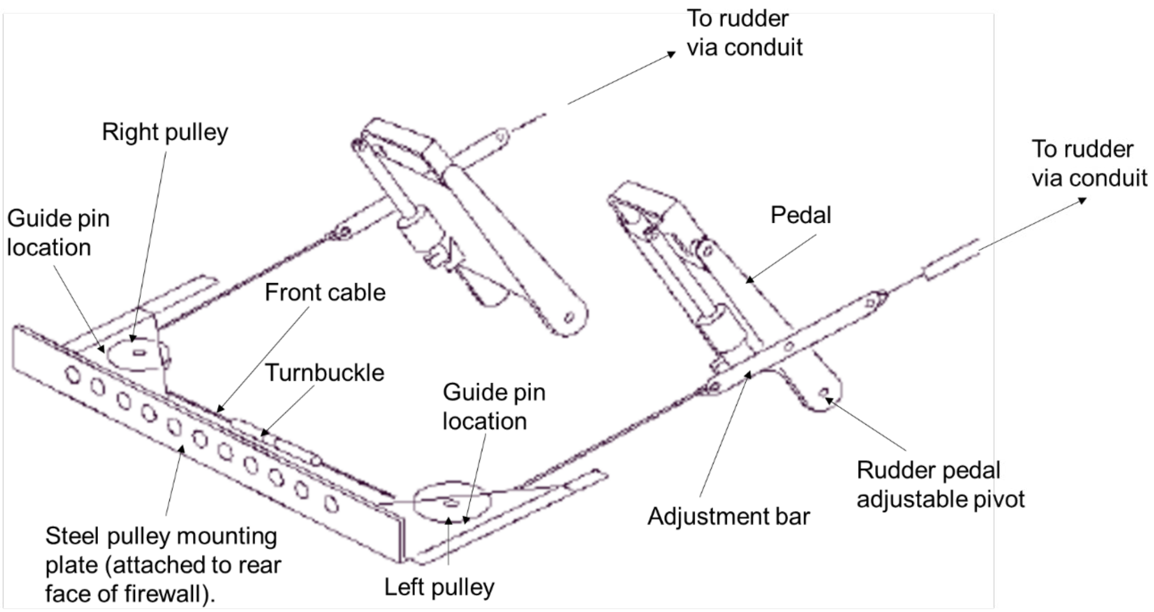

Figure 5

Rudder pedal and cable assembly (schematic)

This aircraft was powered by an Isuzu V6[4] fuel injected, normally aspirated, piston engine driving a three blade variable pitch propeller. The engine was water cooled with a radiator mounted under each wing. An oil cooler was positioned within a scoop on the lower engine cowl.

The aircraft was originally fitted with an electric tab stall warning system on the left wing. This had been removed and the system disabled because it had been incorrectly positioned on the wing leading edge and therefore at the time of the accident flight the aircraft did not have a functioning artificial stall warning system. The cockpit was fitted with modern analogue primary and secondary instruments. In addition, there were several avionic devices which included a digital LCD engine and electrical power monitoring display, and digital radio and transponder.

Footnote

4 Other engine variants and types can be fitted to the Spitfire Mk 25, Mk 26 and Mk 26B depending on the customer's choice.

Aircraft history

Construction of the aircraft by a small team began in 2013. G-CLHJ was constructed under the LAA regulations. The build had been finished in 2019 but the project was delayed by the Covid19 pandemic. After the satisfactory completion of the necessary LAA airworthiness inspections, the aircraft was given a Certificate of Clearance[5]. This allowed it to be flown by a test pilot nominated by the owners, who was accepted by LAA as being suitably competent and experienced to do so, on a flight test programme to enable the issue of a Permit to Fly.

Flight test programme

During the flight test programme several issues had been encountered which required rectifications, modifications and adjustments. Following each flight the test pilot produced a comprehensive report with clear recommendations and solutions for each issue as they arose. Rectification work and adjustment were comprehensively recorded on sequential work cards which included the signatures of the individuals carrying out the work.

From the second test flight, the pilot reported a marked tendency for the aircraft to roll to the right, to the extent that the aircraft could not be flown hands-off and required a constant left aileron input. To correct this roll, the team made several incremental adjustments to the aileron and flap control rods. These adjustments gradually improved the handling of the aircraft although they were not sufficient to fully resolve the issue. The decision was made to fit a narrow expanded foam wedge on the underside trailing edge of the left aileron.

After the 13th test flight, the pilot reported that the tendency to roll to the right had been resolved to his satisfaction. He carried out clean stall tests and found the aircraft tended to rapidly drop its right wing, and he recommended that stall strips should be fitted. The purpose of the strips are twofold; they provide a means of warning to the pilot by increasing buffet as the wing approaches the stall and by fitting them to the inboard leading edge they can promote the wing root to stall first, reducing the risk of the outboard wing stalling first which can cause a wing drop leading to a spin or spiral dive. For kit-built aircraft the positioning and final fitment of stall strips may form part of flight testing before the approval of a Permit to Fly.

The stall strips consisted of short lengths of angled aluminium alloy fitted to the wing leading edge. During the test flights, the strips were held in place by duct tape, which allowed them to be easily moved following each flight. The team examined the position of the stall strips fitted to the other Spitfire Mk 26B at Enstone and initially attached the strips on G-CLHJ in the same position.

Footnote

5 Certificates of Clearance are issued by LAA in accordance with BCAR Section A8-9 following inspection and evaluation of an aircraft, to authorise it to be flown under test conditions in preparation for the issue of a Permit to Fly. They are valid for three months at a time and a record is kept of the progress, test results and adjustments.

Although the next few flights were planned to explore the stall characteristics of the aircraft with the strips fitted, the aircraft experienced a number of engine coolant issues which resulted in an engine-off emergency landing back at the airfield on the 15th flight. The engine faults were caused by a warped cylinder head. It was nearly four months before flying resumed with the 16th flight to check the engine operation was normal.

The aircraft was flown on its 17th flight on 25 May 2023 and the pilot again reported a right wing drop in the stall at around 45 kt to 50 kt. Two more flights were carried out on 7 July 2023 and the pilot reported that the aircraft stall characteristics were not so good with the aircraft dropping its right wing with gear and flaps down at 50 kt to 55 kt. The pilot recommended moving both stall strips a few millimetres lower. The stall strip positions were datum marked with a permanent marker pen in line with the top of the aluminium angle and were moved downwards.

The aircraft was being flown on its 20th flight on 22 August 2023, and whilst conducting further stall testing departed from controlled flight.

Aircraft examination

An initial examination of the aircraft was carried out at the accident site with further, more detailed, examinations carried out at the AAIB.

General examination

An intense fire had taken hold in the cockpit and nose section of the aircraft rendering the majority of light alloy, plastic and composite parts unrecognisable. The main spar on the left side had bent rearwards by 30° and the outer section of the wing had twisted upside down and was only attached by a flying control rod. The right wingtip was severely distorted, and the majority of its attachment rivets were missing. Compression damage and buckling was present over the entire surface of the right wing.

The outer sections of both wings, rear fuselage and empennage had not been damaged by fire but had sustained impact damage during the accident. Flying control continuity checks were carried out. Despite the disruption, continuity could be demonstrated in all axes with the damage to various components within the systems directly attributable to the impact sequence and fire. The flaps were fully up, and the landing gear was fully retracted within the left and right wings.

Stall strips

The stall strip fitted to the leading edge of the right wing was still in place (Figure 6) although there was distortion on its surrounding structure. The stall strip that had been fitted to the left wing was found lying beneath the wing at the accident site. The leading edge section to which it had been attached was melted and burnt through and there was no duct tape present. Therefore, the left wing stall strip position on the wing could not be accurately determined. Both stall strips were 24.5 cm in length.

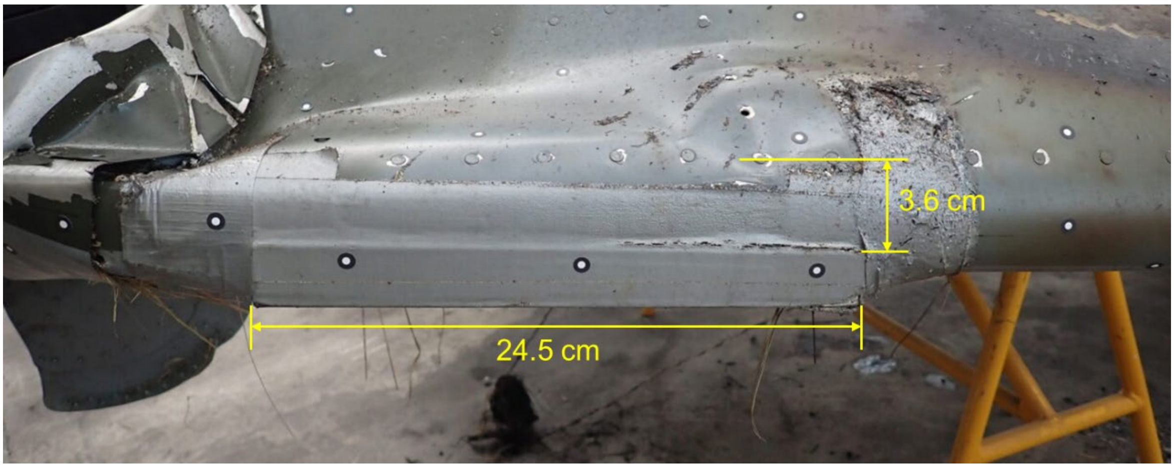

Figure 6

Stall strip fitted to the right wing leading edge

Pictures taken of the aircraft when the stall strips were initially fitted were compared to the current location of the remaining stall strip. Despite the damage to the wing around the stall strip, reference points were established between the before and after pictures which showed that the stall strip had been moved down a few millimetres as requested by the pilot.

Left aileron wedge

Remains of the duct tape attached to the left aileron trailing edge were present with signs of heat degradation of the tape surface. The foam wedge piece or remains of any material identified as such were not found. (Figure 7)

Figure 7

Remains of duct tape on the lower surface of the left aileron

Fin and rudder

A visual examination of the fin and tailplane found the leading edge of the fin appeared to have a significant misalignment to the left. Precision measurements along with laser alignment checks found the fin and rudder were misaligned 4.4° to the left of the aircraft centre line (Figure 8). Removal of the left and right fin root fairings confirmed this and revealed the position of the fin relative to the centre line of its support frame. The left and right tailplane inboard rib measurements show the base of the fin, where it attaches to the fuselage, was misaligned 5 mm to the left of the centre line. Detailed examination of the structure around this area and the fin root fairings found no evidence that the misalignment was because of the impact sequence.

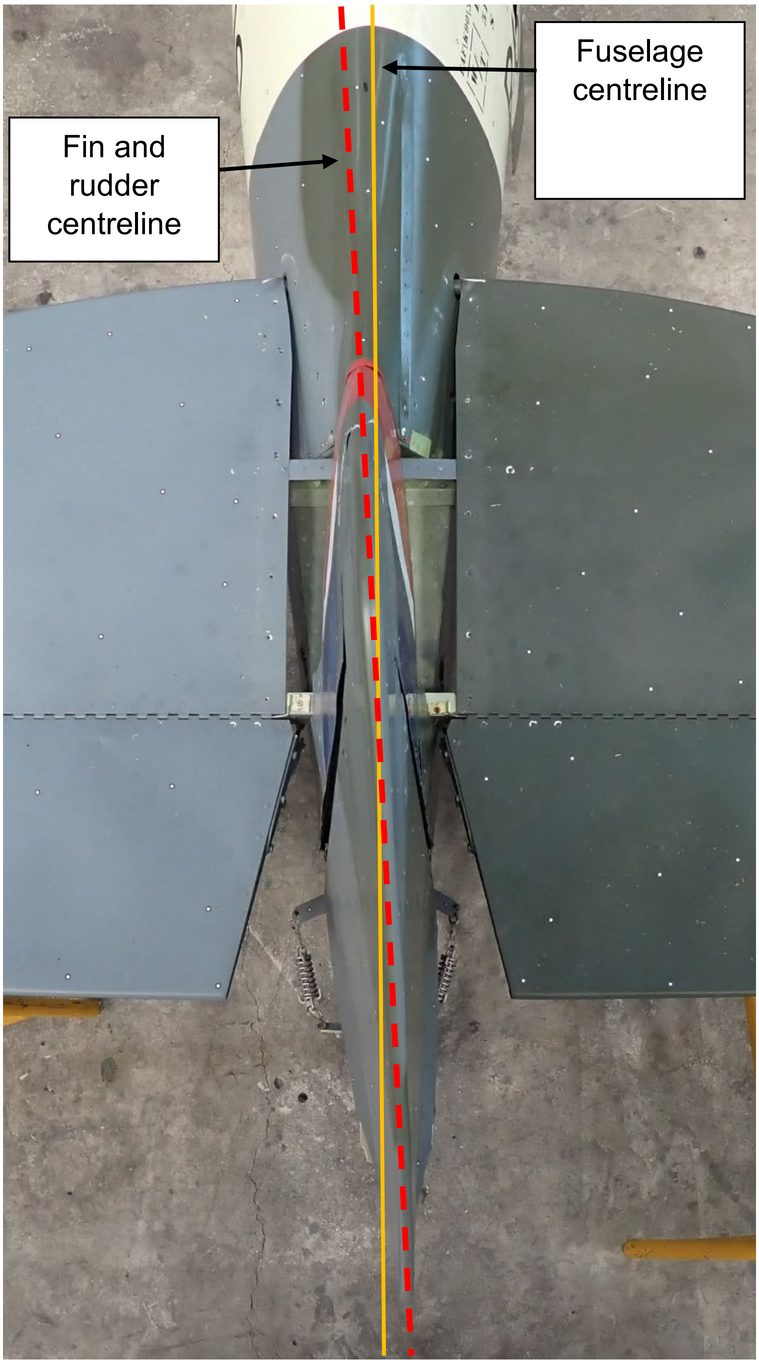

Figure 8

Fin and rudder misalignment from above with the rudder horn aligned with the fin leading edge

Controls

The rudder pedals and adjustment components within the cockpit were partially destroyed in the fire. The steel rudder cables and turnbuckles were generally intact and there was continuity between the ends of each cable. By manually operating the ends of the cables, it was possible to establish that the rudder had a full range of movement and operated in the correct sense.

There have been occurrences on the aircraft type of the rudder cable loop derailing from the pulleys if both rudder pedals are pushed hard at the same time. This can lead to restricted movement. The rudder cable and pulley system were disassembled and examined. Although the pulleys were destroyed in the fire, close examination of the pulley mounting plates and the cables found no evidence of chafing, rubbing, or jamming.

Other examples of the aircraft type were examined and the possibility of a loose item affecting the rudder controls, was considered. Although there is clear space above and around the front of the rudder pedals, the design of the cockpit would make it difficult for a loose object to migrate to this area. The rudder pedal side mechanisms are close to the fuselage inner skin and it is possible that a foreign object could lodge between them.

Due to the damage to the aircraft, the possibility that the rudder controls had been jammed by a foreign object could not be excluded.

Construction of the aircraft

While the aircraft is supplied as ready-to-assemble with parts supplied pre-shaped and pilot drilled, during the construction many of the structural parts required significant rework and alteration. In some cases, this was due to permitted tolerances, and in others, it may have been due to fabrication errors. There is the possibility that as multiple parts are assembled, where these problems exist, a significant non-conformity may go unnoticed. The problems encountered in this aircraft were not dissimilar to those experienced by other builders of this kit. The team took numerous pictures during construction and held regular meetings to discuss and address the problems.

The construction team were aware that there was a slight misalignment in the fin and rudder which was only noticeable when attention was drawn to it. However, the frame and tailplane attachment features presented no difficulties during assembly and fitted together neatly. As the fin assembly was an integral part of the assembly it was assumed that the misalignment was a correct feature of the aircraft. The team inferred that the misalignment was a deliberate feature to offset the propwash yaw effect, but the design of the kit already featured offset engine mounts to deal with this.

The LAA is responsible for inspection and approval of this aircraft type.. An LAA examination of the aircraft after the accident lead to the consideration of additional potential difficulties in constructing the Spitfire Mk 26 series aircraft. With several ongoing projects in the UK, the LAA took action by issuing an MTD:

> The LAA issued Mandatory Technical Directive MTD-01-2024 on 13 February 2024 applicable to all Spitfire Mk 26 and Mk26b aircraft. The MTD required geometry and symmetry checks to be carried out to ensure correct alignment of fin assembly and rigging of rudder with comprehensive illustrated instructions how to achieve the checks.

Weight and balance

The aircraft was within both the maximum takeoff weight and the centre of gravity envelope for the flight. For each test flight the weight and balance of the aircraft was the same as previous flights to allow for consistent handling.

Final manoeuvre

Witnesses described the aircraft as entering a 'spin' or 'rotating' to the right from the third stall. When an aircraft stalls asymmetrically one wing will drop before the other. The dropping wing has an increasing angle of attack and drag. This increase in angle of attack and drag increases any yaw creating a rotation which can continue into a fully developed spin. In a spin an aircraft is rotating about a helical axis and is rolling, pitching and yawing with a very low and stable speed and a high rate of descent. The pitch of the nose will depend on the aircraft characteristics.

To recover from the spin the pilot should close the throttle, apply full opposite rudder to the direction of rotation whilst centralising the ailerons and unstalling the wings by progressively pushing forward on the stick until the rotation stops. The aircraft can then be recovered from the resulting dive.

It is also possible that when a wing drops in a stall, it may then become unstalled and the aircraft may enter a spiral dive. In this condition the aircraft speed will increase rapidly, the rotation will tend to be slower than in a spin but the rate of descent can be very high. In a spiral dive all the controls are effective although they may be heavy due to the high speed of the aircraft. To recover from a spiral dive the pilot must roll the wings level using co-ordinated ailerons and rudder before recovering from the dive.

Aircraft performance

The LAA stated in their Type Acceptance Data Sheet[6] for the Spitfire Mk 26 that:

> *'The first two UK–built examples exhibited a significant wing drop at the stall and no pre-stall warning as first built. Both the wing drop and the lack of stall*

Footnote

[6] https://www.lightaircraftassociation.co.uk/infolibrary/24a9b2c1-92b4-4b77-ab9d-31c646d8ba91 [accessed October 2023]

warning were corrected on G-CCZP by fitting wing leading edge stall strips. Variation between wing leading edge profiles on individual aircraft is likely to cause differences in stall characteristics between individual aircraft'.

The LAA did not approve the aircraft for aerobatics or spinning (Spitfire Mk 26 or 26B) and as such there was no requirement to test the spinning characteristics of the aircraft type. The Spitfire Mk 26B was only approved for a single pilot due to pitch instability with a rearwards centre of gravity.

All of the Supermarine replica spitfires are kit built and can therefore be significantly different in their performance and flying characteristics. These differences are the result of the 'hand built' nature of the aircraft. Other owners and builders of the Spitfire Mk 26 and 26B aircraft had found there was an inconsistency of some of the prefabricated parts of the aircraft. This has led to subtle, but generally acceptable, differences in finished aircraft. This was evident from the comparison between the two Spitfire Mk 26Bs at the airfield with the other showing much more benign characteristics in its stall testing compared to G-CLHJ.

Spinning the Spitfire Mk 25/26/26B

The investigation was unable to find details of spinning trials conducted on any of the scale replica Spitfires produced by the manufacturer, although owners and pilots outside the UK have spun their aircraft. Pilots who have spun the Spitfire Mk 26B state that entering an intentional spin is very easy either by letting the wing drop in a stall or by using rudder in a nose high attitude with low power. The spin was described as smooth, without hesitation in any axis and the recovery was very quick and controllable.

A report from the New Zealand[7] distributor of the replica Spitfire commented that:

'Spins conducted, clean aircraft, one and a half turns each. Entry, full rear stick, throttle closed, full in spin rudder, ailerons central. A/cs nose dropped after 1/2 rotation. Spin slightly faster to right and tending to increase rate when starting recovery. Yaw stopped instantly when opposite rudder applied. Aircraft normal safe recovery, speed builds quickly after roll and yaw stops.'

Meteorology

The weather around Enstone was good. There was scattered cloud with a base of between 3,500 ft and 4,000 ft agl. Wind was from a west or south-westerly direction with a speed of around 8 kt. The temperature was 22°C.

Pilot

The pilot of G-CLHJ had been accepted by LAA as having suitable competence and experience for the required testing, with significant experience on tail wheel aircraft. He had also flown another Spitfire Mk 26B before undertaking the flying on G-CLHJ. The pilot had a PPL which contained valid class ratings for the flight and a Class 2 medical. He also held an aerobatic rating.

Footnote

[7] http://www.campbellaeroclassics.com/id80.html [accessed November 2023].

The pilot had suffered a myocardial infarction (also known as a heart attack) in 2005, aged 50 and there was significant history of heart disease. Since 2005, for Class 2 certification he was required to undergo regular exercise tolerance tests (stress ECGs) which look for ischaemia of the heart muscle with increasing workload. Since these were all negative, his incapacitation risk in the subsequent years was assessed as statistically less than 1%. This means his risk of a subsequent heart problem was the same as the general population, and he was able to hold a CAA Class 2 medical. His last exercise tolerance test was carried out in April 2023.

There was evidence from the post-mortem examination of the pilot's heart of the previous myocardial infarction, as well as long standing heart disease but the examination did not show any clear signs of a recent event. There was evidence of what was considered to be traumatic damage as a result of the accident. The pathologist did however comment that given the signs of significant coronary disease and the previous infarction: *'This could put the individual at risk of indeed [sic] sudden cardiac death potentially at any time.'*

During his flying career the pilot had regularly flown aerobatics and practised spin recoveries, but he had not done this recently. The pilot did regularly fly another light aircraft which had approval for aerobatics and intentional spins of up to three turns, but witnesses reported that he did not use the aircraft for this. The skills required for upset and spin recovery are perishable, and a lack of recency may mean a pilot does not react as quickly or instinctively to a spin as one who is in regular practise.

According to CAA Safety Sence Leaflet 30 – Loss of Control Spin & Stall Awareness, loss of control through stalling or entering a spin remains one of the leading causes of general aviation accidents.[8]

Survivability

The pilot was wearing flying overalls and a modern 'retro style' flying helmet. The aircraft was fitted with a four-point nylon web safety harness. The pilot was not wearing a parachute.

The aircraft struck the ground with considerable force, sufficient to bend the main spar of the wing. These forces were likely not survivable for the pilot. Evidence from the post-mortem indicated that the pilot had died before the fire began. The front seat harness, except for the steel buckles, and seat furnishings had been destroyed in the fire. The front seat buckles, although fire damaged, were in position within their clasp showing that the harness was correctly fastened. Examination of the seat frame showed the seat back frame and pan had shifted to the right and the seat back had collapsed downwards to a fully reclined position; this would have occurred during the impact sequence.

Footnote

[8] https://www.caa.co.uk/media/ajobzoaq/caa8230_safetysense_30-lossofcontrol_v10.pdf [accessed November 2023].

Human performance

Startle response

When a person encounters something that they are not expecting it can generate a startle response. This is a natural response of the brain to a significant stimulus. Whilst the processing of that stimulus within the brain may not be instantaneous, there is an area of the brain that can respond instantly with an aversive reflex. It is this 'instant response' whilst the processing of the stimulus is occurring that is the startle effect.

The United States Federal Aviation Administration talks about the startle response as being when pilots are *'faced with unexpected emergency situations*' and that such a response may delay a reaction from the pilot but may also lead to an incorrect response being triggered.[9]

All humans have a startle response but training and preparing can reduce the startle response time. This promotes a more timely and effective response to emergencies. Although the pilot had significant experience of both aerobatics and spinning, he was not in recent or regular practise.

Incapacitation

The CAA medical system aims to ensure that the risk of pilot incapacitation remains low. The risk does increase with age as it does with the general population. The pilot of G-CLHJ had a number of risk factors that might have raised his chance of incapacitation, although he was regularly assessed by his AME as part of his medical examination.

Incapacitation can be partial or complete but either case can prevent a pilot from operating an aircraft. Incapacitation as the aircraft was at or close to the stall might have prevented the pilot from recovering the aircraft, and once the aircraft had entered a spin or spiral dive, might have prevented or delayed recovery. Incapacitation can also vary in completeness over short periods of time.

Analysis

During a flight test towards obtaining a Permit to Fly, control of the aircraft was lost. The pilot was fatally injured when the aircraft struck the ground.

Aircraft construction and flying control systems

The aircraft had been constructed from a kit over several years, during which the build team followed the LAA guidance and principles on building and test flying home built aircraft. Numerous short comings with the kit had been addressed and overcome by the build team. Test flying started in 2021 and as it progressed the team made adjustments to correct the tendency for the aircraft to roll to the right. Although the fin misalignment was known about by the build team, it was assumed that the misalignment was a feature of the kit design. It was not considered as a possible cause of the tendency to roll to the right. A comparison of the tail with the other Spitfire Mk 26B aircraft at the airfield was never explored by the build team.

Footnote

[9] https://www.faa.gov/newsroom/safety-briefing/startle-response [accessed November 2023]

Despite the damage sustained during the accident there was no evidence of a malfunction or failure of any of the aircraft flying control systems. Whilst the layout and space around the rudder pedals and the cockpit floor would suggest that a loose article would be unlikely to cause a control restriction, the fire damage in the area around the controls meant any plastic or organic components in the vicinity were completely destroyed. Therefore, a control restriction cannot be completely ruled out.

Fin misalignment effect

The aircraft should not have had a fin misalignment. There is no mention of it in the kit construction manual and the fin is shown symmetrically on the fuselage centre line on the manufacturers drawing. Other Spitfire Mk 26 and Mk 26B aircraft do not have the fin misalignment and during the testing of those aircraft, there was no marked tendency for them to roll.

Despite the adjustments made to correct the roll, when the aircraft is approaching the stall and the effect of the ailerons is reduced, the fin misalignment may have had an effect by inducing a constant yaw causing the right wing to stall first and drop as reported by the pilot. In effect the misalignment fin and rudder created a pro-spin condition.

CCTV and witness evidence show the aircraft descending and rotating to the right. If it is considered that the aircraft was in a spin to the right and the standard corrective action was taken, the fin misalignment and full left rudder would have created a significant aerofoil camber and therefore aerodynamic force to counter the rotation. Therefore, had full left rudder been applied, the misalignment would have been more than sufficient to arrest the rotation. Although the fin misalignment was undesirable, it is not considered to be a causal factor in this accident.

Stall strips

Throughout the flight testing of G-CLHJ the pilot had conducted numerous stalls to ascertain the characteristics and stalling speed of the aircraft. In nearly all of these stalls the pilot reported a wing drop to the right. For the accident flight the stall strips had both been moved down a few millimetres. Both stall strips were located at the accident site, although one was no longer attached to the leading edge of the wing due to the fire.

The pilot conducted two stalls and recovered before the aircraft departed from controlled flight on the third stall. Given the pilot was familiar with the tendency of the aircraft to drop its right wing at the stall, and that he had completed two previous stalls during the flight in which the right wing was seen to drop, it would seem unlikely that he was startled by the aircraft behaviour on the third stall. The position of the stall strips did not seem to significantly change the behaviour of the aircraft compared to previous flights.

Flight manoeuvres

Witnesses observed the aircraft depart the airfield without incident. The pilot climbed to between 3,000 and 4,000 ft which was sufficient for the planned elements of the flight.

Although at some distance away they observed the aircraft undergoing stalls as planned. Immediately after the third stall the aircraft departed from controlled flight and descended. The observers considered the aircraft to have entered a spin.

Analysis of the CCTV would indicate that there was little change in the rate of descent or aircraft speed for most of the descent which would fit with the aircraft being in a spin. However, the steep nose-down attitude of the aircraft could be more indicative of a spiral dive. The distance of both the CCTV camera and the witnesses from the aircraft means that it is not possible to clearly identify whether it was a spin or spiral dive. However, the fact that two stalls appeared to have been carried out satisfactorily suggest the pilot was in full control and flying to the plan for the flight. Something appears to have gone wrong during or immediately after the third stall.

The pilot had suffered a heart attack some years previously and there was significant history of heart disease. Although the assessment of his heart condition for his Class 2 aviation medical indicated he was at a low risk of a cardiac event, the post-mortem found evidence of longstanding heart disease and scarring from the previous myocardial infarction. The pathologist suggested that a cardiac event leading to an incapacitation was possible at any time, but there was no definitive evidence that one occurred during the accident flight.

At some point during the third stall the pilot experienced an event which prevented him from immediately recovering from the stall and the aircraft entered into a spin or spiral dive. The CCTV indicates that for the initial period the flight path of the aircraft remained relatively constant which would indicate either no action or a lack of effective recovery action by the pilot. The pilot had extensive experience in aerobatics and spinning, however he was not in recent practice. Although the wing drop was familiar to the pilot, the subsequent departure from controlled flight possibly startled him leading to a delay in any recovery action. The CCTV analysis did indicate there was a change in flight path characteristics as the aircraft approached the ground which in the absence of other changes to the aircraft, could indicate some level of control input from the pilot. Evidence from the accident site would confirm this change in flight path as the aircraft struck the ground at a shallow pitch angle and did not make contact with the electricity cables running above the point where the aircraft initially struck the ground.

The cause of the loss of control following the third stall and the lack of complete recovery could not be established, but either startle, an incapacitation or a control restriction cannot be ruled out.

Conclusion

Control of the aircraft was lost during a test flight towards the grant of a Permit to Fly. Despite the damage sustained during the accident, there was no evidence of a malfunction or failure of any of the aircraft flying control systems. The aircraft was found to have been built with a misaligned fin and rudder. This misalignment made a wing drop at the stall more likely, but it did not prevent or restrict a recovery from the stall nor any subsequent spin or spiral dive that might develop. The pilot had conducted numerous stalls on the aircraft during its flight testing and was familiar with the wing drop in the aircraft and therefore it is unlikely that he was startled by the behaviour although the subsequent entry into a spin or spiral dive may have. There was sufficient height for a recovery from a spin or spiral dive.

Although the pilot's medical history indicated the possibility of an incapacitation this could not be confirmed by the pathologist. The prospect of a control restriction preventing a full recovery could also not be excluded due to the extensive fire damage to the aircraft.

Safety action

The LAA issued Mandatory Technical Directive MTD-01-2024 on 13 February 2024 applicable to all Spitfire Mk 26 and Mk26b aircraft. The MTD required geometry and symmetry checks to be carried out to ensure correct alignment of fin assembly and rigging of rudder with comprehensive illustrated instructions how to achieve the checks.

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