ACCIDENT

Aircraft Type and Registration:	Pitts S-1C (Modified), G-BTOO	
No & Type of Engines:	1 Superior XP-IO-320-A3AD3 piston engine	
Year of Manufacture:	1966	
Date & Time (UTC):	27 March 2022 at 1600 hrs	
Location:	Popham Airfield, Hampshire	
Type of Flight:	Test Flight	
Persons on Board:	Crew - 1	Passengers - None
Injuries:	Crew - 1 (Serious)	Passengers - N/A
Nature of Damage:	Substantial	
Commander's Licence:	FAA Private Pilot's Licence	
Commander's Age:	59 years	
Commander's Flying Experience:	339 hours (of which 188 were on type) Last 90 days - 1 hour 20 minutes Last 28 days - 1 hour 20 minutes	
Information Source:	AAIB Field Investigation	

Synopsis

Whilst on a test flight, after an extensive rebuild, the pilot became aware the elevator was no longer connected to the control column. He was able to maintain control, but during the final stages of approach, the aircraft pitched nose down and landed heavily on the forward fuselage; it came to rest inverted. The pilot received a severe laceration to the head and was assisted from the aircraft before being taken to hospital.

The investigation identified that a pivot joint at the end of an elevator pushrod had become disconnected, most probably due to the lack of a split pin to prevent the securing bolt's castle nut from loosening.

Although not directly linked to this accident, discrepancies were found regarding adherence to LAA guidance for recording work. Inconsistencies were identified within LAA Technical Leaflets regarding who can sign for duplicate inspections. It was also noted that the extent to which the 51% rule for amateur built aircraft needs to be applied in relation to overhaul, repair, and restoration of amateur built aircraft was not clear in regulatory material. The Civil Aviation Authority (CAA) has stated it will be taking two Safety Actions, and the Light Aircraft Association (LAA) has stated it will be taking two Safety Actions to address these issues.

History of the flight

The pilot was conducting a test flight as part of the process for regaining G-BTOO's permit to fly following an extensive rebuild. Prior to takeoff, the pilot stated that he had completed extended ground running of the engine and control checks to ensure all were operating normally. This was followed by an extended period for another 20 minutes of fast taxiing to determine the handling characteristics he was likely to encounter on landing. After departure on Runway 03 at Popham, the pilot then conducted a series of flight manoeuvres for about 15 minutes during which no handling issues were highlighted.

The pilot then joined in formation with another Pitts Special about 4 nautical miles from the airfield and began to route back. He stated that G-BTOO was trimmed in straight and level flight at 2,500 ft amsl with 140 mph indicated airspeed; at this point, he felt that he had some play on the stick in the pitch axis. He determined that he was able to move the control column fully forwards and backwards without any effect on the pitch attitude of the aircraft. Concerned that the elevator may have detached completely, he asked the pilot of the other Pitts to undertake a visual check of the elevator, who reported that it all looked normal.

The pilot then declared a MAYDAY on the Popham radio frequency stating that he had lost all elevator authority and was returning to the airfield. He assessed that the trim control had no tangible effect and understood that the effects of the propeller would affect the pitch attitude of the aircraft when turning. He commenced an unbalanced turn to the left and completed 3 - 4 turns which allowed him to set up on the inbound heading for Runway 03. He then made a flat approach ½ nm from the threshold at 140 mph. The pilot assessed that the aircraft would touch down about ¼ of the way down the runway from the threshold. As the aircraft passed over trees in the undershoot of Runway 03, the pilot reported that he felt the aircraft was affected by turbulence which resulted in a steep nose-down attitude of the aircraft. In response the pilot closed the throttle, before the aircraft struck the ground, flipped over, and came to a stop inverted.

The pilot sustained a severe laceration to the head and was taken to hospital.

Accident site

The aircraft came to rest on Runway 03 at Popham. Figure 1 shows some of the ground markings and the aircraft's final resting position. The AAIB did not attend the site initially and airfield staff recovered the aircraft to its hangar, using a trailer.

Aircraft information

The Pitts Special S-1 aircraft is a small single seat biplane of mixed construction and is capable of aerobatics. The fuselage and tail surfaces are constructed from welded steel tube, and the wings from wood; all are covered with fabric.

Figure 1

View along Runway 03 at Popham
Image used with permission

History of the aircraft

G-BTOO was amateur built[1] and was originally constructed in the United States of America in 1966. It was a S-1C version and was imported into the United Kingdom in 1991. The aircraft had been constructed with an additional bellcrank in the elevator control run, located in the rear fuselage. This non-standard arrangement was approved by the Light Aircraft Association (LAA) during the process to issue the aircraft with its initial UK Permit to Fly.

The aircraft was registered to the current owner in 2011 and underwent an extensive rebuild which was completed in 2014.

In 2018, the owner contracted an individual, who had a business maintaining and rebuilding Permit to Fly aircraft, to rebuild and modify the aircraft. The individual had extensive experience in the maintenance of this type of aircraft and was an LAA approved inspector. The commercial business did not hold any CAA approvals and the business owner held no formal aircraft maintenance qualifications, and they were not required to.

The aircraft was dismantled and taken to a workshop for an extensive rebuild and modification. This modification, which was in the process of being approved by the LAA, entailed fitting a different set of wings which incorporated four ailerons, one on each lower wing, and two on the upper wing, instead of the original configuration of just two ailerons, one on each lower wing. The completed wings were acquired by the owner and were

Footnote

[1] Amateur built – 'aircraft of which at least 51% is built by an amateur, or a non-profit association of amateurs, for their own purposes and without any commercial objective' CAA CAP659, paragraph 3.1.

inspected as part of the rebuild, there was no information provided on their provenance. Modifications were also required to the fuselage structure to accept the replacement wings.

The work was completed in 2021 and the completed work pack for the rebuild was submitted to the LAA. This included an unconventional, but generally comprehensive, narrative of the work that had been undertaken rather than worksheets detailing the work in stages. More conventional documentation was provided for completion and certification of the welding work and the flying control and airframe duplicate inspections. The individual who undertook the work reportedly took photographs of the work, but none were with the work pack or could be located.

The first part of the duplicate inspections was signed by the individual who had completed the work and then acting in their LAA Inspector role, issued the Permit Maintenance Release (PMR). The second part of the duplicate inspections was signed by another person, who did not have any link to the aircraft. This independent person was a licensed pilot and a member of the LAA and had experience in aircraft inspection and met the requirements stated on the aircraft duplicate inspection record they signed.

All the documentation describing the work had been signed on 6 August 2021.

Sadly, the person who had completed the rebuild work, the permit maintenance release and one part of the duplicate inspections passed away after a sudden and unexpected medical event.

The LAA then briefed another inspector, who was taking over supervision of the project, on the details and progress of the modification approval process.

The LAA issued a Certificate of Clearance on 4 November 2021, and it was valid until 3 February 2022. It was duly signed by the owner/pilot and the LAA inspector who had taken over supervision, as required to confirm the aircraft was ready for flight, on 5 November 2021.

A 30-minute flight was conducted without incident on 11 November 2021 and the date and duration was recorded in the aircraft log books. There are no details of the content of this test flight or the functioning of the aircraft.

The airfield log records that G-BTOO departed on 3 December 2021 and again on 5 January 2022. The duration of these flights was not recorded by the airfield. There are no flights recorded in the aircraft log books for these dates. The owner did not recall the exact details of the departures but suggested they may have been high speed taxi tests using the runway.

During March 2022, the owner applied for a new Certificate of Clearance as the previous one had expired. The LAA re-issued it on 24 March 2022, and it was valid until 23 June 2022. It was duly signed by the owner/pilot and an LAA inspector as required on 26 March 2022 confirming the aircraft was ready for flight.

The aircraft was flown for 20 minutes on the 26 March 2022 before the accident flight on 27 March 2022.

Aircraft examination

The aircraft was initially examined in the hangar to which it had been recovered, where it was stored inverted on a trailer. It was later transported to the AAIB facilities for a more detailed examination.

Elevator control system

There were no access panels close to a bellcrank in the elevator control linkage, but it could be seen through a hole in the lower fuselage fabric, created during the accident (Figure 2). One of the push rods was no longer connected to the bellcrank which resulted in the loss of elevator control.

Figure 2

Showing bellcrank and disconnected pivot joint after recovery to the hangar, view looking towards top of fuselage, cockpit is to the left
Image used with permission

The disconnected bolt for the pushrod to the elevator was found in the bellcrank hole furthest from the pivot point. It could not be confirmed whether this was the hole it was in at the time of the accident, as damage to the paint around both bolt holes indicated a bolt had been fitted in both positions. The bolt showed signs of a nut having been fitted. Neither the nut nor a split pin was found, but the fuselage is open at the rear. The other push rod connected to the bellcrank was connected to the control column. Its bolt and the bell crank mounting bolt were secured with a nut and split pin as was the central pivot bolt.

Photographs taken after the previous rebuild, completed in 2014, show at this time the aircraft had access panels next to the bellcrank and that the bellcrank was fitted in the other orientation. The pivot bolt for the control column pushrod was fitted to the inner hole (Figure 3).

No other anomalies were identified with the control systems.

Figure 3

Bellcrank arrangement after previous rebuild
Image orientated to be similar to Figure 2 to show different orientation
Image used with permission

Survivability

Seat harness

The pilot was restrained by a five-point harness. The harness, its attachments and the seat remained intact. The AAIB were informed the harness was new and it appeared to be so. The narrative work pack indicated the person performing the re-build had cleaned and refitted the original harness. There is no record of the harness being replaced.

Cockpit safety

The material of the fuselage skin that formed the coaming above the instrument panel was manufactured from flat sheet. Design drawings for the aircraft specify the resulting sharp edge, in front of the pilot's head, to be thickened with a tube riveted to the panel and then covered with padding. This is to minimise injury to the pilot should they be thrown forward on to it (Figure 4). This had not been installed on G-BTOO.

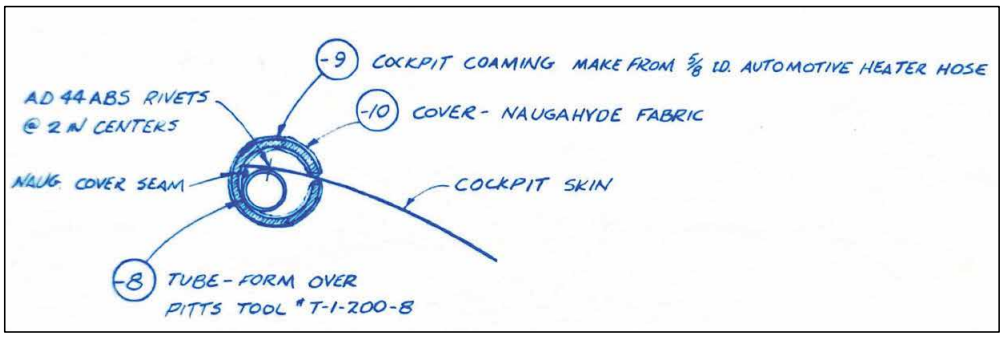

Figure 4

Drawing of padding arrangement for cockpit skin forming instrument panel coaming

Although the pilot was restrained by the seat and harness, the flex in his body and the proximity of the coaming meant his head struck the unprotected edge of the cockpit skin, or coaming, causing a deep cut to his forehead and scalp.

Head protection

The pilot was not wearing any head protection.

Effects of power and the propeller

Pilot's understanding

The pilot stated that he was concerned about the effect of using rudder on a 'floating' elevator and that with:

> *'yaw [from the application of rudder], the gyroscopic effect will come into play which means if I turn right with my rudder the 'P factor of the propeller will put my aircraft in a nose down attitude… I have ailerons, if I turn left just with my ailerons, the P factor of my propeller coming down to the right and up to the left will hold my nose up above the horizon.'*

Effects of power

The secondary effects of power are on the pitch, yaw and roll trim of the aircraft about the axes (Figure 5). Any change in power alters the thrust which, in turn, affects the longitudinal trim of the aircraft about the lateral axis, primarily through the effect of the slipstream on the tailplane – more power – nose up, less power – nose down. Thrust also affects the strength of the slipstream over the fin and rudder changing the yaw trim of the aircraft about the normal axis. Further, as power changes, the torque reaction on the propeller will tend to roll the aircraft in the opposite direction to the rotation of the propeller.

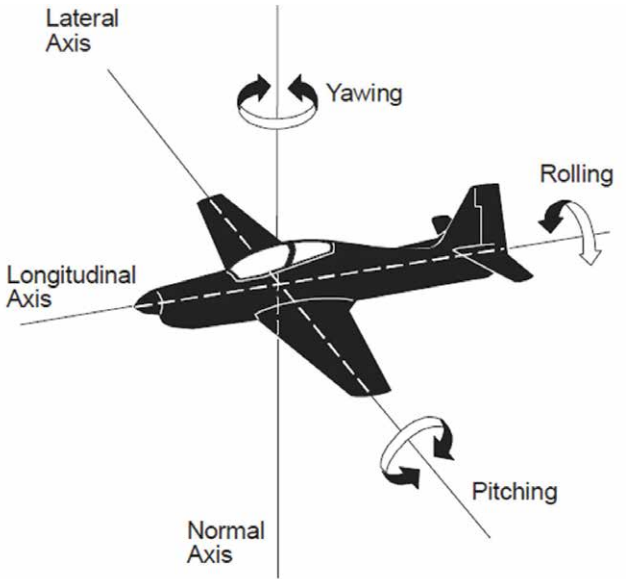

Figure 5

Axes and trim of the aircraft

Gyroscopic effects of the propeller

The effect of precession means that any force which is applied to a rotating object acts at a point 90ºs in the direction of rotation from the point that any force is applied. Thus, for a clockwise rotating propeller, as seen from behind, the application of yaw right will result in a pitch down, while yaw left will result in a pitch up.

Asymmetric blade effect

As an aircraft slows down, the nose of the aircraft is required to pitch up to maintain straight and level flight and the plane of rotation of the propeller becomes less perpendicular to the direction of flight and the airflow. This results in what is known as Asymmetric Blade Effect, also known as the 'P' factor or Asymmetric Loading, owing to the differences in the angle of attack, and hence thrust, between the down-going blade and the up-going blade.

As the nose attitude increases and the plane of rotation of the propeller becomes less perpendicular to the direction of flight, the down-going blade is advancing faster into the airflow than the up-going blade. Consequently, the angle of attack on the down-going blade is greater than the angle of attack on the up-going blade, with the consequent effect on thrust provided by each blade.

This difference in thrust moves the centre of thrust outwards from the centre along the chord of the down-going blade, resulting in asymmetric loading of the propeller, and a consequent yawing moment. For a clockwise rotating propeller, as seen from behind, the resultant yaw from slowing down would be to the left. The effect on yaw trim has no effect on pitch attitude and can be controlled through the rudder pedals.

Meteorology

The pilot reported that the wind was 15 mph from the north. The actual weather at RAF Odiham, approximately 15 miles away, recorded a wind of 8 kt from the northeast.

Popham Airfield

Popham Airfield has two grass strips, Runway 03/21 and Runway 08/26 (Figure 6). There are trees to south of the A303 on the undershoot of the approach to Runway 03; this runway has a marked downslope of 1.3%.

Pilot licencing

Articles 137, 138 and 150 of the UK Air Navigation Order (ANO) 2016 permit a pilot to fly an aircraft with a 'permit to fly' on the privileges of a pilot's licence issued by an ICAO compliant third country.

The pilot held a valid FAA private pilot's licence with a current single engine land airplane rating and a valid FAA third class medical.

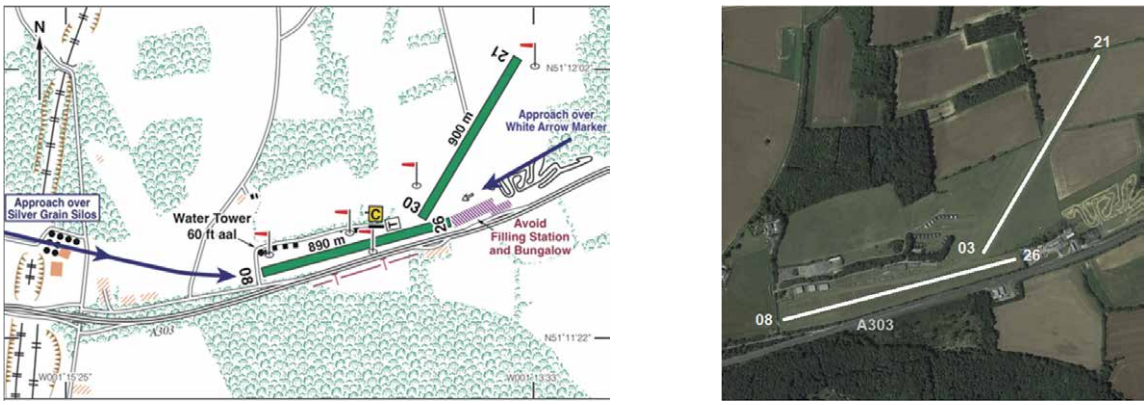

Figure 6

Popham Airfield (Source: Pooleys and Google Earth)

Amateur built aircraft

General legislation

An amateur built aircraft cannot qualify for the issue of a Certificate of Airworthiness as it has not been designed and constructed by an appropriately qualified organisation. Instead, a Permit to Fly may be issued if the requirements of British Civil Airworthiness Requirements (BCAR), Chapter A3-7, '*Permit to Fly Aircraft – Initial and continuing airworthiness*', have been met.

Civil Aviation Publication (CAP) 659, '*Amateur Built Aircraft*', provides guidance to amateur constructors on how to comply with BCAR A3-7 and associated regulations for an amateur built aircraft.

Section 1.8, '*Who This CAP Affects*', states:

> *'1.8.1 This CAP applies to anyone who seeks a Permit to Fly for an amateur built aircraft*
>
> *1.8.2 This CAP is equally applicable to anyone who is restoring an aircraft (which is not eligible for a Certificate of Airworthiness) and seeks a Permit to Fly for it, be it an existing amateur constructed aircraft, or an historic aircraft……'*

When building an aircraft CAP 659 notes:

> *'Anybody is free to construct an amateur built aircraft. But in order for the constructor to maintain amateur status and for the aircraft to subsequently qualify for approval as amateur built, the following criteria will have to be met:'*

These include:

> *'We* [The CAA] *will need to be satisfied that both the building and operation of the aircraft will be solely for the education and recreation of the amateur builder. This means that he would not be permitted to commission someone else to build his aircraft or even, subject to the provisions of the 51% rule, significant parts of it, with the exception of the engine(s), propellers, and helicopter or gyro plane transmissions, rotor heads or rotor blades. Stage inspections made at suitable intervals along with a final inspection of the aircraft and its records will verify these conditions are being met.'*

The LAA and its approved inspectors

The LAA are approved by the CAA, as a BCAR A8-26 organisation[2], to undertake many of the approval activities on the CAA's behalf and they have a network of approved inspectors to undertake inspection activities. The LAA '*Inspector approval scheme document*, *LAA/IAS/17*', explains the scheme along with the responsibilities and limitations of an inspector. Each approved inspector is approved to undertake a certain range of tasks, depending on their skills, knowledge, and experience. These are set out on an LAA Inspector Approval Card individually issued to each approved inspector.

Note 4 of LAA/IAS/17 sets out an approved inspector's limitations for '*Signing Own Work or Aircraft*'.

> *'There is no restriction on LAA inspectors signing off their own work, as long as the work is within the scope of their approval, except for the following. LAA policy is that whilst any suitably approved inspector, even if the owner, may carry out and sign off 'between-permit' work and sign off worksheets and Section 2 of the Permit Renewal application form, only inspectors who do not own or part own the aircraft may sign the Inspector's Declaration (Section 3) of the Permit Renewal application form, unless the inspector is also a licensed engineer. No inspector is permitted to sign off the build stages of any project that they own, or part own.'*

The LAA provide on their website a range of Technical Leaflets (TL's) which explain the various aspects of owning and operating a Permit to fly aircraft.

Owner's responsibilities

Leaflet TL 2.01, '*A guide to LAA aircraft ownership*', provides a summary of the responsibilities of owning and operating an LAA Permit to Fly aircraft. Section 2, '*Maintain your aircraft in an airworthy condition*', includes the following statements.

> *'LAA encourages owners to engage themselves fully with the maintenance of the aircraft, but alternatively this can be carried out on a commercial basis*

Footnote

[2] BCAR A8-26 – Organisations Supporting Recreational Aviation.

either using paid individuals or a maintenance organisation. Either way, by their very nature, Permit to Fly aircraft are somewhat unique and less well supported in airworthiness terms than their C of A cousins and need a greater degree of owner engagement, technical appreciation and vigilance to achieve an equivalent safety level.

Note that if an inspector carries out maintenance on behalf of an owner, he or she can do so but whether renumerated or not, this is not carried out under a LAA inspector's remit. The inspector's remit only covers the inspection and certification role.'

Building an LAA aircraft

Leaflet TL 1.02, '*Building your aircraft with the LAA*', describes the process behind building an LAA aircraft and includes details of the build inspection schedule and the inspection stages required. It also draws attention to the 51% rule.

'The build inspection schedule specifies each of the main inspection stages required for the project. There may be anything from, say, ten to thirty stages depending on the complexity of the aircraft type concerned but this does not mean that ten stages means ten visits from your inspector.

A major hurdle passes with the signing off by the inspector of each main component (fin, tailplane, wing, etc) in the project Inspection Record, indicating that the inspector is entirely satisfied that the part is fit to go on to the next stage. The inspector will want to sign up each stage as it is completed, so keep the build Inspection Record to hand for each visit.

Another function of the inspector is to verify that the aircraft has actually been built by the person claiming to have built it. The rule is that at least 51% of the build must be completed by the amateur builder(s). The amateur-building rules do not allow commercial construction on a commissioned basis, or building an aircraft expressly for the purpose of sale on completion. Were this to happen the finished aircraft would not be able to be issued with a Permit to Fly.

Should you decide to pay someone else to build parts of the aircraft for you, the inspector will warn you that whilst it is acceptable for some specialist work to be farmed out (eg welding, covering, etc) the majority of the work must be done on an amateur basis by the owner.'

Rebuilding an LAA aircraft

Leaflet TL 2.21, '*Rebuilding an aircraft under the LAA system*', sets out in the detail the process and procedures to be followed for an aircraft rebuild. This includes the following extracts.

'LAA procedures require a rebuild project to be inspected throughout the rebuild process at stages agreed between you and your inspector. As the process reaches completion there will be a particularly intensive period of inspection,

> *leading up to the aircraft being ready to be cleared for flight. This applies to all aircraft rebuilt within the LAA system and whilst owners of rebuild projects remain wholly responsible for the quality and conformity of the finished aircraft, these inspections are aimed at helping the owner ensure the aircraft meets accepted standards of build quality, conforms to the approved design and complies with various legal requirements.*
>
> *Between you and your inspector, you will need to write up worksheets describing the rebuild, to be signed up by your inspector as you go along. A copy of the worksheets are to be submitted on completion of the rebuild. It's a good plan to make a photographic record of the work as it is being undertaken, and submit that along with the worksheets.'*

It refers to the obligation in the Air Navigation Order to provide a record of work undertaken and goes on to explain over three pages what should be included and why, and offers a workshop template that can be downloaded.

It gives an example for what would be typically expected for a bi-plane of similar complexity:

> *'In the case of a major rebuild of a Tiger Moth, for example, it might well be that there'd be a page or two of worksheet devoted to each of the four wings, one for each of the tail surfaces, two for the fuselage and another couple for the rigging and final checks, so that by the time the worksheets have been stapled together along with the logbook certificates relating to such things as engine rebuilds, a 'form 1' for a new propeller, certificates of conformity for flying wires, calibration certificates for the instruments and engine ground run results, it all makes up to quite a substantial 'work pack'.'*

Duplicate inspections

Leaflet TL 2.01, '*A guide to LAA aircraft ownership*', contains information about duplicate inspections.

> *'Duplicate inspections are required whenever engine or flying controls are disturbed. Each part of such inspections should be signed by a suitably approved LAA inspector. Where a second inspector is not available, an owner/pilot who is also a member of the LAA may carry out the second part of the duplicate inspection, and sign out the second part.'*

Leaflet TL 2.03, '*Maintaining your own aircraft*', also contains information about duplicate inspections.

> *'Duplicate inspections are required whenever engine or flying controls are disturbed. Each part of such inspections should be signed by a suitably approved LAA inspector or suitably licensed CAA Engineer. Where there is no possibility of such a person being available, an owner/pilot who is also a member of the LAA may sign the second part of the duplicate inspection.'*

Leaflet TL 2.05, '*Pilot authorised maintenance*', defines permitted pilot maintenance tasks including duplicate inspections.

> *'A duplicate inspection is required following reconnection or adjustment of any engine or flying control. For LAA aircraft, a licensed Pilot who is the owner of the aircraft and who is a member of the LAA is an acceptable signatory for one part of a duplicate inspection.'*

The '*Aircraft duplicate inspection record*', form LAA/IC-DUP,

> *'The first part of a duplicate inspection must be certified by an LAA inspector.*
>
> *The second part of the duplicate inspection may be certified by a second inspector or by a licensed pilot who is a current member of the LAA.'*

Analysis

Aircraft Handling

The event resulted in the pilot being faced with a high stress situation in an aircraft with a 'floating elevator' and no means to control the pitch attitude through the control column. At this stage, the aircraft was at 2,500 ft trimmed for straight and level flight at 140 mph. He retained full control in roll and yaw through the ailerons and rudder respectively, and was, therefore, able to maintain and adjust trim in these axes without restriction.

However, the pilot assessed that he had only very limited authority in pitch through the trimmer and could only control the pitch attitude by varying power. Therefore, he sought not to upset the trim of the aircraft but to establish the aircraft on the approach while maintaining the speed at which the aircraft was trimmed.

Landing at such high speed would have provided the pilot a significant challenge to slow the aircraft down after it had touched down. The condition of the 'floating' elevator, with which he was faced, is similar to a pilot having their hands off the control column. In the absence of any comments raised from previous flights with regards to the pitch trim, suggesting that it had been rigged correctly, it is reasonable to believe that the pilot should have had the trim authority to be able to trim the aircraft to a speed lower than 140 mph and significantly closer to normal approach speed. This would have enabled him to fly an approach profile similar to a normal approach.

The pilot's understanding of the effects of the propeller upon the pitch trim of the aircraft do not seem to have been entirely clear, as he associated the 'P' factor, or asymmetric blade effect, with an effect on the aircraft's pitch attitude. Asymmetric blade effect has no influence on pitch attitude.

The pilot elected to fly left turns, recognising that turns to the left would assist him to maintain his pitch attitude owing to the gyroscopic effects of the propeller while enabling him to lose height. As he remained uncertain about the effect of rudder, he elected to fly unbalanced turns. However, the use of rudder to fly balanced turns would have had no influence on the pitch attitude but would have reduced the rate of descent during the turn.

The pilot attributed the sudden nose down attitude that occurred in the very final stages of the approach as a result of turbulence. Any reduction in throttle would have also contributed to a pitch down of the nose. A means to counter a pitch down of the nose would have been to make a short sharp increase in throttle to give a burst of engine power by which to raise the pitch attitude. However, this was likely counter-intuitive owing to the proximity of the ground.

Survivability

Although the pilot was restrained by the seat and harness, he was not wearing any head protection. His unprotected head struck the sharp edge of the coaming, which had not been padded as required, causing a deep cut to his forehead and scalp.

Other accidents involving the forced landing of a high-performance aircraft, such as that involving G-INVN on 4 August 2020[3], have shown the benefit of wearing head protection to minimise injuries.

Although it may not always be practical to wear a full crash helmet, even leather helmets can afford a degree of protection to the head. Other measures, such as padding sharp edges in the cockpit, can also minimise injuries.

Engineering procedures

The aircraft had undergone an extensive rebuild lasting several years, this work was contracted to an individual who was also a LAA approved inspector. The work entailed disassembly of the aircraft, installation of an alternative set of wings and the associated structural changes required for their mounting. The accident flight was one of the first following the rebuild.

The LAA approved inspector submitted an unconventional, but generally comprehensive narrative summary of the work completed. It was not possible to determine when the various elements of the work had been carried out and when they had been inspected as the narrative summary had been signed once on completion of all the work. More conventional documentation was provided for the completion and certification of the welding work and the flying control and airframe duplicate inspections.

Following a fatal accident to Auster AOP.9, G-BXON, on 18 June 2017[4], the LAA undertook safety action to reinforce its existing processes and published guidance in areas relating to the Permit to Fly application process and documentation of aircraft maintenance. In October 2018, the LAA issued revised TL 2.21 *'Rebuilding an aircraft under the LAA system'* which now included additional guidance on the completion of worksheets, the expected level of detail to be recorded, and reiterated the respective responsibilities of owners and inspectors for the quality and conformity of rebuild projects. The TL also suggests taking photographs to support the worksheets. The documentation to support the rebuild of G-BTOO did not meet the guidance provided by TL 2.21.

Footnote

[3] AAIB-26839, published in AAIB Bulletin 10/2021.
[4] EW/C2017/06/01, published in AAIB Bulletin 3/2019.

Whilst the narrative nature of the documentation provided to support the approval of G-BTOO's rebuild broadly met the requirements of LAA Technical Leaflet TL 2.21, it was not sufficiently detailed or comprehensive to properly record the progress and details of the work completed over the three-year rebuild process. When received, the documentation was assessed as acceptable by the LAA. The LAA have stated they will be taking the following safety action.

> The Light Aircraft Association will be reviewing the guidance provided to LAA members and Inspectors regarding worksheets. TL 2.21 *'Rebuilding an aircraft under the LAA system'* and other documents will be reviewed and will result in a revised TL 2.21. This review will include.
>
> Reviewing the minimum acceptable standard for worksheets.
>
> Expanding the recommendation that a photographic record of the work is kept, to include the recommendation for inspectors to make a photographic record of what they have inspected.
>
> Clarification of 'stage inspections' and when they should be made and how they should be recorded.
>
> Once complete the revision of TL 2.21 will be publicised to LAA members and Inspectors.
>
> A new LAA worksheet proforma specifically for larger projects such as rebuilds has been created. The intention that this proforma will guide the restorer towards presenting the worksheet in a format closer to the ideal. This has already been published on the LAA website.
>
> A short item on the importance of full and complete worksheets to properly record work undertaken is included in the 'Engineering matters' column of the December 2021 edition of their Light Aviation magazine.
>
> A briefing for inspectors covering the topic of filling in logbooks and worksheets was conducted on 27 February 2023, with a recording available for inspectors who were unable to attend.

The elevator control system had been signed off as part of the overall PMR by a LAA approved inspector. This was the same person who had completed the work. A duplicate inspection was then completed by two people with both confirming the elevator system was correctly assembled and locked. One was the LAA inspector who had completed the work. The second was not involved in the aircraft in any way but was a licensed pilot and a current member of the LAA. He signed the duplicate inspections as he met the requirements stated on the aircraft duplicate inspection record form used for recording the inspections. *'The first part of a duplicate inspection must be certified by an LAA inspector. The second part of the duplicate inspection may be certified by a second inspector or by a licensed pilot who is a current member of the LAA.'*

There is slightly different wording used in LAA Leaflet TL 2.05, '*Pilot authorised maintenance*', which defines permitted pilot maintenance tasks including duplicate inspections. '*For LAA aircraft, a licensed Pilot who is the owner of the aircraft and who is a member of the LAA is an acceptable signatory for one part of a duplicate inspection.'*

Leaflet TL 2.03, '*Maintaining your Own Aircraft*', contains the wording: '*Duplicate inspections are required whenever engine or flying controls are disturbed. Each part of such inspections should be signed by a suitably approved LAA inspector or suitably licensed CAA Engineer. Where there is no possibility of such a person being available, an owner/pilot who is also a member of the LAA may sign the second part of the duplicate inspection.*

It is not consistent within the TL's as to who can sign duplicate inspections. The Light aircraft Association are taking the following safety action.

> The Light Aircraft Association have amended their Technical Leaflets to ensure the information relating to who can sign a duplicate inspection is consistent.

For this rebuild project, taking several years, it seems unlikely that a suitably approved LAA inspector could not be found to complete the duplicate inspections in addition to the inspector who had completed the work.

The information supplied to the LAA indicates that the duplicate inspections were undertaken all together and after the aircraft was complete. This would have made some inspections more difficult, including the disconnected joint, but nevertheless it could be seen and inspected. Had the inspection been completed prior to fabric covering or had access panels next to the joint been refitted during the rebuild, the inspection would have been easier.

LAA TL 2.21, '*Rebuilding an aircraft under the LAA system*', describes the process for rebuilding an LAA aircraft. It is very much focussed on the owner conducting the rebuild with the support and guidance of an LAA approved inspector.

In this case, the work was contracted to an individual who was an LAA approved inspector. The LAA is clear in TL 2.01, '*A guide to LAA aircraft ownership*', that if an LAA approved inspector carries out maintenance on behalf of an owner, he or she can do so, but whether renumerated or not, this is not carried out under a LAA inspector's remit.

The work was carried out, on a commercial basis, by an individual who is not subject to any qualification or approval requirement, as the procedures allow. It is then up to an LAA approved inspector, who in this case was the same person, to inspect and issue a PMR for the work completed.

LAA TL 1.02, '*Building your aircraft with the LAA*', describes the process for building an aircraft. It is similar to TL 2.21 for rebuilding an aircraft, but for a new build, a pre-determined inspection schedule sets out the main inspection stages of the project and each needs to be signed off as the projects progresses.

With a rebuild project, the reliance is on worksheets to describe and record the work as it is completed and, like a new build, inspections are required as the project progresses.

For a new build aircraft over 51% of the build must be completed by the amateur builder(s). The amateur-building rules also do not allow commercial construction on a commissioned basis, other than for limited specialist tasks.

For the rebuild of G-BTOO, the complete aircraft was disassembled to its individual parts so it could be refurbished and modified to accept a new set of wings with additional ailerons. The parts were either inspected and re-used, overhauled or replaced.

All this work had been contracted-out by the owner, on a commercial basis, to an individual. There was no owner participation in the work. The new wing assemblies were supplied by the owner completely built, with only inspection and covering required. Their provenance is not known and no build records were included in the workpack to show when or where they were constructed, the source of the raw materials or who built them; they were not built by the owner. The inspector assessed them as being satisfactory.

A fundamental question that follows is, what is the difference between a build, a rebuild or restoration and maintenance? The LAA procedures as they stand, align a rebuild with maintenance, mainly in that it can be contracted out, whereas a build cannot, except for certain specialist work. For an amateur build aircraft, the 51% rule needs to be complied with although CAP 659 states its guidance applies equally to anyone who is restoring an amateur built aircraft to seek a Permit to Fly. It could be argued that due to the scope and extent of the work, a rebuild or restoration is more similar to a build than it is to maintenance.

The privileges of an LAA inspector allow them to sign-off their own work, as long as the work is within the scope of their approval with a few exceptions. One of these exceptions is, no inspector is permitted to sign-off the build stages of any project that they own, or part own. This limitation, the restriction on contracting out work, and the 51% rule effectively means that during a build project, an inspector can only sign-off work completed by someone else, apart from limited specialist work.

It is a different situation for a rebuild project. In this case, an LAA inspector was paid to commercially modify and rebuild someone else's project as an individual, and then once the work was complete, they took on the LAA inspector role and issued a PMR for the work.

A rebuild or restoration project, such as this one involving G-BTOO, is arguably like a build project in terms of the scope and complexity of work, and as such it would seem prudent to have the rebuilder's work inspected by an independent inspector as would be the case for a build project in which the inspector had a financial interest.

The CAA became aware of this event through its normal reporting channels. The AAIB have sought its clarification on the relevant regulatory framework relating to this investigation. The CAA has stated that it will be taking the following safety actions.

The Civil Aviation Authority will be reviewing the regulatory framework with respect to British Civil Airworthiness Requirements A8-26, '*Approval of organisations supporting recreational aviation*' and A3-7, '*Permit to Fly Aircraft – Initial and Continuing Airworthiness*', in conjunction with the approved organisations. The review will include an evaluation of the requirements relating to duplicate inspections.

The Civil Aviation Authority will engage separately with the approved organisations on the applicability of the '51% rule' in relation to overhaul, repair, and restoration of amateur built aircraft.

Engineering, the aircraft

One of the pushrods in the elevator control system was found disconnected, its attaching bolt was present, but its securing castellated nut and split pin were not found. The bolt showed signs of having had a nut fitted but it seems most likely that the nut had come undone due to no split pin being fitted to prevent the nut from undoing. Once the nut had loosened and detached, there was nothing to prevent the pushrod end fitting falling off the bolt and detaching from the bellcrank.

The bellcrank in the elevator control was found installed the other way up from how it was before the rebuild (Figures 2 and 3). In this orientation had a pushrod been installed on the inner hole as it was prior to the rebuild, the control feel, and response would have been different from how it was before the rebuild.

In the accident orientation, had the bellcrank been assembled with a pushrod connected to the inner hole, as it was before the rebuild, the control column would have needed to be moved further and with less force to get the same elevator deflection. As a result, the aircraft's elevator control would have felt lighter and less effective than it was prior to the rebuild.

Moving it to the outer hole, where the disconnected bolt was found by the AAIB, would have reduced this effect slightly, but it still would not give the same feel and more direct control response as the arrangement prior to the rebuild.

The firmest feel for the elevator and smallest movement of the control column to obtain an elevator deflection would be in the previous orientation of the bellcrank and position of the push rods.

Both holes on the side of the bellcrank with the disconnected joint showed signs of having had a bolt fitted, as the paint was damaged around both holes. It seems that at some time both the holes had been used for the push rod.

There is no record of which hole was used when the aircraft was rebuilt, and no record of any changes made to the pushrod position. Had the recommendation in LAA TL 2.21 section LAA worksheets, of 'make a photographic record of the work as it is being

undertaken' been adopted, the condition and arrangement of these parts at the end of the rebuild would be clearer. Photographs were reportedly taken during the rebuild, but they did not form part of the workpack, and they were not located.

Conclusion

Aircraft handling

The aircraft was flying trimmed straight and level at 140 mph when the pilot discovered that he had lost his primary means to control the pitch attitude of the aircraft through the control column. He then assessed that he had very limited trim authority as a secondary means, leaving only the use of power to control the pitch of the aircraft. In a high stress situation, and not entirely clear of the effects of controls upon the pitch attitude of the aircraft, he elected to fly unbalanced left turns to descend the aircraft and set it up for a high speed approach to Runway 03 at Popham.

However, on the final stages of the approach, the pitch attitude of the aircraft dropped, which the pilot ascribed to turbulence. He closed the throttle in response and impacted the ground with a nose down heavy landing before coming to rest inverted.

Engineering

The loss of elevator control was caused by a bolted pivot joint in the elevator control system coming undone. This was most likely due to the lack of a split pin to secure the bolt's castellated nut.

At the completion of the rebuild, two separate people signed to say the split pin was fitted.

Both alternative holes in one side of the elevator bellcrank in the rear fuselage, to which the pushrod had been attached, had indications of being used and there is no record of if or when the pushrod position was changed.

It is therefore not possible to determine with any certainty when the split pin was omitted.

The pilot's seat and harness remained intact, but he sustained a significant injury when his unprotected head struck the coaming above the instrument panel. This sharp panel edge should have been thickened and padded to comply with the aircraft's design drawings.

The AAIB were informed that the seat harness was new, and it appeared to be so. This is different from the one described in the narrative of the rebuild. There is no record of its replacement.

Although not directly linked to this accident, discrepancies were found regarding adherence to LAA guidance for recording work. Inconsistencies were identified within LAA Technical Leaflets regarding who can sign for duplicate inspections. It was also noted that the extent to which the 51% rule for amateur built aircraft needs to be applied in relation to overhaul, repair, and restoration of amateur built aircraft was not clear in regulatory material. The Civil Aviation Authority (CAA) has stated it will be taking two Safety Actions, and the Light Aircraft Association (LAA) has stated it will be taking two safety actions.

Safety actions

The CAA has stated that it will be taking the following safety actions.

> The Civil Aviation Authority will be reviewing the regulatory framework with respect to British Civil Airworthiness Requirements A8-26, '*Approval of organisations supporting recreational aviation*' and A3-7, '*Permit to Fly Aircraft – Initial and Continuing Airworthiness*', in conjunction with the approved organisations. The review will include an evaluation of the requirements relating to duplicate inspections.
>
> The Civil Aviation Authority will engage separately with the approved organisations on the applicability of the '51% rule' in relation to overhaul, repair, and restoration of amateur built aircraft.

The LAA have stated they will be taking the following safety actions.

> The Light Aircraft Association will be reviewing the guidance provided to LAA members and Inspectors regarding worksheets. TL 2.21 *'Rebuilding an aircraft under the LAA system'* and other documents will be reviewed and will result in a revised TL 2.21. This review will include.
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> - Reviewing the minimum acceptable standard for worksheets.
> - Expanding the recommendation that a photographic record of the work is kept, to include the recommendation for inspectors to make a photographic record of what they have inspected.
> - Clarification of 'stage inspections' and when they should be made and how they should be recorded.
>
> Once complete the revision of TL 2.21 will be publicised to LAA members and Inspectors.
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> A new LAA worksheet proforma specifically for larger projects such as rebuilds has been created. The intention that this proforma will guide the restorer towards presenting the worksheet in a format closer to the ideal. This has already been published on the LAA website.
>
> A short item on the importance of full and complete worksheets to properly record work undertaken is included in the 'Engineering matters' column of the December edition of the Light Aviation magazine.
>
> The Light Aircraft Association have stated they have amended their Technical Leaflets to ensure the information relating to who can sign a duplicate inspection is consistent.

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