CONTENTS

SPECIAL BULLETINS / INTERIM REPORTS

None

SUMMARIES OF AIRCRAFT ACCIDENT ('FORMAL') REPORTS

None

AAIB FIELD INVESTIGATIONS

COMMERCIAL AIR TRANSPORT

FIXED WING

Beech B200 Super King Air	OO-LET	28-Jul-12	3
BN2A MK.III-2 Trislander	G-BDTO	27-Mar-12	9
Boeing 737-33A	G-ZAPZ	14-Apr-12	20

ROTORCRAFT

None

GENERAL AVIATION

FIXED WING

None

ROTORCRAFT

None

SPORT AVIATION / BALLOONS

Shadow Series CD	G-MYUS	22-Aug-12	34
Team Minimax 93	G-CBPL	18-May-12	41

AAIB CORRESPONDENCE INVESTIGATIONS

COMMERCIAL AIR TRANSPORT

None

GENERAL AVIATION

Cessna 172RG	G-BILU	16-Dec-12	53
DH82A Tiger Moth	G-AMTF	30-Nov-12	55
Hiller UH-12 B	N38763	04-Aug-12	56
Pioneer 400	G-TLOY	26-Aug-12	57
Piper PA-22-135 Tri-Pacer	G-APYI	26-Oct-12	61

CONTENTS Cont

AAIB CORRESPONDENCE INVESTIGATIONS Cont

SPORT AVIATION / BALLOONS

Rotorsport UK Calid	G-CGJD	23-Jan-13	62

MISCELLANEOUS

ADDENDA and CORRECTIONS

None

List of recent aircraft accident reports issued by the AAIB 65

(ALL TIMES IN THIS BULLETIN ARE UTC)

AAIB Field Investigation reports

ACCIDENT

Aircraft Type and Registration:	Beech B200 Super King Air, OO-LET
No & Type of Engines:	2 Pratt & Whitney Canada PT6A-42 turboprop engines
Year of Manufacture:	1994 (Serial no: BB-1473)
Date & Time (UTC):	28 July 2012 at 1540 hrs
Location:	Cambridge Airport
Type of Flight:	Aerial Work
Persons on Board:	Crew - 4 Passengers - None
Injuries:	Crew - None Passengers - None
Nature of Damage:	Extensive to propellers, engines, undercarriage doors and luggage pod
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	68 years
Commander's Flying Experience:	13,180 hours (of which 3,111 were on type) Last 90 days - 187 hours Last 28 days - 74 hours
Information Source:	AAIB Field Investigation

Synopsis

The aircraft was returning to Cambridge Airport after completing an airborne communications relay task for the 2012 Olympic Games when it suffered a complete electrical failure. This necessitated the use of the manual landing gear extension procedure to lower the landing gear. The gear collapsed during the landing and the aircraft came to a halt on the runway.

The investigation was unable to determine the cause of the electrical failure and no fault was found with the landing gear system. It is possible that the crew did not operate the alternate extension system sufficiently to extend the landing gear fully prior to landing.

History of the flight

The aircraft was engaged in communications relay duties over London in support of the 2012 Olympic Games and was operating in the London TMA at FL240 in VMC conditions. It was crewed by two pilots, with two technicians in the cabin to operate the relay equipment. This was the second flight of the day for both the aircraft and crew.

After completing the task, the pilots prepared to return to Cambridge Airport. ATC cleared the aircraft to descend to FL180 and route to the BKY VOR. The co-pilot, who was PF and operating from the left seat, selected the engine anti-ice system on in the understanding that this would provide additional drag[1] for the descent and the pilots then commenced the 'Descent' checklist. Due to the workload in the cockpit, neither pilot recalled seeing the anti-ice annunciations or the inertial vane bypass doors extend on the underside of the engine nacelles. When the PF checked the aircraft fuel gauges as part of this checklist, he noticed that they were indicating zero. Almost immediately, ATC informed the pilots that the Mode C transponder readout was no longer being received. The commander transmitted that they may have an electrical problem; this transmission was received by ATC but there was no further radio communication with the aircraft. The last Mode C readout detected by ATC was at FL183.

Over the next two to three minutes, the pilots experienced a progressive failure of all of the electrical equipment, with the exception of the left instrument panel Electronic Flight Information System display[2]. This remained powered by a backup power supply. However, as the display was giving erroneous information, the pilots decided to turn it off. The abnormal checklist did not contain a procedure for a total electrical failure, so the PF turned off both generators and the battery switch before selecting them on again in an attempt to restore the electrical supply. He also selected the alternate inverter and the PNF recycled the cabin power supply switches. The PF stated that he did not attempt to select the generators to RESET. The left instrument panel had functioning ASI and vertical speed indicator (VSI) instruments; the right panel had a working attitude indicator (which was vacuum-driven), ASI and altimeter indications. The engine rpm gauges and standby compass remained operational. Both pilots reported that they saw no warning lights on the annunciator panel at any stage and that they were not wearing sunglasses, which might otherwise have affected their ability to see any warnings. The technicians in the cabin reported that they could see the alternating current frequency gauge, located in the roof panel, and that, at one point, this could be seen oscillating over full-scale deflection. The PF turned off the engine anti-ice system, but he could not recall when he did this.

Mindful of avoiding a security alert during the Olympic Games, the crew carried out the pre-briefed communications failure procedure and turned the aircraft onto a northerly heading to clear the London TMA, before proceeding towards a designated holding area.

As the aircraft approached the Wisbech area, the commander recognised some land features. The aircraft descended to 5,000 ft from where the crew were able to identify additional landmarks and navigate visually towards Cambridge Airport. By this time the aircraft had been flying for some time without electrical power and therefore without operating fuel gauges, and the crew were concerned about the aircraft's remaining endurance. When they arrived near the airport, they circled it to alert ATC to their presence and then carried out the Landing Gear Manual Extension procedure. When carrying out the procedure the pilots operated the landing gear control handle, but omitted to pull the landing gear relay circuit breaker. The PF operated the alternate extension handle to extend the landing gear. Initially, the handle was easy to operate and the pilots could see the main landing gear as it started to extend. The PF stated that he stopped operating the handle when heavy resistance was felt, in order not to damage the system. The PF also stated that the PNF had mentioned to him not to force the handle. The PF asked the PNF to check the resistance of

Footnote

[1] Operation of the engine anti-icing system causes inertial vane bypass doors to extend on the underside of the each engine cowling causing a small increase in airframe drag.

[2] The electrical symptoms experienced by the crew were similar to those reported by the pilot in a previous incident investigated by the AAIB (see AAIB Bulletin 6/2007 on the incident to Beech B200, G-PCOP, on 28 March 2006).

the handle, which he did. The PF continued to operate the handle whilst they positioned the aircraft downwind and onto base leg, but stopped pumping each time he felt heavy resistance.

The PF carried out a flapless approach and the aircraft touched down gently at approximately 100 kt. Almost immediately after touchdown, the landing gear started to collapse. The PNF immediately operated the fuel condition levers which shut down the engines and feathered the propellers. The aircraft settled onto the centreline luggage pod and the main undercarriage doors. It came to rest after a total ground run of approximately 400 m, during which it yawed slightly to the right. The PF was able to counteract the yaw with rudder sufficiently to prevent the aircraft from leaving the paved surface. After it had come to a halt, the commander ordered the technicians to evacuate. The pilots then completed the shutdown checklist before also vacating the aircraft. The flight time from the electrical failure until the landing was approximately 37 minutes.

Electrical system description

This aircraft type is equipped with a 28 V DC electrical system, supplied by a 24 V battery and two 30 V, 250 ampere starter-generators. Either one of two inverters can supply the AC requirements of the engine instruments and avionics. Each component is capable of supplying power to all systems necessary for normal operation of the aircraft, although the battery, in the absence of both generators, has a limited endurance.

The start cycle for each engine is controlled by a three-position switch on the pilot's left sub-panel. The central position is OFF and the switch toggle must be pulled over a gate to place it in the up, or ON position, which engages the starter. The switch remains in this position until it is returned to the OFF position. Holding the switch to the down, or STARTER ONLY position, causes the associated engine to motor, but without ignition. Releasing the switch causes it to spring back to the OFF position which is the normal in-flight position. After the engine has started, the starter current reduces until, at around 35-49% N_1, the engine drives the starter. The generator can be turned on at approximately 70% N_1. The Ignition and Engine Start switches are on the same panel as, and close to, the Engine Anti-ice switches.

Immediately above the start switches are the GEN 1, GEN 2 and Battery switches, located under a gang bar. The generators are turned on by holding the switch in the GEN RESET position for a minimum of one second before releasing it, when it returns under spring pressure to the ON position. If a generator trips off for any reason, (for example, moving the associated start switch to the ON position), it can only be reset by moving the control switch momentarily to the GEN RESET position.

Landing gear operating system

The landing gear system comprises an electrically-powered hydraulic power pack that operates three hydraulic actuators, one each for the main and nose landing gears. In the event of an electrical power loss or hydraulic power pack malfunction, a hydraulic hand pump is provided as a means of alternate gear extension. The manufacturer stated that the hand pump system has a relief valve that will port fluid when a pre-determined pressure is exceeded. Earlier models of the aircraft are fitted with an electrically operated system in which a 28 V DC motor is connected to a chain drive and torque tubes that transmit power to mechanical actuators at each landing gear. In the event of a motor failure, an alternate extension handle is provided, located in a similar position to that on aircraft with hydraulically operated systems. When pumped, the handle engages the operating mechanism via an emergency drive system.

Aircraft examination

After the accident the aircraft was lifted onto a trailer and taken to a hangar for further examination. On lifting the aircraft, the landing gears had partially extended and they were lashed in this position to prevent additional damage. This allowed a visual inspection of the gear and wheel wells, which revealed that the hydraulic lines had remained intact and that no landing gear component had broken.

At the time of the AAIB examination of the aircraft, it was still on the trailer and was being worked on in preparation to being flown, landing gear locked down, to a maintenance facility in Denmark for a full repair. This immediate rectification work included replacing the engines and propeller assemblies.

The aircraft was fitted with a luggage pod attached to the underside; this accommodated some of the equipment associated with the video relay operation, and served to protect other parts of the airframe such as the flaps.

After removing the engine cowls, it was evident that significant movement of the engines had occurred as a result of the propellers striking the ground. This had taken the form of a 'nodding' action and had caused both starter/generators, which are mounted at the top of the accessory gearbox at the rear of each engine, to contact the underside of their respective upper nacelle panels. This had resulted in some damage to the terminal block dust covers. However, the starter/generators themselves were otherwise intact and there was no evidence of burning or heat damage.

Using a crane and a sling, the aircraft was lifted off the trailer with a technician in the cockpit. He operated the alternate extension handle and all three landing gears were observed to extend to their locked down positions. After a visual inspection to verify that the gears were safe, the aircraft was lowered to the ground and towed to a hangar where the subsequent engine removal and replacement was conducted.

The aircraft battery, which had been disconnected immediately after the accident, was reconnected and the Battery Master switch turned on. Some captions glowed dimly and the battery voltmeter indicated 10 V, so it was apparent that the battery was fully discharged.

The starter/generators were tested before being overhauled, with no fault being found. They were re-installed on the aircraft prior to the ferry flight to Denmark, during which the electrical system functioned normally. Additional investigation of the landing gear during the repair did not reveal any fault with the system.

B200 landing gear system variants

There are two different types of landing gear system commonly fitted to B200 aircraft. The system fitted to OO-LET is usually referred to as a hydraulic system. The other B200 that the crew frequently flew (OO-ASL) was fitted with an electrically-powered mechanical system, usually referred to as a mechanical system. The Pilot's Operating Handbook (POH) describes the landing gear systems and the appropriate abnormal checklists describe the procedures relating to the alternate extension procedures for the system relevant to that aircraft.

OO-LET landing gear system

The manufacturer stated that the alternate extension system for the hydraulic system fitted to this aircraft contains a relief valve that will port fluid if excessive pressure is generated and that there are no adverse system consequences to continued operation of the handle when the landing gear is locked down. This information is not contained in the POH or the abnormal procedures and the manufacturer stated that this information is not required to operate the landing gear system properly.

The abnormal checklist for alternate landing gear extension states:

> *'Alternate Extension Handle - PUMP UP AND DOWN UNTIL THE THREE GREEN GEAR-DOWN ANNUNCIATORS ARE ILLUMINATED. WHILE PUMPING, DO NOT LOWER HANDLE TO THE LEVEL OF THE SECURING CLIP DURING THE DOWN STROKE AS THIS WILL RESULT IN LOSS OF PRESSURE.'*

The abnormal checklist goes on to state:

> *'If one or more green gear-down annunciators do not illuminate for any reason and a decision is made to land in this condition:*
>
> *Alternate Extension Handle – CONTINUE PUMPING UNTIL MAXIMUM RESISTANCE IS FELT.'*

OO-ASL landing gear system

Under the description of the Manual Landing Gear Extension (Mechanical System) that relates to this aircraft, it states:

> *'Stop pumping when all three green gear-down annunciators are illuminated. Further movement of the handle could damage the drive mechanism and prevent subsequent electrical gear retraction.'*

The abnormal checklist for alternate landing gear extension states:

> *'Alternate Extension Handle - PUMP UP AND DOWN UNTIL THE THREE GREEN GEAR-DOWN ANNUNCIATORS ARE ILLUMINATED. ADDITIONAL PUMPING WHEN ALL THREE ANNUNCIATORS ARE ILLUMINATED COULD DAMAGE THE DRIVE MECHANISM AND PREVENT SUBSEQUENT ELECTRICAL GEAR RETRACTION.'*

The abnormal checklist goes on to state:

> *'Alternate Extension Handle – CONTINUE PUMPING UNTIL MAXIMUM RESISTANCE IS FELT, EVEN THOUGH THIS MAY DAMAGE THE DRIVE MECHANISM'*

Analysis

It was not possible to determine the cause of the electrical failure experienced by the crew. Although, due to their proximity, it is possible that the Ignition and Engine Start switches could have been operated by mistake instead of the anti-ice switches, this action would have caused the generators to go off-line and for associated captions to illuminate on the annunciator panel. Both pilots were confident that they would have noticed these annunciators had they illuminated and that they were confident that no annunciator warning lights illuminated at any time. Subsequent ground tests did not reveal any fault with the electrical system. If the generators had gone off-line for some reason, resetting them might have restored electrical power. However, as the crew did not select the generator switches to RESET, no conclusions can be drawn regarding the state of the generators during the electrical failure.

Although the crew omitted to pull the Landing Gear Relay circuit breaker when carrying out the landing gear manual extension procedure, it is unlikely that this would have adversely affected the operation of the manual extension system, as electrical power had already been lost by this stage.

The two B200 aircraft that the pilots regularly flew had different landing gear operating systems. One aircraft, OO-ASL, had a mechanical system, the drive mechanism of which could be damaged by continued operation of the alternate extension handle after the landing gear was locked down. The POH and the Abnormal Procedure checklist contained specific statements alerting the crew to the possibility of such damage.

In contrast, the hydraulic landing gear system fitted to OO-LET could not be damaged by excessive operation of alternate extension handle. The alternate extension system has a relief valve that will port fluid if excessive pressure is generated, but no information was given in either the POH or the abnormal procedures checklist about this, or the consequences of continuing to operate the handle when the landing gear is locked down.

Without electrical power on the aircraft, the crew were unable to determine landing gear position. The PF operated the alternate extension handle until he felt maximum resistance and he did this on more than one occasion before the aircraft turned onto final approach. However, he stopped pumping when he felt maximum resistance to avoid damaging the system and his perception that the system could be damaged by excessive operation of the handle was reinforced by advice from the PNF. As a result, it is most likely that the landing gear was in the unlocked position for the landing, causing it to collapse after touchdown. The lack of contrasting advice relating to the consequences of continued pumping of the hydraulic system compared with the advice for the mechanical system probably contributed to the crew's confusion between the two systems.

Conclusions

No cause for the electrical failure could be determined and no fault was found with the landing gear system. It is possible that the gear collapsed on landing because the crew ceased operating the alternate extension handle before the landing gear was fully extended. The electrical failure meant that the crew had no indication of the landing gear position and therefore could not confirm that the gear was down and locked prior to landing.

SERIOUS INCIDENT

Aircraft Type and Registration:	BN2A MK.III-2 Trislander, G-BDTO
No & Type of Engines:	3 Lycoming O-540-E4C5 piston engines
Year of Manufacture:	1976
Date & Time (UTC):	27 March 2012 at 0724 hrs
Location:	27 nm north-east of Alderney, Channel Islands
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 1 Passengers - 7
Injuries:	Crew - None Passengers - None
Nature of Damage:	Uncontained engine failure with associated cowling damage
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	56 years
Commander's Flying Experience:	6,150 hours (of which 3,116 were on type) Last 90 days - 27 hours Last 28 days - 27 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and additional AAIB enquiries

Synopsis

The aircraft was on a scheduled flight from Alderney Airport, Channel Islands to Southampton International Airport. Shortly after levelling in the cruise, the pilot heard a "very loud bang" and the aircraft experienced severe vibration, which the pilot subsequently identified as a failure of the No 2 tail-mounted engine. The propeller of the inoperative engine could not initially be feathered, and the pilot was unable to maintain altitude, so he declared an emergency. The propeller blades eventually moved to the feather position and the pilot performed an uneventful landing back at Alderney Airport. The No 2 cylinder on the No 2 engine was subsequently found to have released from the crankcase. Two Safety Recommendations have been made.

History of the flight

The aircraft was on a scheduled flight from Alderney Airport, Channel Islands to Southampton International Airport. Shortly after levelling at its cruising level of FL50, 27 nm north-east of Alderney, the pilot heard a "very loud bang" and the aircraft experienced severe vibration. Initially there were no adverse indications on the engine instruments. The pilot subsequently noticed that the No 2 engine oil pressure had started to decrease slowly. He checked the No 2 (mid) engine in the rear-view mirror, and saw that the engine cowling was open on the left side. There were no other abnormal external indications or any indication of the severity of the damage. The pilot selected full power on the No 1 and No 3 engines and advised ATC of his intention to return to Alderney.

While carrying out the engine failure checklist, the pilot was unable to operate the No 2 propeller lever through its feather gate, which left the No 2 propeller unfeathered and 'windmilling'. The aircraft was unable to maintain altitude, despite having full power on the remaining two engines, so he declared an emergency to ATC. The pilot reported the aircraft's rate of descent at this time as being about 200ft/min. At some point during the descent, the propeller blades of the No 2 engine moved to the feather position and the propeller stopped rotating. The pilot was subsequently able to control the rate of descent.

During the return to Alderney, the pilot was cleared by ATC to fly a near continuous descent profile (Figure 1) and thus did not note the altitude the aircraft had drifted down to with one engine inoperative (OEI). The pilot made an uneventful visual approach and landing to Runway 08 at Alderney.

Regulatory Performance Requirements

Commercial transport aircraft performance is categorised separately for aircraft certification purposes and for operational requirements. Compliance with the certification standards must be demonstrated by the manufacturer in order to certify the aircraft type design. Compliance with operational requirements must be demonstrated by the aircraft operators in order to operate the aircraft, although to achieve this they refer to performance data for the aircraft published by the manufacturer.

The Trislander was granted a type certificate by the CAA in 1971, having demonstrated compliance with British Civil Airworthiness Requirements (BCAR), Section K, Issue 3. The aircraft was certified as a performance group C aircraft, with the associated requirements relating to enroute OEI performance stating:

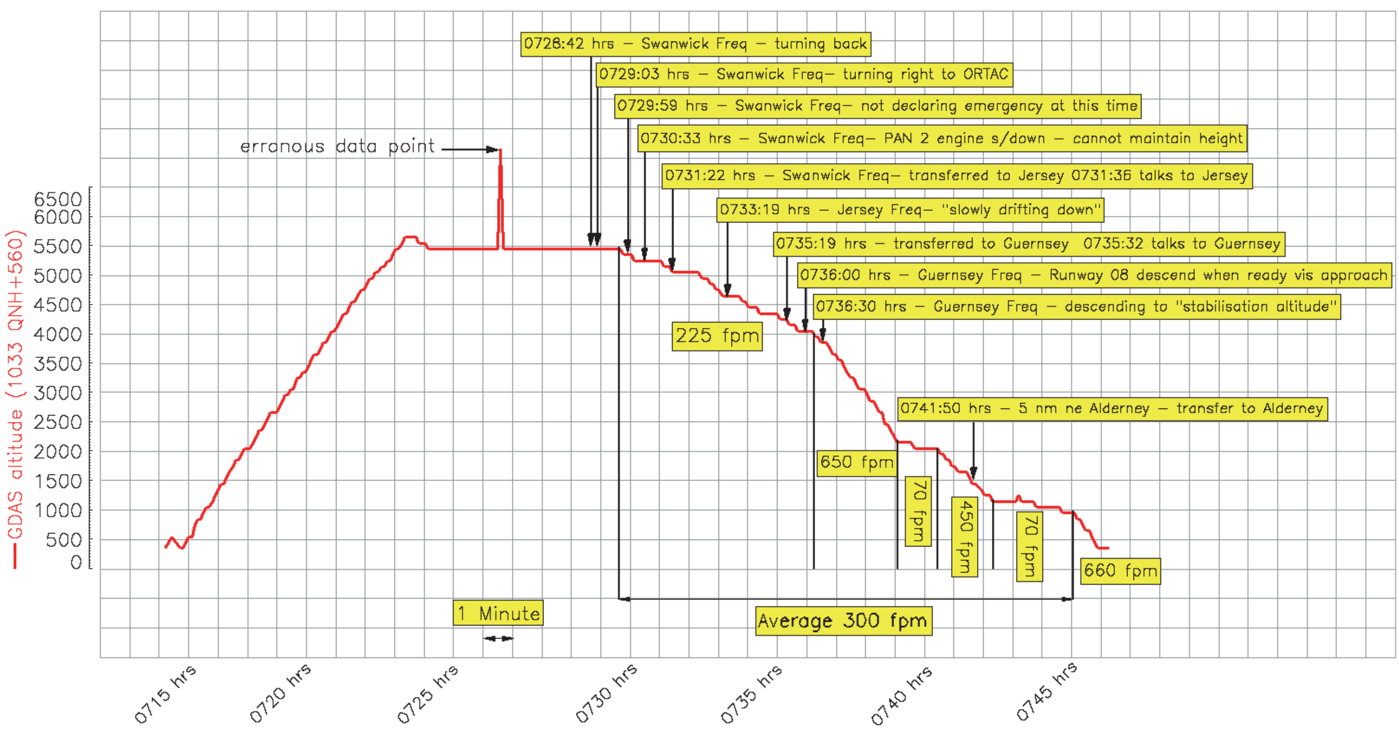


Figure 1

Radar altitude profile of the incident flight

'Sub-section K2

3.3 One-Engine-Inoperative Net Data.

The net gradient of climb with the Critical Engine inoperative[1] *shall be determined and scheduled, the condition of the inoperative engine being consistent with correct action having been taken to deal with the occurrence of fire in the zones related to that engine, and shall be the gross gradient of climb with the Critical Engine inoperative diminished by a gradient of 1 %.'*

The relevant operational aircraft performance requirements are in EU Regulation 965/2012. The Trislander is classified as performance class C under these regulations, as the aircraft has reciprocating engines and a maximum configuration of more than nine passenger seats. These state:

'CAT.POL.A.415 En-route — OEI

(a) In the meteorological conditions expected for the flight, in the event of any one engine becoming inoperative at any point on its route or on any planned diversion there from and with the other engine(s) operating within the maximum continuous power conditions specified, the aeroplane shall be capable of continuing the flight from the cruising altitude to an aerodrome where a landing can be made in accordance with CAT.POL.A.430 or CAT.POL.A.435, as appropriate. The aeroplane shall clear obstacles within 9,3 km (5 nm) either side of the intended track by a vertical interval of at least:

(1) 1 000 ft, when the rate of climb is zero or greater; or

(2) 2 000 ft, when the rate of climb is less than zero.

(b) The flight path shall have a positive slope at an altitude of 450 m (1 500 ft) above the aerodrome where the landing is assumed to be made after the failure of one engine.

(c) The available rate of climb of the aeroplane shall be taken to be 150 ft per minute less than the gross rate of climb specified.

(d) The width margins of (a) shall be increased to 18.5 km (10 NM) if the navigational accuracy does not meet at least RNP5.

(e) Fuel jettisoning is permitted to an extent consistent with reaching the aerodrome with the required fuel reserves, if a safe procedure is used.'

Actual vs. calculated aircraft OEI performance

The aircraft manufacturer calculated that, based on gross performance and an assumption of 98% engine power, for the conditions on the day of the incident a Trislander at a Take Off Weight (TOW) of 3,693 kg, with OEI, an undamaged cowl and a feathered propeller, should have been able to maintain an altitude of approximately 5,500 ft amsl (FL50).

The manufacturer provided an estimate that the effect on rate of climb of an unfeathered propeller would be a reduction of 140 ft/min, but was not able to confirm at what altitude a zero climb rate would be achieved in this configuration. They were also unable to assess the contribution of the damaged engine cowling, other than to suggest it may be significant.

The manufacturer advised this had not been assessed during certification as there was no requirement

Footnote

[1] The critical engine on the Trislander is the No 1 engine.

to account for an unfeathered propeller within the regulations relating to en-route performance.

The operator's Operations Manual states that a Trislander at Maximum Take Off Mass (MTOM) of 4,546 kg, with OEI and the propeller feathered, would drift down to 3,050 ft amsl in a standard atmosphere. However, these figures are based on net performance. For an assumed 1% decrement from gross to net performance, the manufacturer advised that a zero net climb gradient at 3,000 ft would equate to 5,200 ft altitude using gross performance figures.

The manufacturer's flight manual does not contain performance charts, or guidance to pilots in the event of OEI with an unfeathered propeller. Analysis provided by the CAA, derived from comparison of published OEI takeoff data for the Trislander fitted with and without an autofeather device[2] indicated that the aircraft should have been capable of maintaining height during the incident with an unfeathered propeller.

G-BDTO was last flight tested by the CAA in October 2004. At 4,100 kg, with the No 1 (critical) engine feathered, the aircraft achieved a rate of climb of 212 ft/min on one heading. On the reciprocal heading, at 4,056 kg, the aircraft achieved a rate of climb of 248 ft/min.

Propeller feathering mechanism

In normal operation, the pilot sets a propeller rpm using the propeller control lever. A constant speed governor then maintains that rpm by continuously adjusting the pitch of the propeller blades. An oil pump supplies pressurised oil to a piston to act against a feathering spring; there is also an air charge to assist the spring. Flyweights within the governor control the amount of oil in the piston by acting on a pilot valve. This, in turn, changes the balance of force against the feathering spring, causing the blade pitch to change. An optional modification, embodied on G-BDTO, meant the blades were also fitted with counterweights which biased them to move towards the feather position. A Teleflex cable connects the propeller control lever to the governor. The blades are manually selected to the feather position (normal and emergency), by the pilot moving the propeller control levers rearward through a feather gate on the console. The cable then engages a lift rod, which opens the pilot valve on the cylinder, releasing oil until the propeller blades feather under the action of the spring and, on G-BDTO, the counterweights.

Previous events

An event which occurred under similar circumstances was investigated by the AAIB in 1998 (reference EW/G98/06/40 published in AAIB Bulletin 11/98 refers). The aircraft, a BN2A Mk III-1 Trislander, registration G-AZLJ, suffered an engine failure whilst in the cruise at FL60. The pilot was unable to feather the propeller on the failed engine and despite selecting full power on the remaining engines, the aircraft continued to descend at a rate of 100 to 200 feet per minute. The pilot made a successful emergency landing at Blackpool Airport.

A sample review of the CAA's Mandatory Occurrence Reporting (MOR) database for Trislander and Islander aircraft, fitted with a similar powerplant configuration, identified six other previous events where the propeller failed to feather. This included a fatal accident involving a military operated Islander in 1976, where the pilot was forced to ditch the aircraft after being unable to maintain altitude with a failed engine and unfeathered propeller.

Footnote

2 The mark III-3 variant of the Trislander was fitted with an autofeather device to comply with FAA Part 135, Appendix A requirements relating to OEI performance at takeoff.

Some of these MOR events also identified issues relating to the Teleflex control cable. This was not a comprehensive assessment of all previous events in the history of the aircraft type but a number of these events resulted in safety action, with Airworthiness Directives, being taken by the manufacturer at the time.

The aircraft manufacturer was requested to provide supporting data to allow an assessment of the hazard category and probability, in the event of an engine becoming inoperative, of the propeller blades not moving to the feather position within the 11 seconds after selection by the pilot, specified by the Aircraft Maintenance Manual. They responded that no detailed reliability data exists, but offered an estimated reliability figure of 1.2×10^{-7} failures per flight hour, using assumed flying hours for the piston Islander and Trislander aircraft combined.

Engine description

The O-540-E4C5 is a six-cylinder, horizontally-opposed, direct drive engine. The cylinders are numbered from front to rear, odd numbers on the right (looking forward), and even numbers on the left. The cylinders are of conventional air-cooled construction with the two major parts, head and barrel, screwed together. The piston connecting rods are made from alloy steel forgings. The crankcase assembly consists of two reinforced aluminium alloy castings, fastened together by means of studs and nuts. Double-ended studs run through the crankcase and form two of the eight mounting studs for each of the opposing cylinders. The remaining six studs per cylinder are screwed into fixings in the crankcase using a coarse thread. The cylinders are retained in place on the studs by 'hold down' nuts screwed onto a fine thread. The nuts are torque loaded but have no secondary retaining feature.

The manufacturer recommends an overhaul life of 2,000 hours for this engine type. However, based on a life extension approval granted by the CAA, the operator involved in the incident has increased this life for the engines in their fleet to 3,000 hours. The No 2 engine that failed during the incident had operated 996 hours since overhaul and had a time since new of 11,992 hrs.

Initial inspection

On landing, the operator's maintenance provider inspected the aircraft. They reported that a large section of the engine cowling was missing on the left side of the engine (Figure 2). The remaining cowling and aircraft empennage were heavily stained with oil released from the engine during the failure.

Following removal of the engine from the aircraft, it was clear that the No. 2 cylinder had released from

Figure 2

Engine cowl damage and oil staining

the crankcase after failure of the mounting studs. This had resulted in damage to the surrounding crankcase from the flailing connecting rod. The piston head and push rods were missing, as was the inlet pipe from the manifold and the section of exhaust pipe from the cylinder head to the exhaust manifold. The starter motor had been dislodged from the engine, but remained attached by its power lead and the guide tube for the propeller-feathering unit Teleflex control cable was damaged (Figure 3).

Of the eight studs that secured the cylinder to the crankcase prior to failure, four had been lost with the released sections of the crankcase and cylinder. Two of the 'short' studs remained, as did the two 'through' studs, which ran through the crankcase to the opposing cylinder. All four of these studs were removed and sent for metallurgical investigation.

Further occurrence

Two months after the initial incident, a routine maintenance check of the No. 3 engine fitted to another aircraft (G-RLON) from the same operator's fleet, identified another stud failure (Figure 4). This engine had operated 9,041 hours since new and 460 hours since its last overhaul. Only a single stud had failed and the released section of the stud and 'hold down' nut were found trapped in the baffle between the No 2 and No 4 cylinder barrels. The released section of the stud was sent for independent metallurgical assessment, while

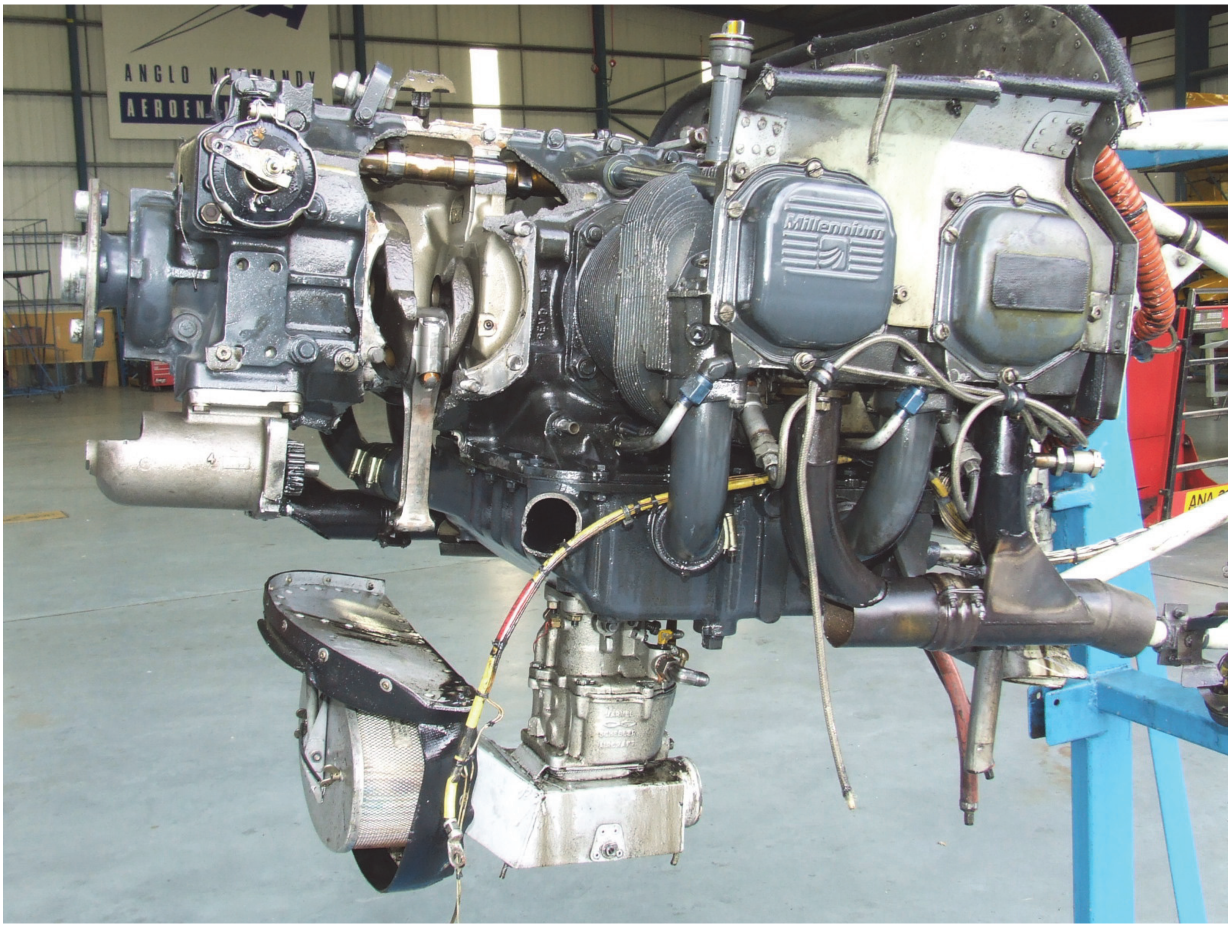


Figure 3

Missing cylinder and associated damage

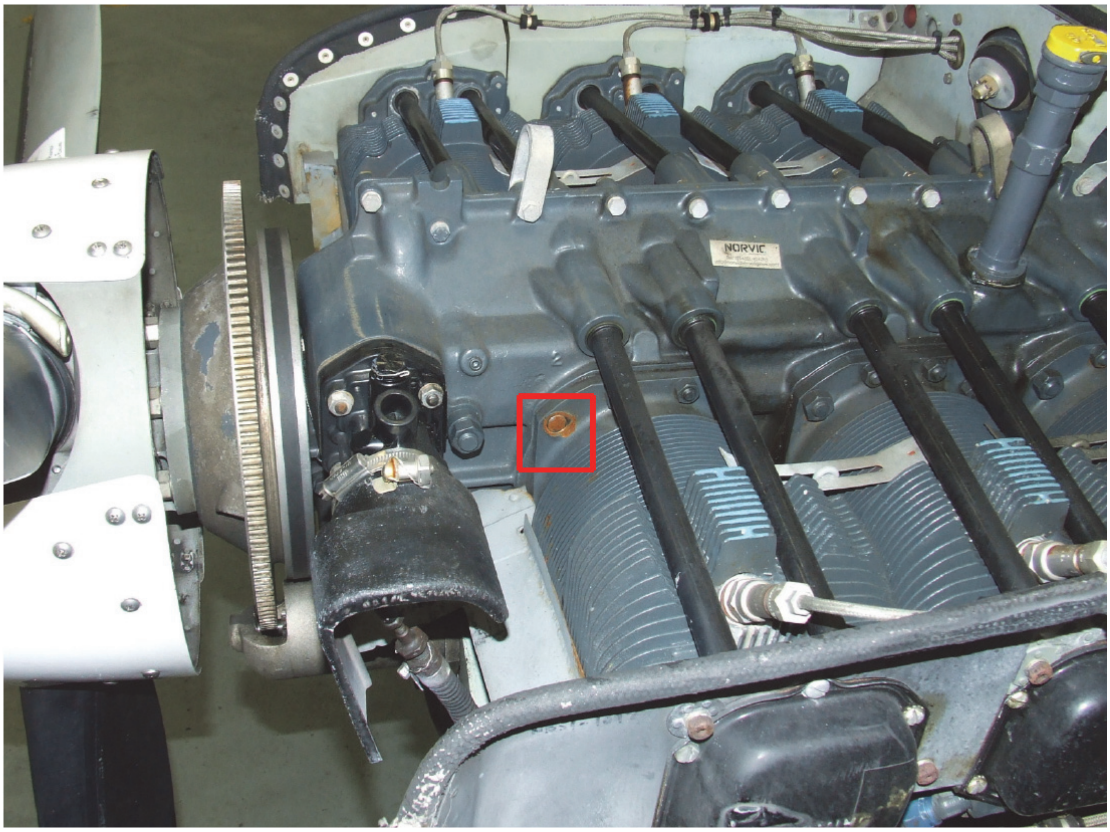


Figure 4

Second mounting stud failure (G-RLON)

the remaining section of the stud was removed from the crankcase and released to the manufacturer for them to carry out their own investigation.

Mounting stud failure investigation

Independent metallurgical analysis using optical and Scanning Electron Microscope (SEM) techniques was conducted on the four failed studs that were recovered from G-BDTO's engine following the incident. The studs were annotated A to D for ease of reference (Figure 5).

The laboratory analysis determined that stud C had suffered a fatigue fracture, which initiated from a single point, coincident with corrosion pitting in one of its thread roots. The stress concentration caused by the pitting had been superimposed onto that provided by the thread root itself. As the pitting grew in depth, the combined stress concentration had exceeded the threshold value for fatigue crack initiation. A primary high cycle fatigue crack initiating from the pitting then propagated across the diameter of the stud, with the continued loading from operation of the engine. The primary crack joined with two secondary fatigue cracks, also initiating from corrosion pits. Eventually, a point was reached when the remaining uncracked ligament of stud C became overloaded and failed. Although the exact time to failure could not be determined from the fracture surface features, the metallurgist advised that in his opinion it was possible for the corrosion pit to develop and the crack to have propagated to failure within the time between engine overhaul of 3,000 hours.

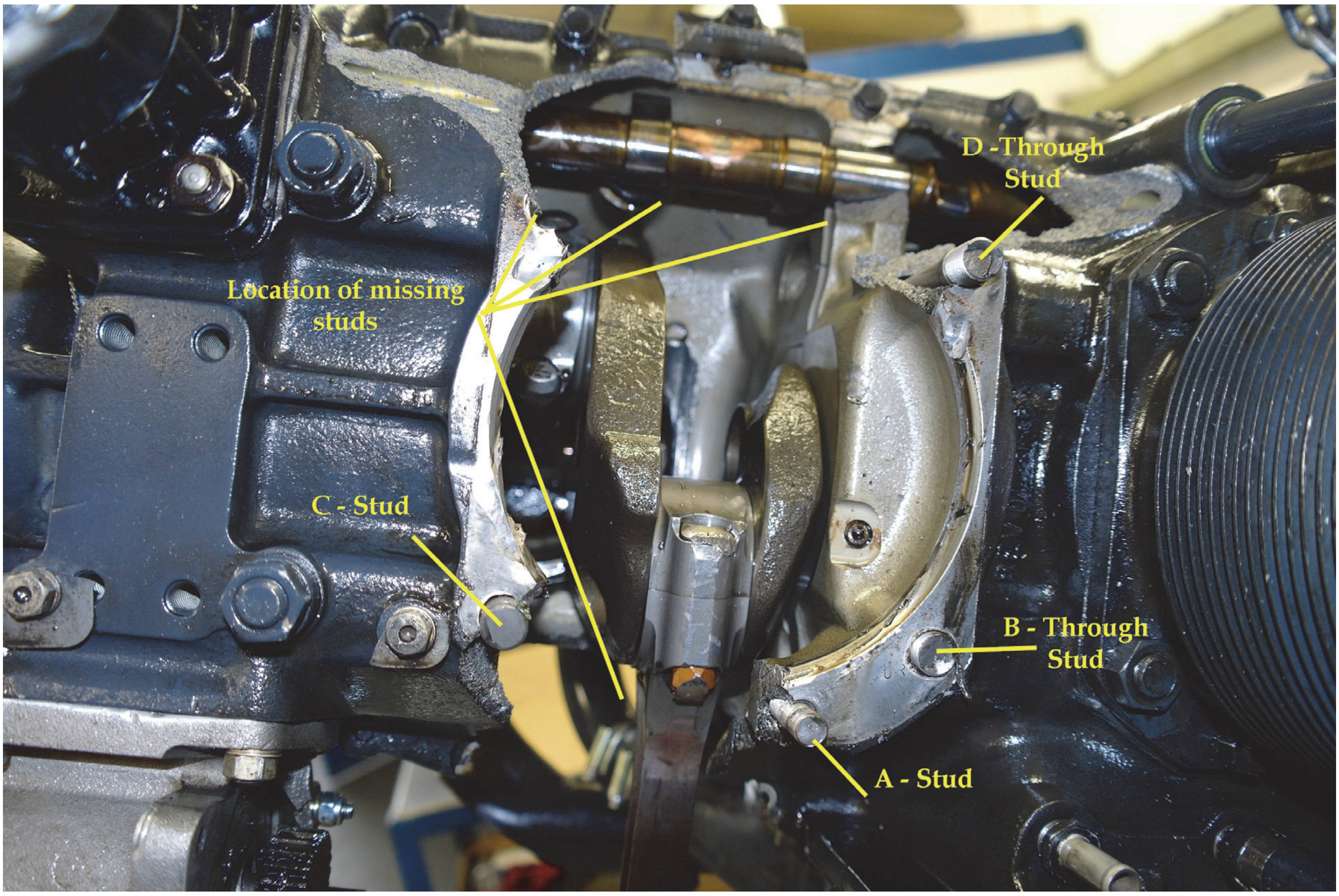


Figure 5

Location of failed studs

Laboratory analysis of stud C confirmed evidence of remains of a protective coating of cadmium on the coarse threaded section of the stud. However, no evidence was present of cadmium coating where the corrosion pit developed, on the fine threaded section. The stud material also tested outside the manufacturer's specification for hardness.

In contrast to stud C, the fatigue fractures of studs A, B and D had all initiated from multiple sites in thread roots ehich were not associated with pre-existing material defects. These were typical of failure of threaded fasteners from abnormal cyclic loading. In this case, the most likely cause of the abnormal loading was following the separation of stud C. However, it was not possible to determine whether the failures of A, B and D had developed concurrently or consecutively to each other. The loss of several of the cylinder mounting studs during the engine failure further restricted the analysis, as no conclusions could be drawn on how they may have contributed to the failure sequence of the retained studs.

Analysis of the failed stud from the engine fitted to G-RLON confirmed that it had also failed in high cycle fatigue initiating from a corrosion pit in the thread root. Again no cadmium coating was found on the section of the stud inspected, although traces of cadmium coating were present on the 'hold down' nut. The inspection techniques could not confirm whether the lack of cadmium coating had been due to corrosion or mechanical action over the life of the stud, or whether the coating on the fine thread had been omitted at manufacture.

Engine manufacturer's response

The engine manufacturer confirmed that the specification for the studs required them to be entirely covered with a cadmium coating during manufacture. They advised that they have not identified any occasions when studs have been delivered to them with the cadmium coating missing. They commented that: "Even though the cylinder deck hold down studs/ bolts are not listed in the Service Bulletin No. 240, 'Replacement of Parts at Normal Overhaul', it is the customer's responsibility to inspect and replace or recondition the parts if any abnormalities were found during normal maintenance or overhaul cycle." They also advised that:"According to the Lycoming Overhaul Manual, Sections 3-22 and 3-33, any studs which are bent, broken, damaged, loose, rusted or pitted, must be replaced."

The engine manufacturer explained that the cadmium coating was in place on the studs as a protective layer to prevent corrosion of the base material, by sacrificially corroding in its place. They advised that it could also be lost due to the chemical cleaning processes carried out on the engine at overhaul.

They confirmed that no specific inspection requirement to assess the condition of the cadmium coating on the studs existed in the overhaul manual and there was no life limit published for the studs. Nor was there a rejection criterion for studs, if a loss of cadmium coating was identified, or a repair scheme for the replacement of the coating. The manufacturer also advised that there was no guidance material issued to operators or overhaul agencies to highlight the presence of the cadmium coating or the implications of operating the engine without the coating present. This was confirmed by the overhaul agency who last overhauled the engine.

The manufacturer also challenged the findings of the independent metallurgical assessment. Their laboratory analysis of the section of failed stud from G-RLON identified overtorqueing of the stud as the cause of the fatigue crack.

Analysis

Engine failure

Review of stud C from G-BDTO's fracture surface confirmed the primary fatigue crack had initiated directly from a corrosion pit before it joined with the two secondary cracks; although, the chronology of each crack initiation was not significant, given that all three cracks were initiated by the same mechanism.

Therefore, the investigation determined that the cause of the loss of the No 2 cylinder during the incident to G-BDTO was the presence of corrosion pitting in the thread root of a cylinder mounting stud. This initiated the growth of fatigue cracks, under the cyclic load of routine operation of the engine, until the stud failed in overload. The same failure mechanism was evident on the stud found on G-RLON.

The engine manufacturer specified a protective cadmium coating on the stud, as it would sacrificially corrode in place of the bulk stud material, in order to prevent fatigue crack growth from corrosion pitting of the kind identified by the investigation. There is a finite period that such a coating provides protection, before it corrodes away and the base material of the stud is exposed. This period is further reduced by the mechanical wear on the studs experienced in service and potentially by aggressive chemical cleaning processes used during overhaul. Despite this, the manufacturer's overhaul manual did not identify the presence of the coating or highlight its purpose, nor did it contain a life limit for the studs or an inspection requirement of the coating condition to initiate rejection or repair of the studs, once the cadmium coating was lost. Whilst the overhaul manual does require corroded studs to be rejected, it is possible for the corrosion and crack propagation, to failure, to occur within the period between engine overhaul inspections. Given the consequences of a stud failure, as demonstrated by this incident, the following Safety Recommendation is made:

Safety Recommendation 2013-001

It is recommended that Lycoming introduce additional maintenance requirements to ensure that the cadmium coating on the cylinder mounting studs, fitted to O-540-E4C5 engines, is not permitted to degrade to a level where corrosion of the base stud material can result in failure of the stud.

It is unlikely that the engines were supplied by the manufacturer with studs that had not been properly cadmium coated as, given the age of both engines involved, without any protection the studs would likely have failed in service much earlier. The stud that initiated the in-flight failure of the engine on G-BDTO (stud C) was found to be outside the manufacturer's specification for material hardness. Again, it was not clear whether this was due to an issue with the manufacturer's supply of studs when the engine was manufactured or whether the stud was an unapproved part that had subsequently been fitted at overhaul. The overhaul agency who last overhauled the engine confirmed that they had no record of the studs having been changed during the life of the engine. As the failure of the stud was initiated by corrosion, the anomaly in the material hardness is not considered to have contributed to the cause of the engine failure. Had stud C been an unapproved replacement part, it is possible that the cadmium coating had never been present on the fine cylinder mounting thread. However, as remnants of the coating were identified on the coarse thread, this is considered unlikely. Given that the same loss of cadmium coating was observed on the failed stud from G-RLON, which did meet the manufacturer's specification and therefore was likely to have been an original manufacturer supplied part, the anomaly identified on the stud from G-BDTO does not affect the concern addressed by the recommendation.

Propeller failure to feather

The operator identified that the propeller had most likely initially failed to feather due to damage to the Teleflex cable guide conduit, preventing the control cable within it from moving freely when the pilot attempted to move the No 2 propeller control lever through the feather gate on the console. They considered the damage may have been caused by the release of the starter motor, which distorted the guide tube. The propeller did eventually feather some time after the pilot shut down the engine. When oil was lost from the engine through the hole in the crankcase, it is likely that there was an associated loss of oil pressure in the blade pitch control piston, allowing the feathering spring and counterweights to move the blades to the feather position.

Performance

The location of the aircraft at the time of the engine failure and the nature of the terrain below the aircraft's return route, meant that Minimum Safe Altitude (MSA) considerations did not present a significant risk to the aircraft and it had adequate range to reach the diversion airport safely. However, the pilot was still sufficiently concerned by the aircraft's performance to declare an emergency. If this had occurred in a remote area with less benign terrain profiles, or had the propeller not eventually feathered, this event may have presented a greater risk to the safety of the aircraft.

During the incident, the aircraft's actual descent rate from FL50 was just over 200 ft/min. Given the manufacturer's assessment that OEI with an unfeathered propeller at this altitude would give a descent rate of 140 ft/min, it would suggest the contribution of the damaged cowl was significantly less in comparison. However, no empirical evidence was available to determine an accurate performance penalty for these factors, so it was not possible to assess if obstacle clearance according to EU 965/2012 would have been maintained.

The assessment carried out by the CAA, based on documented performance data for the aircraft, indicated that the aircraft's performance should have been acceptable even with an unfeathered propeller. An increase in drag from the damaged engine cowl may have contributed to some extent, but given the lack of available data from the manufacturer it was not possible to understand fully the reasons for the difference between the CAA's theoretical assessment of performance and the actual performance of G-BDTO during this incident.

Whilst the OEI performance of the aircraft was affected by the failure of the propeller blades to feather, it is not clear whether the failure to feather can be considered as a completely separate failure to that of the engine. Although a more comprehensive assessment of the history of failures of this nature on the aircraft type is required, the MOR data reviewed shows this was not the first occurrence of a failure of the propeller to feather following an engine failure. There is also evidence that a similar occurrence resulted in a fatal accident, and that causal factors were the failure of the propeller to feather and inability of the aircraft to maintain altitude. The manufacturer stated that the assumed failure rate of a propeller not moving into feather after an engine failure is 1.2 x 10^{-7}. They quoted that they have no detailed reliability data. Therefore, they would not have been in a position to provide an evidence-based assessment of the different powerplant system failure modes or their probability of occurrence, in order to assess fully the safety implications of this and previous events.

Historical evidence and the commonality of the design suggest this is relevant to both the Islander and the Trislander aircraft. Given the continued worldwide operation of both versions of the aircraft in a public transport role, the following Safety Recommendation is therefore made:

Safety Recommendation 2013-002

It is recommended that the European Aviation Safety Agency, in collaboration with the UK Civil Aviation Authority, conduct a risk-based assessment of the Britten-Norman BN2 MKIII Series Trislander and BN2 Series Islander aircraft, with respect to one engine inoperative performance and the hazard and probability of an associated failure to feather of the affected engine's propeller.

Safety actions

Following the identification of the failed stud from G-RLON, the operator carried out a fleet-wide inspection of all their engines, checking the visual condition of the cylinder 'hold down' nuts and their torque load. No anomalies were found. They have subsequently introduced a replacement programme for the cylinder mounting studs fitted to their engines, prioritising engines in the fleet with the highest time since new.

The CAA have stated that they will add the identified aspects of this investigation to their oversight programme for the continued airworthiness of the type.

ACCIDENT

Aircraft Type and Registration:	Boeing 737-33A, G-ZAPZ
No & Type of Engines:	2 CFM56-3C1 turbofan engines
Year of Manufacture:	1991 (Serial no: 25401)
Date & Time (UTC):	14 April 2012 at 1008 hrs
Location:	Chambery Airport, France
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 5 Passengers - 131
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to rear fuselage skin, frames and drain mast
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	34 years
Commander's Flying Experience:	3,950 hours (of which 1,417 were on type) Last 90 days - 75 hours Last 28 days - 25 hours
Information Source:	AAIB Field Investigation

Synopsis

An onboard hand-held Electronic Flight Bag (EFB) computer was used to calculate the aircraft's takeoff performance. The commander omitted to enter the aircraft's takeoff weight into the performance calculation software, which defaulted to the previous flight's takeoff weight. The crew did not cross-check the data and incorrect speeds and thrust were calculated and subsequently used for the takeoff. As a consequence, the airspeed at rotation was too low and the pitch angle was sufficient to strike the tail on the runway. A broken spring within the aircraft's elevator feel and centering unit caused reduced resistance in the flight controls in pitch, contributing to the excessive pitch attitude achieved during rotation.

The investigation also revealed wider issues relating to the general design and use of EFB computers to calculate performance data. Two Safety Recommendations are made.

History of the flight

The crew reported for duty at 0625 hrs at London Stansted Airport and were scheduled to position the aircraft, without passengers, to Chambery Airport in France. They were then scheduled to return, with passengers, to London Gatwick Airport.

No problems were identified during the pre-flight preparations, although engineering assistance was required to resolve an issue starting the No 1 engine.

This resulted in the aircraft departing 25 minutes late, at 0735 hrs. An EFB computer was used to calculate the takeoff performance data. Once this was completed, the EFB was placed in the standby mode. The flight to Chambery was uneventful and the aircraft landed at 0915 hrs, 15 minutes behind schedule.

The return flight to Gatwick was scheduled to depart at 1000 hrs. The pre-flight preparations proceeded normally and the pilots reported no distractions other than those normally experienced during a turnaround. The co-pilot, who was the non-handling pilot for this flight, completed the manual load sheet whilst the commander programmed the route into the Flight Management Computer (FMC). The commander reported that he then cross-checked the load sheet information and, having ensured it was correct, entered the Zero Fuel Weight (ZFW) into the FMC. The FMC then calculated the Takeoff Weight (TOW) using the fuel weight automatically retained in the system. The commander read back the FMC calculated TOW to the co-pilot, who cross-checked it against the load sheet data and confirmed that they agreed.

Having loaded the ZFW into the FMC and cross-checked the TOW, the commander used the EFB computer to calculate the takeoff performance data. This involved waking up the EFB from the standby mode, then entering the airfield, weather and aircraft data, which included the flap position for takeoff. A specific flap setting could be entered, or the computer could be used to provide an optimum setting. The commander stated that he normally entered Flap 5 for the takeoff performance calculation. However, at airports where performance was considered to be more critical, he would set the performance computer to select the optimum setting. As the runway at Chambery is relatively short, the commander chose the optimum flap position calculated by the performance computer. This gave a selection of Flap 1 which, under the circumstances, he did not consider unusual. Similarly, the computed takeoff speeds did not seem unusual to the commander, particularly as they were predicated on a flap setting he did not normally use.

The computed figures, based on the data entered on the EFB, allowed for a reduced thrust takeoff. The calculated assumed temperature to be set to achieve this did not seem unreasonable at the time, although the commander stated that, in hindsight, he considered it to be too high for the airfield and the prevailing conditions.

Both pilots stated that they would normally cross-check the performance figures once they had been calculated on the EFB. However, on this occasion, and for reasons the pilots could not recall, this was not done. The commander wrote the speeds he had computed using the EFB on the flight paperwork and then entered them into the FMC, overwriting the FMC generated speeds. The commander stated that this was standard practice and on this occasion he did not take note of any difference between the two sets of speeds. The rest of the pre-flight preparation was completed and the aircraft took off from Runway 36 at Chambery at 1008 hrs, on schedule, with 131 passengers onboard. The pilots reported the weather at the time was good, with a light wind from the east, good visibility and dry conditions. The ATIS reported a temperature of 8°C and a QNH of 999 hPa.

On takeoff both pilots felt a slight judder, which they considered was due to turbulence from the preceding aircraft. Early in the climb they received a call on the intercom from the rear cabin station informing them that the cabin crew to the rear of the aircraft had also felt a judder. This call was intended for the cabin purser at the front of the cabin, but was mistakenly made to the flight deck. The pilots reassured the cabin crew member, still believing the judder was due to turbulence. Their opinion was reinforced by the absence of any abnormal flight deck indications or calls from ATC at Chambery to the contrary.

The remainder of the flight went without incident and the aircraft landed at Gatwick at 1130 hrs. The aircraft was taxied to stand and, after shutting down, the pilots were informed by ground personnel that the underside of the rear fuselage had sustained damage consistent with a tailstrike. This prompted the crew to reconsider the cause of the judder felt at takeoff and they reviewed the takeoff performance data. This revealed that the commander had omitted to enter the aircraft's TOW into the EFB computer at Chambery, with the result that the computer had reverted to the previous TOW data retained from Stansted to calculate the takeoff performance figures.

Performance figures

The performance figures used for the two sectors flown are shown in Table 1.

Aircraft damage

Damage to the aircraft was confined to deep longitudinal scoring of the rear fuselage skin, over a length of 1.9 m, from just forward of fuselage station BS927 to just aft of BS987 (Figure 1). The lateral extent of the damage was limited to the two lowermost fuselage stringers. The damaged area was within the pressurised section of the fuselage, beneath the aft end of the rear baggage hold. On the 737-300 variant of the aircraft this area is not protected by a tail bumper.

The fuselage skin had been fully abraded at stations BS927 and BS947, resulting in slight scoring of the supporting fuselage frames at these positions. This damage created a small leak path for pressurised cabin air to escape to atmosphere, although the rate of leakage was small and insufficient to affect cabin pressurisation during the flight to Gatwick.

	Stansted to Chambery	Chambery to Gatwick
Load	610 kg	10,894 kg
ZFW	36,491 kg	46,750 kg
Take off fuel	9,800 kg	6,150 kg
TOW	46,291 kg	46,300 kg (correct value 52,900 kg)
Flap setting	Flap 5	Flap 1 (correct value Flap 1)
Assumed temperature	58°C	47°C (correct value 30°C)
Resultant N_1	84.5%	88.6%(correct value 92.8%)
Speeds	V_1 119 kt	V_1 118 kt (correct value 129 kt)
	V_R 123 kt	V_R 127 kt (correct value 139 kt)
	V_2 135 kt	V_2 140 kt (correct value 149 kt)

Table 1

Performance figures for Stansted and Chambery sectors

Figure 1

Damage to the lower fuselage skin and drain mast

In addition to the fuselage skin damage, the rear heated drain mast had been abraded and bent outboard due to contact with the runway.

Post-event maintenance actions

During the initial investigation it was reported to the AAIB that the pitch forces on G-ZAPZ were particularly light. No aircraft technical log entry regarding this had been made prior to the accident, but shortly after the aircraft was repaired and returned to service an entry was made by a flight crew member reporting that the elevator feel force was "light". The operator carried out the 'Low Control Forces' troubleshooting actions from Chapter 27-31-00 of the aircraft maintenance manual, which revealed that a spring had broken within the aircraft's elevator feel and centering unit. The unit was removed from the aircraft and sent to the AAIB for further investigation. During strip inspection, the outer main spring within the unit was found to have fractured (Figure 2). The

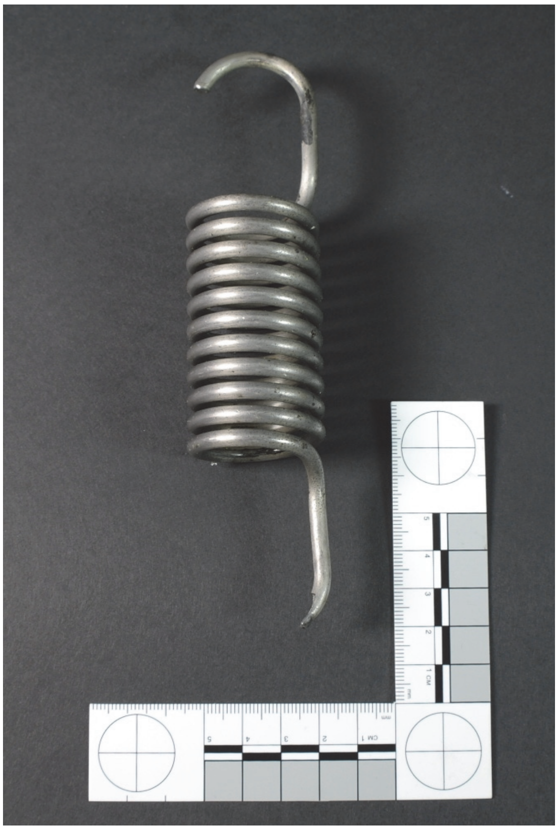


Figure 2

Broken outer main spring from the elevator feel and centering unit elevator feel and centering unit was last inspected during the aircraft's 1C check, performed on 1 June 2011.

An analysis performed by the aircraft manufacturer showed that a broken outer main spring would reduce the control column pull force during aircraft rotation from approximately 30 lb.f, with intact springs, to approximately 20 lb.f.

Recorded information

The aircraft was fitted with a Flight Data Recorder (FDR) and a 30-minute CVR. Due to the length of the flight between Chambery and Gatwick, relevant information on the CVR was overwritten. The FDR recorded just over 26 hours of operation and flight data was also recovered from the operator's Flight Data Monitoring (FDM) programme.

Just prior to takeoff, the recorded aircraft mass was 116,560 lb (52,870 kg). Takeoff commenced at 10:10:13 hrs with N_1 on both engines increasing to 88.5% (Figure 3). At a computed airspeed (CAS) of 126 kt, the control column was pulled back to command a pitch-up attitude, the pitch attitude increased and the nosewheel left the ground. Approximately four seconds later, the pitch attitude increased through 10.8°, the threshold for a tailstrike with the landing gear compressed, and increased further as the mainwheels left the ground. The average pitch rate, calculated from the time of rotation to 10° pitch attitude, was 2.3° per second, within that recommended in the Flight Crew Training Manual.

At approximately the time the pitch attitude passed 10.8°, the recorded control wheel position increased to 21°, signifying a commanded right roll, which led to a corresponding aileron deflection. Spoiler positions were not recorded, but assessment by the aircraft manufacturer was that this may have contributed to a loss of lift as this roll demand would have been sufficient to raise the roll spoilers on the right wing.

After lift-off the aircraft continued to accelerate, with the correct V_2 of 149 kt being achieved at a radio altitude of 30 ft.

Aircraft manufacturer's performance assessment

Flight data and accident details were forwarded to the aircraft manufacturer to review. They concluded that the primary contributory factor to the tailstrike was the aircraft being rotated too early during the takeoff.

Operator's Electronic Flight Bag

Overview

The EFB software[1], referred to as 'the Guru' by the operator, was installed on a touchscreen hand-held computer. Data entry was achieved using an on-screen keyboard, touchscreen and stylus. The operator was involved in the early development of this EFB with the software supplier in 2004, and used it on their Boeing 737, 757 and 767 fleets. The EFB software supplier indicated that this EFB was used by operators in 13 countries.

The operator used the EFB for takeoff and landing performance calculations. To calculate takeoff performance, data is entered into the 'Input' tab (Figure 4) and the takeoff runway selected in the 'Airport' tab. The EFB software then calculates the takeoff performance and displays it, with other relevant information, on the 'Takeoff' tab (Figure 5). During this process some error checking is automatically performed by the software on the input data (eg QNH range, takeoff mass limits), which is flagged if inappropriate.

Footnote

[1] Guru UI version V2 build 2426, Install awc1204.

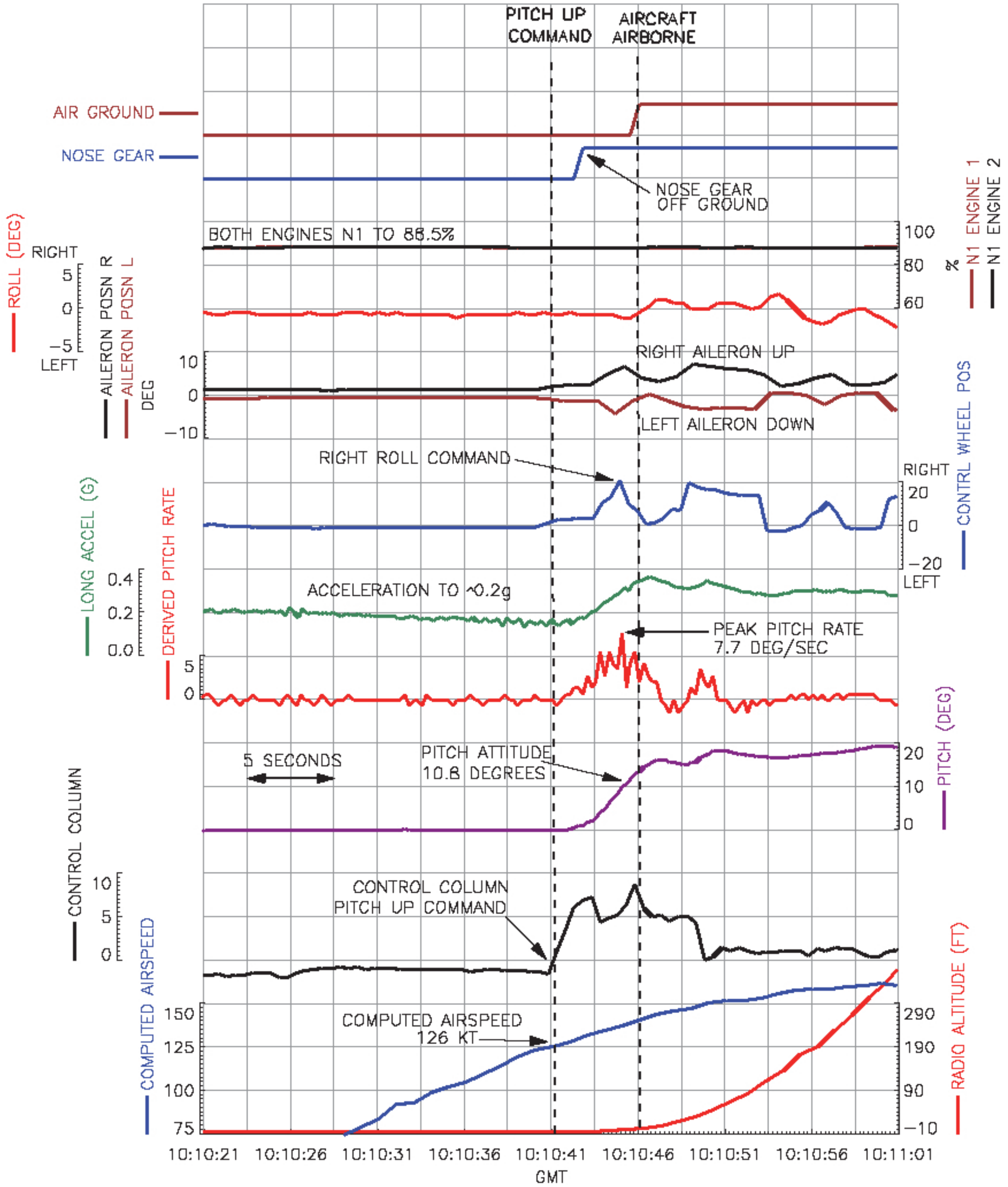


Figure 3

G-ZAPZ Chambery Takeoff FDR Parameters

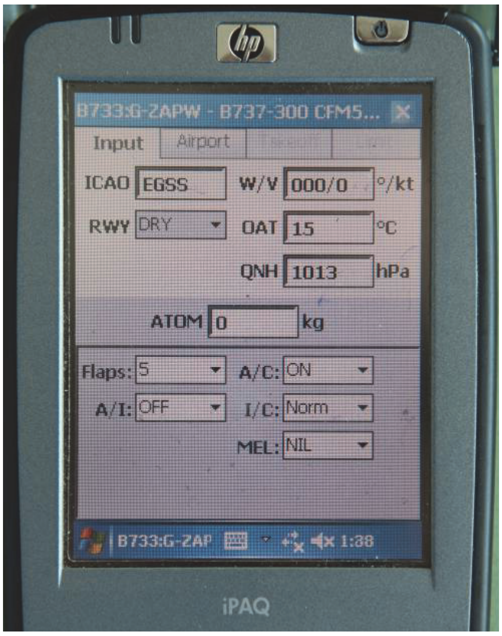


Figure 4

EFB takeoff input screen after software restart

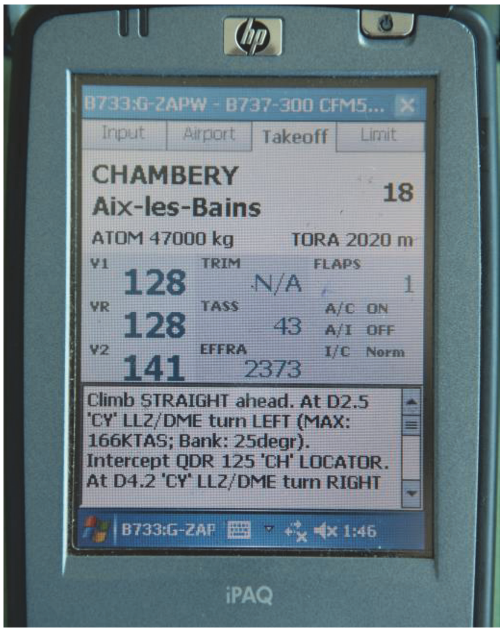


Figure 5

Example takeoff performance calculation showing takeoff speeds and emergency turn information

Hardware and software operation

Once a performance calculation has been completed, the Guru program can be shut down or the EFB can be set to a standby mode. The standby mode essentially switches the screen off, but maintains any active software running. Recovery from standby mode is nearly instantaneous and, of significance, any previously calculated takeoff and landing data is retained. The operator indicated that, in the event of any last-minute operational changes (for example, a runway change), retaining the information in the EFB in this way allowed the flight crew to recalculate performance quickly without having to re-enter data fields.

Restarting the Guru program after shutdown takes approximately 36 seconds and results in the 'Input' data fields being reset to a standard data set (Figure 4). It also resets the 'Takeoff' and 'Limit' tabs to prevent data calculated (V speeds etc) from previous sectors being accessed.

The operator's Operations Manual, Part B, Section 4.1 referred to the loss of stored data when the Guru program is shut down:

> *'All information entered in Guru will automatically be stored in memory when closing the current section or moving to the next tab. However, if the main Guru window is closed and the program is shut down, the previously calculated information will not be displayed when Guru is restarted. This is for flight safety reasons, as only actual and up-to-date information shall be entered.'*

The Operations Manual did not state that the Guru program must be shut down between uses and pilots routinely left the EFB in the standby mode with the Guru program still active.

Keyboards

In reviewing the EFB as part of the investigation, issues relating to the device keyboard were identified which, whilst not causal to this accident, were relevant to the overall EFB design approval.

Data entry for the EFB software can be by one of three on-screen keyboard options. Two of these are bespoke keyboards created by the EFB software supplier; the third is the device's own intrinsic keyboard which is part of its operating system. Examples are shown in Figures 6 and 7.

Both the EFB software supplier's keyboards have a 'scratchpad' which allows the user to see what is being entered even if the keyboard obscures the field being completed (Figure 6). To guard against data lying unknowingly hidden behind the open keyboard, their keyboards must be closed before different tabs can be accessed. If either of the EFB manufacturer's keyboards are selected, the device's intrinsic keyboard can still be opened, but cannot be used to enter data into any of the EFB fields.

The device's intrinsic keyboard (Figure 7) has smaller key sizes (the number boxes are approximately 4 mm x 4 mm) than the EFB manufacturer's version. There is also no scratch pad facility, so should the keyboard cover the field being used, the numbers selected cannot be seen as they populate the field. In addition, the keyboard does not have to be hidden when moving between tabs, potentially allowing information to be hidden from view. For example, if the intrinsic keyboard was left open, the emergency turn information at the bottom of the screen shown in Figure 5 was hidden.

The EFB software supplier indicated that, for these reasons, the EFB is set to one of their bespoke keyboards by default. However, the operator preferred to use the device's intrinsic keyboard and this was the keyboard selected for use across their fleets at the time of this accident.

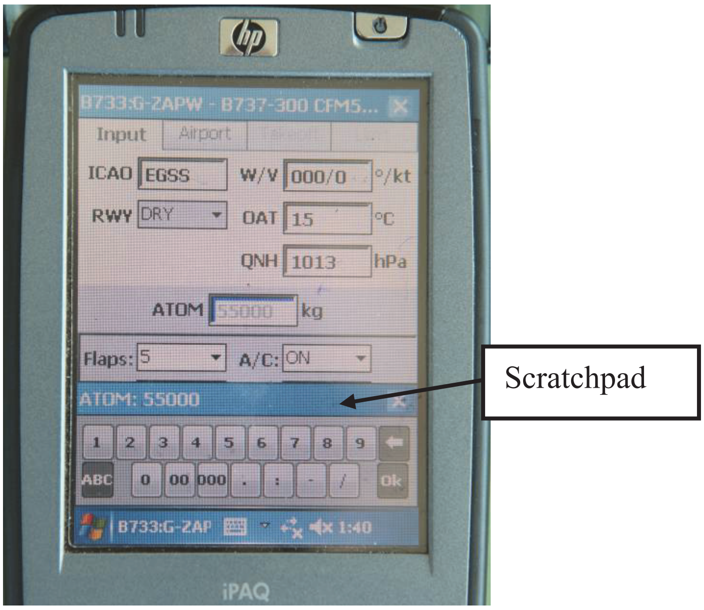


Figure 6

EFB software supplier's keyboard

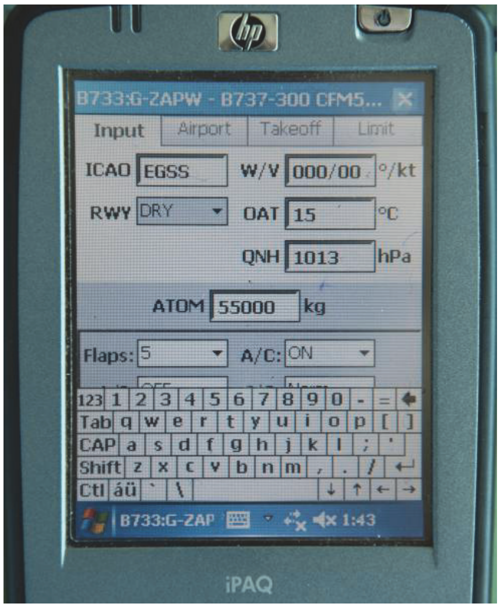


Figure 7

Device's intrinsic keyboard

Standard Operating Procedures (SOPs)

The calculation of takeoff performance data formed part of the operator's pre-departure checks, procedures for which appeared in the Operations Manual Part B, Section 2.14 and Section 2.17. The operator stated that all its pilots were trained on the use of the EFB and were checked on its use during LPC/OPC and line checks. However, the investigation revealed a lack of clarity in the way the procedures were laid out and on details of how information should be checked.

As a result of this accident the operator issued NOTAC OMB B733 02/2012, containing revised procedures. These included the requirement to shut down and restart the Guru program prior to conducting takeoff performance calculations. In addition, it instructed that the calculated V_2 should be compared against simple tabulated values of V_2 obtained by comparing flap position against aircraft weight. This was on the basis that V_2 changes little with other variable conditions, such as weather and runway used, and can therefore be used as a gross error check.

EFB approval

In October 2004, the JAA issued Temporary Guidance Leaflet (TGL) No 36 '*Approval of Electronic Flight Bags (EFBs)*' which provided guidelines to cover airworthiness and operational criteria for the approval of EFBs. Under the TGL 36 guidelines, EFBs are categorised according to their hardware and software functionality and as a consequence, not all EFB categories require airworthiness approval. The operator's EFB software is classified as a Type B application, running on Class 1 hardware, which required operational but not airworthiness approval. Class 1 hardware devices are generally Commercial-Off-The-Shelf (COTS) computers and with the improvement in tablet and mobile telephone computing power over recent years, the options for Class 1 hardware to host EFBs have increased significantly.

Section 7 of TGL 36 details the 'Operational Approval' process with guidelines for operators on how to demonstrate to a regulatory authority the suitability of the EFB and the operational procedures that accompany it. This is demonstrated in a report, usually submitted to their National Airworthiness Authority (NAA) (in this case the UK CAA), who review this and then permit the use of the EFB system[2] if it is acceptable. Within this section are a number of generic requirements for 'Human-Machine Interface Assessment' along with requirements for flight crew operating procedures and training. Appendix D also details guidelines for input devices, which includes:

> *'In choosing and designing input devices such as keyboards or cursor-control devices, applicants should consider the type of entry to be made and flight deck environmental factors, such as turbulence, that could affect the usability of that input device.'*

The guidelines for the 'Final Operational Report (Operational Compliance Summary)' require a summary of activities undertaken by the operator during the approval phase. However, the guidelines do not include specific software testing intended to identify potential sources of input errors, such as data fields not clearing after each flight.

CAA EFB operational approval

The CAA granted the operator permission to use the EFB after an operational evaluation. This evaluation

Footnote

[2] An EFB system refers to the complete EFB operation including risk assessments, human-machine interface, flight crew operating procedures and training, EFB administration and quality assurance.

used TGL 36 as a baseline, plus the CAA's own bespoke 'Operators EFB Checklist'. This checklist added some detail to that in TGL 36 but did not list any requirements for management of retained performance data from previous flights, or specify which of the three keyboard options should be used. Inconsistencies in the operator's SOPs also suggested these would have benefited from closer scrutiny.

Previous occurrences and studies

There have been a number of previous incidents and accidents resulting from incorrect calculation of takeoff performance. The outcome of such events can be: a perceived 'sluggish' takeoff, tailstrike, runway overrun, reduced obstacle clearance, degraded climb performance or, in the worst case, a catastrophic takeoff accident. As it is often the case that takeoff underperformance is subtle, it is possible that events have also occurred but have not been noticed.

On 14 October 2004, a Boeing 747 freighter, registered 9G-MKJ, crashed on takeoff from Halifax International Airport, fatally injuring the crew. The accident was investigated by TSB Canada whose report[3] concluded:

> *'1. The Bradley[4] take-off weight was likely used to generate the Halifax take-off performance data, which resulted in incorrect V speeds and thrust setting being transcribed to the take-off data card.*
>
> *2. The incorrect V speeds and thrust setting were too low to enable the aircraft to takeoff safely for the actual weight of the aircraft.'*

Analysis of the FDR data revealed that the data for the Halifax takeoff (V speeds, thrust derate) was nearly identical to that of the Bradley takeoff. In addition, the report identified that the EFB used for takeoff performance calculation retained *'all the previous settings, data, and information from the last use'* and that it was possible the Bradley takeoff weight retained in the EFB was used for the takeoff performance calculation.

After this report was issued, in August 2006, the JAA issued Safety Information Communication (SIC) No 7 titled 'Information on findings and recommendations relating to the use of an Electronic Flight Bag (EFB)'. This SIC was published as advice to operators in addition to TGL 36, with a view to reducing the chances of flight crews inadvertently using performance data retained in an EFB. The SIC made two recommendations to operators to modify their EFB software; one of these was to prevent:

> *'(ii) Any field in the performance application which is used to derive operational performance for a critical phase of flight from remaining populated after the EFB is shut down.'*

Where a software modification was not achievable, the SIC recommended that robust crew procedures were put in place to ensure independent calculations, cross-checking and gross error-checking, coupled with provision of suitable training.

After an A340-500, registered A6-ERG, suffered a tailstrike and runway overrun in 2009, the ATSB produced a Safety Report titled 'Take-off performance calculation and entry errors: A global perspective'[5].

Footnote

3 Transportation Safety Board of Canada Aviation Investigation report No A04H004.

4 Reference to 'Bradley' refers to Bradley International Airport in the USA; the takeoff runway on the sector prior to the takeoff from Halifax.

5 ASTB Transport Safety Report. Aviation Research and Analysis report AR-2009-052.

This report highlighted 31 global accidents and incidents over 20 years where takeoff performance parameter calculation and data entry led to a variety of consequences ranging from a perceived sluggish takeoff, to tailstrikes, to destruction of the aircraft. The report concluded that the errors appear to occur irrespective of airline or aircraft type and that there are a number of sources to the errors. While a number of errors are captured, due to the large number of methods in calculating and entering takeoff performance data, there was no single solution available. In addition it concluded:

> *'While it is likely that these errors will continue to take place, as humans are fallible, it is imperative that the aviation industry continues to explore solutions to firstly minimise the opportunities for take-off performance parameter errors from occurring and secondly, maximise the chance that any errors that do occur are detected and/or do not lead to negative consequences.'*

In June 2012, a NASA study[6] was concluded which extended that of the ATSB and a BEA commissioned study from 2008[7]. The study listed possible vulnerabilities from case studies and error reducing/trapping strategies. In addition, it proposed that:

> *'more accidents are likely to occur unless existing measures to prevent and catch these errors are improved and new measures are developed.'*

Footnote

[6] NASA (2012) *Performance Data Errors in Air Carrier Operations: Causes and Countermeasures*. NASA/TM-2012-216007

[7] Laboratory of Applied Anthropology (2008). *Use of Erroneous Parameters at Takeoff*, DOC AA 556/2008

Technical solutions have been studied, including Takeoff Performance Monitoring Systems (TPMS). Such systems operate during the takeoff roll and attempt to identify any underperformance in aircraft acceleration relative to runway position and highlight this to the pilots. The AAIB has previously made Safety Recommendations concerning TPMS in the report on an accident to G-OJMC (AAIB Bulletin 11/2009 refers).

EASA work

On 12 March 2012, the EASA issued Notice of Proposed Amendment (NPA) No 2012-02, with a view to integrating TGL 36 into the structure of the Agency's rules and also enhance and update the content. The outcome of this NPA is Acceptable Means of Compliance (AMC) 20-25[8]. The NPA referenced the 9G-MKJ (Halifax) accident but did not include any reference to the recommendations in JAA SIC No 7.

The proposed 'Operational Approval Process' section of this AMC differs from TGL 36 in that, amongst other things, it specifically requires any Type B EFB performance application be evaluated by the EASA. In addition, with a view to standardising the way such EFBs are approved, it states:

> *'The competent authority at national level should then base the granting of the operational approval on the results of the operational evaluation conducted by the Agency.'*

The AMC does not detail any equivalent detailed checklists such as those used by the UK CAA for an operational evaluation, nor do the EASA publish any. At the time of this report, AMC 20-25 was due for final release in early 2013.

Footnote

[8] AMC 20-25 Airworthiness and operational consideration for the approval of Electronic flight Bags (EFBs).

FAA and Transport Canada

The FAA and Transport Canada provide an 'Advisory Circular' for EFBs[9] and both provide checklists for the operational approval of a new EFB. In addition to the Advisory Circular, the FAA provides the 'Electronic Flight Bag Authorization for Use'[10] document which contains detailed criteria for assessing an operator's request to use an EFB.

Safety actions by the operator

The Operator stated that since this accident, it has improved the Operations Manual guidance on the use of the Guru program, adding more robust procedures. It has embarked on a training programme to provide refresher training for all crews on aircraft performance and has also upgraded the aircraft FMC programs.

The operator initially requested a 'clear' button to be added to their EFB screen to allow flight crews to clear all data fields. After discussion with the Guru software supplier, it was agreed that after the application is started, instead of populating fields with ISA data, these will be blanked. In addition, if the four-digit ICAO airport identifier is changed to signify a new airport, data fields will be blanked.

As the current EFB hardware is becoming difficult to source, the operator is also researching different hardware platforms with their EFB software supplier.

Analysis

Aircraft performance

When the EFB was woken from the standby mode, the Guru program retained the TOW from the takeoff at Stansted. The commander omitted to enter the aircraft's TOW at Chambery and neither he nor the co-pilot cross-checked the EFB computed data. Consequently, the erroneous TOW data was not identified and incorrect performance data was computed by the EFB, based on a figure around 6,600 kg lower than the actual TOW. The takeoff speeds were therefore correspondingly lower and the assumed temperature for the reduced thrust takeoff was higher than it should have been.

The aircraft rotation commenced at 126 kt, 13 kt below the required airspeed for the aircraft's TOW. As a result of the early rotation, the aircraft pitched up but did not take off immediately and, with an increasing pitch attitude, the tail struck the runway. Despite the lower than required rotation speed and thrust derate, the aircraft continued to accelerate during the rotation and lift off, achieving V_2 at a radio altitude of 30 ft.

It is considered that the reduction in pitch forces due to the broken outer main spring within the elevator feel and centering unit contributed to the excessive pitch attitude whilst attempting to get airborne.

Operator's EFB

An important contributory factor to this accident was that when the EFB was set to standby mode, the Guru program retained data from the previous flight. To improve the EFB robustness, the operator and EFB software supplier intend to modify the software to help reduce the chance of the EFB software contributing to performance calculation errors.

Footnote

[9] FAA Advisory Circular No AC 120-76B, Transport Canada Advisory Circular AC 700-020.

[10] FAA Flight Standards Information Management System (FSIMS) 8900.1 Volume 4, Chapter 15.

Retaining takeoff performance data after calculation can be useful when last-minute changes are necessary. If flight crews are required to re-enter the takeoff data, especially at a point where workload pressure is likely to be high, this provides an additional opportunity to introduce errors. The retention of performance data is therefore only appropriate if adequate software and operational safeguards are in place.

At the time of the accident the operator was using a keyboard setting not intended for use by the EFB software supplier. An appropriate keyboard was available, but the software still allowed the use of the device's own intrinsic keyboard. Whilst it was not a factor in this accident, use of the intrinsic keyboard increased the potential for incorrect data being entered into the EFB and for information to be missed due to screen obscuration by the on-screen keyboard. The size of this keyboard was such that accurate use of the stylus was required to select the correct figures. This questions the use of the device whilst airborne in turbulent conditions for calculating data such as landing performance.

In developing the software, the supplier of the operator's EFB used the appropriate guidance material available at the time. However, neither this, nor the approval process specifically addressed the issues highlighted above. In order to reduce the risk of human factors errors occurring when using EFBs for calculating performance data, the following Safety Recommendation is made:

Safety Recommendation 2012-035

It is recommended that the Civil Aviation Authority update their criteria for the operational approval of Electronic Flight Bags (EFBs) to ensure operators have procedures in place for the use of any 'standby modes' and on-screen keyboards, and to prevent the inadvertent use of outdated EFB performance data.

EFB evaluation and approval

Although currently integrating TGL 36 into the structure of the agency's rules, the EASA does not provide operational approval for each EFB; this is the responsibility of the National Airworthiness Authorities. NPA 2012-02 proposes that all EFBs capable of performance and mass and balance calculations be evaluated by the EASA to ensure an EASA-wide evaluation consistency, from which NAAs can base their decision to permit EFB use.

Both this accident, and that to 9G-MKF in Halifax, used the takeoff weight from the previous sector for performance calculations. The EFB in this accident, however, differs in that it does erase calculated takeoff data after it is shut down. Guidance in both TGL 36 and the proposed AMC 20-25 is for generic robustness, but there is no specific reference to detailed testing or recommendations such as those contained in JAA SIC No 7. The following Safety Recommendation is therefore made:

Safety Recommendation 2012-036

It is recommended that the European Aviation Safety Agency establish a set of detailed guidelines for the operational evaluation and approval of Electronic Flight Bags. These should be more specific than the proposed Acceptable Means of Compliance (AMC) 20-25 and include information such as provided in the Federal Aviation Authority document *'Electronic Flight Bag Authorization for Use'* and Joint Aviation Authorities Safety Information Communication No 7.

SOPs

Deficiencies identified in the EFB were exacerbated by those identified in the operator's SOPs. The operator was sufficiently small that the relevant managers believed all pilots knew what was expected of them despite these shortcomings. Both pilots stated they were aware of the need to check the EFB performance calculations. The problem came in identifying exactly what was expected and in this the SOPs were, in parts, out of date, insufficiently comprehensive and lacking in clarity. The operator acknowledged this and will be carrying out a review of the relevant SOPs as part of a larger review of their Operations Manual.

Summary

The use of computers in the calculation of performance requirements has brought about improvements in the accuracy and ease with which they can be made. There remains, however, a continued vulnerability to the use of incorrect data in making these calculations, a solution to which remains outstanding. This accident serves to demonstrate that, given these circumstances, the existence of and adherence to robust procedures, and appropriately designed software and hardware, are essential.

This event once again emphasises the need for technical solutions for takeoff performance monitoring, to cater for those occasions where current safeguards have failed, and reiterates previous Safety Recommendations made by the AAIB on this issue.

ACCIDENT

Aircraft Type and Registration:	Shadow Series CD, G-MYUS
No & Type of Engines:	1 Rotax 503-2V piston engine
Year of Manufacture:	1995 (Serial no: 257)
Date & Time (UTC):	22 August 2012 at 1619 hrs
Location:	Near Laverstock, Salisbury, Wiltshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Fatal) Passengers - N/A
Nature of Damage:	Destroyed
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	79
Commander's Flying Experience:	164 hours (of which 164 were on type) Last 90 days - 2 hours Last 28 days - 1 hour
Information Source:	AAIB Field Investigation

Synopsis

The pilot had planned to carry out a local VFR cross-country flight from Old Sarum to Blandford Forum before returning to Old Sarum. Shortly after leaving the circuit, he contacted ATC and informed them that he was returning to the airfield. He gave no reason for his early return and there were no witnesses to the accident. Following concerns at the airfield that he had not arrived after the expected time, another club aircraft carried out a search and located the wreckage of G-MYUS in a field. The aircraft had struck the ground at a relatively high speed for the aircraft type, fatally injuring the pilot. It was possible that the pilot had become incapacitated in-flight, allowing the aircraft to enter a spiral dive.

History of the flight

The pilot was paraplegic and G-MYUS was adapted to enable operation using hand controls. He had booked the flight in advance and arrived at the flying club at Old Sarum about 1130 hrs. The aircraft had not been flown that day, so the pilot performed the daily inspection. The duty instructor pulled the aircraft out of the hangar and refuelled it to full tanks, providing an endurance of approximately 1 hour and 30 minutes.

The instructor and the pilot reviewed the weather prior to the flight which the instructor recalled as being good with isolated showers. They discussed the possibility of weather 'cells' developing and the need to remain clear of them. The pilot planned a one-hour solo flight along a route with which he was familiar, initially to Alderbury and then following the A354 road to Blandford Forum before returning to Old Sarum.

Having performed the pre-flight inspection, the pilot was lowered into the cockpit using a specially adapted winch. The instructor secured the pilot's harness and carried out a final inspection of the aircraft, before pushing it up to the parking area. After engine start, the pilot taxied to the holding point of Runway 24. He departed at 1347 hrs making a left turn climbing towards Alderbury. However, at 1357 hrs the air/ground operator stated that the pilot reported on the radio "Alderbury for re-join with 24, left hand, QFE 1008" (Figure 1).

At 1405 hrs, the aircraft had not returned to Old Sarum, so the air/ground operator attempted to contact the aircraft but with no response. He confirmed with the instructor the intended routing and endurance and after an hour he contacted other local airfields; however, they had not had any contact with the aircraft either. As a result, the instructor and a colleague took off in another aircraft and subsequently located the wreckage of G-MYUS in a field, two miles to the south-east of the airfield. The pilot had been fatally injured.

Meteorological information

The weather over the UK on the day of the accident was characterised by a westerly airflow, which was slightly unstable over the southern part of the country. This meant there were rain showers[1] occurring in the Salisbury area, with the Met Office weather radar showing a moderate rain shower at 1430 hrs.

Conditions outside the rain showers were good with visibility around 30 km and cloud base at 2,500 ft and above. It is likely that within the rain showers the visibility would have dropped to around 7 km and cloud base to approximately 2,000 ft. The surface wind was westerly at 10 to 15 kt and it was possible that in or near rain showers, the wind was gusting to around 25 kt.

Licence, medical and pathological information

The pilot held a valid NPPL, with a current medical declaration and was not taking any prescribed medication. Based on information provided by witnesses at the airfield, the pilot's demeanour prior to the flight was normal and in character.

The post-mortem confirmed the pilot died instantaneously of multiple injuries consistent with a non-survivable accident in a microlight aircraft. The aviation pathologist, who conducted the post-mortem, advised that the toxicology tests showed no evidence of drugs or exposure to carbon monoxide. However, he identified that the condition of the pilot's heart could potentially have led to incapacitation. His opinion was that "while there is no definite pathological evidence to indicate that it had done so, if other strands of the accident investigation indicate that pilot incapacitation was a likely cause of the accident, then this finding provides a possible explanation for such incapacitation."

The pilot's medical records indicated that the heart condition was likely to have been asymptomatic prior to the accident flight. The pathologist advised that it would only have been medically identifiable with specific, non-routine testing. There was no record of the pilot ever having undergone such tests, which are not required for the issue of an NPPL.

Footnote

[1] The rain showers were referred to by the instructor as 'cells'.

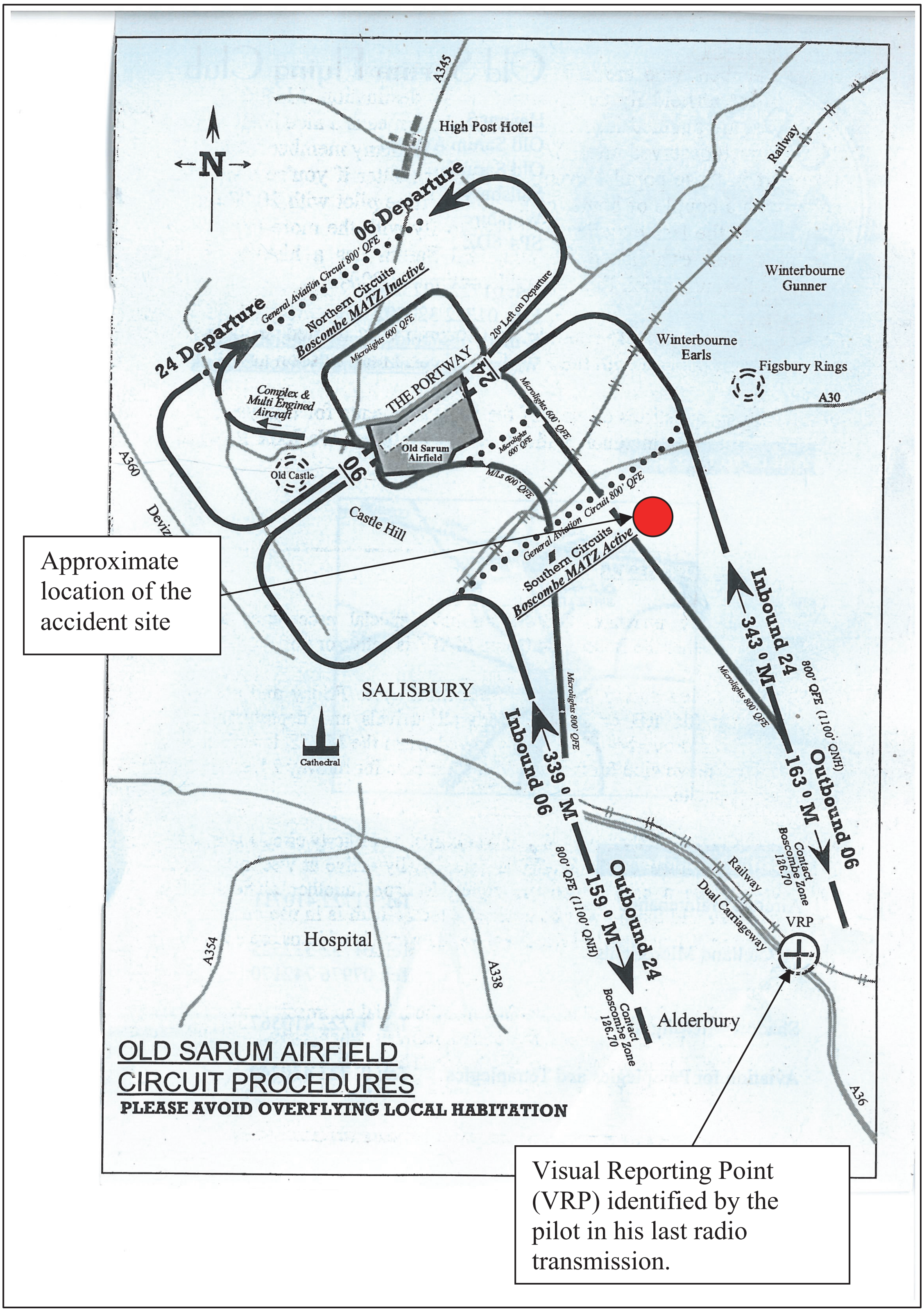


Figure 1

Airfield circuit diagram recovered from the wreckage

Aircraft description

The CFM Shadow is a two-seat, high-wing microlight aircraft, that can be home or factory built. The enclosed polycarbonate, Fibrelam and Glass Fibre Reinforced Plastic (GFRP) cockpit has a dual control, tandem-seat arrangement, but with only the front seat available for solo operation. Longitudinal and lateral control is provided by a right-hand sidestick and conventional pedal arrangement, with a throttle lever on the left side. The two-stroke rotax engine is located behind the rear seat and directly drives a three-blade pusher propeller. The vertical and horizontal stabilisers are located at the end of a tail boom that extends from the rear of the wing/cockpit interface. Twin endplate vertical fins extend above the horizontal stabiliser, with a small ventral fin and large rudder extending below it. The single, full width elevator is fitted with a small electrically operated trim tab. The wing is constructed predominantly from a polyester fabric, stretched over a plywood and aluminium spar structure, with Styrofoam formers providing the aerofoil and leading edge 'D' nose profile, with the leading edge skin constructed from GFRP. The aircraft is fitted with a fixed tricycle landing gear with a castoring nosewheel. The aircraft has a normal cruise speed of 65 kt and a V_{NE} of 94 kt.

Accident aircraft

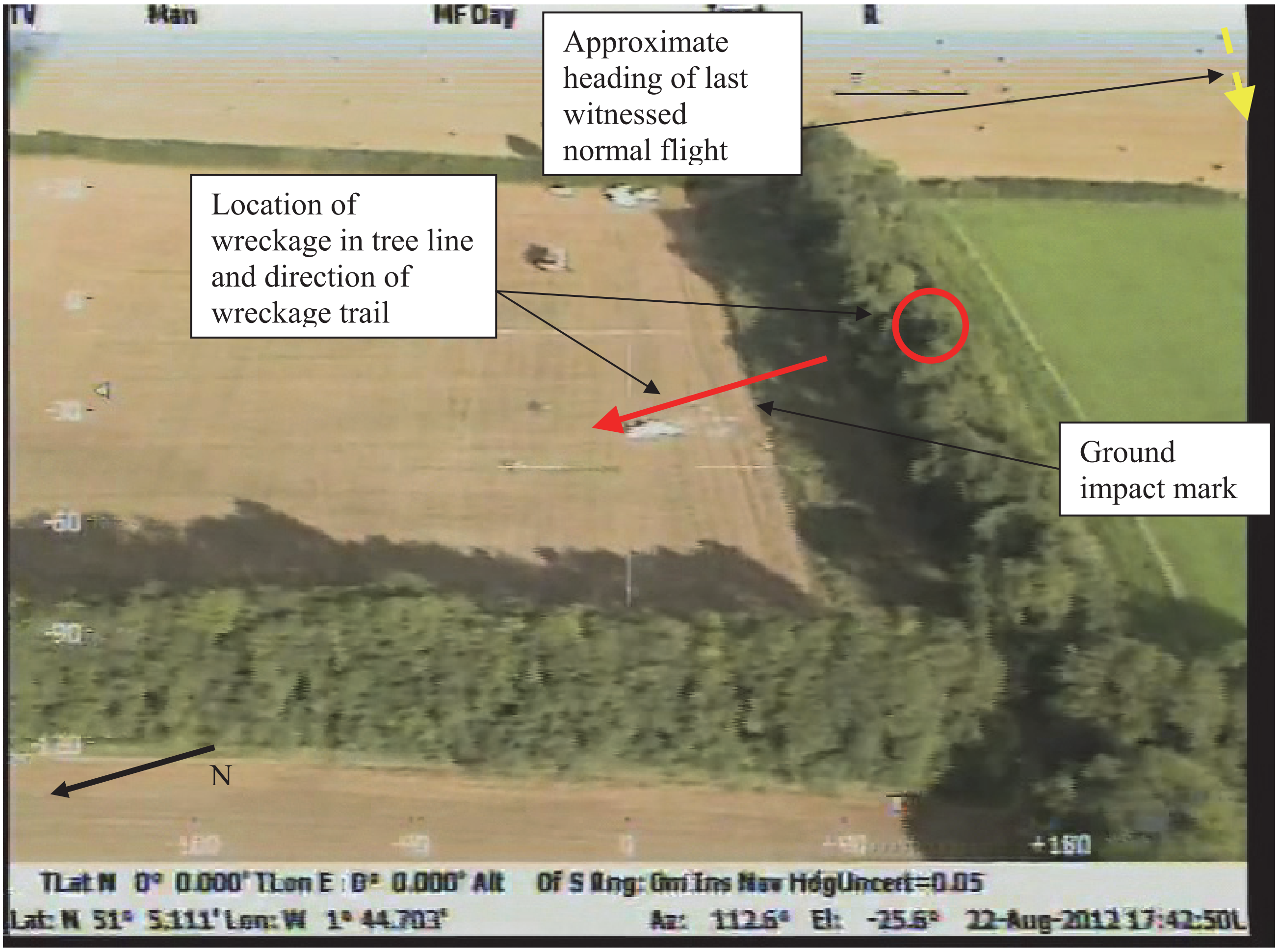
G-MYUS was modified to allow operation by paraplegic pilots, with the conventional rudder pedals and throttle replaced by a multi-function hand control operating both the rudder and throttle functions. The brakes were also modified for hand operation, with brake levers fitted to both control sticks. The aircraft had been involved in an accident in 2006, when the pilot at the time had carried out an unsuccessful forced landing due to bad weather. The aircraft was significantly damaged during this accident, but had been repaired and returned to service using parts from a donor aircraft, under the approval of the BMAA.

Accident site and wreckage

The aircraft wreckage was located on the edge of a field adjacent to the field boundary, which consisted of a line of high trees, surrounded by tall, dense undergrowth. The accident took place following a period of dry, warm weather that had created a very hard, 'concrete like' surface to the field. As such, there was only one small ground mark caused by the initial impact.

A small section of wing leading edge structure was lodged in one of the trees, with associated damaged branches visible. Further small sections from the wing were scattered throughout the undergrowth on the same side of the tree line as the main wreckage. No items of wreckage were found on the opposite side of the tree line. The larger items of wreckage were distributed across the field, beginning at the edge of the cultivated section and extending from the ground impact mark on a bearing of 358°. (Figure 2)

The initial part of the trail was formed predominantly from sections of the wing leading edge 'D' nose structure, which had completely fragmented. The remaining wing and fuselage structure were located together some 10 metres away, inverted and pointing roughly perpendicular to the line of the wreckage trail. The cabin structure was heavily disrupted and detached, with only the seats and engine mount structure, with the engine attached, remaining connected to the wing and tail boom. The tail boom was bent upwards and to the left, whilst the horizontal stabiliser was damaged on the right side. The right main landing gear leg had been bent inwards under the aircraft. The wing structure itself was heavily disrupted, with the leading edge corner of the left wingtip crumpled inwards. Due to the extent



(Image courtesy of Wiltshire Police)

Figure 2

Aerial image of accident site

of the impact damage, it was not possible to determine the position of the flaps. The position of the trim tab on the elevator was approximately 5º nosedown from the neutral position.

The three propeller blades had separated from the propeller hub, but all blades were present in the wreckage trail. Rotational scuffmarks on one of the blades and paint transfer on the fuselage structure showed they had contacted during the ground impact, whilst the propeller was rotating at speed. The engine-cooling fan had been stripped of all its blades. As the engine directly drives the fan, this also confirmed the engine was operating at impact.

Whilst the wreckage was heavily disrupted, no evidence was identified during either the preliminary inspection on-site or the more detailed inspections following recovery of the wreckage to the AAIB's facilities, of a pre-existing defect or mechanical failure of the aircraft.

Aircraft performance and handling assessment

On 26 September 2012, a CAA light aircraft test pilot flew a Shadow CD microlight, G-MWVG, that was considered representative of the accident aircraft. The purpose of the flight was to assess the handling qualities of the aircraft, in particular its lateral, directional and spiral stability. The weather conditions at the time of the test flight were; surface wind 150° at 5 kt, visibility in excess of 10 km, OAT 13°C with isolated showers but no turbulence outside of the showers.

The results of the series of tests determined that the aircraft had benign handling characteristics. The aircraft in a clean configuration at idle power stalled at 29 KIAS, preceded by light buffet and no wing drop. It had moderately positive longitudinal static stability[2] with noticeable force required on the side stick pitch control to execute a 10 kt speed change. Acceleration to V_{NE} in a dive from straight and level flight at 65 kt, even with full nosedown trim, was only achievable with a constant forward stick force measured at approx 10 kgf. Lateral stability was also positive and the aircraft had positive directional stability.

The aircraft exhibited a weak divergent spiral mode when displaced from the wings level attitude by more than 10°. With cruise power set, the aircraft was more likely to diverge to the left, whereas with idle power set, the aircraft tended to deviate to the right. In both cases, if the pilot did not take corrective action, the aircraft entered a gently tightening spiral dive. Without intervention, the spiral dive resulted in steadily increasing airspeed, yaw rate, angle of bank and rate of descent in the nosedown attitude. The tests were discontinued at 80 KIAS in order to prevent the propeller exceeding its maximum rpm limit. However, the test pilot considered the aircraft would have achieved and possibly exceeded its V_{NE} had corrective action not been taken.

Analysis

The pilot was properly licensed and qualified to conduct the flight and held a valid medical declaration. No evidence of a pre-impact defect or mechanical failure of the aircraft was identified during the investigation.

The pilot had intended to fly for approximately one hour but elected to return after only 10 minutes. He did not state the reason for his return in his radio transmission. There was a moderate rain shower in the general area that may have led him to make this decision, having discussed this eventuality with his instructor prior to the flight, or there may have been some other reason not identifiable to the investigation.

The degree of disruption to the aircraft structure and the severity of the injuries sustained by the pilot indicated a relatively high impact speed for the aircraft type. Based on the pilot's stated intention and the position of the wreckage, the pilot appeared to be flying on an extended base leg to rejoin for Runway 24 at Old Sarum. At a point along this route, the aircraft deviated to the right of track, lost height and gained airspeed, before it struck the branches of a tree in the tree line forming the boundary of a small field. Given the minor damage evident in the tree line and the small piece of leading edge wing structure that was retained in the branches, it is likely that only the right wing struck the top of the trees, consistent with the aircraft having a degree of right wing low bank angle and a nosedown attitude. The aircraft's right wingtip then struck the ground, followed by the right side of the cockpit nose and fuselage. The aircraft continued to rotate in a cartwheel motion resulting in the left wingtip striking the ground. Wreckage debris was projected across the field, with the wing and remaining fuselage travelling laterally to their final resting position.

The flight tests demonstrated that even with full nosedown trim, the aircraft's inherent static stability would have required that it be held in a dive by a continuous nosedown sidestick control input force of nearly 10 kgf, to achieve the impact speed estimated from the physical evidence. The investigation did not identify any evidence to suggest this was a likely

Footnote

2 The stability of an aircraft in the longitudinal or pitching axis under steady flight conditions.

scenario. Equally, the aircraft had probably not entered a stall as the final flight path and accident site evidence did not match the stall characteristics of the aircraft type, as demonstrated during the flight test.

The flight test demonstrated that the most likely manner in which the aircraft achieved the impact speed estimated, without an intentional input on the controls, was a spiral dive. This would also be consistent with the deviation seen from the apparent intended flight path and the ground impact sequence identified. Under normal circumstances, given the benign handling characteristics of the aircraft, it was well within the pilot's ability to recover from an incipient spiral dive. However, without pilot intervention the dive would continue to develop, with the aircraft gaining airspeed and losing height until it struck the ground. The most likely explanation for a lack of intervention by the pilot would be incapacitation. Whilst the post-mortem findings were not able to offer conclusive evidence in support of this conclusion, the reported condition of the pilot's heart did offer a possible cause.

To initiate the spiral dive the aircraft needed to be displaced by 10° or more from wings level. This could have occurred due to a gust of wind or turbulence. However, given the functionality of the sidestick controls, it is also feasible that, had the pilot became incapacitated with his hands on the controls, this could have resulted in an inadvertent right rudder and/or right roll control input inducing the required initial angle of bank. This may also have increased the rate at which the spiral dive developed.

Conclusion

It was possible that the pilot, having elected to return to the airfield, subsequently became incapacitated. It is likely the aircraft then entered a spiral dive, from which it was not recovered. The aircraft eventually struck trees followed by the ground, with the impact forces generated being non-survivable. The incapacitation may have been caused by the condition in the pilot's heart, which appeared previously to have been asymptomatic, and for which his category of pilot's licence did not require him to be tested.

ACCIDENT

Aircraft Type and Registration:	Team Minimax 93, G-CBPL
No & Type of Engines:	1 x Mosler CB 40 piston engine
Year of Manufacture:	2002
Date & Time (UTC):	18 May 2012 at 1720 hrs
Location:	Field adjacent to Newnham Way, Ashwell, Herts
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Serious) Passengers - N/A
Nature of Damage:	Aircraft destroyed
Commander's Licence:	UK CAA Private Pilot's Licence (Aeroplanes)
Commander's Age:	62 years
Commander's Flying Experience:	363 hours (of which 0 were on type) Last 90 days - 2 hours Last 28 days - 0 hours
Information Source:	AAIB Field Investigation

Synopsis

The aircraft struck the ground in an erect spin and the pilot was seriously injured. The pilot had flown flexwing aircraft for several years but had very little experience flying three-axis aircraft. The investigation considered the differences between various control systems used in microlight aircraft, and one Safety Recommendation is made concerning pilot licensing.

History of the flight

The aircraft was based at a grass airstrip near Newnham, Hertfordshire, where its owner (who was also the pilot involved in the accident) had prepared it for flight testing for a permit to fly. A Permit Flight Release Certificate (PFRC) had been issued by the Light Aircraft Association (LAA) naming a pilot, with experience on the type, who was to undertake the testing. The pilot named in the PFRC was not the owner. Nonetheless, the owner had conducted a number of taxi trials with the aircraft, including tail-up taxiing.

Very little is known of the circumstances leading to the accident except that the owner was flying the aircraft and received serious injuries when it crashed in a field, near the airstrip, having entered a spin from which it did not recover.

Several eye witnesses (see Figure 1) may have seen the aircraft before the accident. Two witnesses (witnesses 1 and 2) saw an aircraft flying near the airstrip close to

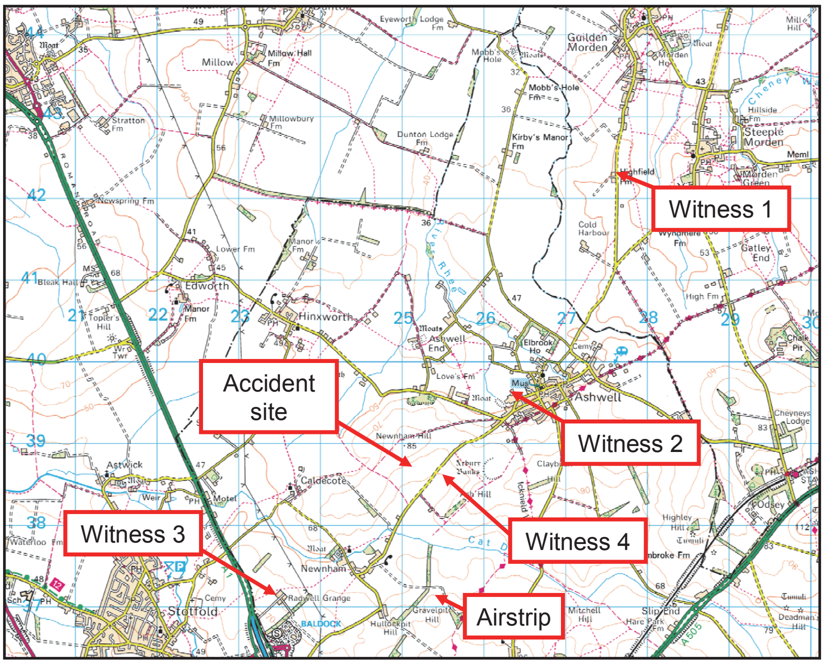


Figure 1

Local area map showing, eyewitness locations, etc

the time of the accident flying at a relatively low height, but straight and level, with the engine sounding "rough" or unusual. Witnesses 3 and 4 saw the aircraft's final manoeuvre, describing an aircraft descending in an erect spin to the left.

The owner could not remember any details of the flight but he did confirm that it was his intention to fly the aircraft that day.

Meteorology

The Met Office provided an aftercast of weather conditions near the accident site which stated that:

> *'The accident site was approximately 12 nm north-east of Luton and 16 nm south-west of Cambridge. METARs for both airport indicated that the wind was light and south-easterly, visibility was in excess of 10 km, and there was no cloud below approximately 3,000 ft amsl. The temperature and dew point were 13° C and 10° C at Luton and 14° C and 9° C at Cambridge respectively.'*

Piston engine icing

A possible cause of power loss in piston engines is carburettor icing. The CAA Safety Sense leaflet, entitled '*Piston engine icing*', included a graph illustrating the likelihood of carburettor icing in various conditions of temperature and dewpoint. Appropriate values for Luton (elevation approximately 500 ft, and therefore approximating the flight altitude) at the time of the accident were entered into the graph. The graph indicated that there was likely to be *'Serious icing'* at *'any power'*.

It was understood that the engine in G-CBPL was probably running on MOGAS rather than AVGAS. The leaflet also stated:

> *'Testing has shown that because of its greater and seasonally variable volatility and higher water content, carb icing is more likely when MOGAS is used.'*

Engineering

Accident site details

The aircraft crashed into a cereal crop approximately 1 nm southwest of the village of Ashwell. It was a compact site, with the disposition of the wreckage indicating that the aircraft had struck the ground in a steep, nose-down attitude, whilst banked to the left. The ground marks indicated that the left wing contacted the ground first, closely followed by the nose, after which the aircraft came to an almost immediate halt. The main force of the impact had been taken on the nose of the aircraft, as evidenced by extensive disintegration of the forward fuselage, which had effectively been destroyed as far back as the rear of the cockpit. The rear fuselage, rudder and tail surfaces had remained relatively intact. The short ground slide suggested a low horizontal velocity component. This was supported by witness evidence, which indicated that the aircraft had been in a spin prior to impact. The damage to the left wing, together with its associated ground mark, indicated that the direction of the spin was to the left.

The wooden propeller had broken into numerous fragments which were scattered close to the nose/engine impact area. The heavy clay soil and the standing crop resulted in an incomplete recovery of the fragments but, the two tip portions were found. It was considered that the degree of fragmentation was indicative of power being developed at impact, although it was difficult to quantify.

The engine and fuel tank (which had been mounted in the nose) had broken away during the impact, with the latter containing a quantity of fuel, although it was clear that some had leaked out via broken fuel lines. The gascolator bowl had also broken off but was not recovered.

The flying controls comprised Teleflex-type cables for the elevator and full span 'flaperons' (combined ailerons and flaps,) with the rudder being operated by conventional cables attached to the rudder pedals. It was established that the control connections had remained intact during the impact.

Following an on-site examination the wreckage was recovered to AAIB's facility at Farnborough for detailed inspection.

Aircraft history

The Minimax is a wood and fabric, shoulder-wing monoplane that can be built either from a kit of parts or from drawings. In the United Kingdom, construction is carried out under the oversight of the LAA. In this process, at its initiation, the project is registered with the LAA Engineering Department. The owner/builder must then find a local LAA approved Inspector who will provide advice and certify, at various stages of construction, the work that has been carried out. On successful completion a further inspection will result in the issue of a PFRC issued by the LAA, which will allow a designated test pilot (which could be the owner/builder if he has the relevant type experience) to fly the aircraft in accordance with a test schedule appropriate to the aircraft type. Only after successful completion of the flight testing, which typically takes around five flying hours, will the LAA recommend to the CAA that a full Permit to Fly be issued.

In the case of G-CBPL, the log book indicated that the aircraft was built in 2004, with a Certificate of Registration issued in May 2002. However, construction of the aircraft was not completed and the log books indicate that the current owner acquired the aircraft during 2009. It was subsequently registered in his name on 11 June 2011. The first engine ground run was recorded as having occurred in 2004, with the next one, conducted by the new owner, not carried out until September 2009. The engine was subsequently run on numerous occasions up until the time of accident, when it had achieved in excess of 25 hours. The first 'tail up' taxi took place on 22 May 2010.

The new owner had appointed a local LAA Inspector who had overseen completion of the aircraft. This had culminated in the issue of the Permit Flight Release Certificate on 30 April 2012, valid for 30 days. This stated that it covered flights made only for the purpose of the issue of a Permit to Fly, and additionally named the test pilot, (who was *not* the owner), who was to conduct these flights.

A flight was attempted on 5 May 2012 but was abandoned due to a problem with leakage in a hose that formed part of the engine induction manifold. This was repaired with a new piece of hose and was written up and signed for by the LAA Inspector in the engine log book.

A few days later another attempt at the first flight was made, although no written record was found. On this occasion, a gust of wind during the takeoff roll caused the pilot to make a sudden, large rudder deflection that resulted in significant distortion to the left rudder pedal hinge. This was detected by the pilot and the takeoff was abandoned. The hinges were made of brass and it was decided to replace them with higher strength, steel components, which in fact is a normal modification for this aircraft type. These were fitted by the owner and were subsequently found in the wreckage. However, as this work had involved disturbing the flying controls, a duplicate inspection by the LAA Inspector was required. This had not been done, although, according to the Inspector, arrangements had been made with the owner and test pilot to conduct the inspection and first flight on Monday 21 May 2012, which was a date dictated by the test pilot's non-availability during the preceding weekend. However, the owner decided to fly the aircraft on Friday 18 May,

Detailed examination of the aircraft

The aircraft was complete prior to impact, with no evidence being found of a pre-impact structural failure.

The full-span flaperons embodied a droop mechanism that enabled them to operate as flaps whilst retaining their aileron function. This comprised a flap-operating torque tube installed laterally across the fuselage floor and which could be set at one of four positions by means of a lever located on the right hand side of the cockpit. The positions were reflex (6º up), neutral, flap 1 and flap 2 (16º), and were selected by placing the lever into one of four hooked detents in a slotted alloy guide that was bolted to the cockpit wall. Examination of the lever and guide failed to reveal any reliable witness marks that may have indicated the flap position at the time of impact.

It was found that the left rudder pedal had broken close to its attachment to its hinge, although it had remained attached to its cable. The pedal was made from plywood and the fracture appeared clean and was considered to be an impact feature, possibly resulting from the force of the pilot's foot during the impact. A bracket attached to each pedal underside was connected both to the rudder cable and a balance spring that in turn was attached to the floor; the purpose of the springs was to apply a centring force to the rudder system. Each spring actually comprised two separate springs that were hooked together at their ends. It was noted that the left pedal springs were not connected together, with the hooks showing no evidence of distress under load. However it could not be determined whether the disconnect was a result of the impact, or possibly a result of the springs not being reconnected following the hinge replacement.

The engine was of a simple design, with two horizontally opposed, air-cooled cylinders. Examination of the engine controls indicated that the carburettor heat was selected to COLD and the choke was IN. It was also observed that the throttle control was pushed firmly against the instrument panel, in the full power position, although it was considered that this was not necessarily a reliable indication of the pre-impact setting. Finally, the fuel selector was found in the ON position.

Only a small quantity of oil was found within the engine, although it had become inverted during the accident and it was clear that considerable leakage had occurred via two breather tubes on top of the crankcase. The repair to the inlet manifold hose, referred to in the aircraft documentation, was found to be intact. The engine could be turned over by hand and it was noted to be smooth in operation, with the valve mechanism operating correctly. The single magneto produced sparks at the plugs when the engine was turned. A borescope inspection revealed that the engine appeared in good condition internally, with honing marks clearly visible on the cylinder walls, consistent with the low number of operating hours. The engine was equipped with a gear-type oil pump, which was driven from the crankshaft. This was noted to operate correctly, with the internal components being in good condition.

Other information

As noted earlier, the subject aircraft was equipped with flaperons. Evaluation of the first examples in the UK by the LAA concluded that the flap function:

> *'..has not, in general, been found to be beneficial, ... causing a reduction in aileron effectiveness when flaperons are drooped.'*

A modification became available, which locked out the droop mechanism. However, later examples of the aircraft retained the flap function and it is estimated that around half of the approximately 60 aircraft flying in the UK are so configured.

The pilot

The pilot began learning to fly flexwing aircraft in 1991, and bought his own aircraft shortly thereafter. He obtained a UK CAA Private Pilot's Licence (Aeroplanes) (PPL(A)) with a Microlight rating in 1997. At the time of the accident, he owned two flexwing aircraft, and had flown them regularly. His log book showed evidence of several flights in three-axis aircraft, annotated *'Pu/t' (pilot under training)*. The pilots of those aircraft stated that, although the accident pilot had manipulated the controls in cruising flight and may have made some gentle turns, climbs, and descents, the flights were not instructional. The pilot had had one flying lesson in a three-axis aircraft in 2010.

The pilot was interviewed in hospital some months after the accident, when he had recovered sufficiently to give an account. He had no recollection of the accident flight, but did recall that he had intended to fly. He explained that he had not undertaken any training to fly three-axis aircraft, but had spent considerable time using a flight simulator programme on his home computer (which was fitted with replica controls), to rehearse the control inputs necessary for flying three-axis aircraft.

The pilot's log book showed four previous flights in G-CBPL, totalling 1 hour 50 minutes. The pilot did not recall having flown the aircraft before the accident flight, and it is possible that the 'flights' in his log book were in fact records of taxi trials.

Other pilots who knew the accident pilot, and were aware of his self-tuition using his personal computer, stated that they had advised him to take proper training before flying a three-axis aircraft solo.

Pilot licensing

Control systems

The pilot's licence entitled him to fly microlight aircraft, as defined in the Air Navigation Order, regardless of control system. Such aircraft are typically of a flexwing or three-axis design. A few hybrid designs exist, and some powered parachutes are also classified as microlight aircraft. The three fundamental control systems are very different. (Powered parachutes are considered to be outside the scope of this report except insofar as distinct training is necessary to operate them safely.)

In the flexwing, the wing is articulated above a pod which accommodates the occupant(s) and engine. The pilot applies forces on a control bar attached to the wing to achieve the desired pitch and roll attitudes. There is no yaw control. Pedals are fitted to enable steering of the nose wheel during ground operations but they have no aerodynamic purpose in flight.

In a three-axis aircraft the pilot applies forces on a control column or yoke, which moves ailerons and elevators on the aircraft, providing control in roll and pitch. Pedals linked to the rudder provide control in yaw.

The senses in which control is applied are opposite: to pitch nose-up in a flexwing, the control bar must be moved away from the pilot; to pitch up in a three-axis aircraft, the control column is moved towards the pilot. To roll left, the flexwing's control bar is moved right; the control column in the three-axis aircraft is moved left. To steer to the left on the ground in a flexwing, pressure is applied with the right foot; to yaw left in a three-axis aircraft, pressure is applied with the left foot. Despite these differences, many pilots alternate between aircraft with different control systems without apparent difficulty.

Legislation

The BMAA is the governing body for microlight aviation in the UK, which is regulated by the CAA. Section 1 Schedule 7 of CAP 393 - *Air Navigation: The Order and the Regulations*' (ANO) in force at the time of the accident stated:

> *'Microlight class rating*
>
> *(1) Subject to paragraph (2) and to the conditions of the licence in which it is included, a microlight class rating entitles the holder to act as pilot in command of any microlight aeroplane.*
>
> *(2) (a) If the current certificate of revalidation for the rating is endorsed "single seat only" the holder is only 'entitled to act as pilot in command of any single seat microlight aeroplane.*
>
> *(b) (i) If the aeroplane has:*
>
> *(aa) three axis controls and the holder's previous training and experience has only been in an aeroplane with flexwing/weightshift controls;*

(bb) flexwing/weightshift controls and the holder's previous training and experience has only been in an aeroplane with three axis controls; or

(cc) more than one engine,

before exercising the privileges of the rating the holder must complete appropriate differences training.

(ii) The differences training must be given by a flight instructor entitled to instruct on the aeroplane on which the training is being given, recorded in the holder's personal flying logbook and endorsed and signed by the instructor conducting the training.'

The document did not define what constituted acceptable '*previous training and experience*'.

Previous accidents and AAIB Safety Recommendations

AAIB Safety Recommendation 98-62, made following a fatal accident to a Kolb Twinstar Mk III Microlight aircraft in July 1998, stated:

'This accident may have resulted from a loss of control by the pilot. The pilot had no training and limited experience on the type of aircraft control system that he was using. Given the fundamental differences between weight shift and 3-axis control systems, notably the diametrically opposed control movements for pitch and roll, it is recommended that the CAA should consider making the guidance [that differences training should be undertaken]… a mandatory requirement.'

Initially the CAA took the view that Alternate Control System training should be mandatory for pilots of microlight aeroplanes converting from weight-shift to three-axis control or vice-versa but it did not accept the recommendation.

Following an accident to Rans S-6 Coyote G-CCNB in 2005[1], the AAIB made the following Safety Recommendation:

Safety Recommendation 2005-128

The Civil Aviation Authority should require holders of the Private Pilots Licence (Aeroplane) (Microlights) converting from weight shift to three-axis control systems, or the reverse, to undertake adequate conversion training and pass a Flight Test conducted by an appropriately qualified microlight pilot examiner.

The CAA responded as follows:

'The CAA accepts this recommendation and proposes that the requirements at Schedule 8 Part A Section 3(7)(b) in respect of differences training between 3-axis and weight shift Microlights be moved to Schedule 8 Part B - Microlight Class Rating, and be revised to incorporate a skills test with an authorised Microlight Flying Examiner as part of differences training. This will require consultation with industry, regulatory impact assessment and an amendment to the Air Navigation Order. A date for possible implementation is likely to be end of 2007.'

Footnote

[1] AAIB reference EW/C2005/03/05 published April 2006.

Discussions with the BMAA and CAA established that the licensing mechanisms by which pilots may be qualified to fly microlight aircraft of different control systems were not straightforward; holders of some licences were required to undertake training while others were not, and for some there was no requirement to pass a test, despite the significant differences between control systems and their methods of use. The qualification routes for microlight instructors and examiners were similarly complex and lacked consistency. When implemented, changes to the ANO did not incorporate the requirement for a flight test.

Analysis

The aircraft

At the time of the accident, the aircraft had not completed test flying for a permit to fly, and therefore its handling, performance, and other characteristics had not been established to be satisfactory. The destruction of the aircraft was such that its pre-accident condition could not be established during the investigation. The investigation did not identify any pre-existing technical malfunction or deficiency. Flying undertaken by the pilot experienced on type named in the permit to test might have identified any shortcomings.

The accident flight

The aircraft impacted the ground in an erect spin. For spin entry, the aircraft must fly at high angle of attack, with yaw present. The pilot had little experience of three-axis flying, amounting to one flying lesson and some flight handling of other people's aircraft. His use of his personal computer flight simulator may have been of some value, but was not a substitute for proper training, especially with a flying instructor.

The departure from controlled flight, involving high angle of attack and undesirable yaw, highlights a crucial difference between flexwing and three-axis aircraft. Flexwing aircraft are not controlled in yaw, other than when steered on the ground. Three-axis aircraft generally require careful control in yaw, especially at high angle of attack. Because the sense in which the aircraft respond to pedal inputs is reversed, instinctive 'steering' inputs learnt in the weight-shift aircraft would exacerbate, rather than counteract, yaw in flight in a three-axis machine.

The weather conditions were suitable for flying, although the temperature and dewpoint indicated that serious carburettor icing was likely at any power setting. If the aircraft's engine was being run on MOGAS, the probability of carburettor icing would have been greater. However, different engines and installations have different susceptibilities, and it was not possible to evaluate the likelihood of icing occurring in this case.

If the engine failed, an instinctive rearwards motion of the control column (which would be appropriate on a flexwing control bar in the same circumstances) might have been the pilot's natural reaction. In the Minimax, this would have caused an increase in angle of attack towards the stall, rather than the desirable entry into gliding flight.

Whether following an engine malfunction or not, a simple handling error may therefore have caused the spin.

Pilot qualification

The pilot was not the pilot named on the permit to test and therefore it was not appropriate for him to have conducted this flight. The accident pilot's experience was almost exclusively on flexwing aircraft and it was not clear if he was qualified to fly a three-axis aircraft. Differences training was required for those pilots whose :

> *'previous training and experience has only been in an aeroplane with flexwing/weightshift controls.'*

However, because 'training and experience' was not quantified, he could have developed the view that he did not need to undertake training because his flying lesson in a three-axis aeroplane satisfied the requirement.

Safety Recommendation 2005-128 was issued by the AAIB to address pilot training on different control systems, and contained the words:

> *'undertake adequate conversion training and pass a Flight Test conducted by an appropriately qualified microlight pilot examiner'*

to ensure that not only was there a requirement for training, but also a requirement that the pilot should demonstrate competence, before being qualified to fly. The CAA accepted this Safety Recommendation but the flight test requirement was not implemented. Also, '*appropriate differences training*' referred to in CAP 393 was not defined. Accordingly, the following Safety Recommendation is made:

Safety Recommendation 2013-003

It is recommended that the Civil Aviation Authority should, in consultation with the British Microlight Aircraft Association, amend the relevant legislation to introduce distinct pilot qualifications for microlight aircraft of each control system, and to require pilots to undertake flight training and pass a flight test in order to gain those qualifications.

Engineering

The investigation indicated that the aircraft had been constructed in accordance with the LAA procedure and had been issued with a PFRC that allowed it to be flown by a designated test pilot. The test pilot, had he flown it first, may have been better equipped to deal with and subsequently advise upon any adverse characteristics of the aircraft.

The aircraft was observed to be descending to the ground in a spin, with the evidence at the accident site indicating that the direction of the spin was to the left. The appropriate corrective recovery action requires the application of right rudder. The left rudder pedal was found to be broken, possibly as a result of reacting pressure from the pilot's foot during the impact, but because the violence of the impact resulted in extensive disruption to the cockpit it was not possible to exclude another cause of this damage.

The investigation did not establish why the aircraft entered a spin after flying apparently normally earlier in its short flight. It is possible that the pilot may have started exploring flight with different flap settings. Had he done so, lowering the full-span flaperons would result in increased adverse yaw, in response to aileron application. The necessary use of rudder to counteract this would not have been intuitive to the pilot, again due to his flexwing background.

Some witnesses described an unusual engine sound. The aircraft was fitted with a two-cylinder, four-stroke engine of a comparatively rare type, the sound of which in flight may have been unfamiliar. There was some evidence of engine power being delivered at impact, although it could not be quantified. Whilst a partial power loss, due, for example, to carburettor icing, could not be discounted, an engine failure would not necessarily cause an aircraft in apparently level flight to enter a spin.

Finally, a disconnected balance spring was found on the left rudder pedal. Whilst it is possible this was an impact feature, it is also possible that the owner omitted to reconnect the spring following the pedal hinge replacement. The cramped area of the cockpit may have made the task difficult to accomplish as the springs would have been obscured by the pedals when viewed from above. The effect of a disconnected left pedal spring would have been to produce a right rudder bias. However, the tension in the circuit (produced by the force of the remaining spring) would have been so small as to be insignificant when the pilot's feet were on the pedals. Consequently, had the condition existed prior to the flight, it is unlikely to have had any bearing on the accident.

Conclusion

The investigation did not reveal any pre-existing mechanical defects that would have affected the flight. The accident pilot's ability to control the aircraft may have been influenced by his lack of training or experience in three-axis aircraft and by his greater familiarity with flexwing aircraft. The aircraft was only permitted to fly in the hands of a designated test pilot who, had he been given this opportunity, may have been able to identify any unacceptable characteristics.

AAIB correspondence reports

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

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

The accuracy of the information provided cannot be assured.

ACCIDENT

Aircraft Type and Registration:	Cessna 172RG, G-BILU
No & Type of Engines:	1 Lycoming O-360-F1A6 piston engine
Year of Manufacture:	1980 (Serial no: 172RG-0564)
Date & Time (UTC):	16 December 2012 at 1815 hrs
Location:	Stapleford Aerodrome, Essex
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to landing gear doors, propeller and engine
Commander's Licence:	Private Pilot's Licence
Commander's Age:	51 years
Commander's Flying Experience:	3,665 hours (of which 1,500 were on type) Last 90 days - 28 hours Last 28 days - 12 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and additional inquiries by the AAIB

Synopsis

The pilot was unable to extend the nose landing gear, despite several attempts. A successful forced landing on the grass at Stapleford was carried out. It was thought that wear in the nose gear door mechanism had caused the nose gear to jam.

History of the flight

The aircraft arrived at Stapleford after a flight from Cardiff and joined the circuit to land on Runway 22. When the pilot selected the landing gear down, he felt the main gears lock into place, but the gear indicator light first failed to illuminate and then lit red. A visual check suggested that the main gears were down and locked, but he could not see the nose gear. Recycling the gear did not rectify the situation and he was unable to obtain a green indication.

The pilot radioed the control tower to tell them he was going around for another circuit, during which time he tried recycling the gear several times, but to no avail. He then asked the tower for a visual inspection and was told that the nose landing gear had not extended. After several more recycling and manual hydraulic pump attempts, a further visual inspection from the tower confirmed that the nose gear had still not moved and so the pilot carried out a landing on the mainwheels only on the grass to the left of Runway 22.

Upon recovery, it was found that the nose gear would not extend because it was jammed by the gear doors. Subsequent testing of the retraction system showed no anomalies, but it was noted that a number of bushes and linkages associated with the gear doors were worn and it is thought that a cumulative effect of the wear had caused the jamming condition.

ACCIDENT

Aircraft Type and Registration:	DH82A Tiger Moth, G-AMTF
No & Type of Engines:	1 De Havilland Gipsy Major 1C piston engine
Year of Manufacture:	1941 (Serial no: 84207)
Date & Time (UTC):	30 November 2012 at 1015 hrs
Location:	Near Hollingbourne, Kent
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to lower wing leading edges, spars, upper wing fabric and engine
Commander's Licence:	Private Pilot's Licence
Commander's Age:	56 years
Commander's Flying Experience:	409 hours (of which 258 were on type) Last 90 days - 12 hours Last 28 days - 2 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft was en route to Spanhoe Airfield when the engine suffered a power loss, loss of oil pressure and emitted smoke. The aircraft was slightly damaged as a result of the ensuing forced landing. The cause of the engine failure had not been determined at the time of preparation of this Bulletin.

History of the flight

The aircraft was on a flight from Lashenden (Headcorn) to Spanhoe near Corby and was en route when the engine started to run roughly. The pilot throttled back and checked each magneto but to no avail. Shortly afterwards, a large amount of smoke appeared on the left side of the cowling and oil ran down the side of the fuselage. He noticed that the oil pressure had dropped to zero or close to zero and realised that a forced landing was now inevitable.

The pilot selected a field, although his choice was limited by power and telephone lines, as well as crops and trees. The aircraft touched down in the field and rolled into a hedge and fence at the end at an estimated speed of 5-10 mph. The pilot was unhurt and telephoned Headcorn to advise them, having previously broadcast a MAYDAY call to them.

At the time of preparation of this Bulletin, the cause of the engine power loss is unknown, although it is understood that the No 3 cylinder showed no compression and that a quantity of oil remained in the oil tank.

ACCIDENT

Aircraft Type and Registration:	Hiller UH-12 B, N38763
No & Type of Engines:	1 Franklin 6V4-200-C33 piston engine
Year of Manufacture:	1953 (Serial no: 497)
Date & Time (UTC):	4 August 2012 at 1330 hrs
Location:	Elstree Aerodrome, Hertfordshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to tail rotor, tail rotor gearbox and tail boom
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	70 years
Commander's Flying Experience:	2,400 hours (of which 57 were on type) Last 90 days - 10 hours Last 28 days - 5 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The pilot carried out hovering practice on the airfield for about 15 minutes before translating away for a visual circuit. Weather conditions were fine, with a surface wind from the south-west at 15 kt and an air temperature of 15°C. Whilst downwind, the pilot noticed a high engine oil temperature and low pressure, which had both been normal during the earlier hovering. He turned towards the grass area to the north of the runway for an immediate landing. As the helicopter lost translational lift, the pilot noticed that main rotor rpm was reducing so he applied power to correct. However, as the rotor rpm did not recover, the pilot lowered the collective control. The helicopter descended in a slight tail-low attitude and the tail struck the ground, causing damage to the airframe and tail rotor assembly. The pilot's assessment was that the helicopter had lost power, compounded by the fact that the carburettor heat control had not been returned to the 'cold' position before the approach and landing.

ACCIDENT

Aircraft Type and Registration:	Pioneer 400, G-TLOY
No & Type of Engines:	1 Rotax 914F piston engine
Year of Manufacture:	2012 (Serial no: LAA 364-15112)
Date & Time (UTC):	26 August 2012 at 1534 hrs
Location:	Ledbury Airstrip, Herefordshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Propeller, underside of aircraft and landing gear jackscrews
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	56 years
Commander's Flying Experience:	6,500 hours (of which 40 were on type) Last 90 days - 28 hours Last 28 days - 19 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and subsequent AAIB enquiries

Synopsis

During a test flight for the initial issue of a Permit to Fly, the pilot reported a loss of pitch control authority during a go-around from low speed. On the subsequent approach the pilot delayed lowering the landing gear to ensure he could land on the airstrip, but it was not fully extended by the time the aircraft touched down and the gear collapsed during the landing roll. Prior to the flight 50% of the length of the elevator trim tab Gurney flap had been removed to correct a perceived problem of limited forward elevator authority during cruise, and post-accident inspection revealed that the elevator cables had low tension. After repair the aircraft was test flown by the LAA's Chief Test Pilot, who considered the design was acceptable without further change.

History of the flight

The pilot was undertaking the fifth in a series of test flights for the aircraft's initial issue of a Permit to Fly. He was accompanied by the owner, who assisted with the test schedule and recording of the results.

On this flight he descended the aircraft from 2,000 ft at 120 kt towards Ledbury Airstrip, before levelling and closing the throttle to decelerate and trim for the best glide speed in the clean configuration. Full aft (nose-up) elevator trim was used and the aircraft's speed settled at approximately 70 kt. At around 600 ft agl, full power was applied to go around. Initially, the aircraft responded normally, with moderate forward pressure required on the control stick to hold the nose down. The pilot reported that he felt something "give" in the elevator controls and the aircraft pitched nose-up sharply and the speed decayed, despite a full forward control stick input. The pilot reduced engine power, which controlled the nose-up pitch and allowed the speed to be maintained. As there was now insufficient runway ahead on which to land, the pilot flew a wide low-speed circuit at reduced power. The elevator trim position was adjusted, but this seemed to make the situation worse, so it was returned to the previous position.

In order to assure a landing on the airstrip, the pilot delayed lowering the gear until late in the approach. The aircraft touched down on the runway and during the landing roll the gear collapsed, causing the propeller to strike the ground. When the aircraft had come to rest, both occupants were able to vacate normally; neither were injured.

Aircraft description

The aircraft is a four-seat design featuring a wooden primary structure (Figure 1). The design was approved by the LAA and two other examples are on the UK register. Power is provided by a Rotax 914F piston engine and the landing gear is retractable via an electric motor driving three screwjacks, one for each landing gear leg. Pitch control is provided by a fixed tailplane with an elevator connected to the control stick by cables. Pitch trim is provided by an electrically-driven trim tab on the left elevator, operated by a rocker switch in the cockpit. A fixed Gurney flap[1] is installed on the lower trailing edge of the trim tab to provide the optimum trim range throughout the wide speed and loading range of this aircraft type.

Figure 1
General view of a similar aircraft

Footnote

[1] A Gurney flap is a small, flat strip fitted to the trailing edge of an aerofoil, typically set at right angles to the airflow.

Background information

The aircraft is an amateur-built design. This particular aircraft was constructed from a kit under the supervision of the LAA. As the build progressed, a number of stage inspections were completed by a suitably qualified LAA Inspector to ensure the aircraft had been built to the required standard. Once complete, a final inspection was carried out to ensure the aircraft was in an airworthy condition before it was cleared for test flying to gain a Permit to Fly. The final inspection and the first flight were completed by a representative of the UK distributor who is experienced on type. No significant discrepancies were found with either the aircraft's construction or its handling.

The pilot reported an apparent limited forward elevator authority during cruise on a previous flight. In an attempt to improve this condition 50% of the length of the fixed Gurney flap was removed from the lower trailing edge of the elevator trim tab prior to the incident flight.

Post-accident inspections

The LAA commissioned an independent inspection of the aircraft and this was undertaken after the aircraft had been dismantled and taken to the UK distributor's premises. The inspection confirmed that the landing gear had failed because it was not fully extended at the time the aircraft landed. Other damage was as a result of the landing gear collapse. The inspection found all the flying control systems operated normally, although there was a slight stiff spot noted on the elevator, which suggested to the Inspector that the hinges were slightly misaligned. The elevator cables, that had been disconnected to allow dismantling, were reconnected and were observed to have low tension. The elevator cables pass through the wing spars and may therefore have been damaged during dismantling, as they had not been disconnected before an initial attempt to remove the wings was made.

The aircraft was returned to the manufacturer for repair and their inspection found no pre-existing defects with the aircraft or its controls.

Post-event flight testing

The LAA commissioned its Chief Test Pilot to conduct a flight test programme to explore the extent and nature of the handling characteristics reported by the pilot. The Gurney flap had been restored to its standard configuration for the flight. The aircraft was loaded so that the centre of gravity was at the aft limit; the worst case scenario. The report concluded:

'The aircraft's forward stick movement was found to be sufficient to allow an idle, full aft trim go-around to be performed safely, even at a speed as low as 1.1 times the stall speed and at full aft Centre of Gravity... ...there was an additional 1.5 inches of stick movement (14.3% of elevator movement) left above and beyond that needed to control the aircraft and speed during the low-speed go-around. Therefore, the current aircraft design was considered acceptable without further change.'

Discussion

The final inspection before first flight did not identify any anomalies with the aircraft and previous flights by the accident pilot and another familiar with the type were without incident. Prior to this flight 50% of the length of the fixed Gurney flap had been removed after the pilot had noted an apparent limited forward elevator authority during cruise. The post-accident inspection by an independent inspector found the tension of the elevator cables was low, but because it is possible that they were damaged during a post-accident attempt at disassembly, their tension at the time of the accident is not certain, although no anomalies had been noted on the previous flights. The reduction of the size of the Gurney flap and possible low tension in the elevator control cables both have the potential to alter the feel and range of the pitch control system. A temporary control restriction in the cockpit also could not be discounted.

Subsequent test flying of the aircraft after repair and with the Gurney flap returned to its standard configuration showed that the aircraft performed as expected and the LAA consider the design is acceptable without change.

ACCIDENT

Aircraft Type and Registration:	Piper PA-22-135 Tri-Pacer, G-APYI
No & Type of Engines:	1 Lycoming O-290-D2 piston engine
Year of Manufacture:	1954 (Serial no: 22-2218)
Date & Time (UTC):	26 October 2012 at 1100 hrs
Location:	Sarngwm Farm Strip, Bethesda, Pembrokeshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to propeller, landing gear, rear fuselage, left elevator and left wing spar
Commander's Licence:	Private Pilot's Licence
Commander's Age:	48 years
Commander's Flying Experience:	160 hours (of which 68 were on type) Last 90 days - 17 hours Last 28 days - 3 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

G-APYI is a Piper Tri-pacer aircraft (built with a tricycle landing gear) converted to a tailwheel configuration.

The pilot was taking off from his grass airstrip, the runway of which is 475 m long, oriented 24/06 and is bordered at each end by hedges. The runway also cuts through two hedges at about its midpoint. The wind was from the north-west at 10 kt and the aircraft was taking off on Runway 24, which has a downward slope. The pilot stated that, after about 150 m of ground roll, the aircraft encountered a soft patch of grass and the combination of this with the crosswind caused him to lose directional control and the aircraft slid into a hedge to the left of the runway.

ACCIDENT

Aircraft Type and Registration:	Rotorsport UK Calidus, G-CGJD
No & Type of Engines:	1 Rotax 914-UL piston engine
Year of Manufacture:	2010 (Serial no: RSUK/CALS/004)
Date & Time (UTC):	23 January 2013 at 1510 hrs
Location:	Kirkbride Airfield, Cumbria
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to rotor, propeller, canopy and tail surfaces
Commander's Licence:	Private Pilot's Licence
Commander's Age:	42 years
Commander's Flying Experience:	151 hours (of which 66 were on type) Last 90 days - 0 hours Last 28 days - 0 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The pilot was landing the gyroplane on Runway 10 at Kirkbride Airfield, in fine weather and light wind conditions. He executed the flare slightly early, causing the gyroplane to enter an extended float just above the runway. It then dropped to the surface, bounced and rolled over to the right. Although the gyroplane was damaged, the pilot suffered only light bruising.

Miscellaneous

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

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

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

1/2010 Boeing 777-236ER, G-YMMM
at London Heathrow Airport
on 17 January 2008.

Published February 2010.

2/2010 Beech 200C Super King Air, VQ-TIU
at 1 nm south-east of North Caicos Airport, Turks and Caicos Islands, British West Indies
on 6 February 2007.

Published May 2010.

3/2010 Cessna Citation 500, VP-BGE
2 nm NNE of Biggin Hill Airport
on 30 March 2008.

Published May 2010.

4/2010 Boeing 777-236, G-VIIR
at Robert L Bradshaw Int Airport
St Kitts, West Indies
on 26 September 2009.

Published September 2010.

5/2010 Grob G115E (Tutor), G-BYXR
and Standard Cirrus Glider, G-CKHT
Drayton, Oxfordshire
on 14 June 2009.

Published September 2010.

6/2010 Grob G115E Tutor, G-BYUT
and Grob G115E Tutor, G-BYVN
near Porthcawl, South Wales
on 11 February 2009.

Published November 2010.

7/2010 Aerospatiale (Eurocopter) AS 332L
Super Puma, G-PUMI
at Aberdeen Airport, Scotland
on 13 October 2006.

Published November 2010.

8/2010 Cessna 402C, G-EYES and
Rand KR-2, G-BOLZ
near Coventry Airport
on 17 August 2008.

Published December 2010.

1/2011 Eurocopter EC225 LP Super Puma, G-REDU
near the Eastern Trough Area Project Central Production Facility Platform in the North Sea
on 18 February 2009.

Published September 2011.

2/2011 Aerospatiale (Eurocopter) AS332 L2
Super Puma, G-REDL
11 nm NE of Peterhead, Scotland
on 1 April 2009.

Published November 2011.

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

http://www.aaib.gov.uk