AAIB
Air Accidents Investigation Branch

AAIB Bulletin 6/2017

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(ALL TIMES IN THIS BULLETIN ARE UTC)

AAIB Field Investigation Reports

A Field Investigation is an independent investigation in which AAIB investigators collect, record and analyse evidence.

The process may include, attending the scene of the accident or serious incident; interviewing witnesses; reviewing documents, procedures and practices; examining aircraft wreckage or components; and analysing recorded data.

The investigation, which can take a number of months to complete, will conclude with a published report.

SERIOUS INCIDENT

Aircraft Type and Registration:	Airbus A319-131, G-EUPM
No & Type of Engines:	2 International Aero Engine V2522-A5 turbofan engines
Year of Manufacture:	2000 (Serial no: 1258)
Date & Time (UTC):	19 October 2016 at 0759 hrs
Location:	Manchester Airport
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 7 Passengers - 117
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to nose landing gear barrel, axle, torque links, steering actuator cylinder and wiring harnesses
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	46 years
Commander's Flying Experience:	11,900 hours (of which 10,700 were on type) Last 90 days - 169 hours Last 28 days - 62 hours
Information Source:	AAIB Field Investigation

Synopsis

The aircraft experienced nosewheel shimmy following a normal landing at Manchester Airport. As the aircraft entered a rapid exit taxiway at a groundspeed of 30 kt, the nose landing gear upper and lower torque links became disconnected and the aircraft did not respond to further steering inputs. The co-pilot brought the aircraft to a halt on the taxiway. The available evidence shows that the probable cause of the torque link disconnection was damage sustained to the torque link apex pin nut locking components due to contact with a towbarless tractor. A Service Bulletin is available to replace the torque link apex pin assembly with a new design, one feature of which reduces the risk of contact damage with towbarless tractors.

History of the flight

The crew first flew G-EUPM from Newcastle International Airport to London Heathrow Airport on the day of the incident; the commander was PF for this sector. The sector was uneventful apart from "a slight nosewheel shimmy" on the landing roll, which subsided as the aircraft slowed to a taxiing speed.

The co-pilot was PF for the next sector from Heathrow to Manchester Airport. During the turnaround the co-pilot did an external inspection of the aircraft and did not notice anything untoward. The subsequent pushback, start up and taxi to Runway 27L were without incident. However, during the takeoff run, between approximately 60 KIAS and 100 KIAS (45 kt and 85 kt groundspeed), a loud rhythmic sound was recorded on the CVR. This was commented upon by the crew at the time, who referred to it as having been caused by nosewheel "SHIMMY". The crew then discussed the previous takeoff and landing, commenting that the takeoff from Newcastle had been uneventful, but they had experienced a similar vibration during the landing roll at Heathrow.

As the flight progressed, the crew further discussed the nosewheel shimmy and the possibility that it may be associated with a problem with either the nosewheels or nose gear torque link. The co-pilot commented that it was difficult to visually inspect the torque link attachments due to them being covered "IN A TYPE OF SEALANT". The commander advised that he would carry out the walk around at Manchester to see if he could identify the cause of the problem and make an entry in the aircraft's technical log accordingly.

The approach and touchdown on Runway 23R at Manchester were uneventful, with autobrake LOW selected. The surface wind was 300° at 6 kt and V_{REF} was calculated as 126 kt. On the landing roll, as the airspeed reduced to 100 KIAS, manual braking was applied. Between 70 kt and 40 kt groundspeed, vibration associated with nosewheel shimmy was recorded on the CVR, with both crew commenting on its severity. At a groundspeed of 35 kt, the co-pilot turned the aircraft onto Exit Bravo Delta (BD), whilst gradually applying the toe brakes.

Shortly after entering Exit BD, at a groundspeed of 30 kt, a significant vibration was recorded in the cockpit, accompanied by high alternating lateral accelerations. After about six seconds, the intensity of the vibration noticeably increased. At the same time, a Landing Gear Control Interface Unit (LGCIU) 1 fault indicated on the aircraft's electronic centralised aircraft monitor (ECAM). The co-pilot continued to apply the brakes, whilst also applying right tiller to try and maintain the taxiway centreline as the aircraft's heading started to deviate to the left, before bringing the aircraft to a stop. As he did so, he alerted the commander that he had lost directional control and the commander declared a PAN, advising ATC that the nose gear had failed and that they required assistance.

The co-pilot then made a passenger announcement (PA) before briefing the cabin crew. The RFFS arrived at the aircraft shortly thereafter and the APU was started before both engines were shut down to enable the RFFS to make a closer inspection. They spent 5 to 10 mins inspecting the aircraft and subsequently reported that the nosewheel was at 90° to the aircraft's heading and there was some debris behind the aircraft on Exit BD.

The passengers and crew subsequently disembarked using stairs and were transported to the airport terminal in buses.

Site examination

The aircraft stopped on Exit BD, 200 m from Runway 23R, with the nose slightly displaced to the left of the taxiway centreline (Figure 1). The upper and lower torque links of the nose landing gear (NLG) had separated and the nosewheels had rotated approximately 95° to the left, causing the aircraft to become immobilised. Tyre marks left on the taxiway surface showed that the nosewheels had rotated to the left following the release of the torque link apex pin.

Debris shed from the nose landing gear was distributed on a 70 m path behind the aircraft. The debris included components from the torque link apex pin assembly, along with other parts of the nose landing gear that had been released due to contact with the upper torque link, which had been forced upwards by contact with the left nosewheel. The apex pin and nut were identified amongst the recovered debris (Figure 2). Despite a search of Exit BD and Runway 23R, no parts from the apex pin lock bolt assembly were found.

Figure 1

G-EUPM position on Exit BD, prior to recovery

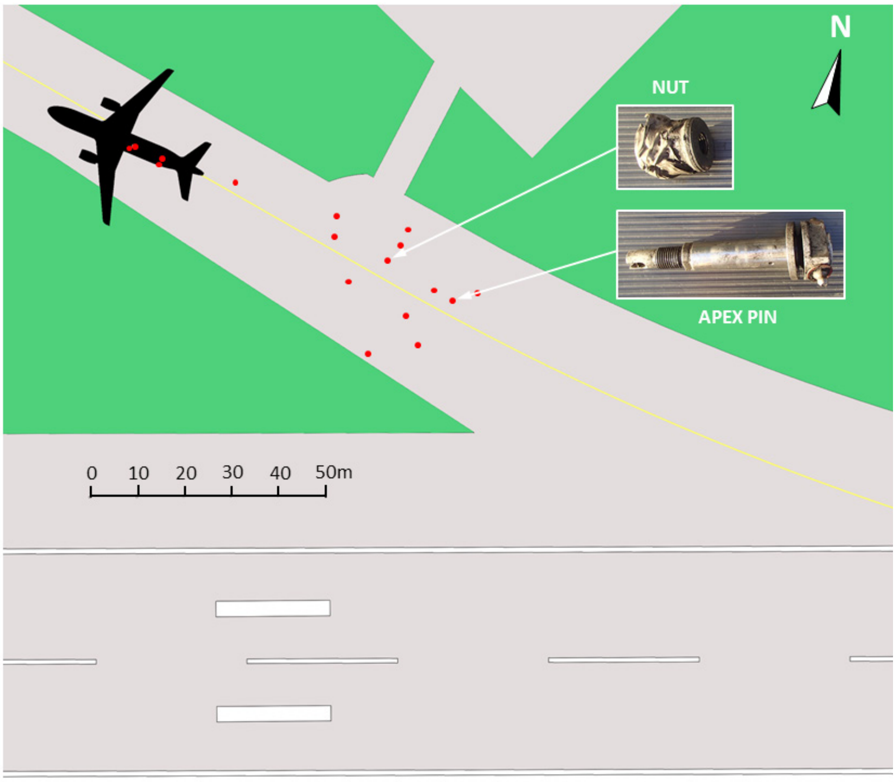

Figure 2

G-EUPM debris locations on Exit BD – red dots indicate recovered debris, including the apex pin and nut

Recorded information

Sources of recorded information

A complete record of the incident flight was available from the aircraft's CVR, FDR and Quick Access Recorder (QAR). The 120 minute CVR record commenced as the aircraft was being prepared for the flight from Heathrow to Manchester and ended 45 minutes[1] after the aircraft had come to a stop on exit Bravo Delta. The FDR contained a total of 14 flights, with the recording ending at the same time as the CVR.

Salient information from the CVR and FDR has been included in the history of flight. Figure 3 shows pertinent parameters recorded during the landing at Manchester Airport.

CVR and FDR automatic start/stop

The Airbus A319/A320/A321 family of aircraft, which includes G-EUPM, are fitted with a system that automatically starts and stops the CVR and FDR.

The start/stop logic uses a signal from LGCIU 1 to indicate if the aircraft is in the 'air' or on the 'ground'. The status of this signal is derived from a number of sensors, including

Footnote

[1] Due to the failure of LGCIU 1, the FDR and CVR were not automatically stopped five minutes after the engines had been shut down.

the left weight-on-wheels (WOW) proximity sensor fitted to the nose landing gear. When the LGCIU 1 signal is set to 'ground', both recorders will stop five minutes after the last engine has been shut down. This is intended to ensure that the most recent recordings are preserved.

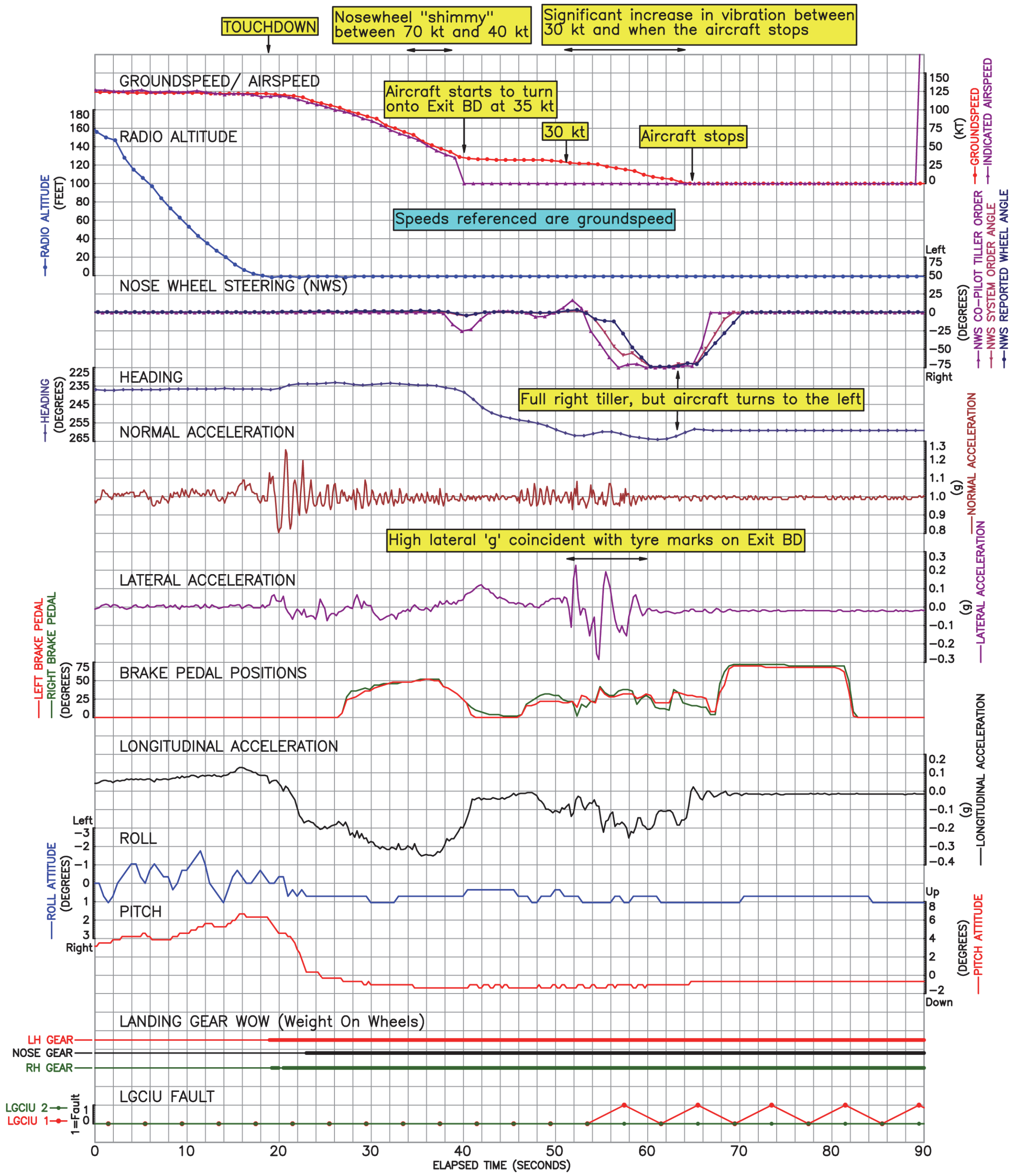

Figure 3

Landing at Manchester Airport

The nose gear is also equipped with a right WOW proximity sensor that provides a signal to LGCIU 2. This signal was recorded on the FDR and indicated that the nose gear shock absorber was compressed.

The aircraft manufacturer reviewed the FDR data from G-EUPM and confirmed that the LGCIU 1 fault was triggered due to damage to the left WOW proximity sensor. This resulted in the LGCIU 1 signal to the flight recording system being set to the 'air' condition and so both recorders continued to operate after the engines were shut down.

CVR and FDR preservation

The aircraft's engines were shut down just over six minutes after the aircraft had come to a stop, however the CVR and FDR continued to operate due to the LGCIU 1 fault. Thirty five minutes later, the RFFS upgraded the 'incident' status to an 'accident'. The operator's maintenance control department (MAINTROL) then requested that the crew preserve the CVR and FDR records by opening the circuit breakers in the cockpit. The continued operation during this period on the ground resulted in the CVR record of the previous landing at Heathrow being overwritten.

Commission Regulation (EU) 965/2012 part CAT.GEN.MPA.105 states that it is the responsibility of the aircraft commander to preserve the CVR and FDR records following *'an accident or an incident that is subject to mandatory reporting'*. The operator's CVR and FDR preservation procedure stated that it should only be invoked when it was '*the considered opinion'* of the Operational Duty Engineering Manager at MAINTROL and the Duty Air Safety Manager that the incident is *'of sufficient gravity and circumstances to deem it necessary*'. This procedure did not provide guidance as to the circumstances when the recorders should be preserved and no guidance was provided to commanders concerning their responsibility.

The AAIB, and other safety investigation authorities, continue to experience CVRs that have been overwritten due to delays in preserving their records. Considering the relatively short recording duration of the CVR, it is often the aircraft commander, rather than the operator's engineering or safety department that is best placed to ensure the timely preservation of recordings. The AAIB is aware that other operators have addressed this by providing guidance information directly to crews. This has included examples as to when the CVR and FDR should be considered for preservation and require an entry is made in the aircraft's technical log, such that an aircraft shall not be dispatched with the recorders inadvertently disabled.

Safety action taken

Following this event, the operator of G-EUPM made changes to its procedures to ensure that the commander is aware of his responsibility to ensure that the recordings are preserved.

Aircraft information

The Airbus A319 nose landing gear is a retractable two-wheel unit equipped with an oleo-pneumatic shock strut and a nosewheel steering system. Two LGCIUs control the extension and retraction of the landing gear and the operation of the landing gear doors. The LGCIUs also supply information about the landing gear to the ECAM for display, and send signals indicating whether the aircraft is in flight or on the ground to other aircraft systems.

Nosewheel steering is performed by a hydraulic actuating cylinder attached to the landing gear barrel. The hydraulic actuator rotates the upper torque link, which transmits torque through the lower torque link to rotate the nose wheels. The upper and lower torque links are attached by an apex pin (Figure 4), providing articulation of the torque links to accommodate vertical displacement of the oleo strut.

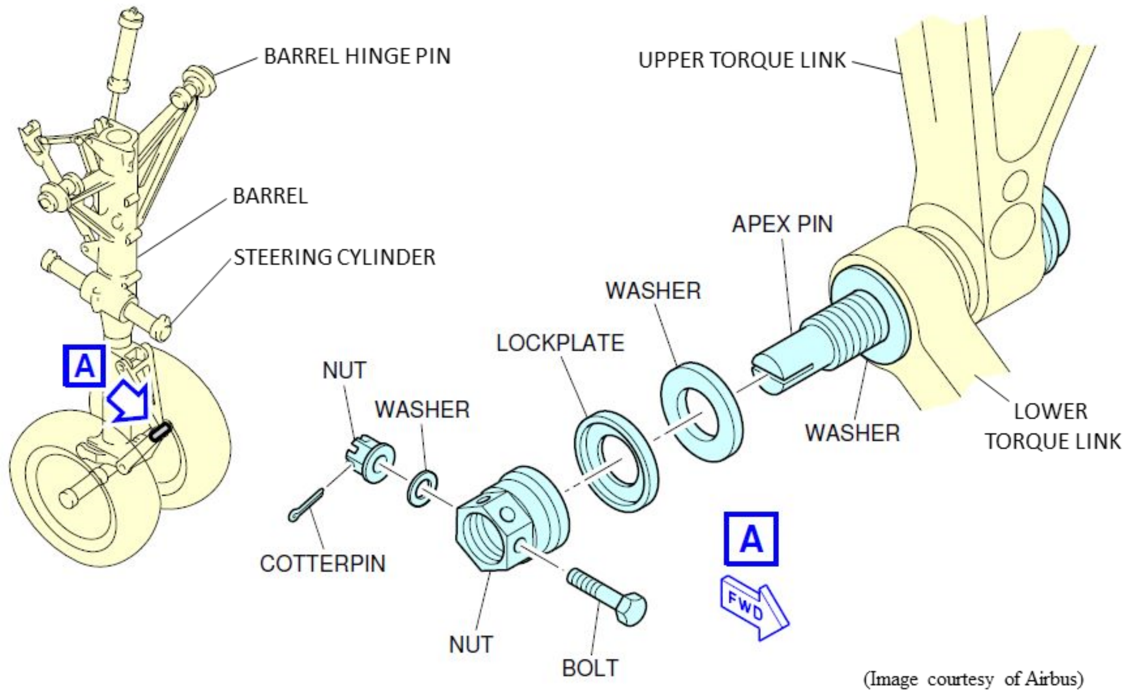

Figure 4

Nose landing gear torque link apex pin assembly

The apex pin is a ¾ inch diameter steel pin, secured in position by a nut. The end of the apex pin has a slot, and the apex pin nut has a hole through each face to permit the insertion of a inch diameter lock bolt, to prevent the apex pin nut from rotating once installed. The inch lock bolt is itself secured in position with a castellated nut and cotterpin. Once installed, the head of the lock bolt and the castellated nut and cotter pin are required by the Aircraft Maintenance Manual (AMM) to be encapsulated in sealant.

Maintenance history

The aircraft underwent a 1C[2] scheduled maintenance inspection in February 2016, during which the NLG torque link apex pin was disassembled as part of a routine check for excessive play. The NLG torque links were reassembled on 23 February 2016, which was the last recorded disturbance to these components. The apex pin reassembly was carried out at the operator's base maintenance facility by a maintenance mechanic and checked by a supervising technician. When interviewed, the mechanic stated that he recalled conducting the apex pin reassembly and that the task had been carried out in accordance with the AMM instructions, including the installation of the locking bolt assembly and securing cotter pin. The mechanic also applied sealant to the locking bolt, castellated nut and cotter pin. The supervising technician could not recall the apex pin installation task on G-EUPM in any detail, due to the passage of time, although he did state that he did not remember anything unusual about the task. He also stated that it was his usual practice to check for the presence of the securing cotter pin before allowing a mechanic to apply sealant on the apex pin nut.

The aircraft's technical records were reviewed to ascertain whether the NLG torque links were disturbed following the 1C check. The only relevant recorded maintenance event occurred on 10 July 2016, relating to a nosewheel steering (NWS) fault whilst the aircraft was at Linate Airport, Italy. The aircraft's technical log recorded that this fault had been rectified by replacement of one of the NLG's two steering angle sensors, using procedures contained in the AMM. The two maintenance technicians who carried out this maintenance task were interviewed by the ANSV[3] and both stated that they had not disturbed the NLG torque link apex pin during the task. They also stated that such a disturbance was not required by the AMM procedures they had followed in isolating the NWS sensor fault, and replacing the NWS sensor.

The aircraft had completed 1,323 flight cycles between the 1C check in February 2016 and the NLG event at Manchester Airport on 19 October 2016.

Maintenance procedures

The AMM requires that the locking bolt passing through the apex pin nut is assembled with a washer and a castellated nut, and that the castellated nut is secured by the insertion of a steel cotter pin. The AMM permits two methods of cotter pin installation for this assembly (Figure 5); a *'First Procedure'* in which the cotter pin is installed perpendicular to the bolt axis, and the projecting prongs of the cotter pin are bent around the sides of the castellated nut and, optionally, are bent inwards into the castellated nut slots. Alternatively a *'Second Procedure'* may be used, where the cotter pin is installed parallel with the bolt axis and the projecting upper prong of the cotter pin is bent tightly against the shank of the bolt, and the lower prong is bent tightly against the base of the nut.

Footnote

[2] A 1C check is a scheduled maintenance inspection carried out at 18 month intervals.
[3] The Agenzia Nazionale per la Sicurezza del Volo (ANSV) is the Italian aircraft accident investigation authority.

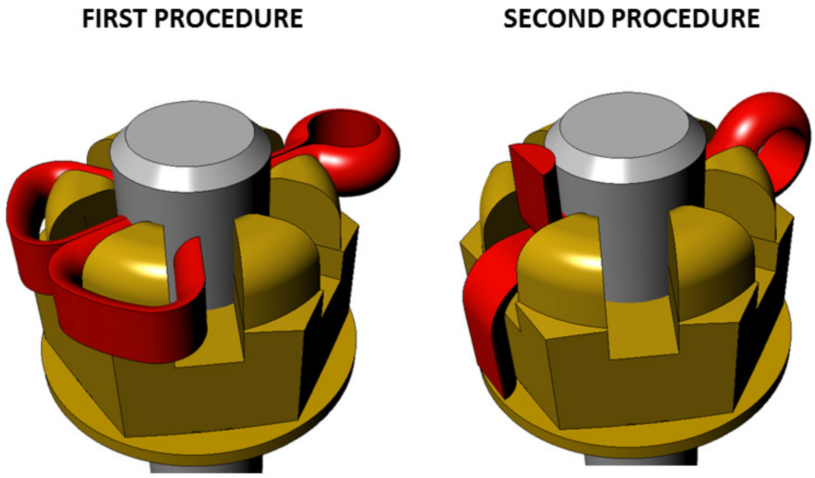

Figure 5

Approved methods of cotter pin installation for apex nut lock bolt

Aircraft examination

The NLG had rotated to approximately 95° to the left and the upper torque link had contacted the left nosewheel tyre, forcing the torque link upwards. The upward movement of the upper torque link caused it to fracture the NLG WOW detector enclosure and displaced the NLG WOW proximity detector target and sensor assemblies. The left WOW proximity detector had detached from its wiring harness due to its connector having pulled out of the proximity detector body. The subsequent open circuit condition of the left WOW proximity detector wiring harness was sensed by LGCIU 1, triggering the LGCIU 1 fault condition.

Figure 6

Displaced nose landing gear following release of the torque link apex pin

The left nosewheel tyre sustained abrasion damage to the inner sidewall but remained inflated, despite being heavily loaded due to the forward rake angle of the NLG (Figure 6). When the NLG was disassembled it was found that the nosewheel axle was bent, the barrel hinge pins were deformed and the rear steering cylinder had sustained an impact depression. The bottom edge of the NLG barrel sustained circumferential gouging damage[4] due to contact with the displaced NLG WOW proximity detector enclosure. The TPIS[5] wiring harness was severed at its attachment point on the upper torque link.

Footnote

4 Following a detailed examination of the NLG barrel, the manufacturer considered the damage to be repairable, preventing the need to scrap the item.

5 Tyre Pressure Indication System, deactivated on G-EUPM.

The apex pin, nut and associated washers and lockplate were recovered from Exit BD. The apex pin and nut were in good condition and did not exhibit any evidence of abnormal loading. The threads on the apex pin and nut were undamaged and when assembled, the nut freely screwed onto the pin without binding. The apex pin nut was covered in light grey cured sealant (Figure 7).

Witness marks in the sealant showed that the 3/16 inch diameter locking bolt, washer, castellated nut and cotter pin had been present when the sealant was applied, although these components were absent at the site. The sealant witness marks were examined by microscope at the AAIB (Figure 7).

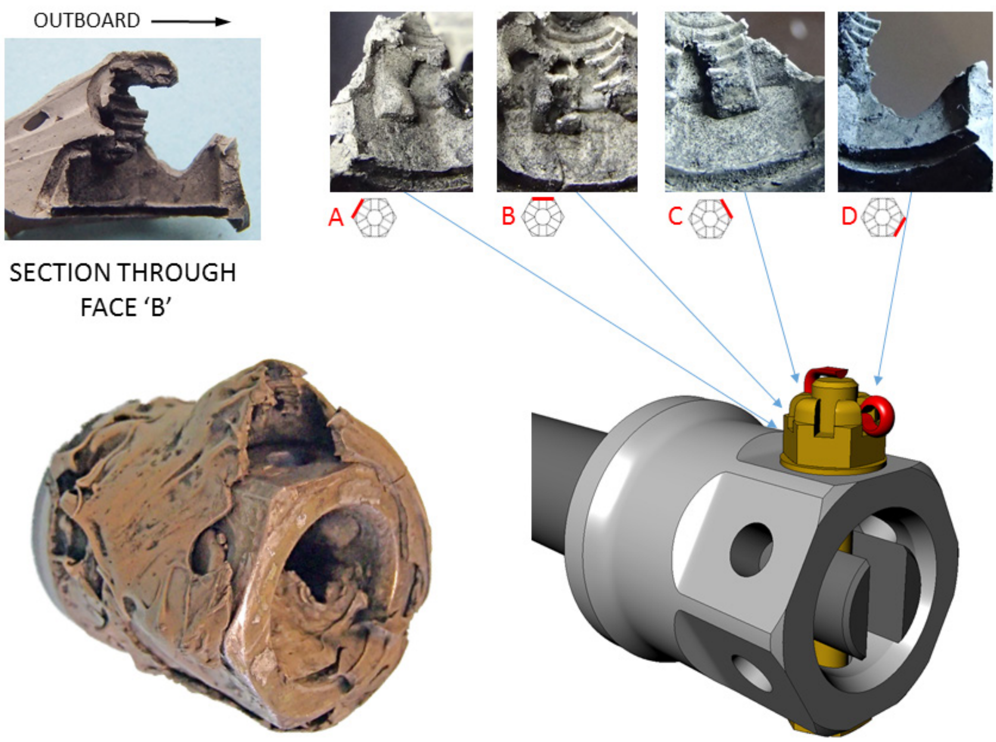

Figure 7
Apex pin nut sealant witness marks

The sealant witness marks showed that the locking bolt had been assembled with a cotter pin prior to the application of the sealant, with the cotter pin oriented parallel to the locking bolt as per the AMM *'Second Procedure'*. The head of the cotter pin had been pointing outboard as shown in the diagram in Figure 7. There was an area of missing sealant in the vicinity of the outboard edge of the castellated nut. The edges of this area of missing sealant were of a torn appearance, consistent with this area having detached from the main mass of sealant at some point after the sealant had been applied and cured.

Previous occurrences

Previous cases of A320-series[6] NLG torque link separation have occurred in which the apex pin nut has detached due to overload rupture of the apex pin, following contact with a towbarless (TBL) tractor paddle. During towing and pushback operations, the left TBL tractor paddle is in close proximity to the apex pin nut and any significant lateral misalignment of the tractor to the aircraft can cause the left paddle to contact the apex pin nut. The contact can occur either when the tractor paddles rotate upwards to retain the nosewheels, or when the tractor rotates the nosewheels to steer the aircraft which imposes a side-load on the nosewheel tyres, causing tyre sidewall lateral deflection.

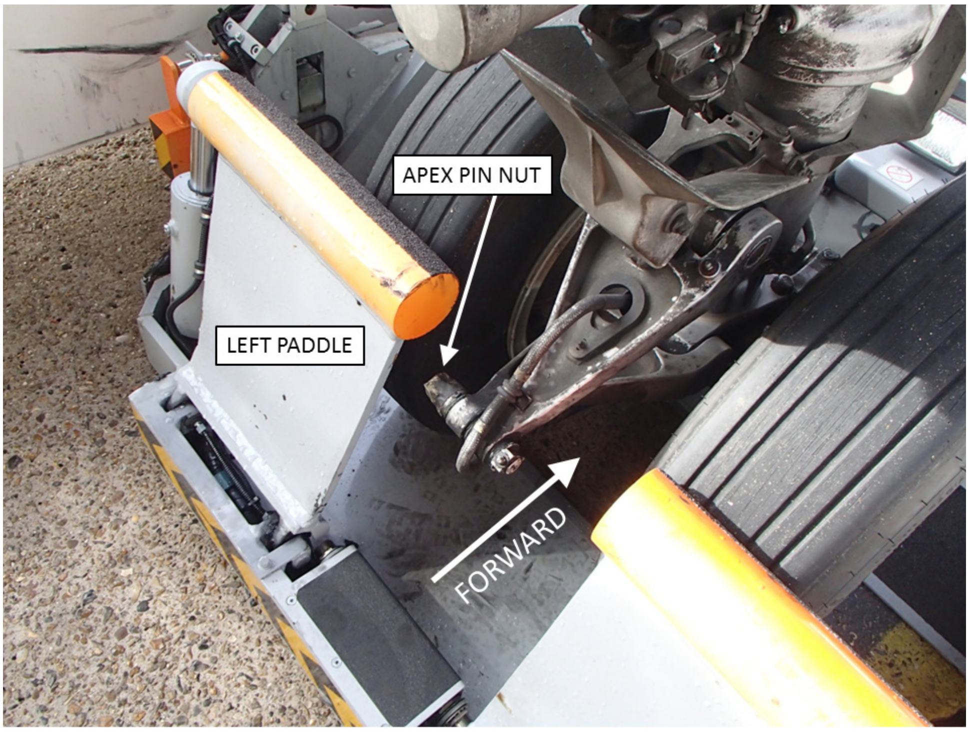

Figure 8

Apex pin nut and TBL tractor left paddle proximity

The operator's internal occurrence reporting system contained three relevant records:

- February 2005 – An A319 NLG apex pin nut separated from the apex pin due to overload, caused by contact from a TBL tractor paddle during pushback.
- August 2007 – Damage to an A320 NLG apex pin nut lock bolt was found during a pre-flight inspection. The lock bolt had fractured through the cotter pin hole and the sealant covering the lock bolt, castellated nut and cotter pin had been *'scraped'* back, consistent with an impact from a TBL tractor paddle.

Footnote

6 'A320-series' includes all variants of Airbus A318/319/320/321 aircraft.

- October 2010 – An A319 NLG apex pin nut lock bolt was found to be bent and the castellated nut damaged, with the cotter pin missing. This damage was recorded as being consistent with the apex pin nut having been stuck by something substantial, possibly a TBL tractor paddle.

In 2009, in response to in-service NLG apex pin fracture events, the aircraft manufacturer launched a redesign of the apex pin assembly. This activity resulted in a '*Technical Follow-up*' notice to operators, TFU 32.21.27.002, which described the in-service cases of NLG torque link separation following apex pin rupture due to TBL tractor contacts. This TFU also drew attention to Service Bulletin (SB) A320-32-1400, issued in June 2012, which introduced a new apex pin with a redesigned nut assembly, reducing the lateral projection of the apex pin nut by 7 mm. In addition to other improvements, the new design was *'developed to reduce the exposure to towbarless tractors'*, and was introduced as standard equipment on production A320-series aircraft at MSN 5154 (although, due to aircraft and parts sequencing during production, not every MSN immediately thereafter is to the post-modification standard). The aircraft manufacturer confirmed that approximately 2,400 in-service A320-series aircraft have been delivered with this modification embodied during production and none of these aircraft has experienced a torque link separation event. SB A320-32-1400 is available for retrofit to all A320-series aircraft.

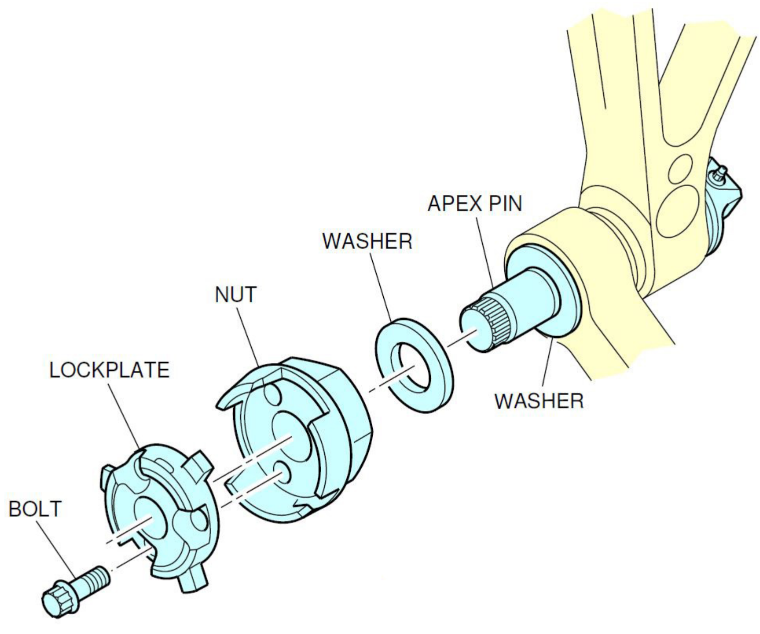

Figure 9

New design of NLG apex pin, nut and locking assembly introduced with SB A320-32-1400

Tests and research

TBL tractor inspections at Heathrow Airport

Immediately following the G-EUPM event the operator carried out an inspection of the TBL tractor, registration AT0935, which had pushed G-EUPM back from its stand at Heathrow Airport prior to the incident flight to Manchester, along with 10 other TBL tractors also in use by the operator at Heathrow. The inspection of AT0935 did not reveal any faults with the tractor, although a rusty witness mark was noted on the inboard edge of the left paddle, at a position adjacent to where the apex pin nut sits when the tractor has engaged an A320-series aircraft. This model of TBL tractor is also used to push back and tow Boeing 767 aircraft, and to push back Boeing 777-200 aircraft although neither of these aircraft types' NLGs have protuberances that could have caused the left paddle witness marks. The corrosion on AT0935's witness mark demonstrated that a paddle contact had not occurred during pushback prior to the incident flight.

Inspection of the other 10 TBL tractors revealed witness marks on the left paddle inboard edges on eight of the units examined, Figure 10.

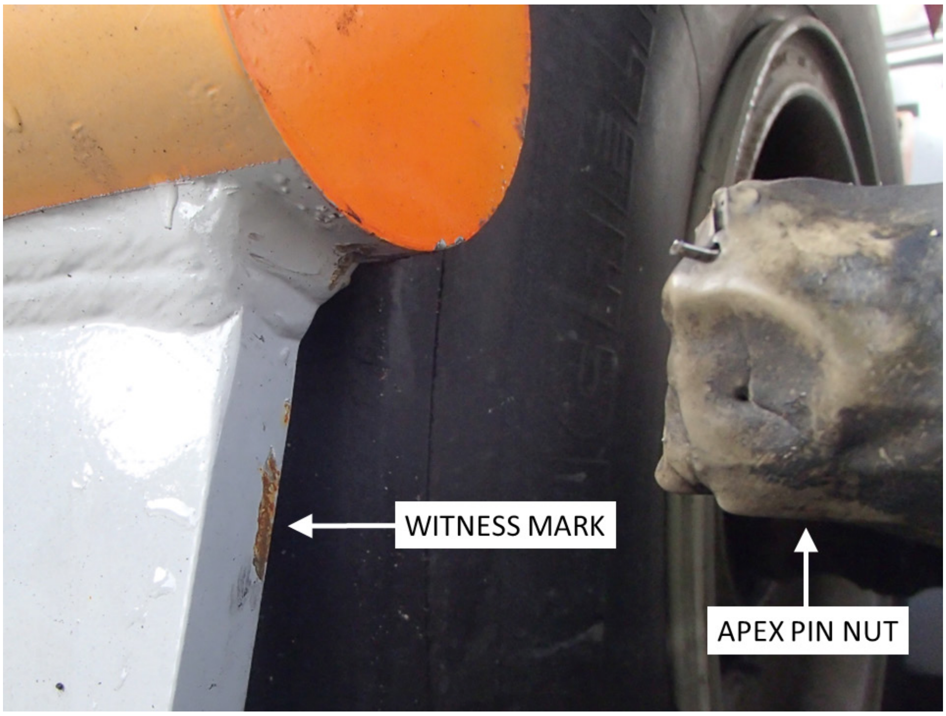

Figure 10

Example of a TBL tractor left paddle witness mark

NLG apex pin nut survey at Heathrow Airport

The AAIB carried out a survey of 34 A320-series aircraft, none of which had SB A320-32-1400 embodied, at Heathrow Airport as part of the G-EUPM investigation. Five of the aircraft surveyed had damaged sealant at the outboard end of the NLG apex pin nut, indicating possible TBL tractor left paddle contacts (Figure 11), although none of the aircraft surveyed had visible damage to components of the lock bolt assembly.

Figure 11

Apex pin nut sealant damage observed during AAIB survey

Analysis

Assessment of the recovered components from G-EUPM's NLG indicates that the torque links separated because the apex pin released from the torque links after the apex pin nut had unscrewed and detached from the apex pin. The close proximity of the recovered apex pin and nut to the aircraft shows that once the apex pin had released, the nosewheels rapidly rotated to an extreme left angle.

The apex pin nut was able to unscrew because the locking bolt became detached from the apex pin nut prior to the landing at Manchester, although it is uncertain when this occurred. The occurrence of NLG shimmy on landing during the sector preceding the incident flight, and during takeoff and landing on the incident flight, is consistent with a loss of apex pin nut torque at least one flight prior to the incident flight.

Witness marks in the apex pin nut sealant show that the lock bolt, washer, castellated nut and cotter pin had been correctly assembled prior to the sealant application. The available evidence shows that this occurred during the 1C maintenance check in February 2016, 1,323 flight cycles prior to the torque link separation.

The cotter pin had been installed in the lock bolt in accordance with the AMM *'Second Procedure'*, with the head of the cotter pin oriented outboard. The missing area of sealant on the apex pin nut was in the same position as where the head of the cotter pin had been. The torn edges of this area of missing sealant indicate that it had detached in service, after the sealant had been applied and cured.

Similar sealant damage was observed on five other A320-series aircraft in the operator's fleet, from a sample of 34 aircraft; such sealant damage is most likely caused by contact with the left paddle of a TBL tractor during pushback and towing operations. In addition, nine out of eleven of the operator's TBL tractors had impact witness marks on the left paddle, adjacent to the position where the apex pin nut sits when the tractor is engaged with A320-series aircraft, further indicating that paddle contacts are occurring in routine operation.

Therefore, it is probable that contact with the left paddle of a TBL tractor damaged the sealant and the lock bolt cotter pin, castellated nut or lock bolt itself, leading to their subsequent detachment from the apex pin nut. This led to the eventual release of apex pin from the NLG torque links.

Previous occurrences of damage to apex pin nuts and locking bolts prompted the aircraft manufacturer to modify the design of the apex pin nut, with the narrower apex pin components becoming available in June 2012.

Safety action being considered

As a result of this event, the operator is considering the embodiment of Service Bulletin A320-32-1400 on its A320-series fleet, in a rolling programme as the aircraft undergo scheduled maintenance.

Conclusion

The detachment of the NLG torque link apex pin was most probably caused by damage sustained to the torque link apex pin nut locking components due to contact with a towbarless tractor. A Service Bulletin is available to replace the torque link apex pin assembly with a new design, intended to reduce the risk of contact damage with towbarless tractors.

ACCIDENT

Aircraft Type and Registration:	Westland Wasp HAS1, G-KAXT
No & Type of Engines:	1 Rolls-Royce Nimbus MK 10301 turboshaft engine
Year of Manufacture:	1967 (Serial no: F9669)
Date & Time (UTC):	23 September 2016 at 0845 hrs
Location:	Bishopstone, Salisbury, Wiltshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Broken universal joint and collective pitch control rod, damaged tail rotor and driveshaft, structural damage
Commander's Licence:	Private Pilot's Licence
Commander's Age:	63 years
Commander's Flying Experience:	984 hours (of which 379 were on type) Last 90 days - 21 hours Last 28 days - 8 hours
Information Source:	AAIB Field Investigation

Synopsis

With the helicopter straight and level at approximately 1,150 ft, the pilot felt vibration through the collective lever. The vibration ceased after two or three seconds.

Approaching higher ground, the pilot pulled up on the collective lever but the helicopter did not respond. He lowered the lever and again, there was no response. Faced with a loss of collective pitch control, the pilot made a precautionary landing, but was unable to control the flare. The tail rotor struck the ground but the helicopter remained upright. The pilot and his passenger were uninjured.

The investigation established that the collective pitch control rod in the main rotor gearbox had broken. The control rod failure was secondary to a universal joint failure that had occurred in the cyclic control circuit due to lack of lubrication and a build-up of corrosion deposits. The pilot had reported vibration in the preceding months but despite diagnostic efforts, the cause had not been identified.

The Civil Aviation Authority (CAA) issued Emergency Mandatory Permit Directive No 2017-002-E, applicable to UK-registered Westland Wasp and Scout helicopters, to perform a visual check of the condition of the universal joint and introduce periodic

lubrication of the joint. One Safety Recommendation has been made to the CAA to review the maintenance requirements for ex-military aircraft.

History of the flight

The pilot and his passenger departed Barton Ashes in Hampshire with the intention of flying to Royal Naval Air Station (RNAS) Yeovilton, where they were scheduled to participate in a fly-in of historic naval helicopters.

Southwest of Salisbury, at approximately 1,150 ft and 80 kt, the pilot felt a two to three second vibration in the collective lever. Shortly thereafter, the pilot realised that he no longer had collective pitch control, so he turned away from rising ground in preparation for a diversion to a landing site in the Chalke Valley.

The pilot made a PAN call and informed Air Traffic Control (ATC) of his intention to land as soon as possible. He was offered diversionary airfields, but with increasing concern over the ability to control his altitude he decided to land in a field near the village of Bishopstone. After a slow speed handling check, he initiated his final approach and selected manual throttle control at a height of approximately 300 ft. His ability to flare was limited and he was unable to cushion the landing, with one wheel touching down first and significant bouncing between all four wheels as he shut the helicopter down. The tail rotor struck the ground but the helicopter remained upright and both occupants, who were uninjured, were able to exit normally.

Helicopter description

General

The Westland Wasp HAS1 was designed to fulfil the Royal Navy's requirement for a shipborne anti-submarine helicopter. It was part of the same programme as the British Army Westland Scout and was introduced in 1964. It was retired by the Royal Navy in 1988.

The helicopter has a four-wheeled castering landing gear and is powered by a Rolls-Royce Nimbus engine, which drives a four-bladed main rotor and a two-bladed tail rotor. The tail boom and main rotor blades can be folded to allow storage in small hangars onboard ship.

Flying controls

The pilot flying controls comprise a collective pitch lever to the left of the pilot's seat, a cyclic control column in front of the seat and a pair of tail rotor control pedals to provide directional control.

The control rods from the collective pitch and cyclic control column run aft under the cabin floor and, through a series of bell cranks and levers, extend upwards to the control spider at the base of the main rotor shaft (Figure 1).

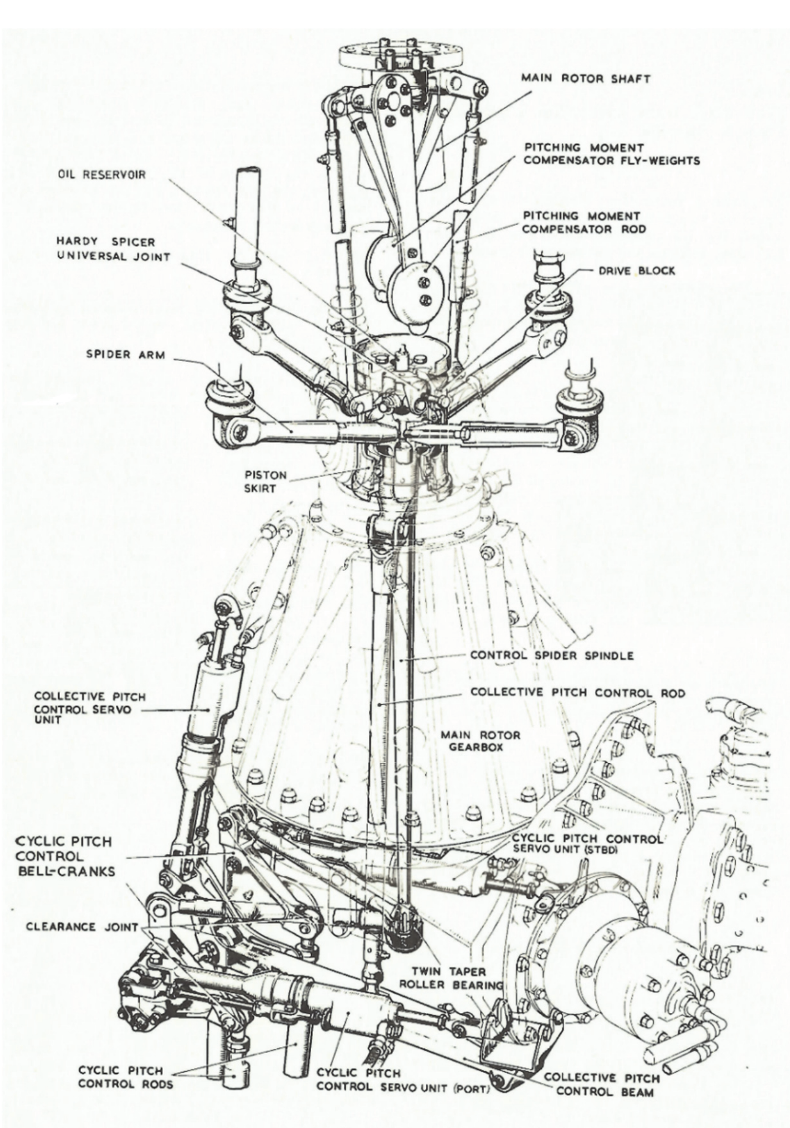

Figure 1

Main rotor gearbox controls

Operation of the collective pitch lever raises or lowers the control spider to alter the pitch of all four main rotor blades by equal amounts. This increases or decreases rotor lift and controls the vertical movement of the helicopter.

Movement of the cyclic control column in any direction is transmitted to the spider which tilts to correspond to the angle of the column. When the rotor is running the tilted spider produces a cyclic change of blade pitch, which tilts the main rotor disc and introduces a horizontal component to the rotor reaction.

The pitching moment compensator provides a balanced collective control in flight by relieving collective pitch control loads imposed by the main rotor blade pitching moments. This comprises of a pair of flyweights, pivoted in bearing blocks at the top of the main rotor shaft and connected by rods to the control spider piston.

G-KAXT

G-KAXT was delivered into service with the Royal Navy in February 1967 with the UK military registration XT787. The helicopter was transferred to the Royal New Zealand Air Force (RNZAF) in 1982, where it remained in service until May 1998. It was subsequently returned to the manufacturer with approximately 2,660 flying hours before being acquired by a private owner and recommissioned in 2000.

When the accident occurred, G-KAXT had accrued 3,012 flying hours and was operating on the UK civil register with a valid Permit to Fly.

The pilot, who also owned the helicopter, advised that vibration had been identified in the months preceding the accident but investigation had been unable to identify the cause. An experienced Scout pilot had expressed concern over the severity of the vibration, but the helicopter had successfully completed an air test four days prior to the accident.

Helicopter examination

Examination, under the supervision of the AAIB, identified that the collective pitch control rod in the main rotor gearbox had broken. The failure occurred in an area where the rod passes through an aperture in a metallic 'guide' (Figure 2). By design, the rod should not touch the guide.

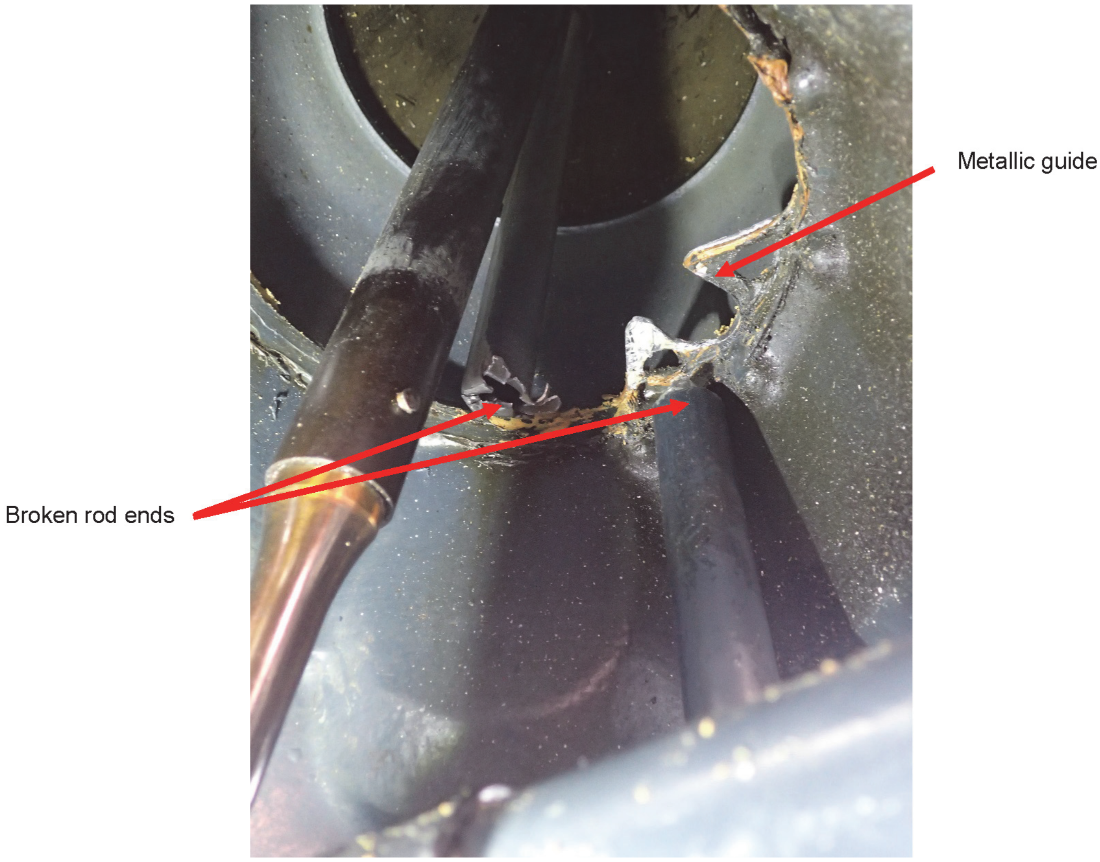

Figure 2

Broken collective pitch control rod

Collective pitch control rod

The circumferential fracture faces had been damaged by repeatedly impacting the surrounding structure and it was not possible to establish the initiating failure mechanism. Nevertheless, axial cracks extended approximately 30 mm away from the failure and the metallurgist identified features that were indicative of fatigue.

Spider (control hub) assembly

The main rotor gearbox was removed and disassembled to access the control hub assembly and the upper section of the broken collective pitch control rod (Figure 3). All four spider arms showed evidence of unexpected wear due to repeated contact with the vertical slots in the main rotor drive shaft, which exhibited corresponding wear.

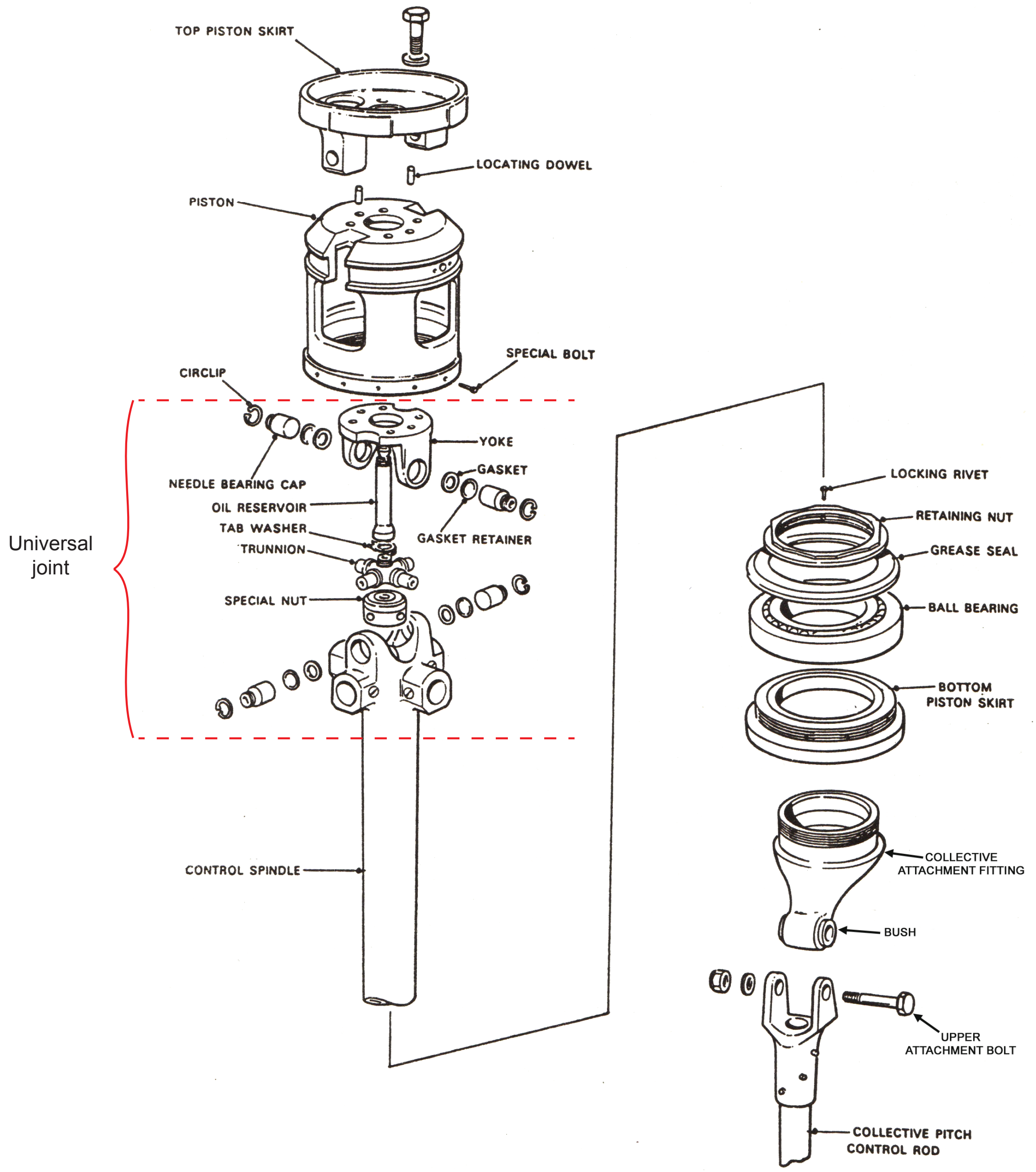

Figure 3

Control hub assembly

The joint between the collective pitch control rod and the collective attachment fitting exhibited excessive play. The bolt and bushes (both of which were cracked) were found to be outside the allowable wear limits. The excess play would allow lateral movement of the control rod resulting in contact with the metal guide.

Further examination of the control hub assembly identified corrosion on the universal joint and one of the ‘ears’ of the cyclic control spindle had broken, allowing the universal joint trunnion to become partially free. A cylindrical component found loose within the gearbox was identified to be the oil reservoir and an indentation on it had been made by contact with the adjacent piston skirt.

Control spindle and universal joint

Corrosion deposits on the fracture faces of the broken control spindle ear indicated that the failure was not recent (Figure 4). Localised bluing of the material was indicative of an overheat condition. Both bearing caps were corroded and sections of their outer walls were missing; only four needles from the two needle bearing assemblies were identified.

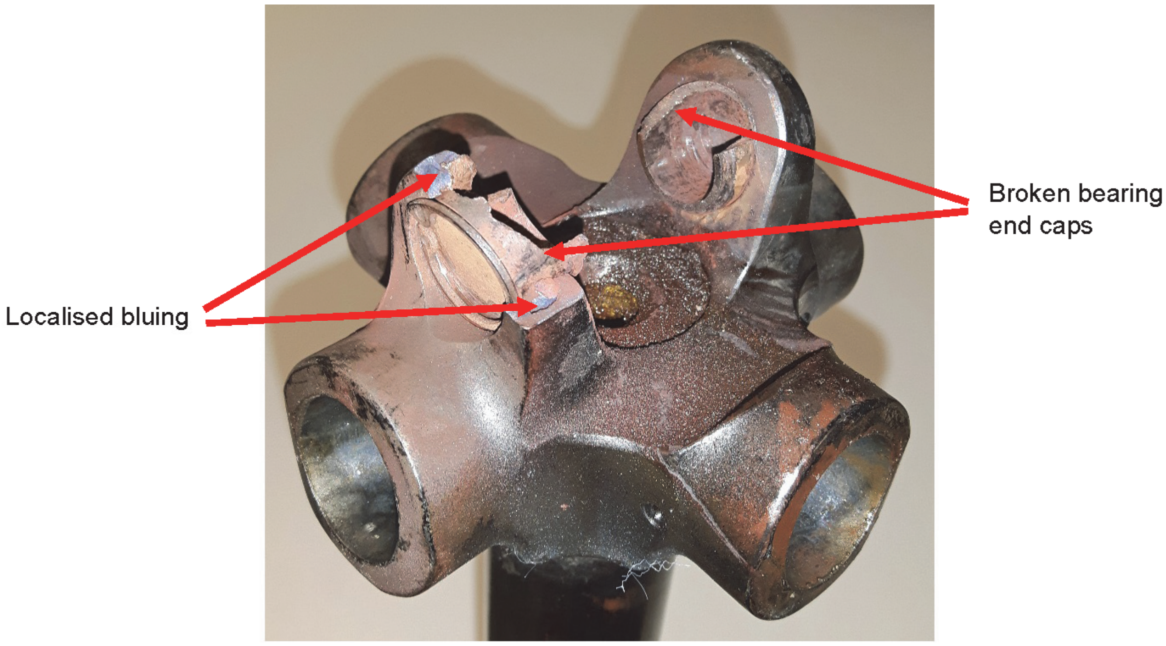

Figure 4

Control spindle showing corrosion, broken ear and damaged end caps

The exposed bearing surfaces of the trunnion showed extensive corrosion and wear (Figure 5). Attempts to move the trunnion about the axis that remained intact required undue force and the range of movement was restricted to approximately 10°. The evidence indicated that that the universal joint had been operating with insufficient lubrication for a considerable period of time.

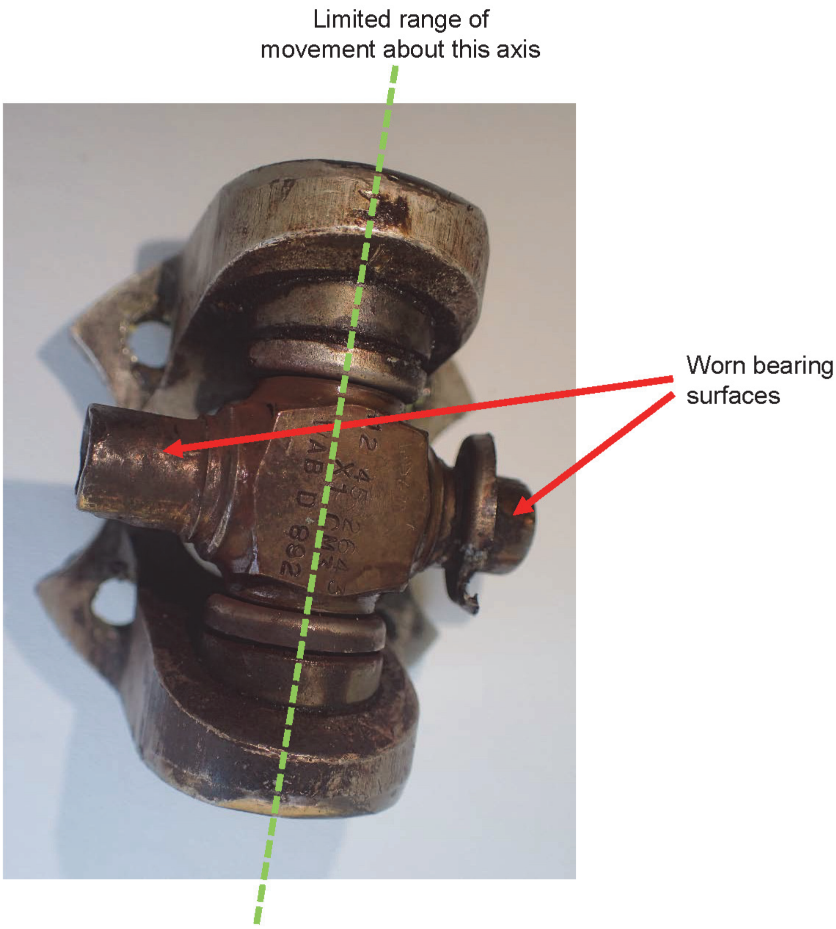

Figure 5

Corroded universal joint trunnion and worn bearing surfaces

Maintenance procedures

General

The helicopter was maintained in accordance with the Ministry of Defence (MoD) Master Maintenance Schedule (MMS), reference AP101C-0601-5A1; this was a condition of the CAA approval for the Permit to Fly.

Main rotor gearbox

The scrap life of the main rotor gearbox is 2,400 hours and the overhaul periodicity depends on the equipment modification state. In the case of G-KAXT, the overhaul period was 600 hours.

The manufacturer advised that typical usage for the Wasp helicopter in UK military service was in the order of 200 hours per year, which would equate to a gearbox overhaul calendar period of approximately three years.

Universal joint

According to AP101C-0601-5A1, a new universal joint must be installed every 600 hours.

The helicopter maintenance manual (AP101C-0601-1A) states that the oil reservoir is lubricated on assembly using OEP 740 oil. The control hub assembly procedure in the gearbox overhaul manual (AP101C-0700-6B) states '*fully charge the reservoir with oil OEP 740*'.

There are no requirements to lubricate the universal joint in service.

Main rotor gearbox history

The main rotor gearbox was installed on G-KAXT in August 1996. The gearbox had accrued 1,777 hours prior to installation and had just been overhauled by the RNZAF. The universal joint was replaced during gearbox overhaul but the provenance of the replacement item is unknown, with the log card stating: '*universal replaced (temp number issued – no serial number supplied with item)*'.

At the time of this accident the gearbox had been installed on G-KAXT for 429 hours, which had been accrued over a period of 20 years.

Analysis

Loss of collective pitch control

When the collective pitch control rod failed, the pilot lost the ability to control the pitch angle of the main rotor blades using the collective lever. The manufacturer considered that catastrophic loss of pitch control was prevented by the pitching moment compensator, which provides a balanced collective control by relieving loads imposed by rotor blade pitching moments. The pilot retained a degree of collective control by varying rotor speed but his ability to control the flare was limited.

Failure mechanism

The mechanical damage indicated that the universal joint had been operating without lubrication for an extended period of time. The manufacturer considered that vibration would have been expected and the pilot advised that vibration had been identified in the months preceding the accident. The cause had not been established and an experienced Scout pilot who had flown in G-KAXT had expressed concern over the severity of the vibration. Irrespective of this, however, the helicopter had successfully completed an air test four days prior to the accident.

The vibration caused accelerated wear and cracking in both bushes in the pitch rod upper attachment fitting. The excess wear allowed lateral movement of the control rod and, therefore, contact with the metal guide. Repeated contact with the guide eventually resulted in the rod failing due to fatigue.

Maintenance aspects

G-KAXT was maintained in accordance with the original military schedule. This required the main rotor gearbox to be overhauled every 600 hours and the universal joint to be replaced at the same interval. The universal joint must be lubricated on installation. Maintenance records showed that the main rotor gearbox on G-KAXT was overhauled in 1996 and a replacement universal joint was installed at this time. The manufacturer advised that typical usage for the Wasp helicopter in UK military service was in the order of 200 hours per year, which would equate to a gearbox overhaul calendar period of about three years. However, due to the low utilisation in civilian operation, in the 20 years since the main rotor gearbox was overhauled, G-KAXT had accrued only 429 hours. Whilst the gearbox was within the required overhaul period of 600 hours, the elapsed calendar time was far greater than would have been expected in military service. The extended elapsed calendar time resulted in the universal joint oil reservoir being depleted, resulting in inadequate lubrication of the joint and its eventual failure.

Safety action

The investigation findings were highlighted to the CAA at an early stage. The CAA took urgent action to ensure the continued airworthiness of Westland Wasp and Scout helicopters on the UK register by issuing Emergency Mandatory Permit Directive (EMPD) No 2017-002-E. (*http://publicapps.caa.co.uk/modalapplication.aspx?appid=11&mode=detail&id=7759*)

The EMPD requires operators to perform a visual check of the condition of the universal joint and conduct periodic lubrication of the joint.

The investigation established that the original military maintenance schedule did not always define calendar-based criteria for maintenance operations, some of which may be critical to ensuring continued safe civil operation. The military servicing regimes were derived for aircraft in military service with a relatively high utilisation. However, civilian-operated ex-military aircraft typically have a much lower utilisation and the original military maintenance schedule may no longer be entirely appropriate. The following Safety Recommendation is therefore made:

Safety Recommendation 2017-012

It is recommended that, for ex-military aircraft on the UK civil register, the Civil Aviation Authority requires maintenance and overhaul tasks to be reviewed in the light of the expected aircraft utilisation and calendar-based time limits introduced where appropriate. Where such calendar-based time limits already exist, these should be reviewed to ensure that they are appropriate for the aircraft utilisation.

Conclusion

The investigation established that the collective pitch control rod in the main rotor gearbox had failed, resulting in the loss of the ability to control the blade pitch via the collective lever. The control rod failure was secondary to a universal joint failure in the cyclic control circuit due to lack of lubrication in the joint and a build-up of corrosion deposits.

The much lower utilisation in civilian operation, and the absence of a calendar time limit for main rotor gearbox overhaul, meant that the gearbox in G-KAXT had been installed for 20 years since previous overhaul. The universal joint had not been replaced in this time and there was no requirement to lubricate it in service. The lubricant in the joint was lost over time, causing the joint to wear and corrode, leading to its eventual failure. The introduction of calendar-based time limits, where appropriate for the aircraft utilisation, would help to prevent similar failures in the future.

ACCIDENT

Aircraft Type and Registration:	Breezer B600E, D-ETDK
No & Type of Engines:	1 Rotax 912 ULS
Year of Manufacture:	2014
Date & Time (UTC):	2 August 2016 at 0933 hrs
Location:	2.5 nm NW of Oban Airport, Argyll
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - 1 (Serious) Passengers - 1 (Serious)
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Light Aircraft Pilot's Licence
Commander's Age:	63
Commander's Flying Experience:	2,500 hours (of which 1,200 hours were on type) Last 90 days - 30 hours Last 28 days - 15 hours
Information Source:	AAIB Field Investigation

Synopsis

The pilot of D-ETDK, who was flying in loose formation with a group of similar aircraft, slowed his aircraft to increase separation from the aircraft ahead. His aircraft then encountered an updraught from airflow over a ridge and stalled. He lost control of the aircraft and deployed the ballistic recovery system (BRS), but there was insufficient time for the aircraft to achieve a stabilised descent before it struck the ground.

The investigation concluded that the stall and subsequent loss of control were made more likely because: the aircraft was susceptible to turbulence and wind gradient because of its low inertia; the Centre of Gravity (CG) was probably behind the aft limit; and the aircraft's speed had been reduced to maintain separation from other aircraft joining the circuit.

History of the flight

D-ETDK departed Glenforsa Airfield on the Isle of Mull at 0918 hrs for a flight to Oban Airport in Argyll. The aircraft was the last of eight Breezer aircraft flying in a loose formation but operating as one speaking unit. The formation leader contacted Oban Information on the radio stating that there were eight Breezer aircraft approximately five minutes away. He was told that Runway 19 was in use with a right hand circuit, the wind was from 130° at 13 gusting 23 kt and the QNH was 1007 hPa. Figure 1 shows an extract of the Oban Aerodrome Chart contained in the UK AIP.

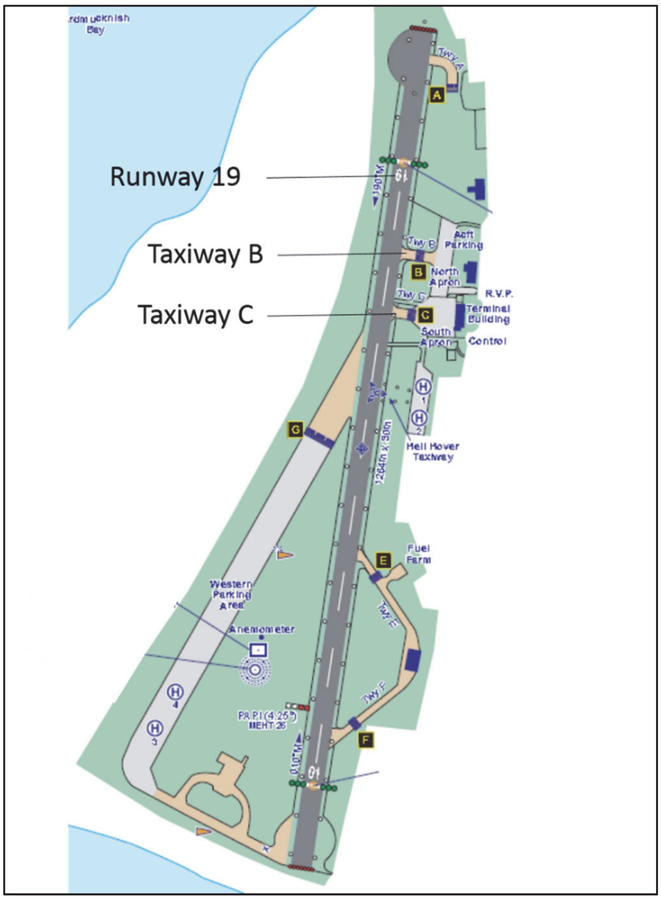

Figure 1

Extract of UK AIP entry for Oban Aerodrome

The formation leader said that there were pilots in the formation with "LANGUAGE DIFFERENCES" and asked the Flight Information Service Officer (FISO) to issue one clearance for the aircraft to land "SEQUENTIALLY, ONE AFTER ANOTHER". The FISO replied that he "WOULD LIKE EACH AIRCRAFT TO REPORT RIGHT BASE FOR ONE NINE AND LEAVE SPACE FOR A POSSIBLE BACKTRACK". He also warned the leader about the possibility of turbulence and windshear on short finals due to the wind.

Approximately two minutes later, the FISO reiterated to the leader that the landing aircraft would be required to backtrack the runway before vacating it and asked him to ensure "WE GET ENOUGH SPACING BETWEEN AIRCRAFT". The leader asked whether the aircraft in the formation could "COLLECT AT THE END OF THE RUNWAY AND THEN BACKTRACK ALL TOGETHER?" but the FISO replied "NEGATIVE. FOR SAFETY WE REQUIRE – YOU WERE TOLD ON THE 'PHONE – TO LEAVE A COUPLE OF MINUTES' SPACING FOR THE SAFETY OF EACH AIRCRAFT AND FOR BACKTRACKING PURPOSES". The leader responded that "WITH EIGHT AIRCRAFT THIS COULD BE A LOT OF TIME AND WE HAVE A NUMBER OF AIRCRAFT WITH LOW FUEL. THIS IS NOT A GOOD SAFETY CONSIDERATION". The FISO asked for the leader to arrange to send the low-fuel aircraft ahead and for each pilot to call when on right base leg. The pilot of the aircraft which was number four in the formation transmitted that he could speak English and the FISO asked him to report when on right base leg.

The pilot of D-ETDK saw some of the aircraft ahead begin to fly “unusual” ground tracks to increase the separation between them before landing. The aircraft immediately ahead of his flew a 360° turn for spacing and the pilot of D-ETDK turned to track approximately 050°M and slowed his aircraft to create his own spacing from the rest of the formation (Figure 2). He flew along the north-western edge of a small inlet, parallel to a ridge which lay upwind to the southeast of him, and, as he reached the end of the inlet, he encountered turbulence and lost control of the aircraft. Aware that his aircraft was descending rapidly at low level, the pilot activated the aircraft’s BRS at what he estimated to be between 600 and 700 ft amsl and the aircraft struck the ground shortly afterwards. The pilot and passenger were seriously injured.

The pilot did not make an emergency transmission on the radio and the remaining members of the formation were unaware that he had crashed.

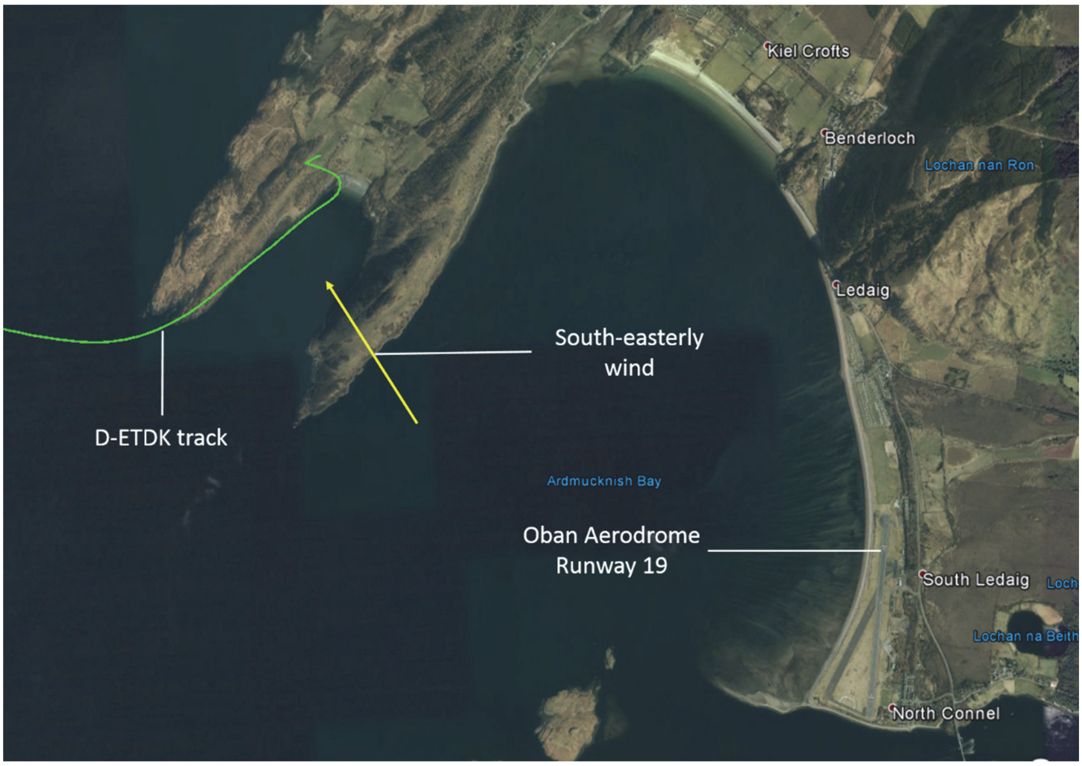

Figure 2

Final portion of the D-ETDK recorded track

The first three aircraft in the formation landed in order and vacated the runway at Taxiway B but the third did not vacate in time for the fourth to land and so the fourth went around. While the remaining aircraft were landing, radio communication between the FISO and aircraft included the following exchanges:

- FISO: "[callsign romeo] on final, just be aware we've got one aircraft on, I'm just getting him to backtrack. [callsign zulu], one eighty backtrack vacate charlie, caution one on finals".

- [Callsign Alpha]: "[callsign alpha] right base for runway one nine".

- FISO: "[callsign alpha], roger, that's copied, just be aware we do have now two aircraft on the runway, so the runway is occupied, you need to let each aircraft backtrack".

- [Callsign Alpha]: "ok, I watch out for the backtracking airplane and the one just landed if it could maintain to pass to the end of the runway".

- FISO: "[callsign alpha], there's limited space at the end of the runway as you've been informed we would have liked spacing for the safety of landings".

[Callsign Alpha] went around after which the FISO asked its pilot to inform the two aircraft at the south end of the runway that they should turn around, backtrack and vacate the runway at Taxiway C. The pilot passed on the instruction in German and then reported to the FISO that the pilots of the two aircraft would comply. After the last aircraft landed, the FISO asked the pilot whether he knew the location of the eighth aircraft (D-ETDK) but the pilot said he did not.

Further information about the flight

Before departure on the day of the accident, the formation leader telephoned Oban Airport's administrator and said that eight aircraft would be landing there to refuel. The airport administrator explained that the aircraft should be separated by five minutes on arrival because formation landings were not permitted at Oban Airport. The pilot of D-ETDK stated subsequently that members of the formation understood that the five-minute separation applied to takeoffs from Oban. "If we [had] understood 'for landing' we would have departed [Glenforsa Airfield] with five minutes separation."

One of the Breezer pilots reported that "there was nothing on the weather forecast to predict severe turbulence. I didn't experience any and neither did numbers five and six. The other aircraft did". Another Breezer pilot reported that his head hit the roof during the turbulence which he described as "remarkable". One pilot warned the others on the radio about strong winds and turbulence over Lismore Island (approximately 2.5 nm west of the accident site). Most pilots in the formation reported severe turbulence on final approach to land.

When interviewed after the flight, one of the Breezer pilots considered that "Oban has a unique management system. The tower's expectation of arriving aircraft is different from what a pilot would consider to be practical. We normally come in one after the other. Oban has a long runway and we only use a fraction of it and we can get a lot of planes on the ground rather than 'by-the-book' separation. Sometimes we come in three at the same time". After landing, the formation's pilots planned to re-group their aircraft in a holding area at the end of the runway before taxiing to the parking area together.

The FISO stated that only one aircraft is allowed on the runway at a time, and aircraft landing on Runway 19 often pass Taxiway Charlie before slowing to taxiing speed and have to backtrack before vacating the runway. He understood that the formation leader had been told on the telephone that the aircraft should arrive with sufficient spacing such that each landing aircraft had time to vacate the runway before the following aircraft touched down. He became concerned when two aircraft on short final were very close together causing one of the pilots to go around at a "very late stage". Only three of the seven pilots spoke to him on the radio and, at one point, he was unable to prevent there being two aircraft on the runway at the same time.

A locally-based pilot airborne at the time of the accident reported that conditions were "very choppy" below 2,000 ft and turbulence in the circuit area was "really horrible". He also said that, in a south-easterly wind, there is typically rotor turbulence to the leeward side of the ridge situated near to and upwind of the accident site.

Accident site

D-ETDK struck the ground in an area of grassland adjacent to woods, on the headland to the northeast of Ardmucknish Bay, opposite Oban Airport (Figure 2). The initial impact created ground marks and removed sections of grass. A second large ground mark, preceded by several 'slash' marks, contained sections of broken propeller blades and parts of the engine cowl. Further sections of propeller blade were found some 20 m away. A wreckage trail of small structural items then extended on a bearing of approximately 324° toward the wreckage of the fuselage. The grass along the wreckage trail had been flattened and further ground marks where the grass had been removed were visible at various points. The fuselage was resting inverted, with the nose of the aircraft pointing back along the wreckage trail, but offset by some 40°. The ballistic recovery parachute was still attached to the aircraft and extended out in a direction of approximately 285°.

Aircraft information

The Breezer B600E is a general aviation aircraft certified with a restricted EASA Type Certificate under Certification Specifications for Light Sport Aeroplanes (CS-LSA). The aircraft is a conventional low wing, aluminium structure design with two seats, a traditional cruciform empennage and fixed tricycle landing gear. It is powered by a geared Rotax 912 engine and composite three blade propeller.

Aircraft examination

The nose section of the aircraft was badly damaged, the cowlings were broken off and the engine had almost completely detached from the firewall. The left wing had twisted vertically and bent backwards along the fuselage, with the left horizontal tailplane also bent vertically upwards. A large clump of grass was attached to the rear of the tail skid. The aircraft canopy had detached, and the cockpit area and instrument panel were significantly disrupted. The fuel tank had become detached and contained a small amount of fuel. The flaps on the intact right wing were extended to 15°. The ignition switch was selected to BOTH and the aircraft master switch was still in the ON position.

The BRS parachute was undamaged and its harness was attached to the aircraft at the four attachment points. The slip ring on the parachute suspension lines was in the fully deployed position.

Recorded information

General information

The aircraft was fitted with two digital displays, each of which recorded a number of flight parameters and the data was successfully downloaded. This data was not subject to the rigours that accompany a Flight Data Recorder but the aircraft manufacturer advised that, during the aircraft's development, the data recorded in these displays showed a good correlation to independent flight test instrumentation.

Included in the list of parameters recorded were: pressure altitude, fuel quantity in USG and alert information provided to the pilot on the display. Angle of attack, BRS parameters, control surface, control column and flap positions were not recorded.

Pressure altitude was recorded, based on a standard pressure setting of 1013 hPa. The 0920 METAR report from Oban was 1007 hPa so pressure altitudes in this report have been corrected, using 27 ft per hPa, to 1007 hPa by removing 162 ft from the recorded value. The recorded pressure setting recovered from the digital displays was 30.04 in Hg (1017 hPa) and, as a consequence, the pressure altitude on the pilot's display would have been over reading by 270 ft.

Accident flight recorded data

The data shows the aircraft took off with a recorded fuel quantity of 3.7 USG (14 litres) and climbed to the maximum recorded altitude for the flight of 1,325 ft amsl. Just over nine minutes later, a fuel MAIN LEVEL LOW alert was recorded, signifying that the fuel quantity had dropped below 12 litres.

At 0931:37 hrs the aircraft turned to track approximately 050°M. During this turn the engine rpm was reduced to 4,100 rpm[1], the aircraft began descending from 1,000 ft amsl and the speed reduced from 75 KIAS. One minute later, the engine rpm had increased to 5,200 rpm and the aircraft levelled at 700 ft amsl with airspeed fluctuating around 55 KIAS. The recorded wind[2] was 16 kt from 137° and 2 USG (7.5 litres) of fuel remained.

Over the next nine seconds, the airspeed fluctuated, reaching up to 58 KIAS but eventually reducing to 47 KIAS. At this point the aircraft's vertical speed and airspeed increased, while the engine rpm and pitch attitude remained constant. This is indicative of turbulent conditions including an updraught, which can have the effect of increasing the angle of attack.

Footnote

1 Maximum recorded rpm on takeoff was 5,750 rpm.
2 Wind speed and direction is that calculated by the on-board avionics which is recorded every two seconds.

One second later, at 0932:44 hrs, the aircraft rolled to the right by 9° and the airspeed began to reduce to 32 KIAS as the aircraft pitched up to 12.7°. The airspeed then increased to a maximum of 45 KIAS over the next few seconds.

Based on an assessment of the recorded data, the likely time of activation of the BRS was at 0932:51 hrs, with the aircraft at 770 ft amsl, an airspeed of 45 KIAS and the engine operating at 4,945 rpm. Airspeed then rapidly decreased and just over four seconds later a peak in the normal acceleration was recorded. The aircraft manufacturer stated that it takes approximately four seconds for the parachute to deploy. Engine rpm remained constant until the end of the recording.

Valid data ceased to be recorded approximately 10 seconds after the activation of the BRS and, with an accident site elevation of 70 ft, this suggests an average rate of descent of 4,200 ft/min.

Weather conditions

The forecast for Oban Airport, valid between 0900 and 1700 hrs on the day of the accident, was wind from 100° at 8 kt, more than 10 km visibility, and FEW clouds at 3,000 ft agl. The actual wind reported at 0920 hrs was from 130° at 19 kt.

The Met Office produced a report into the weather conditions that existed near Oban on the day of the accident. The surface pressure pattern suggested that the wind at 2,000 ft amsl was from the southeast at 20 kt. Information from the relevant radiosonde[3] ascent suggested that the air mass was slightly unstable and not conducive to the development of mountain waves. Mountain waves were not in the forecast valid at the time of the flight, and the satellite image valid at time of the accident showed no evidence of mountain wave activity in the vicinity.

Pilot's Operating Handbook

The Breezer Pilot's Operating Handbook (POH) contains the following statement in the introduction:

> *'…this aircraft possesses characteristics that are unique to light sport type aircraft. These characteristics include low inertia, [and] susceptibility to turbulence and wind gradient[4]'*

Footnote

3 Radiosonde: Instrumentation for the measurement of atmospheric data, usually temperature, pressure and humidity, carried aloft by balloon, together with electronics for transmitting the data to a ground station.

4 Gradient in this sense means the rate of change of wind speed and/or direction, either of which can suddenly affect the headwind experienced by the aircraft and, therefore, its indicated airspeed.

Section 2.6 of the POH, *Operating weights and loading,* includes the following limits (which are also on placards in the aircraft):

a. Maximum takeoff mass (MTOM): 600 kg

b. Maximum loading mass – baggage: 15 kg

Section 2.7 of the POH, *Structure and systems description*, contains the following caution:

> *'- Do not load more than 15 kg (33 lbs) into the baggage compartment. Before loading, check that the mass and balance values are within the limitations…*
>
> *It is important to place the baggage close behind the seats because of the W & B moment.'*

Section 7.12, Information on stalls, spins and any other useful pilot information, states:

> *'A stall during level flight with flaps retracted is preceded by slight buffeting. Usually the aircraft will pitch down; in gusty weather it may have a tendency to drop one wing. The wing can be easily brought back into the horizontal position using the rudder'*

and:

> *'Stall characteristics with flaps extended are exactly the same as those with flaps retracted and may be described as docile'*

and:

> *'Due to excellent slow flight characteristics of the Breezer, inadvertent spins are extremely unlikely to occur … as long as aircraft speed does not fall below stalling speed.'*

Aerodynamic stall

Aerodynamic stall is a condition leading to a loss of lift when the airflow over a conventional wing detaches and becomes turbulent. It occurs when the wing exceeds a given angle of attack (the angle between the relative airflow and the chord line of the wing[5]). The published stall conditions are normally defined with respect to airspeed because this is a parameter which is displayed to the pilot, but it is the angle of attack which predominantly defines when the wing will stall. In most flight conditions, angle of attack and airspeed are closely related, but there are conditions when the aircraft may stall at speeds above the published stall speed, such as when flying in turbulent updraught conditions and/or when the aircraft is overweight.

Footnote

[5] Chord line: a straight line joining the leading and trailing edges of an aerofoil.

Nominal stall recovery technique is to lower the aircraft's nose to reduce the angle of attack and increase airspeed, before applying power to minimise the altitude loss. Any correction in roll attitude during the recovery is normally achieved using the rudder pedals while avoiding aileron use.

Aircraft weight and balance

Breezer POH

Section 4 of the POH states that the acceptable operating CG range for the aircraft is from 258 mm to 448 mm aft of datum[6] (19% to 33% MAC[7]). The following warnings are stated:

> *'If the MTOM is exceeded, the Breezer aircraft will be overloaded. This in turn will lead to deterioration in flight characteristics and performance;'*

and:

> *'Exceeding the centre of gravity limits will detrimentally affect the controllability and stability of the aircraft.'*

Project Breezer B600 – Flight Test Report

The manufacturer produced a report in June 2015 which summarised the results of post-certification flight testing of Breezer aircraft. Although the testing led to a revised Type Certificate for later Breezer aircraft, it did not lead to amendments to the published POH for D-ETDK. However, because the additional testing determined stalling speeds more precisely than the original certification testing, the new speeds were used to assess the performance of D-ETDK on the day of the accident (power-off at MTOM):

a. Flaps up, V_{S1} = 63 km/h (34 kt)

b. Flaps 25°, V_{S0} = 59 km/h (32 kt).

The manufacturer also provided amended moment arms for the fuel tank and pilots' seats which are included in the following weight and balance calculation.

Weight and balance calculation

The pilot provided the following information concerning the aircraft at takeoff:

a. Aircraft mass (empty): 385 kg

b. Occupants: Pilot 100 kg; Passenger 65 kg

Footnote

[6] The reference datum for CG calculations is the wing leading edge.
[7] MAC: Mean Aerodynamic Chord.

Several large bags and camping equipment were stowed in the luggage area behind the two seats, filling most of the baggage compartment. The pilot stated that the baggage weight "had been in the area of 28-30 kg". The baggage recovered from the wreckage was weighed by the AAIB one week after the accident (which gave time for it to dry out) and found to be 50 kg. Whilst there may have been some residual moisture remaining, this is unlikely to have accounted for a 20 kg discrepancy.

There was approximately 7.5 litres (5.4 kg[8]) of fuel on board the aircraft at the time of the accident.

Table 1 shows the calculation of aircraft mass and CG at the time of the accident using the POH, information provided by the manufacturer following the Project Breezer Flight Test Report, and a baggage mass of 30 kg (Table 1). The calculations place the CG at 442 mm aft of the datum (ie 6 mm ahead of the CG aft limit).

	Mass Kg	**Moment arm (mm)**	**Kg.mm**
Empty mass	385	278	107,030
Pilot	100	687	*68,700*
Pax	65	687	*44,655*
Fuel	5.4	-215	*-1,161*
Baggage	30	1,310	39,300
Total	***585.4***	***442***	***258,524***
Maximum	*600*	*448*	

Table 1

Aircraft mass and location of the CG at the time of the accident (30 kg baggage)

Note: As the baggage was distributed throughout the baggage compartment, the actual moment arm for the baggage is likely to have been greater than 1,310 mm. The effect of this would be to move the CG further aft.

Footnote

8 A specific gravity of 0.72 kg/l was used for MOGAS.

The Rules of the Air Regulations 2015

General rules concerning landing and takeoff are contained in CAP 393 Section 2, *Rules of the Air Regulations 2015*. Rule10 states:

> *'(1) Subject to paragraph (4), a flying machine or glider must not land on a runway at an aerodrome if there are other aircraft on the runway'*

and:

> *'(4) Paragraph (1) … [does] not apply if the air traffic control unit at the aerodrome otherwise authorises the flying machine.'*

Oban Airport does not have an air traffic control unit.

CAP 797, *Flight Information Service Officer Manual*

Oban Airport offers a Flight Information Service (FIS) and CAP 797 contains instructions and guidance for Aerodrome FISOs providing a FIS. CAP 797 states in the Introduction:

> *'Nothing in this manual prevents FISOs from using their own discretion and initiative in response to unusual circumstances.'*

The following extracts from CAP 797 Section 1 are relevant:

> *'1.2 FISOs are not permitted to issue instructions except* [to aircraft on the ground] *or when relaying a clearance from an air traffic control unit'*

and:

> *'8.89 To facilitate the integration of arriving aircraft with existing circuit traffic … a FISO may provide advice on the published aerodrome joining procedure and/or a suggested course of action to the traffic situation'*

and:

> *'8.92 Pilots shall not land if there are other aircraft on the runway. FISOs shall provide relevant information on local traffic and aerodrome conditions to assist the pilot in deciding whether to land or go around'*

and:

> *'8.93 A landing aircraft shall not be informed 'land at your discretion' until the runway is unobstructed'*

and:

> *'8.99 Individual elements of a formation may be informed that they may land at their discretion, before the preceding element has reached the runway. The formation elements are responsible for their own separation on final but shall not land whilst the runway is occupied unless they have an exemption against the requirement.'*

Aircraft longitudinal stability with an aft Centre of Gravity

CAA Safety Sense Leaflet 9, *Weight and Balance,* explains that forward and aft CG limits, established as part of the aircraft certification process, define the range of CG positions within which longitudinal stability requirements can be met. The leaflet states that:

> *'Exceeding the aft CG usually results in … longitudinal instability, particularly in turbulence, with the possibility of reversal of control forces [and] degraded stall qualities to an unknown degree.'*

A small displacement in pitch changes the angle of attack of the wing and tailplane but, for positive static stability, the effect of the subsequent forces, and their resultant moment about the CG (the restoring moment), should be to return the aircraft towards its pre-displacement equilibrium state. Forward movement of the CG increases this positive stability, whereas aft movement of the CG reduces it. As the CG is moved further aft, it will eventually reach a position (the neutral point) where the restoring moment is zero and the aircraft is neutrally stable. The aft limit for the CG in the POH is set forward of the neutral point but, if loading limits are exceeded, it is possible to have the CG position on, or aft of, the neutral point. For a given elevator deflection there will be a small response in an aircraft with a forward CG (stable condition) and a large response in an aircraft with an aft CG (less stable condition).

Longitudinal dynamic stability affects the longer-term manner in which an aircraft behaves following a displacement in pitch. A CG outside the aft limit adversely affects longitudinal dynamic stability by reducing the tendency of the aircraft to return towards the equilibrium point following each oscillation through it.

Ballistic Recovery System (BRS)

General information

The aircraft was fitted with a BRS-6™ Emergency Parachute System manufactured by BRS™. This system consists of a parachute, packed into a soft case and an explosive rocket deployment system, triggered by pulling a handle in the cockpit. When the system is activated, a rocket motor ignites and accelerates the rocket from its firing tube located under the nose cowl. The rocket body is attached to the parachute which deploys from its case. A slip ring, located on the suspension lines of the parachute, controls the rate at which the parachute opens relative to the aircraft's forward airspeed. This reduces the shock load as the aircraft begins to decelerate. The aircraft is initially pitched nose-up to assist in the reduction in forward speed, before stabilising in a predominantly level attitude once established under the parachute. The manufacturer quotes a descent rate, with a fully deployed parachute, of between 20 and 25 fps, resulting in a (vertical) touchdown speed of 17 to 20 mph. The manufacturer's manual includes a caution that following the deployment of the parachute a period of instability occurs, where the aircraft swings like a pendulum. Whilst this is normally damped out relatively quickly, if the parachute is deployed at low level, the aircraft may still be oscillating as it reaches the ground. This can result in an impact in an unusual attitude, increasing the risk of injury to the occupants.

The attitude and speed data recovered from the accident aircraft indicated that the pilot activated the BRS at approximately 770 ft amsl. Although the BRS functioned correctly, the aircraft did not achieve a stabilised descent before contacting the ground.

Limitations

The following information was taken from the *Owner's Manual and General Installation Guide for BRS-6™ Emergency Parachute Recovery Systems.*

The ballistic recovery system fitted to the accident aircraft was a BRS-6-1350. This has a gross maximum aircraft deployment weight of 612 kg, not including the parachute system, which weighs 13.2 kg. The procedure for deploying the parachute advises the pilot to shut the engine down prior to activation. This increases safety by stopping the rotation of the propeller blades, isolating the fuel supply and ensuring that the reduction in forward speed caused by the parachute is achieved as efficiently, and therefore as rapidly, as possible.

The following conditions (among others) aid rapid deployment of a correctly fitted BRS: aircraft surfaces intact; 'generous' forward speed; level flight; engine shutdown; and deployment handle operated quickly. The manual states that:

> *'If the situation is optimal, theoretical projections show deployment can be rapid enough to save the craft and occupant(s) from extremely low altitudes'*

and:

> *'When you use an emergency parachute system, you have entered a realm of flight where the unpredictable is the norm.'*

Commission Regulation (EU) No 1178/2011, *Part Flight Crew Licensing (FCL)*

Paragraph FCL.055 to Part FCL, Subpart A, *General Requirements,* gives details of language proficiency requirements for pilots. Pilots are required to have a language proficiency endorsement on their licence in either English or the language used for radio communications involved in the flight. Pilots must demonstrate at least an 'Operational Level'[9] of language proficiency which includes the ability to "*communicate effectively in voice-only … situations".*

Footnote

9 Operational Level means ICAO Level 4.

Analysis

Aircraft technical condition

Neither data downloaded from aircraft avionics, nor engineering examination revealed any evidence that a technical fault with the aircraft contributed to this accident.

Turbulence

The Met Office report stated that mountain waves were not forecast for the area of the accident, and there was no evidence that they had actually occurred. It was evident from the turbulence experienced by pilots in the circuit, however, that the wind was strong enough to generate turbulence downwind of hilly terrain. A locally based pilot reported that a south-easterly wind often caused turbulence to the lee of the ridge near to, and upwind of the accident site. Recorded data showed that the aircraft experienced an increase in airspeed and vertical speed which was not accounted for by a change in engine power or pitch attitude, but which could be explained by an updraught.

It was concluded that the aircraft was struck by an updraught in turbulence caused by the south-easterly wind flowing over the ridge upwind of the accident site.

Aircraft reaction to the turbulence

The data showed that the aircraft was flying below 50 kt in the two seconds prior to the updraught and evidence from the accident site showed that the flaps were extended to 15°. By interpolation, the power-off stall speed with flaps extended to 15° would have been approximately 33 kt[10], although the actual stall speed might have been marginally lower because the engine was producing more than idle power.

The POH stated that the aircraft is susceptible to turbulence and wind gradient because of its low inertia. It also warned that overloading the aircraft would lead to a deterioration in flight characteristics and performance, and exceeding the CG limits would detrimentally affect controllability and stability.

The actual location of the aircraft CG at the time of the accident was not determined precisely, but using the 30 kg baggage weight provided by the pilot gave a CG position of 442 mm aft of datum, where the limit given in the POH is 448 mm. The AAIB recorded a baggage weight of 50 kg, with the baggage in a slightly damp condition. The moisture is unlikely to have accounted for a 20 kg discrepancy in the weight and so it is probable that baggage weight was in excess of 30 kg. In addition, the distribution of the baggage within the baggage compartment was likely to have moved the CG further aft than the weight and balance calculation suggested. It was considered that this probably placed the aircraft's CG aft of the limit as it approached the updraught and the aircraft's handling qualities might have been compromised.

Footnote

[10] Stalling speeds: flaps up = 34 kt; flaps 25° = 32 kt.

The updraught would have increased the wing's angle of attack by adding a vertical component to the relative airflow and it was concluded that the increase was sufficient to cause the wing to reach or exceed its stalling angle of attack. Recorded data showed that, following this updraught, the aircraft pitched nose-up, dropped a wing and the airspeed reduced to 32 KIAS. There appeared to be no stall recovery action taken because no significant increase in engine power was observed in the data and there was no nose-down attitude change. Had the aircraft CG been located behind the aft limit, however, this might have compromised the effectiveness of any nose-down control input.

Survivability

The BRS owner's manual states that, in optimal conditions, successful deployment of the BRS should be possible from '*extremely'* low altitudes. Optimal deployment conditions include '*generous'* forward speed, level flight, engine shutdown, and deployment handle operated quickly. In this accident, only the last condition was met and, from the evidence available, it appeared likely that the BRS was deployed in circumstances that did not allow enough time for the aircraft to stabilise beneath the parachute before striking the ground. This resulted in extensive damage to the aircraft and the serious injuries sustained by the pilot and passenger.

Planning for the flight

During a telephone briefing before the flight, the leader of the formation was advised that the aircraft should arrive at Oban Airport separated by five minutes to enable each landing aircraft to vacate the runway before the following aircraft touched down. The pilots, however, did not appreciate that the requested separation was to satisfy a mandatory runway occupancy requirement on landing; they believed, incorrectly, that the separation applied to their subsequent departure. Consequently, they did not change their plan, which was to remain closely-spaced as one speaking unit and ask to land sequentially and re-group at the upwind end of the runway.

The leader reported to the FISO that some pilots had "language differences", and the FISO was only able to make radio contact with three of the seven pilots who landed. It is therefore likely that some of the remaining four pilots did not understand fully what was being said on the radio, and that the wish to help those pilots contributed to the original decision to remain as one speaking unit.

The plan to land sequentially and re-group at the end of the runway reflected what the formation normally did. This, along with pilot language difficulties and concern about fuel, probably contributed to the leader's reluctance to change a plan which was incompatible with landing requirements at Oban, and led to there being more than one aircraft on the runway at one point in time.

Conclusion

It was concluded that D-ETDK stalled and departed from controlled flight after encountering an updraught due to wind flowing over a ridge. The stall and subsequent loss of control were made more likely by the fact that:

a. The aircraft is of a type susceptible to turbulence and wind gradient because of its low inertia.

b. The aircraft's CG was probably behind the aft limit.

c. The aircraft's speed had been reduced to maintain separation from other aircraft joining the circuit.

The pilots departed for Oban Airport with the intention of remaining in a closely-spaced formation, landing sequentially and re-grouping at the end of the runway before taxiing together to the parking area. Their plan, formed on the ground after misunderstanding a telephone briefing, was incompatible with landing requirements at Oban but their options to re-plan while airborne were compromised by language difficulties and a concern that some aircraft were short of fuel.

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.

SERIOUS INCIDENT

Aircraft Type and Registration:	DHC-8-402, Dash 8, G-FLBB
No & Type of Engines:	2 Pratt & Whitney Canada PW150A turboprop engines
Year of Manufacture:	2009 (Serial no: 4255)
Date & Time (UTC):	8 December 2016 at 0718 hrs
Location:	En route from Manchester to Jersey, overhead Dudley
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 4 Passengers - 23
Injuries:	Crew - None Passengers - None
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	51 years
Commander's Flying Experience:	5,600 hours (of which 375 were on type) Last 90 days - 234 hours Last 28 days - 82 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and further enquiries made by the AAIB

Synopsis

The aircraft was on a scheduled flight from Manchester to Jersey, in the cruise at FL250, when there was a loss in cabin pressure with an associated warning. The crew donned oxygen masks and carried out an emergency descent to FL100. The crew obtained ATC clearance to continue the flight to Jersey at FL100 and informed the passengers about the pressurisation problem and their intentions. The remainder of the flight was uneventful and the aircraft landed in Jersey. The loss of pressurisation was caused by a faulty outflow valve, which was replaced and the aircraft returned to service.

History of the flight

The aircraft departed at 0705 hrs on a scheduled flight from Manchester (EGCC) to Jersey (EGJJ) with four crew and 23 passengers. The aircraft had climbed to FL250 and was on autopilot. Then, approximately two minutes into the cruise, there was a loss in cabin pressurisation indicated by a master warning with associated triple chime alert. The co-pilot noted the warning and immediately called for oxygen and donned his oxygen mask. The commander handed control to the co-pilot, directed him to initiate a descent and inform ATC. The co-pilot started the descent using the autopilot and then disengaged the autopilot to manually fly a descent at 3,500 fpm. By this time the commander had donned his oxygen mask and re-took control, reengaged the autopilot and declared a

MAYDAY. The aircraft was stabilised at FL100. Satisfied there were no structural issues with the aircraft, the commander cancelled the MAYDAY and obtained clearance from ATC to continue to Jersey maintaining FL100. Whilst the crew were dealing with the situation the commander was having difficulties with his oxygen mask microphone so swapped masks. The crew completed the quick reference handbook (QRH) actions and removed their oxygen masks. They then informed and reassured the passengers about the situation over the PA. The flight continued at FL100 and landed at Jersey without further incident. A normal disembarkation was carried out and there were no injuries to the passengers or crew.

Recorded information

The aircraft was fitted with an FDR and CVR. The FDR captured the whole flight, including the climb to FL250 and the master warning. The cabin altitude warning remained illuminated for 7 minutes and 48 seconds and extinguished when FL100 was reached. The FDR showed that no other systems were affected. The CVR did not capture the event as it was not secured until about 1 hour and 40 mins after landing, thus overwriting the event.

Operator's Procedures

Part A of the operator's Operational Manual stated:

> ***'11.4.1 Preservation of FDR Data and CVR Recordings***
>
> *(a) Following an accident or serious incident involving a Flybe aircraft, the Commander or in his absence the First Officer shall ensure, to the extent possible, the preservation of all related flight recorder records and, if necessary, the associated flight recorders…*
>
> *(c) When appropriate, the relevant circuit breakers should be pulled and collared/ tagged and an entry made in the aircraft technical log…'*

This is also printed on the back of the QRH.

The commander commented that after shutdown he was "busy on the phone and did not consider it [securing the recorders]". He was later told by 'Maintrol' that the operators third-party maintenance company in Jersey had pulled the CVR circuit breaker.

Additionally, the operator's Maintenance Operations procedures stated:

> *'4.1 Whenever an incident is reported…the flight data recorder must be considered for removal and download in order to preserve or rapidly assess vital and important aircraft systems information. …*
>
> *4.2 On receipt of information advising of an incident, the Duty Maintenance Control Engineer will assess the incident type and arrange for the FDR, CVR and QAR preservation, removal or download.*

> *4.3 In an AAIB involved event, the aircraft, FDR and CVR should be isolated and quarantined, and not released to service until authorised by the duty Flight Safety representative.'*

The operator commented that it was aware the procedure was not followed and this "has been highlighted as an error" in this incident.

Aircraft information

The Bombardier (De Havilland Canada) DHC-8-402 is an all-metal high-wing monoplane designed for medium range regional passenger flights. It has the capacity for 78 passengers, a range of approximately 1,100 nautical miles and a service ceiling of 25,000 feet.

Pressurisation and oxygen system

The aircraft cabin is pressurised by engine bleed air supplied to and distributed by the air-conditioning system. It is controlled by the cabin pressure control system modifying the rate of outflow from the cabin via a valve located on the aft pressure bulkhead, assisted by a safety valve in the same area. An additional controllable safety valve is fitted on the forward pressure bulkhead. For normal flight the outflow valve controller is set to AUTO and the cabin pressure is automatically maintained in a preprogramed pressurisation schedule by the outflow valve. Cabin altitude, differential pressure and rate of change of cabin altitude are indicated to the crew by analogue gauges. There is also a warning light which illuminates when the cabin pressure altitude is too high.

There is a fixed integral emergency oxygen supply for the flight crew in the cockpit. Oxygen is stored in a pressurised cylinder within the nose section of the aircraft and delivered via a regulator to three face masks stowed in holders on the cockpit rear bulkhead. Portable oxygen supplies are carried in the cabin for passenger use if required for depressurisation events where an immediate descent is not possible, or in the case of a medical emergency.

Aircraft examination

The aircraft was flown back to Manchester, unpressurised, for a system fault diagnosis which found the outflow valve to have been the cause of the depressurisation. The faulty outflow valve was replaced and the aircraft returned to service.

Component history

The operator's engineering team researched the history of the faulty outflow valve, serial number 00369, and found that it was originally fitted to G-ECOT at build. It was removed from G-ECOT in April 2015 as part of a pressurisation system fault diagnosis, where no specific faulty component could be identified, but the fault was eventually resolved after multiple component replacements. The same outflow valve was fitted to G-KKEV in September 2015. Whilst fitted to G-KKEV, during a climb at FL200, the crew experienced a sudden cabin altitude rate increase with a momentary fault light which appeared to cure itself without intervention. This was a repeat of a similar occurrence three days before and after diagnosis the outflow valve was replaced. It was then fitted to G-FLBB on 7 December 2016 to cure a problem described as '*pressurisation erratic in descent*'. This work was carried out the day before the loss of cabin pressure en route to Jersey. The valve has now been removed from service and quarantined and is the subject of a reliability investigation being carried out by the spares provider and the original equipment manufacturer (OEM).

Cockpit crew actions and observations

The co-pilot was quick to react, understand the situation and take appropriate action. Concurrently the commander was completing a Technical Log entry and at this point the electronic flight bag (EFB) and its mounting fell off the windscreen. The commander saw the co-pilot was ahead of him in donning his oxygen mask and so instructed him to take control and carry out the emergency descent vital action drills, in accordance with the QRH. The commander discarded the Technical Log and moved the EFB out of the way before donning his oxygen mask. Although all of these actions only took a few seconds, both crew describe feeling slightly lightheaded. In the commander's own analysis, after the event, he realised that he was having difficulty completing the Technical Log, which was a relatively simple task and therefore considered that he was already slightly hypoxic when the pressurisation warning occurred. He also believes that this affected his performance and slowed his initial reactions to the situation.

Initially the descent was on the autopilot but the co-pilot felt the rate of descent was too low and disengaged the autopilot and manually increased the rate of descent from 2,000 fpm to 3,500 fpm. With hindsight the co-pilot felt that he should not have deselected the autopilot during the emergency descent. The EFB falling from the windscreen and the oxygen mask microphone difficulties added to the already heightened workload. With hindsight the commander considered all of this to have influenced the remainder of the flight and the final approach into Jersey which was "not up to the usual standard". After landing the crew realised the significant effects that hypoxia had had on their performance.

Cabin crew actions

During the event the senior cabin crew (SCC) member and cabin attendant felt the aircraft suddenly adopt a descent profile and saw the seat belt signs illuminate. Although they noticed their "ears popping" they did not associate this with a depressurisation and did not experience symptoms of hypoxia. Initially they were unable to contact the cockpit crew but realised there was a problem and secured the cabin anyway. The cabin crew were unaware of the difficulties the commander was having with his microphone in the early stages of the incident. Communication was eventually established as the aircraft descended through FL150. The cabin crew actions were taken without knowledge of the problem but good crew resource management (CRM) and training meant that cabin and passenger safety was maintained.

Technical Log

The commander had noted the Technical Log entry regarding the pressurisation problem on 7 December 2016. The SCC member was also aware of the problem on this aircraft as she had flown in it over the previous two days. With hindsight the commander felt that had time allowed he would have liked to brief his crew on the potential outcomes in the light of the Technical Log entries.

Conclusions

Technical cause

The cause of the pressurisation problem was the outflow valve, serial number 00369, which the evidence suggests had a history of being causal or contributory to pressurisation problems in other aircraft. It also appears that the problem did not manifest itself during post installation functional checks as, shown by its fitment to G-KKEV and G-FLBB. In this situation it is sometimes difficult for engineering staff to reject an item which, when subjected to normal checks detailed in the AMM, meets the requirements for release to service.

Effect on the commander and co-pilot

It is probable that the loss of pressurisation was gradual but maintained just within system limits during the climb to FL250. When the aircraft was established in the cruise at FL250 the cabin pressure altitude continued to climb over a period of two minutes until the warning level was reached. Although by no means debilitating in this case, it shows how quickly the flight deck crew appeared to suffer the early signs of hypoxia.

AAIB observation

The 'coincidental' detachment of the EFB with its holder from the windscreen was probably as a result of the ambient pressure surrounding the 'sucker' pad reducing its ability to support the weight of the EFB. Although in this case it had no bearing on the incident, it has the potential to create an additional alarming or stress raising feature during high workload situations. There is also the possibility that the EFB could fall into the rudder pedal area with the potential to cause a control restriction. However, the operator is introducing a lighter version of the tablet device on which the EFB is run, so that the risk of it detaching is reduced.

Safety actions

> The operator has expressed concerns over the reliability of the outflow valve and has initiated a reliability investigation involving the spare part provider and the OEM. At the time of writing the results of the reliability investigation are not known.

ACCIDENT

Aircraft Type and Registration:	Luscombe 8A Silvaire, G-BRJK
No & Type of Engines:	1 Continental Motors Corp A65-8F piston engine
Year of Manufacture:	1946 (Serial no: 4205)
Date & Time (UTC):	27 December 2016 at 1530 hrs
Location:	Chilbolton Airfield, Hampshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Undercarriage, leading edge, lift strut and engine
Commander's Licence:	Private Pilot's Licence
Commander's Age:	43 years
Commander's Flying Experience:	330 hours (of which 185 were on type) Last 90 days - 4 hours Last 28 days - 2 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The pilot was landing on Runway 06 at Chilbolton Airfield, a grass runway with power lines to the side and across the extended centreline. The pilot crossed the threshold approximately 10 mph faster than normal, bounced after touchdown and elected to go around. The engine faltered when power was demanded. Rather than risk not clearing the hedge at the end of the runway and power lines ahead, he cut the power, landed and applied full brakes. The aircraft struck the hedge at approximately 15-25 mph and was brought to a halt. The pilot was not injured but the hedge and the aircraft were damaged.

Weather records from airfields in the vicinity indicated that the conditions were conducive to severe carburettor icing under any power setting. The pilot recalled using carburettor heat on the approach but could not rule carburettor icing out as a possible factor.

The pilot stated that the engine faltering was likely due to the carburettor not having an accelerator pump and being more sensitive to mixture setting than other types of carburettor he had used. The pilot stated that he should have taken the known carburettor limitations into account and made an earlier go-around decision.

ACCIDENT

Aircraft Type and Registration:	Maule MX-7-160, N3110J	
No & Type of Engines:	1 Lycoming O-360-C4F piston engine	
Year of Manufacture:	1994 (Serial no: 19031C)	
Date & Time (UTC):	23 June 2016 at 1830 hrs	
Location:	Near Alford, Aberdeenshire	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 1
Injuries:	Crew - None	Passengers - None
Nature of Damage:	Substantial damage, beyond economic repair	
Commander's Licence:	Commercial Pilot's Licence (Federal Aviation Administration, USA)	
Commander's Age:	53 years	
Commander's Flying Experience:	1,185 hours (of which 620 were on type) Last 90 days - n/k hours Last 28 days - n/k hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

Synopsis

The pilot reported that he was attempting to find a landing area, when he encountered a severe downdraft and was unable to climb clear of rising terrain.

History of the flight

The pilot reported that he had planned to fly from a privately operated strip at Fledmyre Field, Forfar, in Angus, to Meikle Eindovie, a location near Alford, Aberdeenshire. He selected Meikle Endovie in the flight planning overlay from the Garmin GPSMap 496 airfield database - it was listed as a microlight/sports airfield site, with its airfield information and coordinates pre-entered in the GPS database - and flew en-route at 3,000 ft to a position indicated on the GPS as being overhead Meikle Endovie. On arrival, he was not able to identify a landing area, so he descended to a height of 600 ft agl, deployed landing flap and circled the position indicated by the GPS.

After three orbits, and still unable to identify the landing area, the pilot was turning to the north when he noticed the VSI indicating a high rate of descent. He applied power and attempted to climb but was not able to clear steeply rising terrain. The aircraft struck a wall and a fence, flipped inverted and suffered substantial damage. The pilot and passenger, who were both wearing lap straps, with a diagonal shoulder strap, were not injured and were able to evacuate the aircraft through their respective side windows. During the accident, the Emergency Locator Transmitter activated, which alerted the emergency services.

The pilot concluded that the accident was caused by a mountain wave which he had encountered while flying at low level on the lee side of the Grampian Mountains.

Accident site

The accident site was situated on open ground between two hills located approximately 1.6 nm south of Alford and 1.4 nm south-west of Meikle Endovie Farm.

Meteorology

The pilot reported that there was a southerly wind of 25 mph in the area of the accident. A Met Office observation at 1800 hrs at Cairn Gorm summit, 30 nm to the south-west of the accident site, recorded a surface wind from the south-south-east at 11 kt. The 1820 hrs METAR for Aberdeen Airport, located 15 nm to the east of the accident site, indicated a surface wind from 160° at 7 kt, CAVOK and no significant weather.

Airfield information

Meikle Eindovie, the destination reported by the pilot, is not a recognised airfield. So, the AAIB contacted the manufacturer of the pilot's GPS, who confirmed that Meikle Endovie is not in the current database.

Other information

The twenty-fifth edition of the Aircraft Owners and Pilots Association (AOPA) Air Safety Institute (ASI) Nall Report[1] identifies manoeuvring at low level as a high risk phase of flight and states: *'the vast majority of fixed-wing maneuvering accidents share a common element: the sequence is initiated at low altitude.'*

Discussion

The pilot reported that the accident occurred while he was manoeuvring the aircraft at low level, in search of his destination airfield. The surface wind was reported to be from the south and the pilot indicated that the aircraft struck the ground while it was on a northerly heading. Recent analysis of general aviation accidents in the USA has identified manoeuvring at low level as a high risk phase of flight. The airfield that the pilot was attempting to locate does not appear to exist.

Footnote

[1] Issued August 2016. The report analyses General Aviation accidents in United States (US) national airspace and on flights departing from or returning to the US or its territories, or possessions, during the most recent year.

ACCIDENT

Aircraft Type and Registration:	Piper PA-28-161 Cadet, G-CDEF
No & Type of Engines:	1 Lycoming O-320-D3G piston engine
Year of Manufacture:	1994 (Serial no: 2841341)
Date & Time (UTC):	11 November 2016 at 1245 hrs
Location:	Sandown (Isle of Wight) Airfield
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 2
Injuries:	Crew - None Passengers - None
Nature of Damage:	Propeller and nosewheel
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	64 years
Commander's Flying Experience:	23,618 hours (of which 17 were on type) Last 90 days - 143 hours Last 28 days - 68 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The pilot stated that he was on a flight from Thruxton, Hampshire, to Sandown, Isle of Wight; an airfield he had not landed at before. Runway 05 was in use and the weather was good with a light wind.

The pilot established on the final approach at a planned approach speed of 70 kt[1]. At about 300 feet, with the IAS at about 65 kt, the pilot noticed that the runway threshold was displaced, so advanced the throttle to increase the speed and land beyond it. The aircraft landing firmly and bounced. After the second touchdown the pilot became aware that the nosewheel was damaged, but the aircraft bounced again, after which the propeller contacted the grass runway and the aircraft stopped. The pilot and passengers vacated uninjured and moved the aircraft clear of the runway.

The pilot believes the initial touchdown may have been just before the displaced threshold and on an upslope. Later he was informed by a witness at the local flying club that motion of the aircraft indicated pilot induced oscillation.

Footnote

[1] The PA-28's Pilot's Operating Handbook states that at its maximum landing weight (MLW) and Flap 40 the final approach speed should be 63 kt. The pilot had increased this to take into account a large passenger. However, the aircraft was less than the MLW.

ACCIDENT

Aircraft Type and Registration:	Silence Twister, G-TWSS
No & Type of Engines:	1 Jabiru 2200A piston engine
Year of Manufacture:	2008 (Serial no: PFA 329-14608)
Date & Time (UTC):	5 June 2016 at 1800 hrs
Location:	Wing Farm Airstrip, Warminster, Wiltshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Fire damage to engine and engine bay
Commander's Licence:	Private Pilot's Licence
Commander's Age:	53 years
Commander's Flying Experience:	2,250 hours (of which 42 were on type) Last 90 days - 43 hours Last 28 days - 14 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

During an attempt to start the engine, and after about 5 seconds of cranking, smoke appeared above the engine cowling. The pilot turned off the fuel and fuel pump while continuing to crank. He then turned off the electrics and ran to a hangar to get a fire extinguisher. He returned to the aircraft about 20 seconds later and was able to extinguish the fire (Figure 1). The fault was traced to a sticking float inside the carburettor.

Figure 1

G-TWSS after the fire was extinguished

ACCIDENT

Aircraft Type and Registration:	Vans RV-8, G-CHPK
No & Type of Engines:	1 Lycoming YIO-360-M1B piston engine
Year of Manufacture:	2014 (Serial no: PFA 303-14535)
Date & Time (UTC):	24 February 2017 at 1400 hrs
Location:	On approach to Bidford Airfield, Warwickshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Engine shock-loaded, propeller, spats and firewall damaged
Commander's Licence:	Private Pilot's Licence
Commander's Age:	65 years
Commander's Flying Experience:	4,000 hours (of which 20 were on type) Last 90 days - 18 hours Last 28 days - 2 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The pilot reported that the takeoff was normal but at a height of approximately 1,500 ft he detected some mild vibration from the engine and decided to return to the airfield. During the downwind leg for a landing on Runway 24 he noted that the exhaust gas temperature (EGT) for the number 4 cylinder was very low at 150ºF. This was lower than the EGT on the other three cylinders, which all read 1,500ºF.

The pilot conducted a glide approach using sideslip to control his height. However, during the flare and landing the sun was in his eyes and he lost his visual references, with the result that the aircraft ran off the side of the runway into a ploughed field and tipped onto its nose. Both occupants were uninjured, but the aircraft sustained damage to the propeller, firewall, and wheel spats.

ACCIDENT

Aircraft Type and Registration:	Aircreation Flexwing BioniX Tanarg 912ES, SP-MTKI	
No & Type of Engines:	Rotax 912S	
Year of Manufacture:	2010	
Date & Time (UTC):	23 August 2016 at 1145hrs	
Location:	Popham Airfield, Hampshire	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	Extensive	
Commander's Licence:	Other	
Commander's Age:	41 years	
Commander's Flying Experience:	500 hours (of which 420 were on type) Last 90 days - 75 hours Last 28 days - 15 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

The pilot was landing on Runway 21 at Popham Airfield with the wind from his left. The pilot reported that it was a very hot day and, with a height above ground of less than a metre, he experienced violent air movement which rotated the aircraft to the right. After loss of directional control the aircraft landed sideways and rolled over. The pilot was unharmed but the aircraft sustained wing and propeller damage.

ACCIDENT

Aircraft Type and Registration:	EV-97 Teameurostar UK, G-CEFZ
No & Type of Engines:	1 Rotax 912-UL piston engine
Year of Manufacture:	2006 (Serial no: 2824)
Date & Time (UTC):	10 January 2017 at 1525 hrs
Location:	Cotswold (Kemble) Airport, Gloucestershire
Type of Flight:	Training
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to right wing, right fuselage and propeller
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	45 years
Commander's Flying Experience:	96 hours (of which 41 were on type) Last 90 days - 3 hours Last 28 days - 2 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and additional enquiries made by the AAIB

The pilot was taxiing in after his first solo flight in two years when the right wingtip struck a fence. He reported that this impact turned the aircraft towards the fence line, causing the nose of the aircraft to strike the fence, destroying the propeller and stopping the engine. The pilot was uninjured and vacated the aircraft normally without assistance. He considered that the completion of his first solo in two years had distracted him from the task of taxiing the aircraft.

ACCIDENT

Aircraft Type and Registration:	EV-97 Teameurostar UK Eurostar, G-CGGM
No & Type of Engines:	1 Rotax 912-UL piston engine
Year of Manufacture:	2009 (Serial no: 3401)
Date & Time (UTC):	8 April 2017 at 1155 hrs
Location:	Wycombe Air Park, Buckinghamshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Floor pan, firewall, nose leg, steering rods and engine frame
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	54 years
Commander's Flying Experience:	121 hours (of which 121 were on type) Last 90 days - 4 hours Last 28 days - 4 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The pilot reported that he had been flying in the local area and, on return to Wycombe, landed on the grass Runway 24. He normally used the parallel hard runway but it was closed as a result of an incident. The visibility was good and the wind was light.

The pilot considered that he landed too fast and consequently the aircraft bounced a couple of times, damaging the nose leg. Although the steering seemed not to be functioning correctly and there was excessive vibration, he was able to taxi to his normal parking spot on the north side of the airfield. Examination revealed extensive damage to the nose leg and surrounding structural components.

ACCIDENT

Aircraft Type and Registration:	Replica Campbell Cricket Cricket, G-BTMP
No & Type of Engines:	1 Rotax 532 piston engine
Year of Manufacture:	1994 (Serial no: PFA G/03-1226)
Date & Time (UTC):	19 February 2017 at 1600 hrs
Location:	Garford Farm Airstrip, Oxfordshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Minor) Passengers - N/A
Nature of Damage:	Rotors bent, right axle broken, nosewheel bracket broken, top engine mount broken and nacelle cracked
Commander's Licence:	Private Pilot's Licence
Commander's Age:	61 years
Commander's Flying Experience:	207 hours (of which 188 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 had not flown for several months and intended to re-familiarise himself by making a short flight along the length of the runway, whilst checking his instruments, and then land. The wind was from the south-south-west at between 5 kt and 10 kt. The pilot initially carried out a short flight along Runway 18, but, due to its relatively short length, he found that it did not provide him with sufficient time to complete the checks that he wanted.

He taxied to Runway 27, which was longer, with the intention of repeating the same short flight. Once airborne, the pilot turned the aircraft to the left and climbed, before then flying a right-hand circuit to land on Runway 27. As he turned onto final approach, the aircraft lost airspeed and height and impacted the ground heavily. It turned onto its side and rotated through 180° before coming to a stop. The pilot suffered minor injuries, but was able to shut down the engine, release himself from his harness and exit the aircraft.

The pilot considered that his lack of recency was a causal factor.

ACCIDENT

Aircraft Type and Registration:	Rotorsport UK MTOsport, G-SIXG	
No & Type of Engines:	1 Rotax 912ULS piston engine	
Year of Manufacture:	2012 (Serial no: RSUK/MTOS/047)	
Date & Time (UTC):	17 December 2016 at 1045 hrs	
Location:	Hope Farm, Braithwaite, Caldbeck, Cumbria	
Type of Flight:	Training	
Persons on Board:	Crew - 1	Passengers - 1
Injuries:	Crew - None	Passengers - 1 (Minor)
Nature of Damage:	Substantial	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	64 years	
Commander's Flying Experience:	3,000 hours (of which all were on type) Last 90 days - 35 hours Last 28 days - 25 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

G-SIXG was flying at approximately 2,000 ft amsl when it struck a bird, causing "violent shaking" of the airframe until the propeller blades detached. The pilot positioned the aircraft for a forced landing onto a field on a southerly heading. He saw power cables running along the side of the field but the low sun prevented him from seeing other power cables running across the field. Just before the aircraft landed it struck one of the cables running across the field, which brought it to a halt and tipped it onto its side. The occupants exited the aircraft unaided although the passenger had minor injuries.

ACCIDENT

Aircraft Type and Registration:	Rotorsport UK MT-03, G-RTIN
No & Type of Engines:	1 Rotax 914-UL piston engine
Year of Manufacture:	2008 (Serial no: RSUK/MT-03/047)
Date & Time (UTC):	13 February 2017 at 1300 hrs
Location:	Turweston Aerodrome, Northamptonshire
Type of Flight:	Training
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Severe damage to rotor assembly and propeller, plus damage to vertical stabiliser, nosecone and right wheel spat
Commander's Licence:	Private Pilot's Licence
Commander's Age:	45 years
Commander's Flying Experience:	915 hours (of which 461 were on type) Last 90 days - 77 hours Last 28 days - 29 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and further AAIB enquiries

Synopsis

After landing directly into wind, the student pilot began taxiing the gyroplane and made a turn to the right. During this turn the control stick moved right without restraint and, with the assistance of the wind which was now from the left of the nose, the gyroplane rolled to the right. The instructor was unable to correct the stick position before the rotor struck the ground, and the gyroplane rolled over onto its right side.

History of the flight

The aim of the flight was for the student pilot to refine his takeoffs and landings with "hops" along the paved Runway 09 at Turweston. Each hop consisted of a takeoff, a short level flight a few feet above the runway, and then a landing. Visibility was good, and the wind was estimated to be from 090º and fairly steady at 13 kt.

Following each landing the gyroplane was stopped and then taxied back to the takeoff point, after being turned left through 180º. To create enough space on the runway for a 180º left turn, the gyroplane was initially turned right and taxied towards the edge of the runway. After the first two "hops", the instructor took control as they taxied and debriefed the student on the previous manoeuvre. During the next "hops", the instructor took control of the throttle only whilst they were airborne, so the student could concentrate on his control stick inputs. The instructor believed the handover of control was always executed clearly, using appropriate "I have control" and "you have control" announcements.

Following the fifth landing and with the gyroplane stopped, the instructor recalled handing control of the throttle back to the student. The instructor reported that as the right turn began, he believed the student was in full control, the control stick was fully forward and he, the instructor, was "covering" it to prevent any inappropriate rearwards movement of the stick. At this stage, with the wind from the left of the nose, the control stick moved right quickly.

The gyroplane rolled right and the instructor was unable to intervene before he felt he had to withdraw his arms and brace for impact with the ground. When the gyroplane came to rest, the instructor made an appropriate radio call on the air/ground frequency, before he and the student unstrapped and vacated the open cockpit.

Student's recollection

The student was unsure of the precise accident sequence although he remembered landing and coming to a halt before he moved the control stick fully forward. He thought he then detected the instructor making inputs on the control stick and, as there had been a lot of changing of control during the flight, he assumed the instructor was now controlling the stick. When they taxied forward he believes he was steering with the foot pedals to turn right and he recalled the control stick moving quickly right before the gyrocopter over-turned.

Instructor's assessment

Although the instructor was sure that neither he took control, nor did the student offer him control before taxiing commenced, he appreciated that the previous exchanges of control/partial control might have confused the student, who he assessed was in a high workload situation. It was unclear how the control stick initially moved to the right but, once this happened and the gyroplane started turning right, the underside of the rotor disc was exposed to the wind, which was now from the left of the nose. With a relatively high rotor speed and a brisk wind, the rotor probably lifted quickly, moving the control stick further right and rolling the gyroplane rapidly right.

The instructor has stated that he now ensures the rotor rpm is slower before taxiing commences, and that he is more vigilant for circumstances that require him to assume control.

ACCIDENT

Aircraft Type and Registration:	UAS Schiebel Camcopter S-100 (unregistered)
No & Type of Engines:	1 Austro Engine Wankel R-1
Year of Manufacture:	2008 (Serial no: 232)
Date & Time (UTC):	18 October 2016 at 0926 hrs
Location:	Ship stationed off the coast of Benbecula, Outer Hebrides
Type of Flight:	Aerial Work
Persons on Board:	Crew - N/A Passengers - N/A
Injuries:	Crew - N/A Passengers - N/A
Nature of Damage:	Destroyed on impact with, and immersion in, water
Commander's Licence:	N/A
Commander's Age:	31 years
Commander's Flying Experience:	999 hours (of which 999 were on type) Last 90 days - 8 hours Last 28 days - 6 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot, and manufacturer's investigation report

Synopsis

As the unmanned aircraft (UA) lifted off from the ship's helideck it immediately pitched up and transited rearwards with insufficient height to clear the 19-cm high gunwale about 2 m behind it. The impact damaged the UA tail structure, leading to a failure of the tail rotor transmission and resulting in the UA spiralling into the sea alongside the ship.

Following an investigation by the manufacturer software changes have been made to reduce operator workload during the takeoff.

History of the flight

The flight was part of a trial to demonstrate the transfer of command and control from a land-based control station to one located on the ship *SD Northern River*. The ship-based pilot control operator, positioned on the ship's deck adjacent to the helipad, took control of the UAS and was flying a series of planned deck landings and takeoffs. These were uneventful until the third takeoff when, as the UAS became airborne, it immediately pitched up and transited rearwards with insufficient height to clear the 19-cm high gunwale about 2 m behind it. The wind was 310° at 13 kt.

The impact damaged the UA tail structure which subsequently led to a failure of the tail rotor transmission, resulting in the UA spiralling into the sea alongside the ship where it sank to the seabed. The water depth was approximately 30 m.

The UAS was recovered 48 hours later and sent to the manufacturer, where the on-board data logger was downloaded and the recorded data analysed.

UAS information

General

The Schiebel CAMCOPTER S-100 (Figure 1) is a vertical takeoff and landing (VTOL) UAS that can operate at day and night with a data-link range of 200 km. It can navigate automatically via pre-programmed GPS waypoints or can be operated with a control unit carried by the pilot control operator. Its maximum airspeed is 130 kt; a loiter speed of 55 kt provides a maximum endurance of more than 6 hours with a 35 kg payload (extendable to over 10 hours with optional external AVGAS fuel tanks fitted). The maximum wind speed for takeoff and landing is 25 kt. It is 3.11 m long, 1.12 m high and has a main rotor diameter of 3.4 m. The empty mass is 110 kg and the maximum takeoff mass is 200 kg. Payload capacity is 50 kg.

Figure 1
Schiebel CAMCOPTER S-100

Operator control of the UA

The UA control unit carried by the operator includes a joystick for cyclic control with a force sensitive thumb rocker sensor located on the top for climb-rate inputs (Figure 2). It includes a display of input commands.

The control system also includes a selectable trim mode that enables the operator to enter a trim setting for the UA. However, the trim does not take effect until the UA is airborne and certain climb performance and control conditions are met.

Figure 2
Operator joystick showing climb-rate thumb rocker control

Shipboard take-off procedures

For shipboard operations, the manufacturer specifies that a climb-rate input of at least 55% (of the maximum) is required for takeoff. This is emphasised during pilot operator training.

Manufacturer's investigation findings

An investigation was carried out by the manufacturer which, in summary, determined that for all three takeoffs, the operator's climb-rate inputs were below the 55% minimum required for shipboard operations. For the accident flight this started at 37%, reducing to 7% over 1.3 seconds; however, this was in addition to a rear cyclic command not present on the first two takeoffs until the UA was higher off the helideck. As the UA moved backwards without climbing, the operator selected 100% climb rate but continued to command more rear cyclic, increasing rearward acceleration. The investigation also noted that the ship's upward heave at the time also contributed to the UA's failure to climb away from the ship.

The logged data also suggested that the conditions for the trim commands to become active would have been met about 2.2 seconds after takeoff (about 0.1 seconds before the collision).

Safety action

The manufacturer has implemented a software change to reduce operator workload during takeoff. If the UA is on the ground and the trim mode has been selected:

- Operator thumb rocker climb-rate inputs between -50% and +50% produce an automatic climb rate command of +50% until the trim becomes active, and
- All cyclic joystick inputs are ignored until the trim becomes active.

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).

BULLETIN CORRECTION

Aircraft Type and Registration:	Tango 2, RA-0542A
Date & Time (UTC):	25 August 2016 at 1345 hrs
Location:	Popham Airfield, Hampshire
Information Source:	Aircraft Accident Report Form submitted by the pilot

AAIB Bulletin No 5/2017, page 52 refers

There was an error in the report header information when this report was sent to press.. The text should read:

Persons on Board: Crew **- 2** Passengers - None

The online version of this report was corrected when published on 11 May 2017.

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

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

Published November 2011.

1/2014 Airbus A330-343, G-VSXY
at London Gatwick Airport
on 16 April 2012.

Published February 2014.

2/2014 Eurocopter EC225 LP Super Puma
G-REDW, 34 nm east of Aberdeen, Scotland on 10 May 2012
and
G-CHCN, 32 nm south-west of Sumburgh, Shetland Islands
on 22 October 2012.

Published June 2014.

3/2014 Agusta A109E, G-CRST
Near Vauxhall Bridge, Central London
on 16 January 2013.

Published September 2014.

1/2015 Airbus A319-131, G-EUOE
London Heathrow Airport
on 24 May 2013.

Published July 2015.

2/2015 Boeing B787-8, ET-AOP
London Heathrow Airport
on 12 July 2013.

Published August 2015.

3/2015 Eurocopter (Deutschland) EC135 T2+, G-SPAO
Glasgow City Centre, Scotland
on 29 November 2013.

Published October 2015.

1/2016 AS332 L2 Super Puma, G-WNSB
on approach to Sumburgh Airport
on 23 August 2013.

Published March 2016.

2/2016 Saab 2000, G-LGNO
approximately 7 nm east of Sumburgh Airport, Shetland
on 15 December 2014.

Published September 2016.

1/2017 Hawker Hunter T7, G-BXFI
near Shoreham Airport
on 22 August 2015.

Published March 2017.

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

GLOSSARY OF ABBREVIATIONS

aal	above airfield level
ACAS	Airborne Collision Avoidance System
ACARS	Automatic Communications And Reporting System
ADF	Automatic Direction Finding equipment
AFIS(O)	Aerodrome Flight Information Service (Officer)
agl	above ground level
AIC	Aeronautical Information Circular
amsl	above mean sea level
AOM	Aerodrome Operating Minima
APU	Auxiliary Power Unit
ASI	airspeed indicator
ATC(C)(O)	Air Traffic Control (Centre)(Officer)
ATIS	Automatic Terminal Information System
ATPL	Airline Transport Pilot's Licence
BMAA	British Microlight Aircraft Association
BGA	British Gliding Association
BBAC	British Balloon and Airship Club
BHPA	British Hang Gliding & Paragliding Association
CAA	Civil Aviation Authority
CAVOK	Ceiling And Visibility OK (for VFR flight)
CAS	calibrated airspeed
cc	cubic centimetres
CG	Centre of Gravity
cm	centimetre(s)
CPL	Commercial Pilot's Licence
°C,F,M,T	Celsius, Fahrenheit, magnetic, true
CVR	Cockpit Voice Recorder
DME	Distance Measuring Equipment
EAS	equivalent airspeed
EASA	European Aviation Safety Agency
ECAM	Electronic Centralised Aircraft Monitoring
EGPWS	Enhanced GPWS
EGT	Exhaust Gas Temperature
EICAS	Engine Indication and Crew Alerting System
EPR	Engine Pressure Ratio
ETA	Estimated Time of Arrival
ETD	Estimated Time of Departure
FAA	Federal Aviation Administration (USA)
FDR	Flight Data Recorder
FIR	Flight Information Region
FL	Flight Level
ft	feet
ft/min	feet per minute
g	acceleration due to Earth's gravity
GPS	Global Positioning System
GPWS	Ground Proximity Warning System
hrs	hours (clock time as in 1200 hrs)
HP	high pressure
hPa	hectopascal (equivalent unit to mb)
IAS	indicated airspeed
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
IP	Intermediate Pressure
IR	Instrument Rating
ISA	International Standard Atmosphere
kg	kilogram(s)
KCAS	knots calibrated airspeed
KIAS	knots indicated airspeed
KTAS	knots true airspeed
km	kilometre(s)
kt	knot(s)
lb	pound(s)
LP	low pressure
LAA	Light Aircraft Association
LDA	Landing Distance Available
LPC	Licence Proficiency Check
m	metre(s)
mb	millibar(s)
MDA	Minimum Descent Altitude
METAR	a timed aerodrome meteorological report
min	minutes
mm	millimetre(s)
mph	miles per hour
MTWA	Maximum Total Weight Authorised
N	Newtons
N_R	Main rotor rotation speed (rotorcraft)
N_g	Gas generator rotation speed (rotorcraft)
N_1	engine fan or LP compressor speed
NDB	Non-Directional radio Beacon
nm	nautical mile(s)
NOTAM	Notice to Airmen
OAT	Outside Air Temperature
OPC	Operator Proficiency Check
PAPI	Precision Approach Path Indicator
PF	Pilot Flying
PIC	Pilot in Command
PNF	Pilot Not Flying
POH	Pilot's Operating Handbook
PPL	Private Pilot's Licence
psi	pounds per square inch
QFE	altimeter pressure setting to indicate height above aerodrome
QNH	altimeter pressure setting to indicate elevation amsl
RA	Resolution Advisory
RFFS	Rescue and Fire Fighting Service
rpm	revolutions per minute
RTF	radiotelephony
RVR	Runway Visual Range
SAR	Search and Rescue
SB	Service Bulletin
SSR	Secondary Surveillance Radar
TA	Traffic Advisory
TAF	Terminal Aerodrome Forecast
TAS	true airspeed
TAWS	Terrain Awareness and Warning System
TCAS	Traffic Collision Avoidance System
TGT	Turbine Gas Temperature
TODA	Takeoff Distance Available
UHF	Ultra High Frequency
USG	US gallons
UTC	Co-ordinated Universal Time (GMT)
V	Volt(s)
V_1	Takeoff decision speed
V_2	Takeoff safety speed
V_R	Rotation speed
V_{REF}	Reference airspeed (approach)
V_{NE}	Never Exceed airspeed
VASI	Visual Approach Slope Indicator
VFR	Visual Flight Rules
VHF	Very High Frequency
VMC	Visual Meteorological Conditions
VOR	VHF Omnidirectional radio Range

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