AAIB
Air Accidents Investigation Branch

AAIB Bulletin 7/2015

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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.

ACCIDENT

Aircraft Type and Registration:	Hawker Sea Fury T Mk 20, G-RNHF	
No & Type of Engines:	1 Bristol Centaurus XVIII piston engine	
Year of Manufacture:	1949 (Serial no: ES3615)	
Date & Time (UTC):	31 July 2014 at 1601 hrs	
Location:	RNAS Culdrose, Cornwall	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	Engine internal disruption, right wingtip, flap and minor fuselage abrasion damage	
Commander's Licence:	Military	
Commander's Age:	44 years	
Commander's Flying Experience:	3,545 hours (of which 232 were on type) Last 90 days - 54 hours Last 28 days - 35 hours	
Information Source:	AAIB Field Investigation	

Synopsis

The aircraft was performing in a public air display at Culdrose when the pilot became aware of a significant engine vibration and then a corresponding loss of thrust. Despite the loss of engine power the pilot was able to land the aircraft on the runway but the landing gear collapsed on touchdown, causing it to veer off the runway. The aircraft came to a stop on the grass approximately 1,500 ft from the initial touchdown point. The pilot vacated the aircraft unaided and without injury. The accident was a result of the loss of engine power caused by severe mechanical disruption within the 'front row' crankcase of the engine. The breakup may have been caused by the failure of an articulated connecting rod wrist pin bearing, possibly due to overheating, the cause of which is not yet known. Forensic investigation is continuing, to establish the exact cause.

History of the flight

The aircraft launched to carry out a public air display at RNAS Culdrose. The pilot noted at takeoff that all the engine temperatures and pressures were normal and remained so during the first few manoeuvres of the display. However, as the aircraft descended from 2,000 feet at 200 KIAS for the next stage of the display, the pilot became aware of a significant engine vibration and brought the power back to a "more gentle" cruise position and declared a PAN. The instrument panel was vibrating but no abnormal indications were evident and the pilot could not accurately read the engine oil pressure. At about this time witnesses saw white smoke coming from the engine exhaust stubs. The pilot immediately aborted the manoeuvre and used the aircraft inertia to zoom-climb back to 2,000 feet at 130 KIAS and then positioned the aircraft abeam for a landing on Runway 30. As he approached the runway he lowered the landing gear and lowered the nose to maintain 130 KIAS. At this point he opened the throttle to maintain the runway sight line but it became clear that the engine was producing no usable power. The glide angle was unsuitable so the pilot selected rpm to AUTO to coarsen the propeller and he raised the landing gear to reduce drag and improve the glide angle. He considered abandoning the aircraft but decided against it as the actions already taken, along with selection of flap, had improved the situation and gave a probable touchdown point just inside the airfield boundary.

The pilot initially aligned the aircraft to the left of the runway and then, as the aircraft flared over the grass, manoeuvred towards the runway for landing. He noted that there seemed to be sufficient hydraulic pressure being developed by the still-turning engine and re-selected the landing gear down, to minimise damage to the aircraft. After holding off for as long as possible he landed the aircraft with a gentle touchdown, on the left landing gear followed by the right. At this point the right landing gear folded, the wing dropped and the propeller blades struck the runway. The aircraft veered to the right and shortly before leaving the runway the left landing gear also collapsed. The aircraft eventually came to a stop on the grass, approximately 1,500 feet from the initial touchdown point. The pilot then made the aircraft safe and exited without further incident. The aircraft had sustained damage to all five propeller blades, the spinner and to the underside of the fuselage, landing gear and wing (Figure 1). Both sides of the fuselage and tailplane were almost completely covered by a film of oil. Despite the loss of power and the propeller impact with the ground, the engine had no external signs of damage.

Figure 1

Sea Fury T Mk 20 G-RNHF

Bristol Centaurus Mk18 engine description

The Centaurus engine was designed and built by the Bristol Aeroplane Company in the early 1940s for use in a variety of single and multi-engine aircraft types. It was derived from the Bristol Perseus and Hercules engines used before and during World War II. The Centaurus was, and remains, one of the most powerful piston aero-engines to enter service and was very successful in the Hawker Sea Fury. The engine is an eighteen-cylinder double-row sleeve valve supercharged radial, with a 53 litre capacity and capable of producing 2,500 horsepower. In the Sea Fury it is fitted with a five-bladed Rotol propeller. This combination gives the aircraft a service ceiling of 35,800 ft and a top speed of 460 mph at 18,000 ft. G-RNHF is a T Mk 20 which is the two-seat trainer variant of the Sea Fury aircraft.

Fuel, ignition and lubricating systems

Fuel is metered via an injection carburettor and ignition is by twin magnetos and two spark plugs per cylinder. The engine has a direct-pressure filtered 'dry sump' lubrication system and oil is fed under pressure to the main crankshaft white metal bearing and, via drillings, to each wrist pin. The wrist pin bearings are made of phosphor bronze, an alloy of copper, tin and a small proportion of phosphor. The pistons, gudgeon pins, cylinders and sleeve valves are lubricated by splash and oil jets.

Valve gear

The engine uses sleeve valves rather than conventional poppet valves. The advantages of sleeve valves are a high volumetric efficiency and better thermodynamics and gas flow during combustion. They also overcome the problems of 'valve bounce', spring resonance and inertia; the energy required to operate sleeve valves remains constant throughout the rpm range. The disadvantages are that sleeve valves require a complex gear drive and synchronising mechanism and can have lubricating, sealing and cooling problems, along with high oil usage.

In the Centaurus the sleeve valves in each cylinder row are driven by front and rear spur reduction gear trains. There are three gear sets per row, driven by the crankshaft, and each set has three outputs to the sleeve cranks. The cranks are attached to the sleeves by knuckle joints and as the cranks rotate, the sleeves are driven up and down the cylinders. The arrangement of the cranks causes the sleeves to twist through a few degrees as they pass up and down the cylinder.

Engine history

This engine, serial number 37726, was one of four originally exported to Iraq by the Bristol Aeroplane Company in the late 1940s. In 2010 the engine returned to the UK still in its original crate and was stripped to confirm fits and clearances. An internal inspection confirmed it as only ever having been test run and the overhaul required one sleeve replacement, due to corrosion, along with rubber parts for age-related deterioration. The engine was fitted to G-RNHF and by the date of the accident had accumulated 220 hrs of its 500 hr overhaul life.

Engineering investigation

After the accident, the aircraft was recovered to a hangar at RNAS Culdrose and the damage assessed. The damage to the fuselage, wing and flaps was minor and attributable to the aircraft veering from the runway and sliding along the grass. The propeller blade damage was consistent with striking the ground at low power. The evidence suggested that a major but contained component failure had occurred within the engine, although there were no outward signs of distress. There were approximately 10 gallons of lubricating oil removed from the tank and oil and filter debris samples were sent for analysis. The engine was removed and transferred to the aircraft maintenance facility at North Weald. After a boroscope examination the cylinder heads were removed, which revealed that the No16 (front-row) piston and articulated connecting rod ('con-rod') were missing. Figure 2 shows the distressed wrist pins through the No16 cylinder. There was also substantial mechanical damage to the other visible con-rods, of which some were detached from the master con-rod.

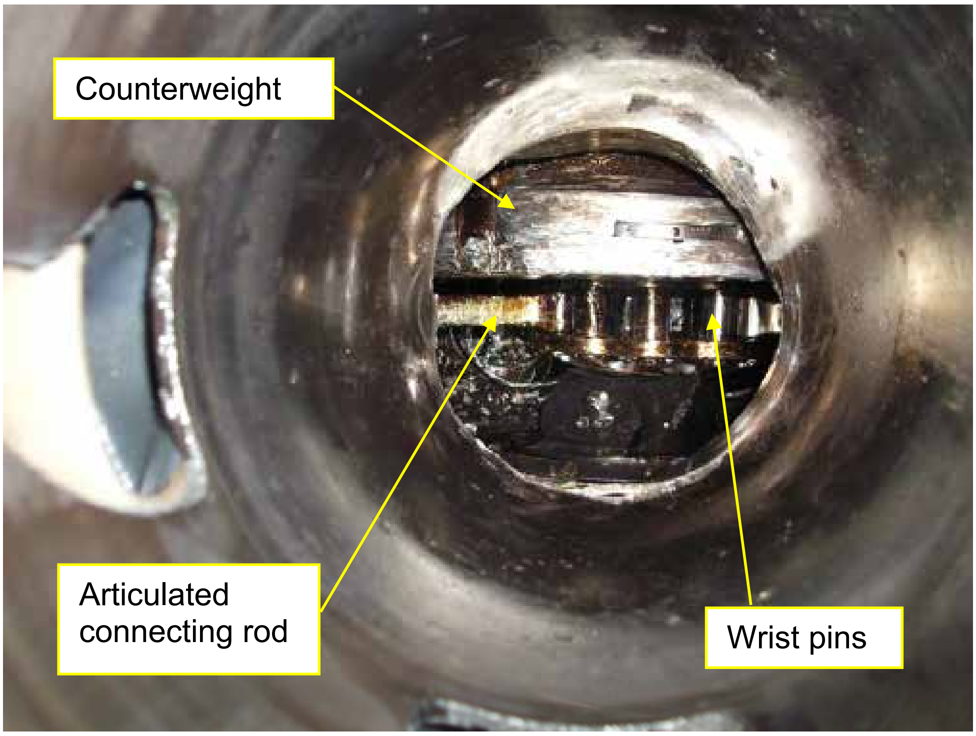

Figure 2

Master con-rod wrist pins viewed through the No16 cylinder

Further conventional disassembly was not possible due to distortion of the cylinders and sleeve valves. In order the gain access to the front row crankcase the gear carrier plate was chain drilled and removed. Figure 3 shows the crankcase component damage and debris.

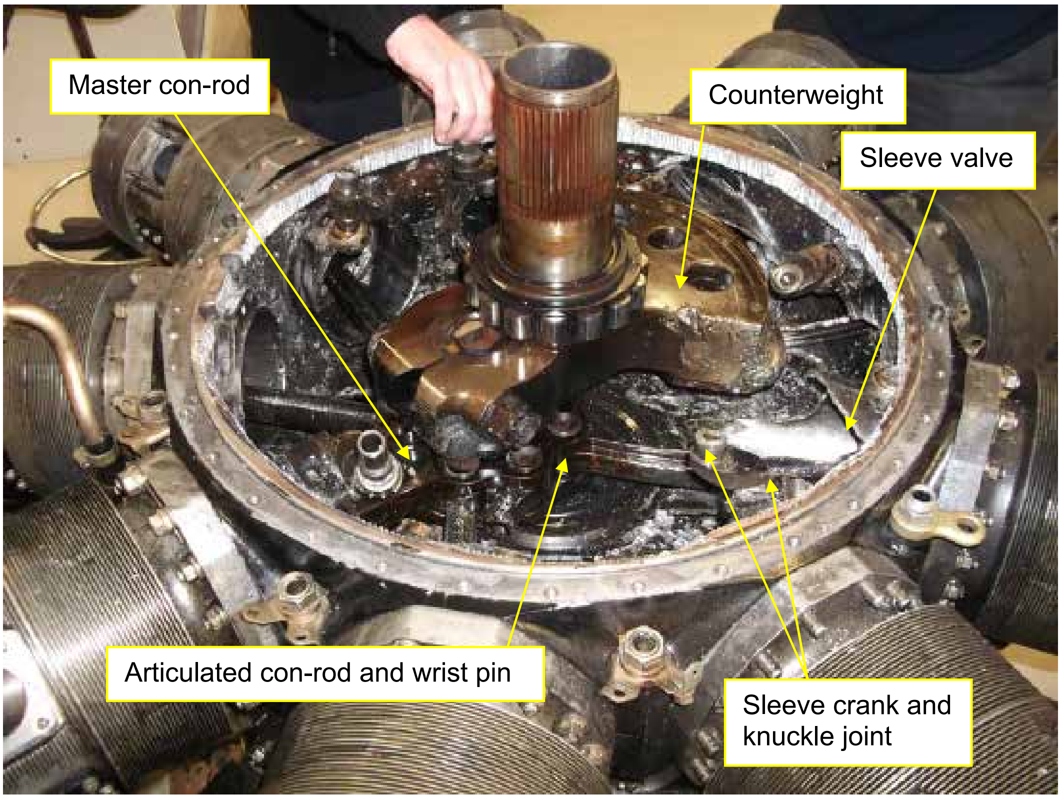

Figure 3
Front row crankcase component damage

The majority of the components within the crankcase were severely damaged. All the sleeve driveshafts showed signs of torsional overload and some of the driveshafts had failed. The majority of the knuckle joints, which attach the drive crank to the sleeve, were damaged and in some cases had detached. Several of the sleeves had been severely damaged, in particular where they had extended out of their respective cylinders into the path of the crankshaft counterweight. Multiple impact marks were also present as a result of increasing amounts of churned-up debris. The front row sleeve valve gear trains were generally intact and meshed, except for one of the valve crank drive and idler gears which had damage indicative of gear tooth overload.

Closer examination of the debris removed from the crankcase identified forged steel con-rod and aluminium piston material. The remains of No16 piston were found loose and had the appearance of a pulverised and flattened sphere. The con-rod material, particularly from the wrist pin ends, showed signs of extreme heating and appeared to have been splattered with molten copper. Examination of the wrist pins and their associated holes in the master con-rod showed similar evidence and one of the broken con-rod wrist pin ends exhibited the characteristics of plastic deformation leading to failure. Lubricating oil was present throughout the crankcase but showed evidence of overheating and had lacquered various surfaces. It was also observed that the gear carrier diaphragm outer surface was discoloured with hot oil lacquering. Normally this surface would be a bright silver grey.

The rear row of cylinders, con-rods, sleeve valves and pistons were generally undamaged, although some metallic debris had found its way through ports in the diaphragm which separates the front and rear row. The supercharger, plugs, magnetos and accessories were also found undamaged.

The results of the oil analysis showed that, although various metallic chemical elements were present, their levels were only slightly above those found in normal running and were consistent with previous routine sample analysis of this engine. However, the filter was heavily contaminated with metallic debris and twelve different types of metal were identified including white metal, bronze, aluminium and various types of carbon steel.

Analysis

Witness video evidence showed the aircraft carrying out the various phases of the display normally. However, during one of the manoeuvres white smoke emerged from the exhaust stubs on both sides of the aircraft. The propeller remained turning, at a reduced rpm, until eventual impact with the ground. The pilot was of the opinion that, although the engine was not producing significant power, one row of cylinders continued to operate. The evidence confirms that it was the rear row of cylinders that continued to operate. The performance, temperatures, pressures and settings of the engine seemed normal. This led the pilot to believe that, in the early stages of the incident, he just had a rough running engine. It was only after he attempted to change his power setting that he realised that all was not well and that the engine could not be relied upon. Despite the engine problem the pilot was able to make a forced landing and cause little further damage to the aircraft.

There are two possibilities as to the nature of the initiating event within the engine. The lack of any physical warning immediately prior to the engine failure suggests that the situation may have developed slowly, without adversely effecting other systems or components. Alternatively, it is possible that the initiating event occurred very quickly, leaving no time for secondary indications. The evidence of heat on remote components, such as the gear carrier diaphragm, indicates that it was a slow development.

The localised heat evidence on the master con-rod suggests that one or more adjacent wrist pin and con-rod bearings overheated, leading to material failure and resulting in a piston, and the remains of its con-rod, stopping in its sleeve. The clearance of the crankshaft counterweight is such that anything in its path would be struck with massive force. It appears that the No16 con-rod was caught and dragged out of its cylinder and this resulted in it being knocked around the inside of crankcase, causing further damage. The counterweight and knuckle joint clearance is very small, so damage caused by high-energy loose debris impact would quickly lead to sleeve valve de-synchronisation.

Some of the sleeve valves were found at or below lowest points of travel in the path of the counterweight, with substantial swaging and tearing of their lower ends, enough to jam them within the cylinders. This disruption is likely to have caused the gear slip and the torsional damage found on the cranks, which led to the complete loss of synchronisation and further damage to the sleeves.

Conclusion

The engine failure was a result of the breakup of mechanical components within the front row of the crankcase. The evidence suggests the failure sequence included the failure of one of the articulated con-rods, in the vicinity of its wrist pin bearing, and that this was caused by severe heating. The cause of the overheating is yet unknown. Forensic investigation is continuing, to establish the exact cause of the engine failure.

ACCIDENT

Aircraft Type and Registration:	Jetstream 3102 31, G-GAVA
No & Type of Engines:	2 Garrett Airesearch TPE331-10UGR-516H turboprop engines
Year of Manufacture:	1987 (Serial no: 785)
Date & Time (UTC):	15 August 2014 at 1836 hrs
Location:	Doncaster Sheffield Airport, Yorkshire
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 2 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Left main landing gear, left propeller, fuselage and wing
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	54 years
Commander's Flying Experience:	8,740 hours (of which 3,263 were on type) Last 90 days - 147 hours Last 28 days - 60 hours
Information Source:	AAIB Field Investigation

Synopsis

The aircraft's left main landing gear failed shortly after it landed on Runway 20 at Doncaster Sheffield Airport. The left main landing gear detached from its mounts and the aircraft slid along the runway on its remaining landing gear, left wingtip and baggage pannier, before veering off the runway and coming to rest on the adjacent grass. The single passenger and the flight crew vacated the aircraft without injury. The failure occurred as a result of stress corrosion cracking in the forward pintle housing, at the top of the left landing gear cylinder.

The same aircraft, operating under a different registration, was involved in a similar accident in 2012[1] during which the right main landing gear failed in the same location, also due to stress corrosion cracking.

This investigation determined that a design solution implemented by the aircraft manufacturer following the 2012 accident, which introduced a protective washer on the forward pintle housing, had not met its original design intent. A fouling condition, not identified when the design solution was first implemented, caused rotational movement of the protective washer on G-GAVA resulting in degradation of the surface protection on the forward pintle

Footnote

[1] G-CCPW at Isle of Man Airport on 8 March 2012, report EW/C2012/03/03, published in AAIB Bulletin 10/2012.

housing. This created conditions conducive to the formation of corrosion pits, from which a stress corrosion crack initiated and propagated to failure.

This report follows publication of AAIB Special Bulletin S5/2014, in which two Safety Recommendations were made. One additional Safety Recommendation is made.

History of the flight

G-GAVA took off from Belfast City Airport at 1745 hrs operating a scheduled air service to Doncaster Sheffield Airport with one passenger and a crew of two pilots on board. The commander was the Pilot Flying (PF) and the co-pilot was the Pilot Monitoring (PM).

The departure, cruise and approach to Doncaster Sheffield were uneventful. The 1820 hrs ATIS for the airport stated that the wind was from 260° at 5 kt, varying between 220° and 280°. Visibility was greater than 10 km, there were few clouds at 3,000 ft aal, the temperature was 17°C and the QNH was 1,019 hPa. Although Runway 02 was the active runway, the crew requested radar vectors for a visual final approach to Runway 20, a request which was approved by ATC. The loadsheet recorded that the aircraft's mass at landing was expected to be 5,059 kg which required a target threshold indicated airspeed (IAS) of 101 kt.

The aircraft touched down at 1836 hrs with an IAS of 102 kt and a peak normal acceleration of 1.3 g, and the commander moved the power levers aft to GROUND IDLE and then to REVERSE. As the aircraft decelerated, the commander moved the power levers forward to GROUND IDLE and asked the co-pilot to move the RPM levers to TAXI. At an IAS of 65 kt, eight seconds after touchdown, the left wing dropped suddenly, the aircraft began to yaw to the left and the commander was unable to maintain directional control with either the rudder or the nosewheel steering tiller. The aircraft ran off the left side of the runway and stopped on the grass having turned through approximately 90°. The left landing gear had collapsed and the aircraft had come to a halt resting on its baggage pannier, right landing gear and left wing (Figure 1).

Figure 1

The aircraft as it came to rest

The commander pulled both feather levers, to ensure that both engines were shut down, and switched the Electrics Master switch to EMERGENCY OFF. The co-pilot transmitted "TOWER……[CALLSIGN]" and the controller replied "[CALLSIGN] COPIED, EMERGENCY SERVICES ON THEIR WAY". The commander instructed the co-pilot to evacuate the aircraft. The co-pilot moved into the main cabin where he found that the passenger appeared to be uninjured. He considered evacuating the aircraft through the emergency exit on the right side but judged that the main exit on the left side at the rear of the cabin would be the best option. The left side cabin door released normally but would not open completely because the sill of the doorway was at ground level (Figure 1) but, all occupants were able to evacuate the aircraft.

The Aerodrome Controller in the ATC tower activated the Crash Alarm at 1836 hrs while the aircraft was still on the paved surface of the runway. Two Rescue and Fire Fighting Service vehicles arrived on scene at 1838 hrs by which time the occupants were clear of the aircraft.

Recorded information

The aircraft was fitted with a 30-minute Cockpit Voice Recorder (CVR) and a Flight Data Recorder (FDR); both recorders captured the landing. The FDR recorded just over 116 hours of operation but only five parameters which were pressure altitude, heading, airspeed, normal acceleration and a VHF transmission discrete. Additionally, a Terrain Awareness and Warning System (TAWS) was installed in the aircraft recording 30 separate parameters, including aircraft rate of descent, time and pressure altitude, at a higher sampling rate than the FDR.

A review of the previous 82 landings recorded on the FDR has not identified any of concern with the highest normal acceleration at touchdown of 1.72g recorded during the 18th landing prior to the accident.

The aircraft touched down at 1835:52 hrs at an IAS of 102 kt and normal acceleration of 1.3g (Figure 2). Recorded rate of descent was approximately 245 ft/min (4 ft/sec) which was within the touchdown landing gear load limit which is defined as a rate of descent of 10 ft/sec at a maximum landing weight of 14,900 lb (6,758 kg).

While decelerating through a groundspeed of 65 kt, a normal acceleration spike was recorded, indicating the point at which the left main landing gear failed.

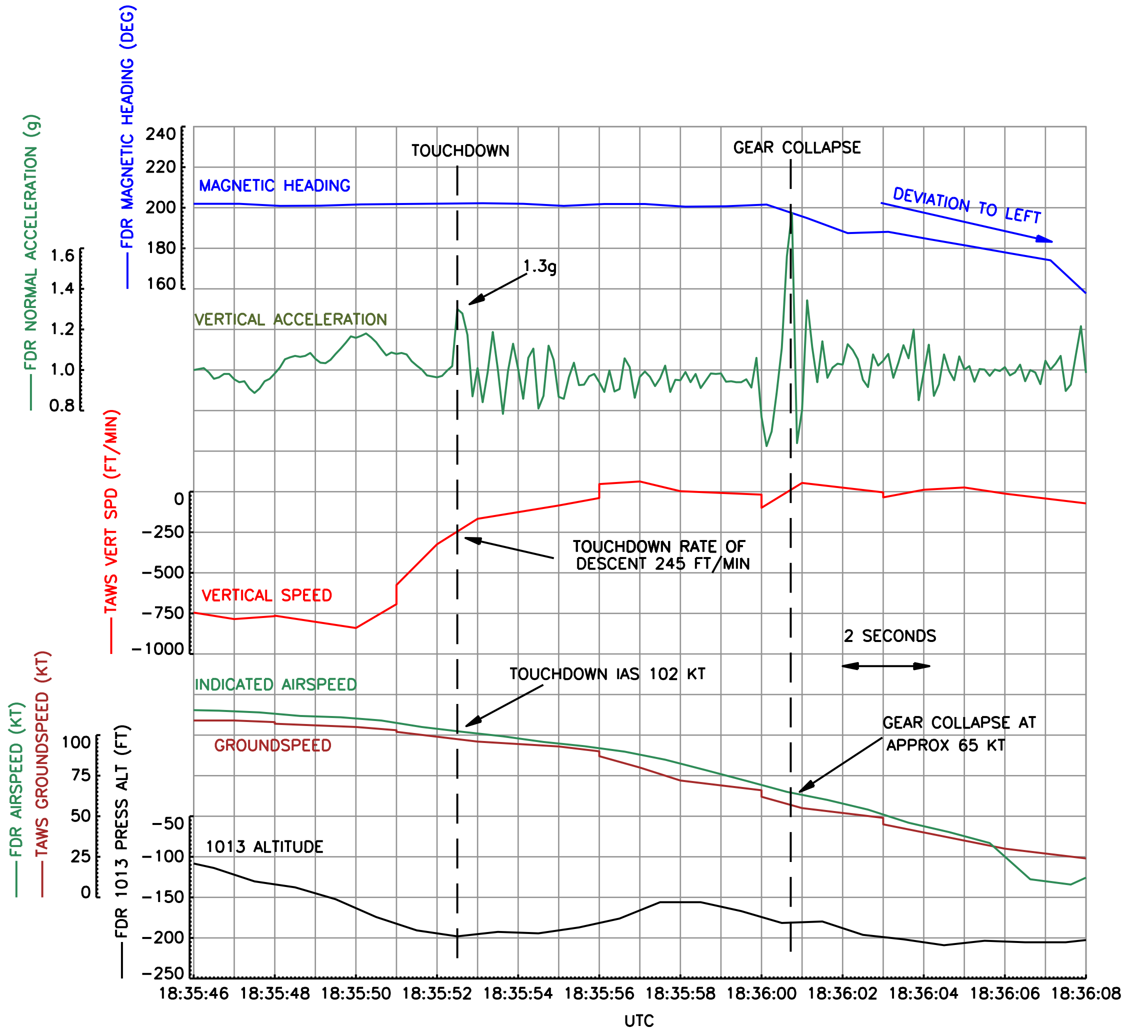

Figure 2

Flight data recorded during the landing

Runway marks

The aircraft left a number of marks on the runway, starting approximately 370 m from the start of the runway threshold markings. The first marks were made by the top of the left landing gear cylinder, after it had folded under the wing, followed immediately by the left engine propeller striking the runway surface.

Aircraft damage

The left landing gear had broken away from its mounts as a result of the failure of the forward pintle housing. Two sections of the pintle housing stayed attached to the pintle spigot (Figure 3). However, the landing gear remained attached to the aircraft by the radius arm (retraction jack) and hydraulic pipelines.

The blades on the left engine propeller had been badly damaged. The left aileron balance horn separated from the aircraft after it left the runway, becoming lodged in the soft ground. The left wingtip had sustained abrasion damage, resulting in a fuel leak from this area. The baggage pannier and anti-collision beacon on the underside of the fuselage also sustained considerable abrasion damage.

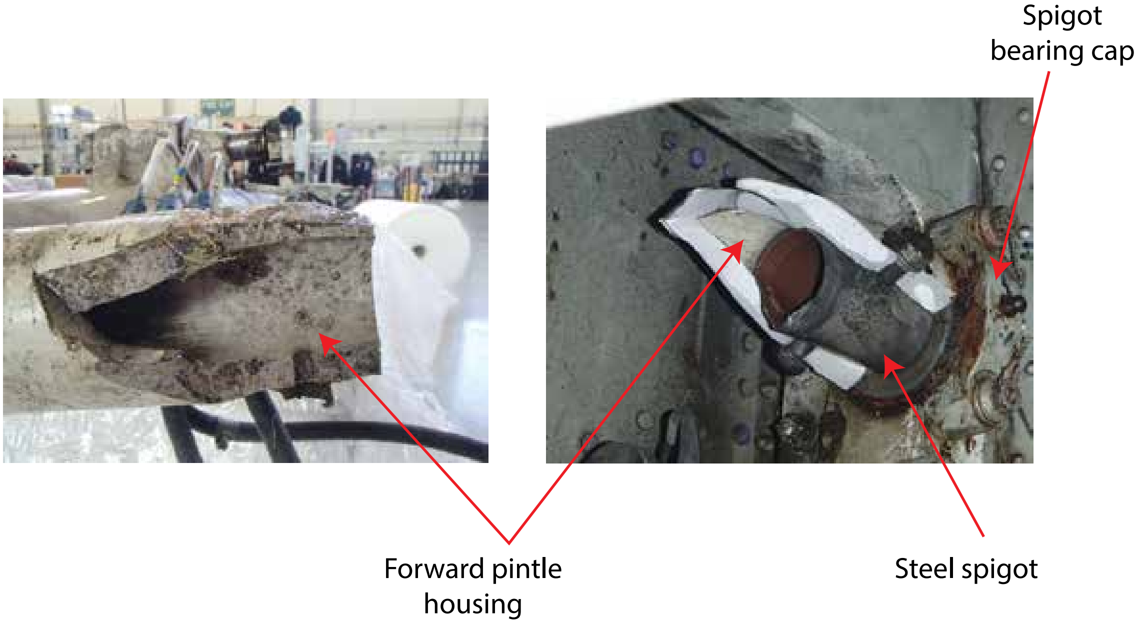

Figure 3

Left main landing gear forward pintle housing

Landing gear

The Jetstream 31 main landing gear leg consists of a cylinder, manufactured from DTD 5094 aluminium alloy, and an inner sliding tube on which the single wheel and brake assembly are mounted. The landing gear cylinder is attached to the airframe by a yoke which fits onto steel spigots, which are bolted through the pintle housings. The upper surfaces on the forward and rear pintle housings are machined flat to introduce a weak link which will fail, allowing the landing gear to detach from the airframe without damaging the fuel tanks, if it is subjected to a force outside its design limits. During the accident, the forward pintle housing failed along the machined flat (Figure 4).

The DTD 5094 landing gear cylinder is known to be susceptible to stress corrosion cracking (SCC) and similar landing gear failures have occurred on other Jetstream 31 aircraft. In particular, SCC has occurred in the forward pintle housing as a result of the forward face rotating against the spigot bearing during extension and retraction of the landing gear. The resulting abrasion causes degradation of the protective surface treatment, the consequent formation of corrosion pits and, ultimately, cracking. The Jetstream 32 main landing gear cylinder and later versions of the Jetstream 31 main landing gear cylinder are manufactured from L161 alloy and are not susceptible to SCC.

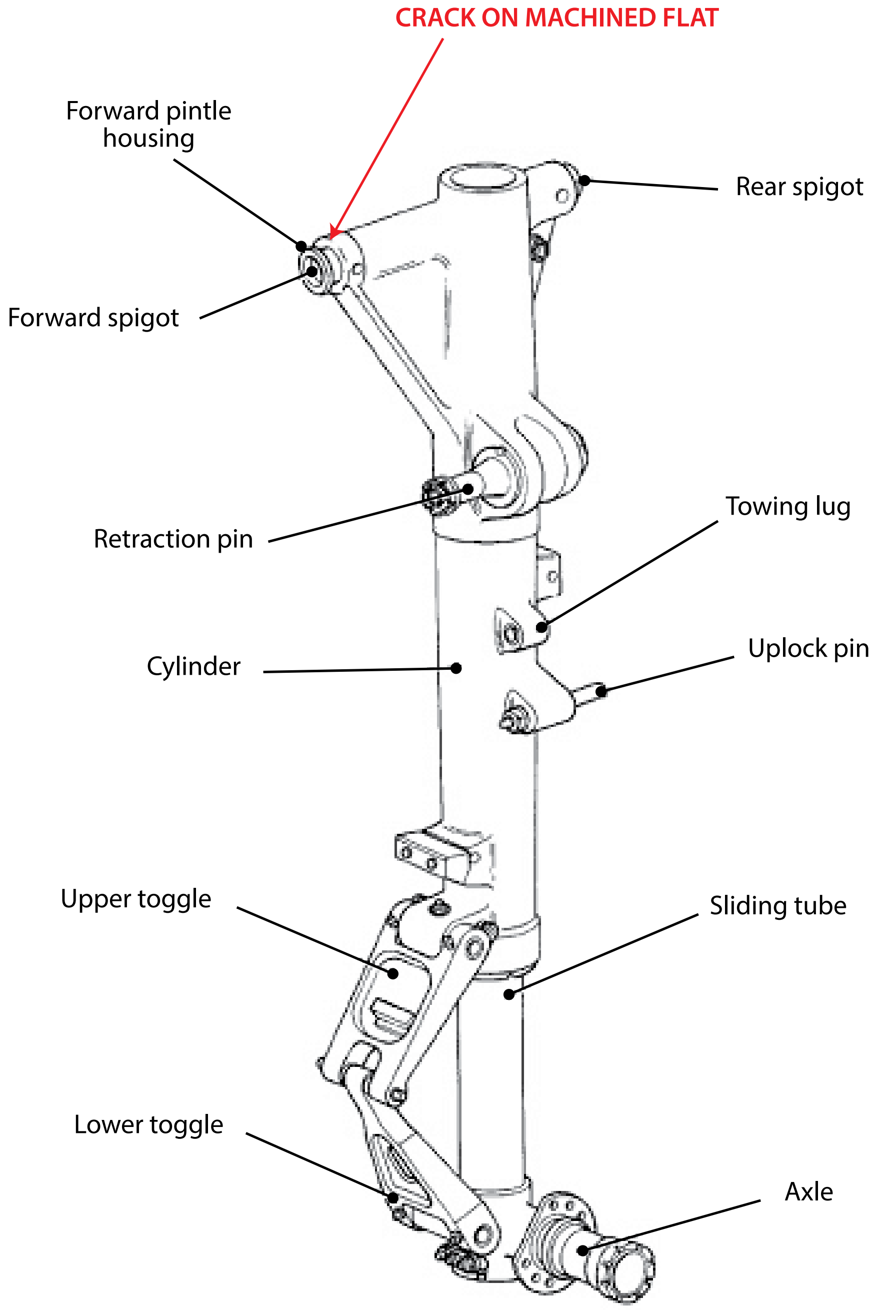

Figure 4
Jetstream 31 main landing gear leg

Previous occurrence

On 8 March 2012, the same aircraft, operating under its previous registration G-CCPW, suffered a failure to its right main landing gear as it landed at Isle of Man Airport. The subsequent investigation identified intergranular corrosion / stress corrosion cracking of the forward pintle housing as the cause of the failure and a Safety Recommendation was made to address this issue.

Stress corrosion cracking

Stress corrosion cracking can occur when susceptible metals or alloys are subject to a continuing tensile stress above a threshold level in a corrosive environment. Initiation normally occurs when the protective surface finish has been compromised allowing corrosion to start. Unless the stress is relieved or the corrosive environment is removed, the crack will continue to grow over time, travelling along the material's grain boundaries until it reaches the critical crack length, when the remaining metal will fail in sudden overload.

The issue of SCC in the Jetstream 31 main landing gear cylinder forward pintle housing was first identified in 1985 and the AAIB report into the 2012 G-CCPW accident documents the history of the problem. At the time of the G-CCPW accident, UK CAA Airworthiness Directive (AD) G-003-01-86 and BAE Systems mandatory Service Bulletin (SB) 32-A-JA851226, Revision 4 were in force, and required regular high-frequency eddy current (HFEC) and visual inspections of this area. The visual and HFEC inspections were described in Heroux-Devtek[2] SB 32-19, Revision 3, which was called up in SB 32-A-JA851226. The visual inspection of the forward and rear machined flats on the top of the pintle housing was required to be performed with the landing gear in-situ, every 300 cycles or three calendar months, whichever occurred sooner. The HFEC inspection of the machined flats and the forward and rear faces of the pintle housing was required to be performed with the landing gear removed, every 1,200 cycles or one calendar year.

The G-CCPW investigation determined that the HFEC and visual inspections had not been successful in detecting the presence of cracks before failure occurred. In particular, the report raised concerns about the limitations of the HFEC technique in detecting cracks in the forward pintle housing caused by SCC, due to edge effects, minimum detectable crack length and sensitivity of the technique in the presence of corrosion. Previous work done by BAE Systems in response to stress corrosion cracking events in the 1980s, and documented in the G-CCPW AAIB report, established that a minimum crack length of 1.57 mm was required to initiate steady crack growth. Once the crack had reached 1.57 mm it could then grow steadily to 6 mm over a period of approximately 120 days, at which point the crack length would become critical and could fail in overload. The HFEC technique described in SB 32-A-JA851226 Revision 4 and SB 32-19 Revision 3 was capable of detecting cracks of approximately 2.03 – 2.54 mm.

As a result, the G-CCPW investigation made the following Safety Recommendation on 23 March 2012:

> **Safety Recommendation 2012-008**
>
> It is recommended that the European Aviation Safety Agency review the effectiveness of Airworthiness Directive G-003-01-86 in identifying cracks in the yoke pintle housing on landing gears fitted to Jetstream 31 aircraft.

Footnote

2 Heroux-Devtek, formally known as APPH, the landing gear Type Certificate holder.

Safety actions arising from G-CCPW accident

Responding to Safety Recommendation 2012-008 on 19 June 2012, the European Aviation Safety Agency (EASA) indicated their intention to undertake a review of AD G-003-01-86 and SB 32-A-JA851226, in conjunction with the aircraft manufacturer. EASA stated:

> *'It is agreed that the current service bulletin is not adequate and it is under the process of revision. A revised service bulletin will be produced which will be mandated by an Airworthiness Directive.'*

Based on this response the AAIB categorised the status of this Safety Recommendation as *'Accepted – Closed'*. Subsequently SB 32-A-JA851226 was updated to Revision 6, published on 18 December 2013, and this was mandated by EASA AD 2013-0208[3], which superseded UK CAA AD G-003-01-86. SB 32-19 was also updated to Revision 6, published on 02 December 2013. The changes to SB 32-A-JA851226 and SB 32-19 included revised access instructions, revised instructions for re-protecting the forward pintle housing after the HFEC inspection and various administrative updates. However, there were no changes to the HFEC technique, equipment or inspection intervals.

As BAE Systems concluded that the HFEC inspection technique may have been of limited effectiveness in identifying SCC, because the estimated critical crack size is small and the rate of crack growth can be rapid, following the G-CCPW event, BAE Systems decided to place increased emphasis on prevention rather than detection of SCC. As such, they published modification service bulletin SB 32-JM7862, dated May 2013, to introduce a new design solution. This SB, which was mandated by EASA AD 2013-0206, dated 9 September 2013, required installation of a 'special' washer to protect the forward face of the pintle housing from rubbing against the spigot bearing during landing gear extension and retraction and therefore prevent the initiation of SCC. A new bearing with a reduced-thickness flange was also introduced to accommodate the washer. SB 32-JM7862 required an anaerobically-curing[4], low-adhesion, liquid gasket to be applied to the washer's contact surfaces, the primary purpose of which is to keep moisture out. A pre-formed 90º rectangular tab on the washer was designed to fit flush against the machined flat on top of the pintle housing to lock the washer in position and prevent rotation. The tab included an 'inspection window' to facilitate the routine visual inspections of the machined flat without the need to remove the landing gear. SB 32-JM7862 was applicable to all Jetstream 31 and 32 aircraft in order to maintain commonality, although different compliance times were specified for L161 landing gear cylinders.

In April 2014, while embodying SB 32-JM7862, a Jetstream 31 operator reported a possible integration issue to BAE Systems, where the bearing locking pins in the spigot bearing cap protruded through the bearing flange and fouled against the special washer, preventing reinstallation of the landing gear. As a consequence, BAE Systems issued Revision 2 of SB 32-JM7862 on 13 June 2014, with an instruction to transpose the spigot bearing

Footnote

3 EASA AD2013-0208 mandated Revision 5 of SB 32-A-JA851226. However Revision 5 was not issued to operators but was revised to Revision 6 prior to release.

4 An anaerobic adhesive, in this case the gasket material, will not cure in the presence of air.

cap by 180º so that the bearing locking pins did not come into contact with the washer. The compliance instructions for aircraft which already had SB 32-JM7862 embodied at Revision 1, were to reverse the orientation of the spigot bearing cap '*at the next convenient maintenance input (e.g. when the aircraft is jacked)*'.

Initial examination of landing gears

Post-accident examination of G-GAVA's left landing gear identified that the special washer was in approximately the correct position, although the rectangular tab was bent up at a slight angle at one edge, rather than lying flush against the machined flat of the forward pintle housing. The special washer on the right landing gear had rotated out of position in an inboard direction. Prior to this accident BAE Systems had not received any reports relating to rotation of the special washers introduced by SB 32-JM7862.

Metallurgical examination of left landing gear

General

Metallurgical examination of the forward pintle housing on G-GAVA's left main landing gear was carried out by QinetiQ, under the direction of the AAIB. This examination determined that the failure initiated from a corrosion pit on the forward face of the pintle housing. The resulting crack propagated axially along the top of the pintle housing, which then finally failed in overload.

Axial crack through pintle housing

The axial crack propagated aft for 74 mm, before extending a further 76 mm in a downwards and outboard direction (Figure 5).

Both fracture surfaces of the axial crack had a 'woody' appearance, characteristic of SCC. Smeared gasket material was present on the top of the fracture surfaces, towards the start of the crack. Examination of the inboard fracture surface showed that corrosion was present within the first 35 mm, extending rearwards and downwards. A narrow band of corrosion along the top of the fracture surface extended for a further 40 mm. Figure 6 shows the corrosion staining in the area bounded by the dashed red line.

Scanning electron microscopy of the fracture faces, showed a small flat fracture region, measuring 2.4 mm x 1.5 mm, extending from a corrosion pit on the forward face of the pintle housing, close to the top surface. Within this flat fracture region, the surface showed extensive corrosion and the crack growth appeared intergranular, typical of SCC. Beyond the flat fracture region, the corrosion staining was less severe but the fracture surface was still intergranular in nature. Approximately 14 mm from the crack origin, ductile features start to become evident in the corrosion-stained area. The remainder of the fracture surface within the corrosion-stained region exhibited a combination of intergranular features and ductile dimples, with ductile features becoming more prevalent and corrosion less severe as the crack progressed. Although DTD 5094 fracture surfaces are difficult to interpret, the prevalence of ductile features on some areas of the fracture surface suggests that overload failure also contributed to the later stages of the axial

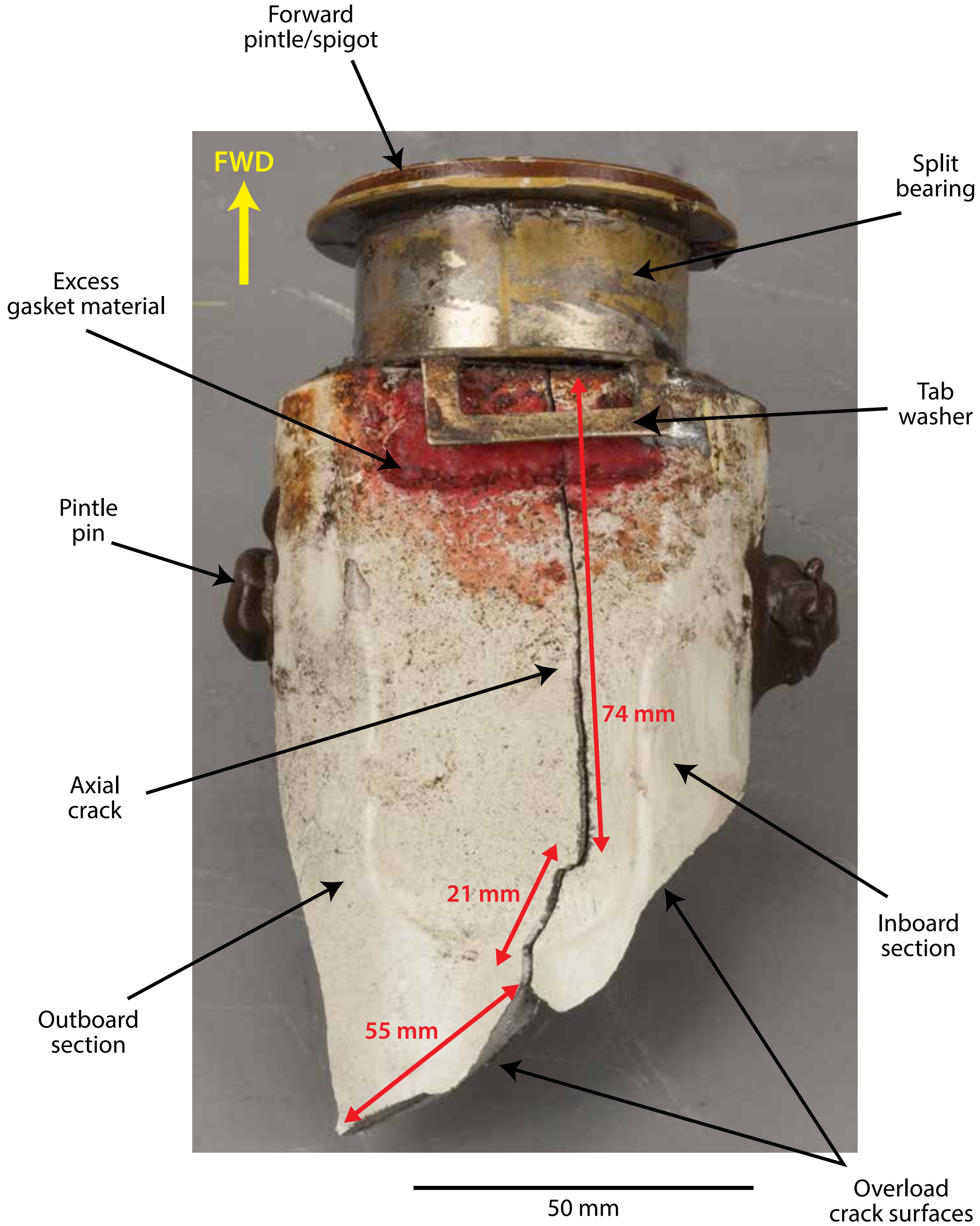

Figure 5

Left landing gear forward pintle housing showing crack

crack progression. The severity and depth of the corrosion staining towards the start of the crack suggest that this part of axial crack had been open for some time prior to final failure, although it was not possible from the metallurgical analysis to determine for what length of time the crack may have been present. The reduced severity and depth of the corrosion band in the later stages of the axial crack suggest that this part of the crack was open for a shorter period of time.

Energy dispersive x-ray spectroscopy (EDX) analysis identified the presence of oxygen, suggesting oxidation (corrosion) of the surface, as well as cadmium, which is likely to have come from corrosion of the steel spigot. Chlorine, which is known to cause SCC in aluminium alloys and is normally present in marine environments, was also detected in the corrosion product.

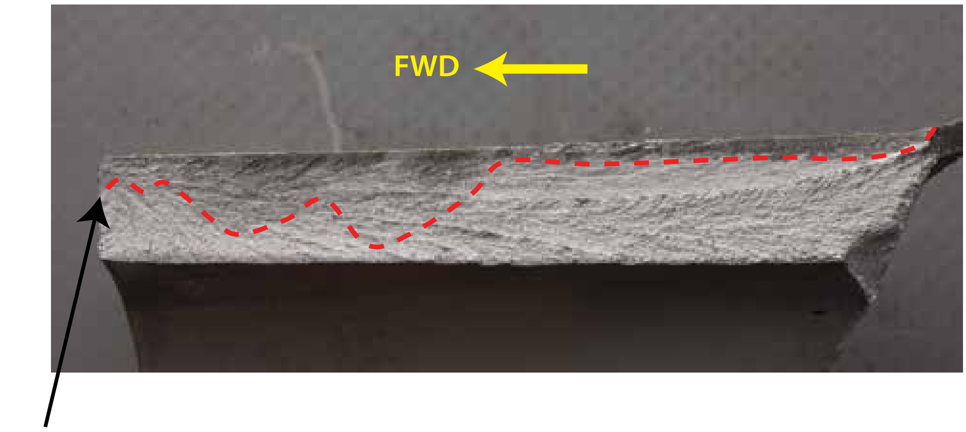

Figure 6

Left landing gear, inboard half of axial crack fracture surface after cleaning, showing corrosion staining

Forward face of the pintle housing and special washer

The forward face of the pintle housing exhibited rotational wear marks where the Alochrome surface treatment was worn off and corresponding wear marks were evident on the mating face of the special washer. One witness mark on the washer aligned with the position of the axial crack.

Corrosion pitting was evident on the forward face of the pintle housing. A polished micro-section through the forward face showed that some of the pits extended to a depth of 180 μm, and intergranular cracks were evident adjacent to the pits suggesting other possible crack initiation sites. No gasket material was visible on the forward face of the pintle housing or the mating face of the washer. However, the Locktite 5203 gasket material fluoresces under UV light, and using this technique, two tiny fragments of gasket material were identified, indicating that gasket material had previously been present.

The smeared gasket material on the machined flat, on the top surface of the pintle housing, visible in Figure 5, did not fluoresce under UV light and its consistency confirmed that it had only partially cured. After removing this gasket material from the machined flat, it was noted that the paint in this area was blistered.

Washer and bearing locking pins

The washer tab was distorted and rotational wear marks were evident on the forward face of the washer, around the inboard edge. This wear is consistent with contact between the washer and the bearing locking pins in the spigot bearing cap. Substantial wear was evident on the bearing locking pins, including a distinctive notch on each pin, created by the outer edge of the washer (Figure 7). The top and bottom pins protruded 1.95 mm and 2.03mm respectively, from the surface of the spigot bearing cap. The bearing flange measured 1.64 mm thick.

A witness mark on the forward face of the washer corresponding to the gap between the split bearing halves indicated the washer's normal position; a similar witness mark displaced by 40° indicated the extent to which the washer was able to rotate out of position.

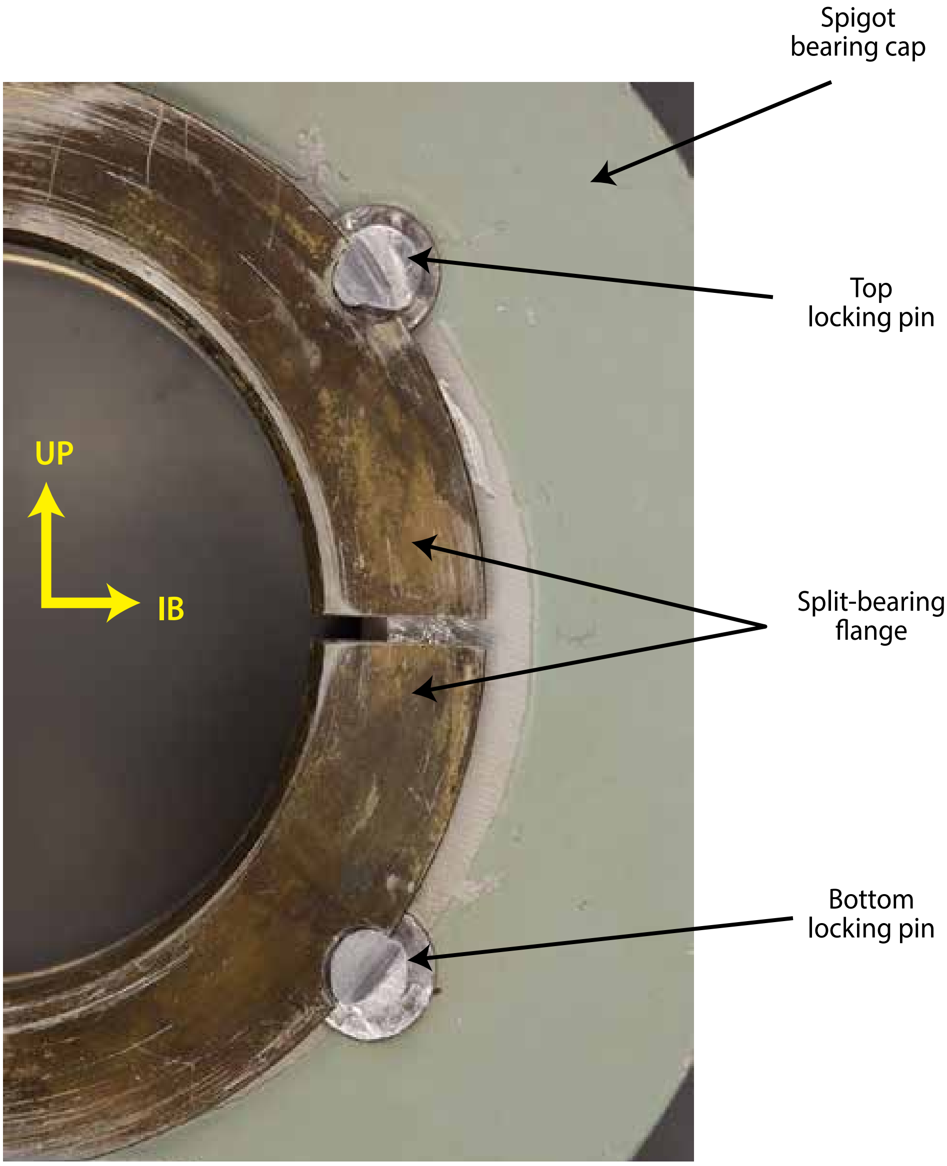

Figure 7

Left landing gear, wear on bearing locking pins

Pintle housing bore

Corrosion pitting was present in the bore of the pintle housing, heavily concentrated towards the forward end and gradually decreasing towards the rear. Corresponding dark staining, characteristic of galvanic corrosion, was also present on the steel spigot, most likely as a result of interaction between the spigot and the aluminium pintle bore. Although the corrosion in the bore did not contribute to the failure of the pintle housing, corrosion in this area is undesirable and was the subject of Safety Recommendation 2012-024, arising from the G-CCPW investigation.

Overload cracks through the pintle housing

The final overload failure of the pintle housing initiated at the internal edges of both pintle pin holes, close to the bore, with separate cracks propagating forward and aft. The fracture surfaces through the holes appeared dull and fibrous, characteristic of overload failure. The crack surfaces from the pintle pin holes to the end of the axial crack were relatively clean, suggesting they were the last parts of the pintle housing to crack, most likely during the final landing immediately prior to the landing gear collapse.

Eddy current examination

As part of the landing gear examination, a HFEC inspection was performed on the forward face of the three broken sections of the pintle housing, using the technique called up in SB 32-A-JA851226, Revision 6 and SB 32-19 Revision 6. The examination did not identify any defect indications. However, parts of the forward face were missing and other areas had suffered mechanical damage during the accident, which may have obscured any defects in those areas.

Detailed examination of right landing gear

G-GAVA's right main landing gear cylinder had been subject to the same overhaul and recent component history as the failed left gear. Additionally, post-accident inspection showed that the special washer on the right landing gear had rotated out of position. Therefore a detailed examination of the forward pintle housing on the right landing gear cylinder was conducted for comparative purposes.

The special washer had rotated such that its tab had passed the inboard corner of the machined flat on the pintle housing. Correctly cured gasket material was evident on the machined flat, under the footprint of the washer tab, but the gasket was absent from the forward face of the pintle housing, except for one small fragment. This fragment had collected in a small depression on the surface, which had the appearance of a blend, possibly indicating the site of a previous repair on the cylinder, although no such repair was referenced in the component records. Rotational wear patterns and witness marks on the forward face of the pintle housing and both faces of the washer, and wear on the bearing locking pins were very similar to those on the left landing gear and indicated that the washer had rotated up to 53^{o} from its normal position.

There was extensive corrosion pitting on the forward face of the pintle housing, most prevalent around the bore, with crack-like features appearing to emanate from the corrosion pits. A HFEC inspection using the technique called up in SB 32-A-JA851226, Revision 6 and SB 32-19 Revision 6, identified defect indications which exceeded the maximum permissible limit. A dye-penetrant inspection was conducted to highlight these defects; the results are shown in Figure 8. The damage was determined to be outside permissible repair limits and the right landing gear cylinder was deemed to be 'scrapped'.

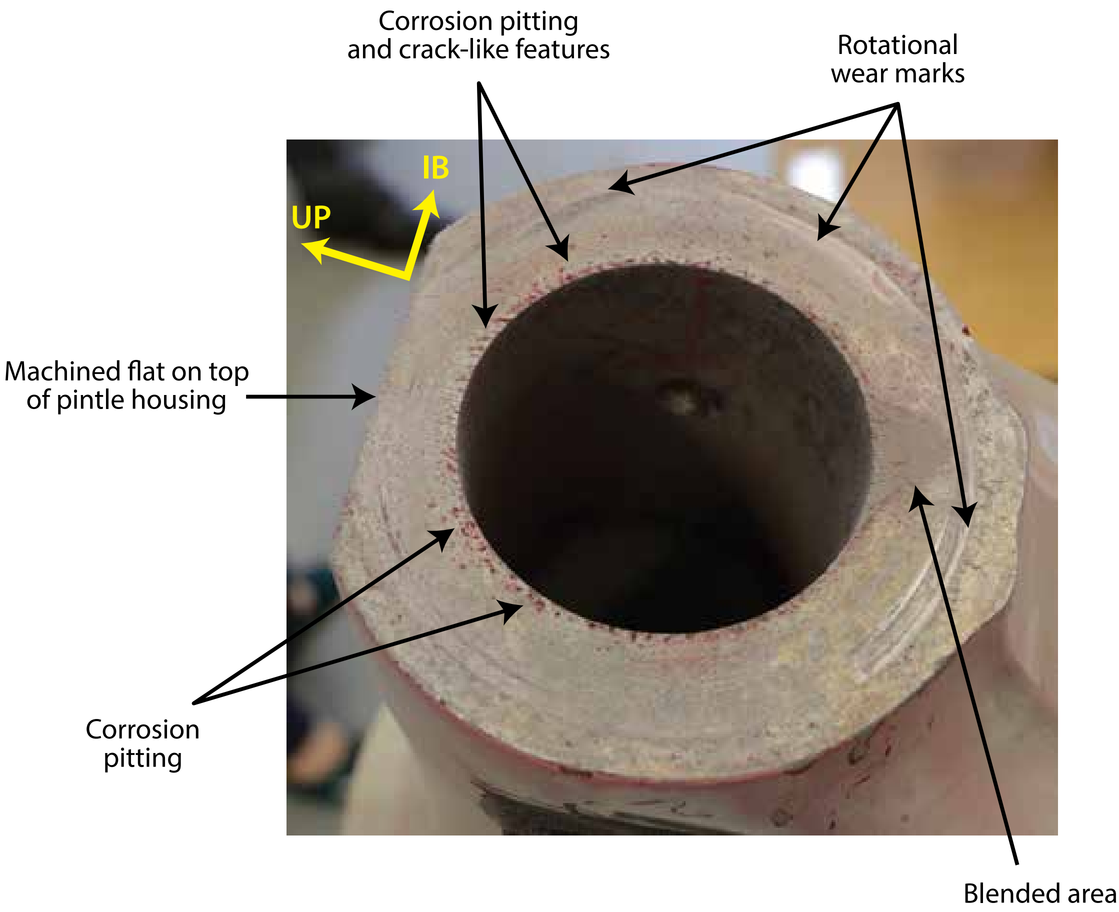

Figure 8

Right landing gear, forward face of pintle housing after dye penetrant examination

Gasket curing trial

The curing performance of the Locktite 5203 liquid gasket material on the landing gear cylinder was assessed. Liquid gasket material applied on the painted surface of the machined flat did not cure after 24 hours at room temperature because one surface of the gasket was exposed to the air. Liquid gasket was also used to install a special washer on the pintle housing, in accordance with the SB 32-JM7862 instructions, and was subject to the same cure time and temperature. The gasket adequately cured on the forward face but only partially cured under the washer tab. The investigation considered that the gap between the washer tab and the pintle surface may have been too large to allow full anaerobic curing of the gasket. The gasket material had also softened the top coat of paint on the machined flat of the pintle housing.

Design tolerances

Following the G-GAVA accident, BAE Systems conducted an assessment of the modification described in SB 32-JM7862 Revision 1, to understand how fouling could occur between the bearing locking pins and the special washer. Each locking pin engages in a cut-out on the split bearing flange, ensuring that both halves of the bearing remain in position. The spigot bearing cap can be installed either with the bearing locking pins facing aft towards the special washer (as was the case on G-GAVA) or, with the bearing locking pins facing forward so that they engage with the opposite bearing flange, where no fouling condition would exist. Post-accident assessment determined that, with the bearing locking pins facing aft, a foul of up to 0.022 in (0.559 mm) could occur on some aircraft as a result of adverse tolerances. However, on aircraft with more favourable tolerances, a small clearance of up to 0.005 in (0.127 mm) might exist between the bearing locking pins and the washer. The written instructions in SB 32-JM7862 Revision 1 did not specify a particular orientation for the spigot bearing cap, although Figure 1 of the SB showed the bearing locking pins facing aft towards the special washer, as did the relevant Aircraft Maintenance Manual (AMM) instructions for reinstalling the landing gear.

Maintenance history

General

Jetstream 31 landing gears are required to be overhauled every 10,000 cycles or six calendar years and both main landing gears were overhauled in December 2012 and fitted to G-GAVA later that month[5]. The aircraft returned to service in April 2013. At the time of the accident in August 2014, both landing gears had accumulated 955 cycles since overhaul.

Routine line and base maintenance of the operator's aircraft was provided by a maintenance organisation at Humberside Airport, which was a wholly-owned subsidiary of the operator. Ad hoc maintenance and larger maintenance checks were carried out by a third-party maintenance organisation based at Cranfield Airport.

Third-party maintenance

The most recent HFEC inspection for stress corrosion cracking on the pintle housing was performed on both landing gears by a specialist Non-Destructive Testing (NDT) company on 10 December 2013, 803 cycles prior to the accident, during a 200 hr check at the third-party maintenance organisation. No defects were detected. SB-32-JM-7862 Revision 1 was embodied on both landing gears to install the protective washer on the forward pintle housing on 12 December 2013 during the same maintenance input.

During a subsequent 1200 hr maintenance input at the third-party maintenance organisation in March 2014, while performing a detailed visual inspection (DVI) of the landing gear, the protective washers on both landing gears were observed to have rotated out of position. The DVI also identified extensive corrosion and encrusted salt contamination in both main landing gear bays, on a number of hydraulic connectors, and the radius rod attachment pins and nuts.

The senior engineer who certified the work performed on G-GAVA during the December 2013 and March 2014 maintenance inputs, informed the investigation that he had been surprised at the extent of the deterioration in the landing gear bays in the intervening three months. He also noted an absence of lubrication on the landing gears, despite them having been

Footnote

[5] Both landing gears were overhauled at a dedicated overhaul facility in the USA and carried different serial numbers from those that were fitted to G-CCPW at the time of the previous accident.

lubricated in December 2013. The operator was informed of the findings and advised the maintenance organisation that the aircraft had operated to a number of coastal locations and had spent a lot of time on the ground in the preceding months, due to adverse winter weather.

Upon removing both landing gears to rectify the migrated washers, circular wear patterns were observed on the forward face of the pintle housings where the washers had rotated, but there was no visible corrosion. The forward face of the pintles was cleaned and the surface protection reapplied prior to reinstallation of the washers. Neither the third-party maintenance organisation nor the operator informed the aircraft manufacturer that the protective washers had rotated out of position.

The senior engineer informed the investigation that during both the original embodiment of SB 32-JM7862 and the subsequent reinstallation of the washer, some difficulty had been experienced achieving an adequate cure on the liquid gasket and getting the washer tab to sit flush against the top of the pintle housing. On both occasions a heat gun had been used to accelerate the cure. He expressed some concern that SB 32-JM7862 did not provide a definitive procedure for achieving an accelerated cure of the gasket, nor a means to determine when the gasket had fully cured. Instead maintenance personnel must assume the gasket has started to cure once the washer is secure. The third-party maintenance organisation did not report these observations to the aircraft manufacturer.

The senior engineer was aware of the importance of the inspection window in the washer tab and was certain that the excess gasket material (visible in Figure 5) had not been present when G-GAVA left the third-party maintenance facility in March 2014. Another aircraft on which the third-party maintenance organisation had embodied SB 32-JM7862 was inspected by the AAIB and no anomalies were noted; the washer was in the correct position, with the tab secure and flush against the machined flat, and no excess gasket material was visible.

In-house maintenance

The aircraft's technical records indicated that three visual inspections for stress corrosion cracking, as required by SB 32-A-JA851226, had been performed between reinstallation of the special washer in March 2014 and the accident on 15 August 2014. The most recent of these inspections was on 30 June 2014, 168 cycles[6] before the accident and prior to that, on 15 June 2014 during a 200 hr check. The records indicated that both of these inspections were performed and certified by the maintenance manager at the operator's maintenance organisation. No defects were recorded. The previous visual inspection had been performed on 29 April 2014.

Although aware of the requirements of the visual inspection and of the need to clean the pintle housings and use a torch and inspection mirror to facilitate the inspection, the

Footnote

[6] AAIB Special Bulletin S5/2014 reported that this inspection occurred 226 cycles before the accident. This figure was incorrect, having been calculated from a printed work-card, which contained out-of-date hours and cycles information.

maintenance manager reported that the inspections were often rushed and he did not usually have time to clean the landing gears due to his workload. He also stated that he commonly conducted the *'DVI described in the AMM'* rather than referring to the specific visual inspection described in SB 32-A-JA851226.

The DVI inspection detailed in the AMM is required to be completed every 400 hours and describes a visual inspection of the pintle housings. It states:

> *'Areas to be inspected must be clean and clear of grease….. Using a good light source, a magnifying glass and mirror, do a thorough visual inspection of [the] pintle housing for signs of cracks and corrosion damage.'*

While similar to the visual inspection described in in SB 32-A-JA851226, unlike SB 32-A-JA851226 it does not specifically refer to the machined flat at the top of the pintle housing, or contain any illustrations showing the specific location in which the inspections should be performed.

The last maintenance performed on the landing gears was a scheduled DVI, which was conducted during a 200 / 400 hr check on 10 August 2014, 5 days before the accident. No findings were recorded. The work-pack also included a task to lubricate both landing gears, including the split bearings on the spigots.

The maintenance manager had commenced employment with the maintenance organisation in late January 2014, having been recruited to manage a small team of engineers responsible for carrying out unscheduled and line maintenance (up to 400 hr checks) for the operator's fleet. At that time he was the only permanently-employed, type-rated, B1[7] licensed engineer working on the operator's aircraft, although he was assisted by an unlicensed engineer, a B2[8] licensed engineer and, on occasion, by licensed and unlicensed contract engineers. He did not consider that the maintenance organisation was sufficiently resourced to fulfil the maintenance requirements of the operator's fleet and reported that he was routinely behind with performing maintenance tasks and signing off the associated maintenance paperwork. He advised the investigation that he did not believe the operator allocated sufficient aircraft down-time for maintenance inputs and he often released aircraft to service in advance of the maintenance paperwork having been reviewed and certified. The maintenance manager left the company a number of weeks after the G-GAVA accident.

In late April 2014 another licensed but non type-rated engineer was employed to assist the maintenance manager. However, his employment coincided with a long-term sickness absence of the operator's Continuing Airworthiness Manager, during which time the operator's technical records had become considerably out of date. As a consequence, the licensed engineer was soon diverted to fulfil this role instead. He received some limited training on the technical records software and spent a number of months learning to use

Footnote

[7] An aircraft engineer with an EASA Part 66 B1 category licence (mechanical, airframe and engines), with an appropriate type rating, can certify work on an aircraft's airframe and engines.
[8] An aircraft engineer with an EASA Part 66 B2 category licence (avionics), with an appropriate type rating, can certify work on an aircraft's avionics systems.

the technical records system, preparing work-packs for upcoming maintenance checks, entering the details of maintenance tasks, while attempting to update the historical technical records retrospectively.

The out-of-date technical records had an adverse impact on the forecasting of maintenance tasks for the operator's aircraft. A number of maintenance tasks became overdue and some tasks were erroneously scheduled. The later effect was evidenced by the close scheduling of the two visual inspections on G-GAVA on 15 and 30 June 2014, despite the required three-month interval. In particular, the printed work cards for these two visual inspections recorded the same date (29 April 2014) for the previous satisfactory visual inspection, confirming that the operator's technical records database had not been updated in the intervening period. Despite the anomalies with the maintenance forecasting, the investigation determined that the visual inspection on G-GAVA had not been overdue at the time of the accident.

CAA oversight

The operator held an EASA Part M 'Continuing Airworthiness Requirements' approval and the operator's maintenance organisation held an EASA Part 145 'Maintenance Organisation' approval[9]. The CAA was responsible for providing oversight of these functions and carrying out routine audits. The maintenance organisation was a wholly-owned subsidiary of the operator and shared the same Accountable Manager[10].

In early January 2014 the CAA attempted to carry out an audit of the Part 145 and Part M functions, but the audit was terminated early due to the number of issues noted on the Part 145 side. These included concerns with the hangar facilities, inadequate engineering stores provision and inadequate training and competency records for engineering staff and contractors. As the audit was terminated early no formal audit findings were raised. However the CAA's concerns were communicated to the Accountable Manager and the maintenance organisation was given ten days to provide a corrective action plan detailing how they intended to re-establish compliance. The CAA were satisfied with the proposed plan and over the following months they maintained a dialogue with the Accountable Manager to monitor progress. The maintenance organisation appointed a new maintenance manager and part-time quality manager and work commenced to re-establish compliance with the Part 145 requirements. The CAA was satisfied that things were moving in the right direction.

Footnote

[9] European Regulation EC 2042/2003(and its subsequent amendments) were valid at the time of the accident and detailed the rules for the continuing airworthiness and maintenance of aircraft subject to EASA regulation. Part 145 of the regulation concerned the maintenance of EASA aircraft used for commercial air transport. Part M, Subpart G of the regulation concerned the management of continuing airworthiness of EASA aircraft. European Regulation EC 2042/2003 was superseded by Commission Regulation (EU) No 1321/2014 on 26 November 2014.

[10] Under Regulation EC 2042/2003, the 'Accountable Manager' is the designated person responsible for those organisational functions which are subject to regulation. Persons nominated for this post in UK aviation organisations must be approved by the CAA. The Accountable Manager normally has corporate authority for ensuring that all of the organisation's activities can be financed and carried out to the standard required by the Regulator.

The CAA performed a rescheduled audit of the Part M and Part 145 functions between 22 and 24 July 2014, which identified seven Level 2[11] findings against the Part M approval and nine Level 2 findings against the Part 145 approval.

Among the Part M findings were the following concerns:

- The Maintenance Programme being used by the operator did not reflect the latest manufacturer's requirements, nor the actual aircraft utilisation in the operator's fleet.
- The operator was unable to demonstrate to the CAA that it was fully compliant with regard to the certification of maintenance tasks.
- The CAA deemed that operator's available staff resources were insufficient to complete all the required continuing airworthiness management tasks and the organisation could not demonstrate to the CAA how it had completed internal audits or how it monitored its Part M functions.

The Part 145 audit findings included:

- The maintenance organisation was unable to demonstrate to the CAA that it was fully compliant with regard to '*certification of maintenance beyond licence privilege.*' In particular the audit noted that the maintenance manager had signed off a maintenance task which was outside the entitlement of his licence.
- The maintenance organisation could not demonstrate to the CAA how it had completed internal audits of its Part 145 functions.
- The maintenance organisation was unable to demonstrate to the CAA that it was fully compliant with regard to staff resources. In particular, the CAA deemed the available resources insufficient to support projected workload as there was only one permanent licensed certifying engineer.

The findings of the audit were verbally briefed to the Accountable Manager and the management team at both organisations at the conclusion of the audit on 24 July 2014. Prior to issuing the formal notification of audit findings, the CAA requested the operator to provide additional information. Consequently, formal notification of the audit findings was not issued until 26 August 2014.

In September 2014 the Accountable Manager submitted responses to the audit findings, but the CAA deemed that they did not adequately address the concerns identified in the audit. Therefore, at the CAA's recommendation, the maintenance organisation voluntarily

Footnote

[11] The CAA audit form defines a Level 2 finding as '*any non-compliance with the applicable requirements which could lower the safety standard and possibly hazard flight safety*' and a Level 1 finding as *'any significant non-compliance with the applicable requirements which lowers the safety standard and hazards seriously the flight safety*.'

suspended its Part 145 approval on 18 September 2014, contracting all Part 145 maintenance activities to a third-party maintenance organisation. Additionally, the operator contracted a number of Part M functions to the same third-party organisation, including maintaining and updating maintenance records, maintenance forecasting, production of work-packs and assessment of applicable ADs.

Safety recommendations and actions arising from this investigation

Safety recommendations

As a result of the preliminary findings of this investigation, reported in AAIB Special Bulletin S5/2014, the following Safety Recommendations were published on 2 September 2014:

Safety Recommendation 2014-038

It is recommended that the European Aviation Safety Agency take action to assure the continued airworthiness of those BAE Systems Jetstream 31 main landing gear legs that are manufactured from DTD 5094 aluminium alloy and have SB 32-JM7862 embodied.

and,

Safety Recommendation 2014-039

It is recommended that the European Aviation Safety Agency take action to mandate an effective inspection regime for the Jetstream 31 that will detect cracking and prevent failure of the yoke pintle of main landing gear legs manufactured from DTD 5094 aluminium alloy.

Response to Safety Recommendations 2014-038

In response to the preliminary findings of this investigation and to Safety Recommendation 2014-38, BAE Systems published SB 32-A-JA140940 and SB 32-JM7862 Revision 3 on 3 October 2014, to address the unsafe condition which had been identified on aircraft where SB 32-JM7862 had previously been accomplished to Revision 1 and Revision 2. SB 32-A-JA140940 has three parts:

- Part 1 requires a one-off visual inspection on all aircraft where SB 32-JM7862 was first accomplished at Revision 2, within 50 cycles or 2 weeks of the date of the SB, to determine if the special washer had migrated. If there is no evidence of migration the SB requires a small amount of witness paint to be applied between the washer tab and the machined flat on the forward pintle housing, to aid identification of any subsequent rotation of the washer.
- For any aircraft where migration of the washer was identified or suspected and, for all aircraft where SB 32-JM7862 was first accomplished at Revision 1, Part 2 of SB 32-A-JA140940 is required to be performed within 200 cycles or 2 months for DTD5094 landing gears, and 600 cycles or 6 months for

L161 landing gears. Part 2 requires removal of the landing gear and special washer, inspection of the washer and the forward pintle housing for signs of wear or corrosion and rectification of any findings, an HFEC inspection of the forward pintle housing accordance with SB 32-A-JA851226 and reapplication of the corrosion protection. Reinstallation of the special washer must be performed in accordance with the enhanced instructions of concurrently-issued SB 32-JM7862 Revision 3, which include specification of the gap size to be achieved between the washer tab and machined flat, the application of witness paint and a landing gear extension/retraction check.

- For all landing gears on which Part 1 or Part 2 of SB 32-A-JA140940 has been accomplished, Part 3 requires a one-off visual inspection to be performed between 20 and 30 cycles, or 4 and 6 weeks, to determine if the witness paint is intact.

Additionally SB 32-A-JA140940 contains instructions to report all findings from the inspections to BAE Systems, even if no faults were found, using a dedicated feedback form included in the SB. At the time of publication of this report, SB feedback forms received and targeted operator follow-up by the manufacturer, indicated that SB 32-A-JA140940 and SB 32 JM7862 Revision 3 have been embodied on approximately 76% of the operational Jetstream 31 and 32 fleet. The feedback included one report of a post-SB 32-A-JA14090/ SB32-JM7862 Revision 3 installation on a JS31 aircraft, where the washer tab had lifted slightly and the witness paint had broken, although there was no evidence of washer rotation. BAE Systems requested further details and the operator advised that, following subsequent reinstallation of the washer in accordance with SB 32-JM7862 Revision 3, no further anomalies have been noted.

On 3 November 2014 EASA published AD 2014-0239, superseding AD 2013-0206, to mandate the requirements of SB 32-A-JA140940 and SB 32-JM7862 at Revision 3. The mandated compliance times differed from those recommended in SB 32-A-JA140940 as the AD publication date was one month later than that of the SB.

EASA disseminated AD 2014-0239 to other National Aviation Authorities (NAA) in countries where Jetstream 31/32s are registered. The US Federal Aviation Administration issued equivalent AD 2015-06-01, effective 24 April 2015, and other NAAs including Transport Canada and the Australian Civil Aviation Safety Authority have made AD 2014-0239 available on their website.

Based on these actions, the AAIB has categorised the status of Safety Recommendation 2014-038 as '*Adequate – Closed*.'

Response to Safety Recommendations 2014-039

In response to Safety Recommendation 2014-039, EASA provided the following interim response to the AAIB on 28 October 2014:

> *'EASA is working with British Aerospace (BAe) Systems to review and improve the inspection regime required by the Service Bulletin (SB) 32-A-JA851226 and mandated by the Airworthiness Directive (AD) 2013-0208. In the short term, the new SB, that is being produced to check the correct installation of the special washer and thus prevent the stress corrosion, together with the inspections of SB 32-A-JA851226 are deemed to provide an acceptable level of safety. In recognition of the on-going AAIB investigation, due consideration will be given to any and all future findings from the investigation.'*

The existing HFEC inspection technique called up in SB 32-JA851226 Revision 6 can achieve a detectable crack size of approximately 0.08 – 0.1 in (2.03 – 2.54 mm). Following the G-GAVA accident, BAE Systems developed a revised HFEC inspection procedure which can detect cracks of 0.05 in (1.27 mm) or greater in length and corrosion pits of 0.05 in x 0.05 in (1.27 mm x 1.27 mm) deep or greater, on the machined flat and forward face of the pintle housing. These dimensions are closer to the likely initiation size of a stress corrosion crack and should therefore improve the likelihood of crack detection using this technique. BAE Systems plan to update SB 32-A-JA851226 to incorporate the new HFEC technique by the end of June 2015. Heroux-Devtek will also update SB 32-19. EASA AD action will then be required to mandate the new procedure.

The current service bulletins relating to stress corrosion cracking in the forward pintle housing still employ the existing HFEC inspection technique. Until such times as the new HFEC technique is mandated, the AAIB has categorised the status of this Safety Recommendation as '*Partially Adequate - Open*'.

Further safety actions planned by the aircraft manufacturer

In addition to the steps previously described, BAE Systems plan to undertake the following safety actions to ensure the continued airworthiness of Jetstream 31 landing gear cylinders manufactured from DTD5094:

- Integration testing to determine if there are any mechanisms, other than the issue of adverse tolerances with the bearing locking pins, which might cause rotation or migration of the special washer. This relies on identification of a suitable operational aircraft on which to perform the integration testing.
- Identification of a higher-adhesion gasket material with better cure performance. The new gasket will be trialled in the integration tests.
- Updating SB 32-A-JA851226 to incorporate the new HFEC technique and instructions to inspect for corrosion pits as well as cracks.

- Revision of the maintenance documentation for the Jetstream 31 and 32 to reflect enhanced corrosion protection requirements for the forward face of the pintle housing.

Safety actions by the operator

Following the G-GAVA accident the operator decided to reduce the inspection intervals required by SB 32-A-JA851226. They amended their maintenance programme so that the HFEC inspection is performed every 700 landings or six calendar months, and the visual inspection is performed every 50 hours or 8 days, coincident with the service check. Additionally they have equipped each of their aircraft with an inspection mirror, so that flight crew can inspect the position of the special washer during the pre-flight walk-round.

Analysis

Failure of the landing gear

The ground marks on the runway from the failed landing gear and the left engine propeller, together with FDR data and audio analysis of the CVR, indicate that the left main gear failed eight seconds after touchdown. The aircraft weight was considerably below the maximum permissible landing weight and its descent rate and vertical acceleration were well within the design specification for the landing gear. As such the landing gear should not have failed.

Metallurgical analysis determined that the landing gear failed as a result of a crack which initiated from a corrosion pit on the forward face of the pintle housing. This crack propagated axially along the top of the pintle housing to a point where the remainder of the structure was unable to sustain landing loads and failed in sudden overload. The failure mechanism was identified as stress corrosion cracking, to which the DTD 5094 landing gear cylinders are known to be susceptible. It was not possible to determine how long the crack took to grow to failure, but the presence of corrosion and smeared gasket material on the fracture surfaces of the axial crack indicate that it was present for some time prior to final failure.

Rotational wear marks evident on the mating faces of the pintle housing and the washer were determined to have been caused by rotation of the washer, due to fouling by the bearing locking pins. This wear led to a degradation of the corrosion protection on the forward face of the pintle housing, exposing the surface of the aluminium to the environment. Observations of corrosion and salt contamination in the landing gear bays during the March 2014 maintenance input identified that the aircraft operated to coastal locations. Although the landing gear bays were cleaned at this time, continued salt contamination and poor cleaning of the landing gears, in combination with the exposed aluminium surface, is likely to have created an environment conducive to corrosion.

The manner in which the maintenance manager described performing the most recent routine visual inspections for stress corrosion cracking of the pintle housing, required by SB-32-A-JA851226 and SB 32-19, indicates that they were either not carried out, or not carried out effectively.

The last visual inspection of the pintle housing was documented as having taken place on 30 June 2014, 6½ weeks prior to the accident. It is not known whether the axial crack would have been visible at this time, and if so what length it might have been. The G-CCPW investigation determined that the visual inspections may be of limited effectiveness, especially if the crack size is small, and it was noted that a crack could grow rapidly in the interval between inspections. Nonetheless the inspection regime described in SB-32-A-JA851226 and SB 32-19 contributes to the continuing airworthiness of the JS31 landing gear legs manufactured from DTD 5094 and is mandated by EASA AD 2013-0208. It is possible that the manner in which the visual inspections were performed, and the presence of excess gasket material partially obscuring the inspection window in the washer tab, could have limited any opportunity to detect the crack had it been present.

Safety actions following the previous occurrence

Following publication of Safety Recommendation 2012-008, arising from the G-CCPW accident investigation, BAE Systems and EASA determined that the established inspection regime described in SB-32-A-JA851226 was inadequate. In their response to the recommendation EASA indicated that the HFEC inspection technique would be amended, and on this basis the AAIB categorised the status of the Safety Recommendation as '*Accepted – Closed*.' However, despite the subsequent revision to the SB and the publication of EASA AD 2013-0208, no substantive changes were made to the HFEC technique, equipment or inspection intervals nor to the intermediate visual inspections. It is clear therefore that the actions taken did not meet the intent of Safety Recommendation 2012-008.

Due to the identified limitations of the HFEC inspection technique, the aircraft manufacturer decided to address the failure condition by placing increased emphasis on prevention rather than detection of stress corrosion cracking in the forward pintle housing. SB 32-JM7862 Revision 1 was introduced to install a protective washer on the forward face of the pintle housing, with the intent of preventing contact between the spigot bearing flange and the forward face of the pintle housing and removing the previously identified failure mechanism. However, this investigation determined that it is possible for the special washer to migrate/rotate out of position and in doing so, abrade the forward face of the pintle housing, degrading the surface protection and creating a condition where stress corrosion cracking can occur. It is therefore evident that SB 32-JM7862 Revision 1 did not meet its original design intent and failed to protect the forward face of the pintle housing from wear.

The most recent HFEC inspection on the forward pintle housing was performed in December 2013, at the same time SB 32-JM7862 was embodied on G-GAVA. The landing gear failed eight months later, four months before the next HFEC inspection was due.

The interim visual inspections did not detect the presence of a crack. It has not been possible to determine whether this was because the crack was not visible at the last inspection, or because the lack of cleaning and the manner in which the visual inspections were performed may have hindered its detection.

Identification of the fouling condition

The initial SB 32-JM7862 modification introduced a new split-bearing with a reduced-thickness flange to accommodate the new washer and gasket. However, it did not take account of the orientation of the spigot bearing cap, nor the extent to which the bearing locking pins might protrude beyond the bearing flange.

When BAE Systems first became aware of the potential for fouling between the bearing locking pins and the special washer, it was identified as an integration issue which might prevent reinstallation of the landing gear. BAE Systems received only one operator report of this issue and therefore assumed that the fouling condition could not exist on aircraft on which the landing gear had been successfully reinstalled. Nonetheless they issued SB 32-JM7862 Revision 2 to address the fouling condition, with instructions to transpose the spigot bearing cap at the next convenient maintenance input when the aircraft was jacked. For aircraft on which SB 32-JM7862 Revision 1 had already been embodied, the compliance time may have coincided with the next scheduled landing gear removal for HFEC inspection, and could therefore have been up to 12 months.

Prior to the G-GAVA accident, the manufacturer had not received any reports relating to migration of the special washer. In particular, neither the operator nor the third-party maintenance organisation had informed BAE Systems of the migrated washer findings on G-GAVA in March 2014 or the difficulties in installing SB 32-JM7862 Revision 1. BAE Systems was therefore unaware of the potential for rotation of the washer and did not recognise the relevance of the fouling condition in terms of its potential to degrade the surface protection on the forward pintle housing.

G-GAVA's left landing gear failed eight months after original embodiment of SB 32-JM7862, and within 5 months of the washer having been reinstalled. Revision 2 of SB 32-JM7862 had not been published at the time the washer was reinstalled in March 2014, and the next scheduled opportunity for embodiment of Revision 2 was not until December 2014.

Gasket material

In addition to the fouling condition identified with SB 32-JM7862 Revision 1, this investigation identified a number of issues with the gasket material. The third-party maintenance organisation who performed SB 32-JM7862 Revision 1 on G-GAVA expressed a number of concerns to the investigation about the curing instructions in the SB. Post-accident testing indicated that if the washer tab does not sit fully flush against the machined flat of the pintle housing, the gap might be too big to allow full anaerobic curing of the gasket, when subjected to the cure conditions described in the SB.

Following the accident, excess gasket material was found outside the profile of the washer tab on G-GAVA and no remaining gasket was evident of the forward face of the pintle housing. The third-party maintenance organisation were certain that all visible excess gasket material had been removed after the washer was reinstalled in March 2014. However, if the gasket under the washer tab had failed to cure fully, it could easily have been squeezed out when the washer rotated. The rotating washer is likely to have destroyed the gasket on the forward face of the pintle housing.

As the gasket's primary function is to prevent moisture coming into contact with the forward face of the pintle housing, its absence, in combination with the mechanical damage, would have allowed corrosion to develop. The gasket material was originally chosen based on its low-adhesion properties, so that it could be easily removed for the regular HFEC inspections. However its low adhesive nature meant that the gasket would have been easily displaced by the mechanical force when the washer rotated. BAE Systems are in the process of defining a new gasket material with higher adhesive properties and better cure performance.

Safety actions to address the unsafe condition

SB 32-A-JA140940, published in October 2014, provided the means for a one-off inspection of all landing gears on which SB 32-JM7862 had previously been embodied at Revision 1 or 2. It also defined associated rectification actions to detect, repair and re-protect any damage which may have been induced to the forward face of the pintle housing in cases where rotation of the special washer was identified or suspected. The concurrently-issued SB 32-JM7862 Revision 3 provided enhanced instructions for reinstallation of the special washer and re-protection of the surface treatment on the pintle housing. Both SB 32-A-JA140940 and SB 32-JM7862 Revision 3, mandated by EASA AD 2014-0239, describe the required mitigations to address the unsafe fouling condition identified by this investigation. In addition the aircraft manufacturer has developed an enhanced HFEC inspection technique to reduce the detectable crack size, although this has yet to be published and mandated.

The aircraft manufacturer is also taking additional steps to assure the continued airworthiness of landing gear cylinders manufactured from DTD 5094 by investigating whether any other mechanisms have the potential to cause migration of the special washer or to induce similar damage to the pintle housing, identifying an improved gasket material and enhancing the associated maintenance documentation. These activities rely on the identification of an operational aircraft on which to perform integration testing. The aircraft manufacturer has been unable to confirm the timescale for completion of this trial and so the following Safety Recommendation is made:

Safety Recommendation 2015-013

It is recommended that the European Aviation Safety Agency require BAE Systems to expedite the proposed aircraft integration trial, to investigate whether any other mechanisms have the potential to cause migration of the special washer or to induce similar damage to the pintle housing.

In the event that the ongoing safety actions, when complete, do not adequately assure the continued airworthiness of the landing gear, the manufacturer has indicated that it may have to consider mandating the removal of DTD5094 landing gear cylinders from service.

Oversight of the operator and operator's maintenance organisation

The CAA terminated an audit of the operator and maintenance organisations' Part M and Part 145 approvals in January 2014 due to the number of issues identified in the Part 145 facility and a re-audit was not scheduled until seven months later. However, during the intervening period, the CAA continued to monitor both organisations and maintained a dialogue with the Accountable Manager and key personnel while they worked to re-establish compliance with their Part 145 approval. The CAA was satisfied that improvements were being made. Both operator and maintenance organisations were going through a period of organisational change with new staff appointed and other role changes. Due to the early termination of the January 2014 audit the Part M functions had not been examined. It was not until the July 2014 audit that some of the Part M issues became evident. In particular the CAA had not been made aware of the long-term sickness absence of the Continuing Airworthiness Manager and the adverse impact this had had on the technical records database and the forecasting of maintenance tasks.

A number of the Part M and Part 145 findings identified during the audit in July 2014, particularly those relating to technical records, Part M resources for continuing airworthiness tasks and available engineering resources, may have been pertinent to the manner in which the visual inspections were conducted on G-GAVA. However, the investigation did not determine whether these issues were contributory to the crack not being detected.

The CAA audit findings were verbally communicated to the Accountable Manger at the conclusion of the audit. They were not formally issued in writing until one month later but, throughout that period, there was ongoing communication relative to the findings, between the CAA and both organisations. G-GAVA's accident occurred in this intervening period, but it is unlikely that any actions arising from the CAA findings would have had any bearing on the outcome.

The operator and maintenance organisations did not adequately address the concerns identified in the audit findings to the satisfaction of the CAA. However, the CAA considered that the subsequent suspension of the maintenance organisation's Part 145 approval, and the contracting of all maintenance and selected Part M functions, provided an alternative acceptable solution. As a result of these actions, and the consequent dissolution of the operator's maintenance organisation, the investigation did not explore these issues further and therefore no additional Safety Recommendations have been made on these aspects.

Conclusion

The aircraft's left main landing gear failed as a result of stress corrosion cracking in the forward pintle housing, at the top of the left landing gear cylinder. The landing gear material is known to be susceptible to stress corrosion cracking. The investigation determined that a design solution implemented by the aircraft manufacturer following the 2012 accident, which was intended to prevent stress corrosion cracking, had not met its original design intent.

In light of the findings of this investigation, the aircraft manufacturer is taking additional steps to assure the continued airworthiness of landing gear cylinders manufactured from DTD 5094. In addition to the two Safety Recommendations made in AAIB Special Bulletin 5/2014 published on 2 September 2014, this final report contains one further Safety Recommendation to expedite that process.

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:	Airbus A380-861, A6-EEC
No & Type of Engines:	4 Engine Alliance GP7200 turbofan engines
Year of Manufacture:	2012 (Serial no: 110)
Date & Time (UTC):	24 December 2014 at 1140 hrs
Location:	Manchester Airport
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 26 Passengers - 378
Injuries:	Crew - None Passengers - None
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	42 years
Commander's Flying Experience:	12,757 hours (of which 1,799 were on type) Last 90 days - 260 hours Last 28 days - 74 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and subsequent information provided by the operator and the aircraft manufacturer

A small external fire was observed on the exhaust nozzle of the No 4 engine after shutdown; this was extinguished with a hand-held fire extinguisher. The passengers and crew disembarked normally.

Investigation by the operator found a fuel leak at the pylon Zone F fuel double-walled junction and the pipe intended to route any leaked fuel to an overboard drain was found blocked. As a result the leaked fuel, rather than being drained away, dripped from the pylon area onto the hot exhaust nozzle.

Based on information provided by the operator and the engine manufacturer, the aircraft manufacturer is in the process of issuing an Alert Operators Transmission to all A380 operators, requiring detailed inspections of the area to identify any anomalies.

ACCIDENT

Aircraft Type and Registration:	Beech BE99, VQ-THL
No & Type of Engines:	2 Pratt And Whitney PT6-27 turboprop engines
Year of Manufacture:	1974
Date & Time (UTC):	7 December 2014 at 1910 hrs
Location:	Providenciales Airport, Turks & Caicos
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 2 Passengers - 2
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to lower nose cone, both propellers
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	34 years
Commander's Flying Experience:	5,905 hours (of which 1,871 were on type) Last 90 days - 227 hours Last 28 days - 80 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and additional AAIB inquiries

Synopsis

During a flight from Providenciales to Grand Turk, the crew were unable to extend the nose landing gear either by the normal or emergency procedures. The aircraft eventually landed with the nose gear locked in the UP position. It was subsequently found that a chain in the nose gear linkage had failed following the failure of the master link. The design of the system was such that the chain failure effectively isolated the nose gear from the operating mechanism.

History of the flight

The aircraft had departed Providenciales Airport for the short flight to Grand Turk. On selecting the landing gear down during final approach, the crew noted an 'unsafe' indication for the nose leg. Recycling the gear effected no change in the condition, so the co-pilot called ATC to advise them of the situation and to request permission for the aircraft to over-fly the airfield at 500 ft. This allowed ATC personnel in the tower to confirm that the nose landing gear had not extended. The commander then flew the aircraft in a holding pattern overhead the airfield while he considered his options. He decided to return to Providenciales as he considered that the airport there was better equipped for emergencies and it was also the maintenance base for the aircraft. After contacting the airfield the commander entered a hold approximately 15 nm away while he attempted to extend the landing gear manually in accordance with the Emergency Checklist. This once again resulted in the main landing gear extending, but the nose leg remained in the UP position.

The commander then called his company's Flight Operations department who sought advice from the maintenance team. They suggested conducting a 'touch and go' on the main wheels in an attempt to shake the nose leg into the DOWN position. The commander performed this manoeuvre but to no avail. Considering he had explored all the available options, he then took the aircraft back into a holding pattern while he briefed the co-pilot and passengers for an emergency landing. The commander declared an emergency and advised the tower of his intentions. The aircraft landed on its main landing gear and, as the speed decayed, the nose lowered to the runway surface, causing abrasion damage to the underside of the nose cone and nose gear doors. The propeller tips also contacted the runway. The aircraft was met by airfield Fire Service vehicles but there was no fire and the occupants vacated the aircraft without injury.

Investigation

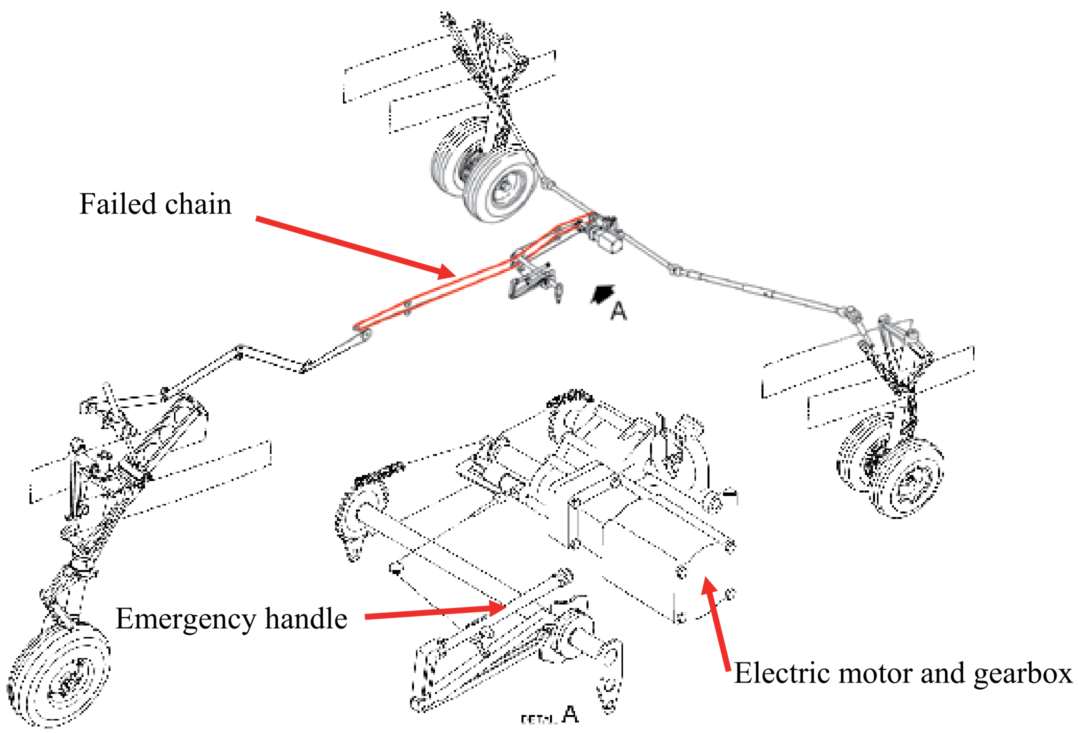

Figure 1

Illustration of Beech 99 landing gear operating system

A diagram of the landing gear system is shown at Figure 1. It can be seen that the gear is raised and lowered by an electric motor driving the linkage via a gearbox; the two other Beech 99 aircraft in the operator's fleet are equipped with a hydraulic system.

Investigation by the operator's maintenance organisation revealed that the forward segment of the chain (the portion within the area bounded by the red line in Figure 1) was found broken at the master link following a failure of the master link itself. This effectively isolated the nose gear from the rest of the system, such that operation of the emergency handle (intended to be used in the event of a failure of the motor or gearbox) would only operate the main gear. Figure 2 shows a photograph, taken by the maintenance company, of the master link components.

Figure 2

Master link components

The chain had been installed new on the aircraft on 2 October 2014 and had achieved approximately 185 hours and 540 cycles at the time of the accident. The Aircraft Maintenance Schedule required inspection at intervals of 100 flying hours; it was last inspected 39 hrs and 102 cycles prior to the accident.

The reason for the failure of the master link was not established with clarity; all the observed fracture surfaces were the result of overload. After the operator's preliminary investigation the aircraft and chain components were examined by an independent engineer. Whilst it was theoretically possible to install the master link incorrectly, the engineers who had installed the chain and the independent engineer were confident that the work had been carried out correctly.

Following the accident, the maintenance organisation has revised their maintenance programme such that, following any maintenance task requiring removal of the subject chain, an inspection will be carried out after 50 cycles. After this initial inspection the schedule would revert to the 100 hrs interval.

ACCIDENT

Aircraft Type and Registration:	Cessna F172H Skyhawk, G-AWGD
No & Type of Engines:	1 Continental Motors Corp O-300-D piston engine
Year of Manufacture:	1968 (Serial no: 503)
Date & Time (UTC):	15 April 2015 at 1300 hrs
Location:	Keyston Airfield, Cambridgeshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Major damage to wings, engine cowling and nose landing gear
Commander's Licence:	Private Pilot's Licence
Commander's Age:	47 years
Commander's Flying Experience:	104 hours (of which 75 were on type) Last 90 days - 3 hours Last 28 days - 1 hour
Information Source:	Aircraft Accident Report Form submitted by the pilot

The pilot had flown to Keyston Airfield, where he carried out a low approach and go-around to assess the condition of grass Runway 02/20, which is 724 metres long. He landed on Runway 02, which slopes upwards in the direction he was landing, without any problems. Upon departure, some two minutes later, he elected to take off on the reciprocal, Runway 20, as he wished to utilise the downslope to shorten the ground roll; the wind was from 270º and variable in strength.

However, during the takeoff roll, the pilot reports that the aircraft struck a ridge in the runway and became prematurely airborne. Despite holding into-wind aileron, the pilot was unable to prevent the left wing from striking a tall hedge, which spun the aircraft into the hedge and through about 180º before it came to rest. The pilot shut down the fuel and electrics and vacated the aircraft. He has cited an unexpected crosswind gust, combined with his unfamiliarity with the airfield, as factors in the accident.

ACCIDENT

Aircraft Type and Registration:	DA 40 D Diamond Star, G-CCHD	
No & Type of Engines:	1 Thielert TAE 125-02-99 piston engine	
Year of Manufacture:	2003 (Serial no: D4.051)	
Date & Time (UTC):	7 March 2015 at 1700 hrs	
Location:	Approx 4 miles west of Shoreham Airport, West Sussex	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	Rear fuselage partially detached, damage to right wing, propeller and nosewheel	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	28 years	
Commander's Flying Experience:	126 hours (of which 31 were on type) Last 90 days - 4 hours Last 28 days - 0 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

Synopsis

The aircraft was climbing out after takeoff when the engine stopped at a height of about 1,100 ft. In the subsequent forced landing, three sheep were killed and the aircraft was badly damaged. It was found that a fuel injector and its unions had become loose and caused a total loss of fuel pressure. It could not be determined how the injector support and its securing screw had come undone as neither were recovered.

History of the flight

The purpose of the flight was to build the flying hours of the pilot, who was registered as a student at the flying school which owned the aircraft. Prior to departure from Shoreham, he performed all the required checks and completed the necessary paperwork before taxiing for takeoff on Runway 20.

During the initial climb the aircraft's performance and all indications appeared normal and, at a height of about 600 ft agl, the pilot executed a planned 90º climbing turn to the right. However as he reached approximately 1,000 ft, he sensed a slight reduction in engine noise and saw a drop to about 95% rpm from the full power selected. Although this appeared to correct itself, he commenced a precautionary wide turn to the right in anticipation that he might have to return to Shoreham. Upon reaching about 1,100 ft, he sensed another drop in noise which reduced to silence after a few seconds, with less than 2% engine rpm indicated. With the sea to his left and a built-up area below him, he steepened the right turn towards north and open ground whilst trying to restart the engine without success.

With only two suitable fields to choose from, he had to select one which contained a flock of sheep, since the other had power lines obstructing it. As he touched down in the muddy field the aircraft struck three of the sheep, killing them before it ran through the boundary fence and into another field containing trees. As the left wing struck one of the trees, the aircraft was spun through 90° anticlockwise before coming to a halt with the rear fuselage partially detached and the nosewheel collapsed.

The pilot shut down the aircraft and exited normally in time to warn a couple who had come to help to stay clear in case of fire (he recalled he had smelt burning during the descent). There was no fire and, whilst the couple called the emergency services, he called the flying club to advise them of his situation.

Engine examination

Engineers from the aircraft's maintainers arrived at the site and checked fluid levels and downloaded the data from the engine FADEC (Full Authority Digital Engine Control) unit. Although at first it visually appeared that nothing was wrong with the engine, the data for the accident flight showed a series of alerts for low fuel rail pressure. The next day, upon closer inspection, it was found that No 2 cylinder injector securing screw and injector support were missing, the injector itself was out of position by about 50 mm and the associated fuel pipe unions had loosened (Figure 1).

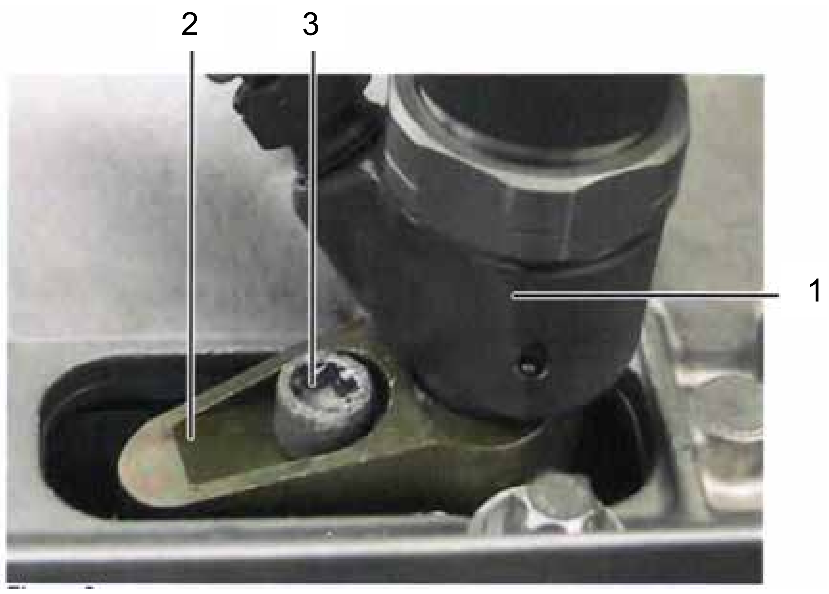

Figure 1

Photograph of intact assembly showing Injector (1), Injector Support (2) and Securing Screw (3).
(Photo courtesy Technify Motors)

The injector had been removed and replaced on 24 February 2015 in order to rectify a leak from its injector seal. The spares invoice for this task indicates that, in addition to a new sealing ring, the injector securing screw was also replaced as required by Technify Repair Manual RM-02-02 Chapter 73-10.05 Issue 3.

The same section of the manual, revised in July 2014, also specified the following:

> *'Note:*
> *Before a third injector change – the Repair of the Thread for Injector Attachment must be done. Refer to Chapter 73-10.10'*

The repair involved insertion of a helicoil insert into the female thread.

The manufacturer has advised that this requirement arose from a case that occurred earlier in 2014 in which an Italian registered DA 40 suffered an engine failure and subsequent successful forced landing. Like G-CCHD, the FADEC data showed a loss of rail pressure occurring at the moment of failure. Physical examination revealed that an injector was similarly displaced and the screw and support were also displaced but were still present. Investigation by the Italian Authorities and the manufacturer showed that the thread in the aluminium cylinder head had stripped.

The manufacturer decided that the corrective action would be to do the thread repair at the third injector change, hence the revision of Chapter 73-10.05. It was not felt necessary to issue a Service Bulletin or similar to highlight this change and it was noted that Chapter 73-10.10 did not refer to the third injector change requirement and remained dated December 2013.

The maintenance company stated that the staff involved in G-CCHD's injector removal on 24 February 2015 were aware of the repair requirement, but were using the engine log book to ascertain how many times the injector had been changed. However, the log book was not used to record how many times the injector had been removed and refitted. Such an action could occur several times for processes such as cleaning, sealing ring replacement or for the scheduled 900-hour timing chain replacement but would be entered on work sheets. All staff have now been instructed to make a record in the engine log book every time an injector is disturbed.

Discussion

The cause of the loss of engine power on G-CCHD was the loss of fuel pressure due to a loose fuel injector. After the accident, the maintainer inserted a new screw into No 2 female thread and was able to torque it up to the required value; therefore, it is unlikely that the thread in the cylinder head was stripped. In addition to the screw and injector support, the copper injector seal was also found to be missing.

In their report into the previous Italian incident, the engine manufacturer provided three scenarios which it considered could cause a fuel injector to come loose:

1. The presence of fluid at the base of the thread which could expand with temperature and cause stripping of the thread. Fluid had been found at the bottom of all four threads (which were also damaged) of the engine involved in the Italian incident and this, according to the manufacturer, was the most probable reason for the failure in that case.

2. The screw was either overtorqued or undertorqued by the mechanic. Overtorquing would risk stripping the thread in the aluminium cylinder head whilst undertorquing could result in the screw working loose. The type of screw used requires a specific tightening method and failure to observe the correct sequence could result in either of the above.

3. The screw was not renewed at its last removal/replacement[1].

The maintainer's paperwork records that a new screw had been requisitioned for the injector removal on 24 February 2015 and the hole should have been cleaned before it was inserted. The missing copper injector seal was unusual because it should have been present and the injector did not come completely out of its housing. The manufacturer ran tests without a seal present and believes that the high temperatures from leaking gas may have been sufficient to compromise the self-locking feature of the screw.

Therefore it could not be determined why the screw had apparently become loose and neither it, the injector support nor the seal were recovered. At the time of the accident, the aircraft had flown 8 hours and 40 minutes in over 13 flights since the injector seal replacement.

Footnote

[1] The screw is of a 'Torque-to-Yield' type which must not be re-used after removal. The method of torquing is to tighten to a set torque and then perform two separate 90° turn operations. The manufacturer also advises that the screws have a self-locking feature which is destroyed when they are undone.

ACCIDENT

Aircraft Type and Registration:	De Havilland DH82A Tiger Moth, G-BYTN
No & Type of Engines:	1 De Havilland Gipsy Major 1C piston engine
Year of Manufacture:	1939 (Serial no: 3993)
Date & Time (UTC):	16 April 2015 at 1245 hrs
Location:	Near Netherthorpe Airfield, Nottinghamshire
Type of Flight:	Aerial Work
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Severe damage to lower right wing, fin, propeller and possible distortion of fuselage
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	29 years
Commander's Flying Experience:	1,050 hours (of which 10 were on type) Last 90 days - 46 hours Last 28 days - 13 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The pilot and passenger were taking off for a pleasure flight in the local area. The aircraft had full fuel and was just below its Maximum Takeoff Weight (MTOW). After lift off, the pilot found that he was unable to climb out of ground effect and decided to land in a field of crops. During the subsequent landing, the aircraft flipped inverted. The pilot believes that a slight reduction in available power, coupled with calm wind conditions and the short runways at Netherthorpe, contributed to the accident.

History of the flight

The aircraft was operated by a company specialising in scenic experience flights, principally in the Tiger Moth aircraft. On the day of the accident, the pilot had flown 'TN' four times and the aircraft itself had flown six times. He elected to use grass Runway 24, which has a Takeoff Run Available (TORA) of 490 metres, since there was no discernible wind. This runway has a 1.9% upslope.

After his second flight of the day, the pilot had been advised by an observer to use more of the TORA since it appeared that he was starting the takeoff roll from the intersection with the cross runway 18/36. Having assured the observer that this was not the case and he was, in fact, starting adjacent to the runway numbers, he resolved to make better use of the TORA and start further back during subsequent takeoffs.

After his last successful takeoff, the aircraft was refuelled whilst the pilot briefed his next passenger. He was aware that, with full fuel and a passenger weighing 101 kg, the aircraft would be heavy, but some 32 kg less than the 828 kg MTOW. After briefing his passenger, the pilot started the engine and backtracked along the southern side of Runway 24 to position the aircraft just before the beginning of the displaced threshold arrow for the start of the takeoff run.

The first part of the run seemed normal and he let the tail rise. The aircraft then struck an undulation and briefly became airborne but, despite the pilot's attempt to stay airborne, it touched down again. He tried again, aware that he had used about 250 metres of the runway compared with some 175 metres on previous takeoffs. Conscious of the extra weight, he briefly allowed the aircraft to stay in ground effect in order to accelerate, before raising the nose to climb away. At this point, the pilot felt that there was a general lack of energy and the climb rate reduced. He glanced at the airspeed indicator and recalls it reading 36-37 kt, so he lowered the nose to try and regain some energy, but this inevitably caused the aircraft to sink. He later noted from his GPS that he had reached a maximum height of 20 ft, although it had appeared to him at the time more like 30-50 ft.

Aware that the aircraft was sinking and that there were buildings and hedgerows ahead hidden underneath the nose, the pilot decided to put the aircraft down in a field and chose an oil seed rape field at about his 11 o'clock position. He touched down in the field but was still applying left bank to steer the aircraft away from a hedgerow. The left lower wingtip brushed the crop and then the ground. In trying to straighten up, the right lower wingtip and the main landing gear struck the ground, causing the aircraft to flip inverted at a speed the pilot estimates to have been about 35 kt. The passenger evacuated the aircraft first, followed by the pilot.

The pilot believes that there was insufficient power to climb out of ground effect and advocated a more restrictive weight limit than the MTOW when operating out of Netherthorpe in calm conditions. He also had anecdotal evidence that the Tiger Moth's Gipsy engine was prone to a reduction of available power when operating continually over a lengthy period, due to heat build-up. Both the organisations with Type Responsibility for the Tiger Moth and Gypsy engines are not aware of such an issue with correctly set up and maintained engines.

ACCIDENT

Aircraft Type and Registration:	Piper PA-28-161, G-BZMT
No & Type of Engines:	1 Lycoming 0-320-D3G piston engine
Year of Manufacture:	2000 (Serial no: 2842107)
Date & Time (UTC):	11 May 2015 at 1700 hrs
Location:	White Waltham Airfield, Berkshire
Type of Flight:	Training
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - 1 (Minor)
Nature of Damage:	Aircraft damaged beyond economic repair
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	30 years
Commander's Flying Experience:	762 hours (of which 649 were on type) Last 90 days - 154 hours Last 28 days - 61 hours (all on type)
Information Source:	Aircraft Accident Report Form submitted by the pilot and AAIB enquiries

Synopsis

The engine failed shortly after takeoff and the aircraft was subsequently damaged during the subsequent forced landing. The instructor was uninjured and the student sustained minor injuries.

History of the flight

This was the instructor's fourth, and the student's first, flight flown in G-BZMT on the day of the accident. The engine power checks were reported as normal and the wind was 12 kt from 210º. The aircraft departed from Runway 25 and shortly after passing 200 ft aal the engine failed. The instructor took control of the aircraft and made a MAYDAY call on the airfield frequency. The instructor reported that at such a low height there were few options available and he elected to manoeuvre the aircraft to land in the field directly beneath the aircraft. The aircraft touched down, with full flap selected, on a heading of approximately 90º and ran along the ground for about 50 m before it collided with an earth bank and fence.

On vacating the aircraft the instructor noticed that there was a fire in the right side of the engine compartment. He instructed the student to turn the fuel selector to OFF and after assisting the student to vacate the aircraft he discharged the aircraft hand fire extinguisher into the engine compartment. The fire continued to burn and was eventually extinguished by the airfield first responders who had been directed to the accident site by the pilot of an aircraft orbiting in the overhead. The student reported that he experienced difficulty in moving the fuel selector valve beyond the safety catch into the OFF position and, as the aircraft was on fire, vacated the aircraft leaving the fuel selector valve in the LEFT position.

While the instructor was uninjured, the student reported pains in his back and chest and was taken by ambulance to a local hospital. The student subsequently reported that he had sustained severe bruising to his lower back, chest and legs.

The aircraft was extensively damaged. The engine mount was distorted and the engine fuel pipes and carburettor were damaged. The left fuel tank had been punctured and the nose and right main landing gear leg had broken. The aircraft was assessed as being beyond economic repair.

ACCIDENT

Aircraft Type and Registration:	Rans S10 Sakota, G-BRPT
No & Type of Engines:	1 Rotax 532 piston engine
Year of Manufacture:	1990 (Serial no: PFA 194-11554)
Date & Time (UTC):	27 April 2015 at 1440 hrs
Location:	Approx 2 miles east of Henstridge Airfield, Somerset
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to both main landing gear legs and minor scrapes on fuselage
Commander's Licence:	Private Pilot's Licence
Commander's Age:	61 years
Commander's Flying Experience:	14,994 hours (of which 9 were on type) Last 90 days - 11 hours Last 28 days - 4 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft had commenced a descent to land when the engine started to run erratically and then stopped. During the subsequent forced landing into a field, the aircraft ground looped and suffered damage to its main landing gear. Low fuel levels may have been responsible for the engine failure.

History of the flight

The aircraft had taken off for a short local flight. A couple of steep turns were carried out before starting a descent from about 2,000 ft agl to join a wide left base leg for Runway 25 at Henstridge. However, at about 1,500 ft, the engine started to run erratically and the pilot checked the fuel in both wing tanks. Whilst difficult to see, a visual check showed fuel 'sloshing' in both tanks but at this point the engine stopped completely.

The pilot commenced a glide towards the runway but it soon became obvious that he would not reach the airfield, so he selected a field and made a radio call. On turning short finals for the field, it became apparent that the aircraft was very low and a mainwheel clipped a protruding branch of the hedge bordering the field. This caused the aircraft to yaw and then ground loop on landing, damaging both main landing gear legs. The pilot was unhurt and vacated the aircraft normally.

An inspection of the aircraft the following day, as it was being salvaged, confirmed that fuel was present in both tanks and in the lines leading to the primer. When recovered to a hangar, it was found that the forward carburettor float chamber contained fuel whilst the rear one did not and the gascolator was also empty. From this, the pilot concluded that the relatively low fuel level in the fuel tanks may have led to the ports in the tanks, which are located towards the rear, becoming uncovered either during the turns or in the descent. His aircraft had neither a collector tank nor electric pump and an airlock may have occurred.

ACCIDENT

Aircraft Type and Registration:	Robin ATL, G-GFRO
No & Type of Engines:	1 JPX 4T60/A piston engine
Year of Manufacture:	1991 (Serial no: 64)
Date & Time (UTC):	11 April 2015 at 1200 hrs
Location:	Nympsfield gliding site, Gloucestershire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Nosewheel detached and propeller blade damaged
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	56 years
Commander's Flying Experience:	8,388 hours (of which 1 was on type) Last 90 days - 154 hours Last 28 days - 53 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft was taking off from a grass gliding field, having abandoned a previous attempt due to an apparent lack of performance. Although the takeoff roll and lift off were normal, at about 100 ft agl the engine lost power, but sufficient power remained for the pilot to position the aircraft back for a normal approach and landing. However, he had to land in a different part of the site due to conflict with a landing glider and the nose landing gear detached as the aircraft travelled over some rough ground during the landing roll. Carburettor icing is suspected as the most probable cause of the power loss.

History of the flight

The pilot intended to perform a ferry flight as a favour for the new owner of the aircraft. He had performed a couple of short test flights the week before the accident under the supervision of the previous owner, who had warned him of the aircraft's susceptibility to carburettor icing. The forecast temperature and dewpoint were 15ºC and 12ºC, respectively.

For this trip, the pilot was accompanied by an engineer acting for the new owner. After warming the engine they attempted a takeoff, but aborted when the aircraft failed to accelerate sufficiently and had reached a pre-arranged marker. The two occupants decided that carburettor icing from the damp grass was the most probable cause and taxied back with the carburettor heat applied. The carburettor heat was left on for a further 5 minutes before starting a second takeoff roll. This time the pilot confirmed that full rpm was achieved and the aircraft lifted off at the expected position. However, as they crossed the airfield perimeter at a height of 100 ft agl, the engine rpm dropped abruptly, prompting the pilot to select a field suitable for a forced landing in the valley below. Having made his choice, he selected carburettor heat, changed fuel tanks and checked that the fuel pump was selected on. The engine appeared to recover to full power, so the pilot started a gentle climb and turned back towards the airfield. The power reduced again and engine rpm fluctuated randomly between 2,700 (normal full power) and 2,200; this was just sufficient to maintain a shallow climb and the pilot was able to position the aircraft for a touchdown in the area of the field normally used for landing.

However, as he prepared to land, he was warned over the radio that a glider was below and slightly to his right. The pilot judged that a go-around would be too risky considering the unreliability of the engine, so he left power on and the flaps up in order to land long, clear of the normal glider area. When he reduced power to land, the engine power reduced dramatically to a sub-idle condition and stopped completely upon touchdown, which was otherwise smooth, in the middle of the airfield. After a ground roll of about 50 metres, the aircraft bounced heavily over a ridge and down into rougher ground, whereupon the nosewheel detached and then the nose landing gear leg collapsed.

The pilot reports that the engine generally, and the spark plugs and leads in particular, were examined, with no anomalies found. The fuel was sampled and found to be free of contaminants. Although it could not be proved, it was suspected that carburettor icing may have been responsible for the loss of power.

ACCIDENT

Aircraft Type and Registration:	Sipa 903, G-ASXC	
No & Type of Engines:	1 Continental Motors Corp C90-14F piston engine	
Year of Manufacture:	1951 (Serial no: 8)	
Date & Time (UTC):	4 April 2015 at 1140 hrs	
Location:	Eaglescott Airfield, Devon	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 1
Injuries:	Crew - None	Passengers - None
Nature of Damage:	Aircraft damaged beyond economic repair	
Commander's Licence:	Light Aircraft Pilot's Licence	
Commander's Age:	24 years	
Commander's Flying Experience:	144 hours (of which 9 were on type) Last 90 days - 12 hours Last 28 days - 9 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

The accident occurred as the aircraft was landing on Runway 07 at Eaglescott Airfield. The pilot estimated that the wind was from 010º at 14 kt and he reported that just as the aircraft reached the runway he experienced a strong gust of wind that destabilised his approach. He applied full engine power and commenced a go-around. However the aircraft yawed, rolled to the left and collided with a glider trailer before flying into a hedge that ran parallel to the runway. The trailer and hedge were situated approximately 150 m from the edge of the runway. The pilot stated that when he commenced the go-around the aircraft was flying relatively slowly and he was of the opinion that the accident occurred because he did not apply sufficient rudder to maintain directional control. The aircraft was damaged beyond economic repair.

ACCIDENT

Aircraft Type and Registration:	Z-1RA Stummelflitzer, G-ZIRA
No & Type of Engines:	1 Rotec R2800 piston engine
Year of Manufacture:	2008 (Serial no: PFA 342-14596)
Date & Time (UTC):	25 April 2015 at 1715 hrs
Location:	White Waltham Airfield, Berkshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to propeller, fin, rudder and engine mounting/firewall
Commander's Licence:	Private Pilot's Licence
Commander's Age:	52 years
Commander's Flying Experience:	518 hours (of which 5 were on type) Last 90 days - 23 hours Last 28 days - 13 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The Z-1RA Stummelflitzer is an aircraft of tail skid design. The approach appeared normal with a wind of 8 kt from 250°. Upon touching down on grass Runway 25 at an airspeed of 50 kt the aircraft bounced and the pilot applied a small amount of corrective forward stick. As the aircraft touched down again, the pilot applied the brake pedals and the aircraft nosed over onto its back. The pilot, who had been using a full harness and wearing a protective helmet, exited the aircraft uninjured.

The pilot had taken ownership of the aircraft six days prior to the accident, during which he had accrued a total of five hours flying time and made approximately 16 landings. The pilot felt that he had become familiar with the braking action during this period, commenting that they had not felt particularly powerful. On the day of the accident the pilot had flown the aircraft wearing a new pair of shoes that he thought would improve his tactile feel of the brake and rudder pedals.

The pilot considered the reason for the accident was a culmination of factors, which included inexperience on type, excessive brake application due to a change in footwear and reversion to the heavier braking technique he used for tricycle landing gear aircraft when landing on short runways.

ACCIDENT

Aircraft Type and Registration:	Ace Aviation Magic Cyclone, G-IXXY
No & Type of Engines:	1 Rotax 447 piston engine
Year of Manufacture:	2015
Date & Time (UTC):	5 February 2015 at 1520 hrs
Location:	Perth Airport, Perthshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Minimal damage to landing gear assembly
Commander's Licence:	Private Pilot's Licence
Commander's Age:	54 years
Commander's Flying Experience:	1,500 hours (of which 610 were on type) Last 90 days - 6 hours Last 28 days - 6 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The pilot was carrying out an initial flight test of the microlight. The weather was fine, with calm wind and good visibility. Five minutes after takeoff from Perth Airport, the pilot flew an approach to Runway 09, a 609 m asphalt runway. After touchdown, the pilot was unable to prevent the microlight veering to the right and the right mainwheel ran onto the adjacent grass. He reported that the runway excursion caused a jolt through the airframe which resulted in the fracture of a 'D' shackle in the rear drag link tension cable assembly. This in turn caused the right landing gear to collapse (it was designed to fold for de-rigging, once the 'D' shackle was unfastened).

ACCIDENT

Aircraft Type and Registration:	Hoffmann H 36 Dimona, G-BNUX	
No & Type of Engines:	1 Limbach L 2000-EBIC piston engine	
Year of Manufacture:	1987 (Serial no: 36236)	
Date & Time (UTC):	24 April 2015 at 1400 hrs	
Location:	Saltby Airfield, Lincolnshire	
Type of Flight:	Training	
Persons on Board:	Crew - 1	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	Damage to propeller and engine	
Commander's Licence:	National Private Pilot's Licence	
Commander's Age:	67 years	
Commander's Flying Experience:	243 hours (of which 22 were on type) Last 90 days - 6 hours Last 28 days - 3 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

The pilot had been practising circuits on Runway 25 at Saltby Airfield. Having successfully completed two, on his third circuit he found that the crosswind and level of turbulence had increased such that the approach had become "a bit challenging". The aircraft ballooned at a height of 20 ft, so he executed a go-around. The actual wind was from 210-220º at 15-20 kt.

On the next approach the turbulence had worsened. The pilot was having to fly with his left hand on the control column and his right on the spoiler/brake lever, whereas most of his previous experience on other aircraft had used the opposite method. At about 40 ft, the aircraft was buffeted strongly but the pilot's reactions were on the wrong controls – treating the spoiler lever as the control column and vice-versa. The aircraft descended rapidly and either ballooned or bounced back into the air. He admits he was confused and lacked the presence of mind at that stage to open the throttle and abandon the landing. He continued and hit the ground hard in a level attitude, causing damage to the propeller and engine but coming to a halt after a normal ground roll.

ACCIDENT

Aircraft Type and Registration:	Jabiru UL-450, G-CBOP	
No & Type of Engines:	1 Jabiru 2200A piston engine	
Year of Manufacture:	2002 (Serial no: PFA 274A-13611)	
Date & Time (UTC):	10 March 2015 at 1430 hrs	
Location:	Oxenhope Airfield, West Yorkshire	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	Bent nose landing gear, lower front fuselage at gear attachment point, front floor, propeller, and side rear window cracked	
Commander's Licence:	National Private Pilot's Licence	
Commander's Age:	67 years	
Commander's Flying Experience:	4 hours (of which 3 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 went around from his first approach to land on Runway 29 as, due to thermal activity, he was too high over the threshold. The second approach, with a slight crosswind from the right at 12 kt, was better but, as the aircraft touched down on the main wheels, a gust lifted the right wing causing the aircraft to drift to the left and the nose to drop. On contact with the ground, the nose leg collapsed, the propeller struck the ground and the aircraft tipped over onto its back. The pilot, who had been wearing a lap and diagonal harness, was unhurt and he vacated the aircraft unaided.

ACCIDENT

Aircraft Type and Registration:	Pegasus Quantum 15, G-MZGG
No & Type of Engines:	1 Rotax 503-2V piston engine
Year of Manufacture:	1997 (Serial no: 7327)
Date & Time (UTC):	15 April 2015 at 1320 hrs
Location:	Sutton Meadows Airfield, Cambridgeshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Extensive damage to pod, front strut, base bar, steering mechanism, and wing
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	37 years
Commander's Flying Experience:	94 hours (of which 44 were on type) Last 90 days - 2 hours Last 28 days - 1 hour
Information Source:	Aircraft Accident Report Form submitted by the pilot

The aircraft took off from Runway 28 at Sutton Meadows Airfield and was climbing under full power to about 200 ft agl when the engine failed abruptly. The pilot intended to land straight ahead in a farmer's field but soon realised that he would probably have insufficient energy to clear a dyke which lay between the end of the runway and the chosen landing field.

He then attempted to lose height in order to land on the end of the runway before the dyke but he was unable to prevent the aircraft from rolling off the end of the runway and into the dyke. It came to rest with its wings suspended between the dyke banks and the pod partly submerged in the water.

The pilot reports that the cause of the engine failure has not been ascertained. He has stated an intention to practise engine failures during takeoff rather than just from level flight, and also to consider first the option of losing height to land back on the departure runway rather than gliding to a field beyond it. He believes that, had he done this immediately, he may have been able to stop before the dyke.

ACCIDENT

Aircraft Type and Registration:	Rans S6-ESD XI (Modified) Coyote II, G-MZBV
No & Type of Engines:	1 Rotax 582-48 piston engine
Year of Manufacture:	1996 (Serial no: PFA 204-13009)
Date & Time (UTC):	21 April 2015 at 1800 hrs
Location:	Near Andreas Airfield, Isle of Man
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers – 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Severe damage to nose cowling, engine, propeller, left wing and nose leg
Commander's Licence:	Private Pilot's Licence
Commander's Age:	60 years
Commander's Flying Experience:	748 hours (of which 320 were on type) Last 90 days - 4 hours Last 28 days - 2 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The aircraft had taken off from Runway 11 at Andreas Airfield and was climbing out towards the coast when, approximately 4 minutes later, the engine suffered a reduction in power. The pilot turned the aircraft back towards the airfield as a precaution but, halfway through the turn, the engine stopped completely. He continued the turn and headed for Runway 29 as he switched fuel tanks and tried to restart the engine, but without success.

The pilot realised that he was not going to reach the airfield and selected a field for a forced landing. However, as he made his approach to the field he realised that he had not anticipated the high sink rate, with the result that the main landing gear contacted a high hedge bordering the field. This pitched the aircraft into the field in a nose-down attitude. Both occupants were able to exit normally.

A number of checks were performed after the accident and these indicated that any issues with fuel supply or contamination were unlikely. It was, however, found that there were no ignition sparks from either magneto. The reasons why this may have occurred are not known at the time of preparation of this Bulletin.

ACCIDENT

Aircraft Type and Registration:	Rotorsport UK Calidus, G-PCPC
No & Type of Engines:	1 Rotax 912 Piston Engine
Year of Manufacture:	2015 (Serial no: RSUK/CALS/026)
Date & Time (UTC):	8 April 2015 at 0959 hrs
Location:	Damyns Hall Aerodrome, Essex
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Rotor blades, propeller, tailplane, right landing gear and possible engine damage
Commander's Licence:	Private Pilot's Licence
Commander's Age:	56 years
Commander's Flying Experience:	240 hours (of which 9 were on type) Last 90 days - 12 hours Last 28 days - 8 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and further enquiries by the AAIB

Synopsis

The gyroplane began to move forward against the brakes before sufficient rotor rpm had been achieved for takeoff. The pilot responded by re-positioning the control stick fully aft and the rotors struck the tailplane. The pilot lost directional control and the right landing gear subsequently failed, causing the gyroplane to tip onto its right side. The pilot was uninjured.

History of the flight

The pilot had gained most of his flying experience in a Rotorsport MT-03 gyroplane. He had recently acquired G-PCPC, a gyroplane with an enclosed cockpit and a variable pitch propeller, and had flown his new machine several times over the preceding few days. On the morning of the accident, he planned to remain in the circuit at Damyns Hall Aerodrome. The weather was excellent, there was no wind, little circuit traffic and he did not feel he was affected by any external pressures. Pre-flight checks were completed at the holding point of grass Runway 03.

After lining-up, the pilot slowly began to pre-rotate the rotor, gradually increasing engine revolutions as the rotor speed increased. The control stick was held fully forward and the brakes were applied. The pilot was aiming to achieve a rotor speed of at least 200 rpm before releasing the brakes but, despite a continued increase of engine speed, the rotor rpm would not accelerate beyond 150 rpm. The gyroplane began to move forward, against the brakes, and the pilot decided not to take off. Instead, he opted to run the gyroplane along the runway, to practice rotor management and wheel balancing.

The pilot released the pre-rotator and, with the propeller set to fine, he reduced engine power a little and moved the control stick fully aft. He released the brakes and the gyroplane started to accelerate but shortly afterwards there was a loud series of bangs and severe vibration. The rotor had struck the tailplane and a piece of the fin had detached.

The gyroplane veered to the left and ran off the runway, despite the pilot trying to correct this by applying right pedal. He had difficulty dealing with the problem, due to the severe vibration, but did reduce the engine power to idle and re-positioned the control stick fully forward. At this stage, the right wheel caught in a shallow furrow adjacent to the runway and the wheel snapped off.

The gyroplane tipped onto its right side and the propeller blades struck the ground. The pilot was encouraged by the smell of petrol to turn off the ignition but he then had difficulty opening the canopy. Other people arrived and helped him to vacate the gyroplane, uninjured.

Discussion

The pilot considered that the accident happened because he moved the control stick fully aft when the gyroplane started to move forwards, before sufficient rotor rpm had been achieved. He thought that he had been too gentle with the pre-engagement process and that if he had increased the engine rpm more positively the rotor rpm would have increased further. He also noted that, when the gyroplane started moving, he should have reduced engine rpm and let the rotor rpm slow towards 50 rpm, while keeping the control stick fully forward.

He suggested that, when the rotor struck the tailplane, he ought to have been quicker to reduce engine power and move the stick forward. He was disorientated by the noise and the vibration and did not make use of all available right rudder, which might have allowed him to regain directional control.

Miscellaneous

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

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

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

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

Published September 2010.

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

Published September 2010.

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

Published November 2010.

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

Published November 2010.

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

Published December 2010.

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

Published September 2011.

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

Published November 2011.

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 southwest 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.

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
DFDR	Digital Flight Data 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)
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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