ACCIDENT

Aircraft Type and Registration:	BAE Systems Jetstream 31, G-CCPW
No & Type of Engines:	2 Garrett Airesearch TPE 331-10UGR-5164 turboprop engines
Year of Manufacture:	1987
Location:	Runway 26, Isle of Man Airport
Date & Time (UTC):	8 March 2012 at 1757 hrs
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 2 Passengers - 12
Injuries:	Crew - None Passengers - None
Nature of Damage:	Right main landing gear yoke pintle fractured, right engine and propeller blades damaged
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	58 years
Commander's Flying Experience:	About 6,000 hrs (of which about 1,500 hrs were on type)
Information Source:	AAIB Field Investigation

Synopsis

The aircraft's right main landing gear failed as it landed on Runway 26 at Isle of Man Airport. The right main landing gear detached, the aircraft slid along the runway on its remaining landing gears, right wingtip and luggage pannier and came to rest on the grass adjacent to the runway. The passengers and crew vacated the aircraft without injury. The mechanism to final failure is not yet fully understood, but was initiated as a result of stress corrosion cracking in the forward yoke pintle at the top of the right main landing gear leg. One Safety Recommendation is made.

History of the flight

The aircraft and crew were operating a passenger service from Leeds Bradford International Airport to Isle of Man Airport. The flight had been routine and the crew were flying a day, visual approach to Runway 26, in good weather, with the surface wind reported as 210° at 14 kt. The commander was the pilot flying (PF) and the co-pilot, who had recently joined the company, was nearing the end of his line training on type.

The approach was flown with full flap and the gear locked and confirmed down by the three green gear indicators. The landing weight was estimated to be 13,448 lb (6,099 kg) and the crew recalled that the V_{ref} was about 105 kt.

Almost immediately the aircraft touched down it leaned to the right and there was an unusual noise. The commander levelled the aircraft with a left roll input. However, as the speed decayed the lean increased and it became apparent that there was a problem with the right gear. The commander continued to apply left aileron and rudder. Both pilots recognised that the aircraft was likely to leave the paved surface and so the co-pilot held the control wheel and rudder to allow the commander to apply nosewheel steering and operate the feather levers[1]. The left engine was shut down and feathered as the aircraft departed the runway. The right engine was also shut down but its propeller did not feather as the mechanism appears to have been damaged when the blades contacted the runway. The aircraft left the paved surface, yawed to the right and slid sideways before it came to a stop 90° to the runway heading.

Footnote

[1] The appropriate feather lever shuts off fuel to its engine as well as feathering the propeller.

The Air Traffic Controller Officer located in the visual control room of the tower, to the north of the runway, saw the right propeller strike the runway as the gear collapsed. This was also seen by the airport fire-fighter on duty at the Airport Fire and Rescue Service (AFRS) watch office, located to the south of the runway. Both pressed their respective crash alarms while the aircraft was still moving and the AFRS arrived at the aircraft less than 2 minutes after it had come to a stop.

The commander shut down the aircraft while the co-pilot entered the passenger cabin, ascertained that there were no significant injuries and opened the rear passenger door. The passengers and crew deplaned without injury.

Runway marks and debris

The aircraft left a number of marks on the runway surface starting approximately 90 m from the start of the threshold markings. The first marks were made by the right engine propeller blades cutting into the runway surface. Sections of the right landing gear yoke pintle were found at 150 m and 180 m from the runway threshold near the right landing gear door.

Flight data

The aircraft was equipped with a 25 hour continuous-loop Digital Flight Data Recorder (DFDR) that recorded five parameters: time, pressure altitude, indicated airspeed, normal acceleration and heading. The normal acceleration at touchdown, after adjusting for maximum accelerometer drift of 0.04 g, was established as 1.72 g. This was the highest value recorded during the 20 flights recorded on the DFDR.

Additionally, a Terrain Avoidance Warning System (TAWS) installed in the aircraft recorded 30 separate parameters including Radio Altitude (Rad Alt) and

pressure altitude at a higher sampling rate than the DFDR. From this altitude information it was established that the rate of descent, just prior to touchdown, was 463 ft / min (7.7 ft/sec). This is within the landing gear limit load defined for a touchdown with a rate of descent of 10 ft/sec at the maximum landing weight of 14,900 lb (6,758 kg).

The aircraft was also equipped with a 30 minute continuous-loop Cockpit Voice Recorder (CVR), which recorded crew speech and ambient flight deck sounds from an area microphone. From the area microphone it was possible to identify a loud mechanical noise and the propeller blades striking the runway as the aircraft touched down.

The information from the DFDR, TAWS and CVR has been combined and is shown in Figure 1.

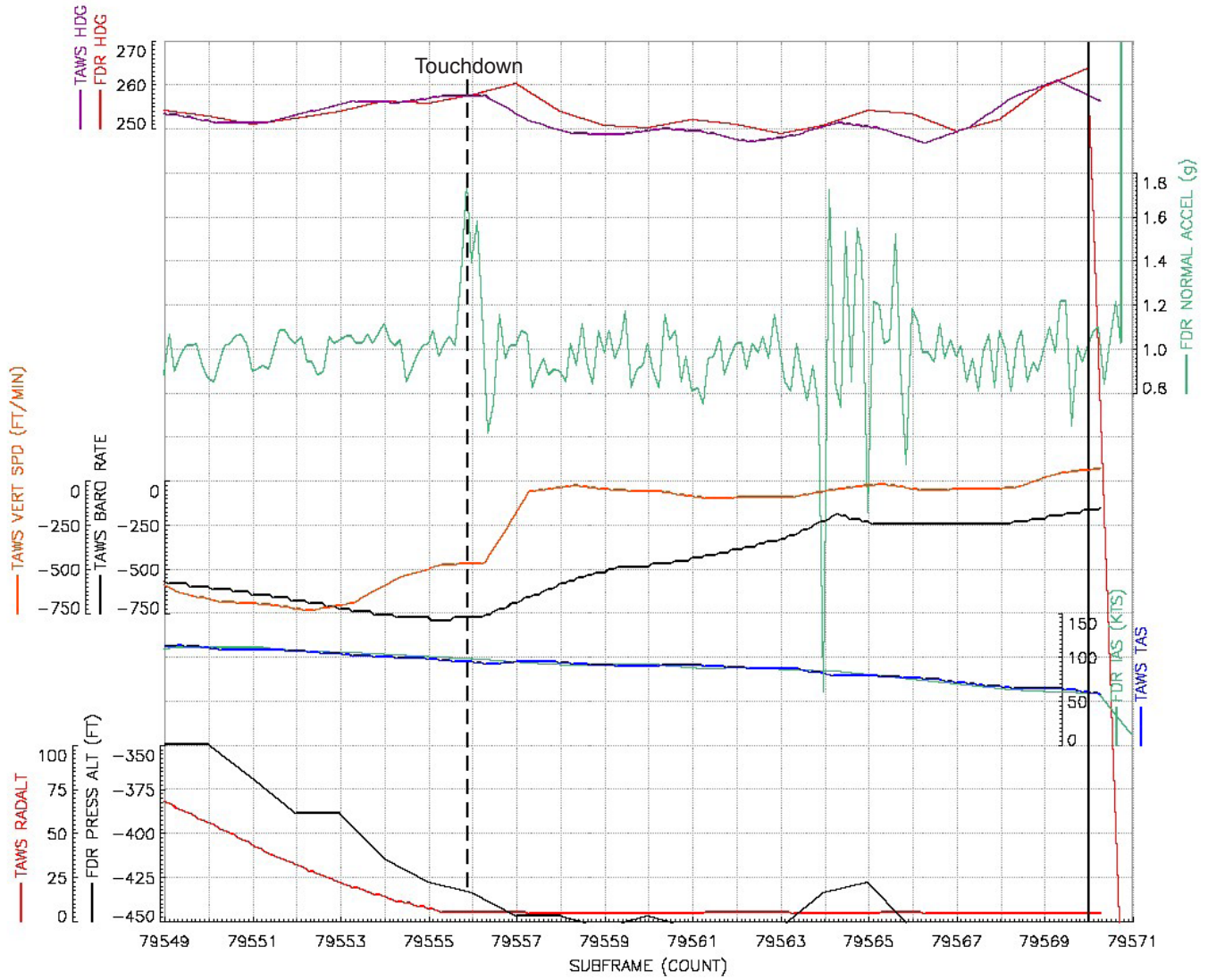

Figure 1

Data recorded during the landing

Aircraft damage

The right landing gear had broken away from its trunnions as a result of a failure of the forward yoke pintle housing (refer to Figure 2). However, the landing gear remained attached to the aircraft by the radius arm (retraction jack) and hydraulic pipelines. The downlock microswitch, which is fitted to the radius arm, remained intact and when electrical power was selected ON all three green landing gear position lights illuminated.

The blades on the right propeller had been badly damaged and the right engine appeared to be distorted in its engine mounts. The right aileron balance horn, wingtip and a section of the pannier had abraded away. There was some distortion to the right wheel well and flaps where the landing gear had broken away; there was no evidence of a leak from the wing fuel tanks. The main cabin door and over-wing emergency exit both opened freely. Apart from the failure of the yoke forward pintle on the right main landing gear, there was no visible evidence that the aircraft had sustained a heavy landing.

Metallurgy

The main landing gear is manufactured from DTD 5094 aluminium alloy, which is known to be susceptible to Stress Corrosion Cracking (SCC). The landing gear is attached to the airframe by trunnions that fit into steel spigots that are bolted to the inside of the yoke pintles. The upper surfaces of the pintles have been machined to introduce a weak link that, in the event of the landing gear being subjected to a force outside of its design limits, will fail and allow the gear to detach from the aircraft without damaging the fuel tanks. During the accident sequence the forward yoke pintle had failed with three large segments breaking away from the landing gear.

Figure 2

Right main landing gear yoke forward pintle

Examination established that the failure initiated at the top outer edge of the forward yoke pintle (see Figure 3) and the crack extended along the top of the pintle for approximately 120 mm before final failure occurred. The first 10 mm of the crack was heavily corroded and lighter deposits of corrosion were found along the remainder of the crack. Scanning Electron Microscopy (SEM) of the first 10 mm of the crack showed evidence of inter-granular failure consistent with SCC. A microsection through the first 35 mm of the crack identified branching crack growth which is a characteristic of SCC. The remainder of the crack showed a combination of both ductile overload and patches of SCC. Corrosion was also found on the steel spigot. Energy-dispersive X-ray spectroscopy (EDX) of the fracture surface of the crack in the yoke pintle identified the presence of cadmium that had leached into the crack from the corroded steel spigot.

Main landing gear leg

This model of landing gear is fitted to Jetstream 31 aircraft only. The landing gear legs are overhauled every 10,000 cycles or six calendar years after the previous overhaul. Both legs had last been overhauled in July 2009 and fitted to G-CCPW in August 2009. At the time of the accident they had been subjected to 1,445 cycles.

SCC was identified in the yoke pintle housing of a main landing gear in 1985 and there is currently an Airworthiness Directive (EASA AD G-003-01-86) and Mandatory Service Bulletin (SB A-JA851226) in force to carry out an eddy current and visual inspection of this area. The eddy current inspection is required every 1,200 cycles or within one calendar year of the last eddy current inspection. The visual inspection is required

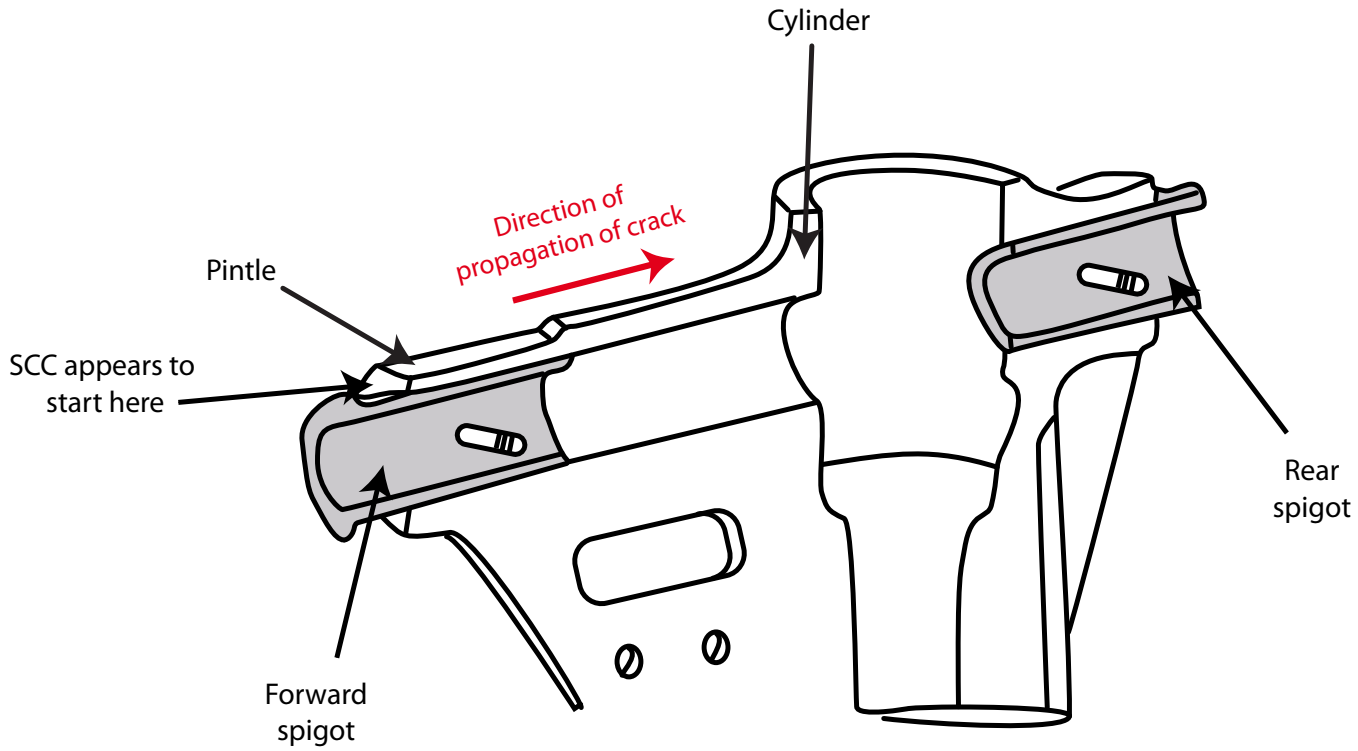

Figure 3

Main landing gear diagram

every 300 cycles or within three calendar months of the last visual inspection. The SB also requires the inspections to be carried out following a heavy or abnormal landing.

The last eddy current inspection on both landing gear legs was carried out on 13 May 2011, 743 cycles prior to the accident, and a visual inspection was carried out on 26 February 2012, 29 cycles prior to the accident. There was no record of any damage having been found during these inspections. The aircraft operator also advised the investigation that they had no reports of the aircraft having sustained a heavy landing.

Other reports of stress corrosion cracking in the yoke pintle

In addition to the failure on G-CCPW, the investigation is aware of only one other occurrence of SCC in the yoke pintle, which occurred in 1985 and resulted in the mandatory SB to inspect this area. Both the aircraft manufacturer and the landing gear design authority have advised the investigation that they have received no reports of cracking found as a result of carrying out the mandated inspections detailed in SB A-JA851226.

Discussion

The propeller marks on the runway, the location of the detached right main landing gear door and segments of the right main landing gear yoke pintle, together with audio analysis of the CVR indicates that the right main landing gear failed at touchdown.

The landing gear was designed to BCAR Section D with a limit load that equates to a maximum landing weight of 14,900 lb (6,758 kg) at a descent rate of10 ft / sec. On the accident flight the landing weight was estimated to be 13,448 lb (6,099 kg) and from the data on the TAWS it was established that the descent rate was 7.7 ft /sec. Therefore the forces exerted on the landing gear leg were within the design specifications and thus the leg should not have failed.

The metallurgy determined that a crack, emanating from the top edge of the forward yoke pintle, grew to approximately 120 mm before the remainder of the pintle failed in ductile overload. The first 10 mm of the crack occurred as a result of SCC and the heavy corrosion deposits indicated that this damage had been present for some time. The failure mechanism of the remainder of the crack is less clear. The patches of ductile overload and SCC, and the presence of cadmium in the crack, suggest that the crack grew over a period of time. Whilst the investigation has not yet determined how long the crack took to grow to failure, the amount of corrosion in the crack and on the steel spigots suggests that it was present during the last visual inspection carried out 11 days earlier and may have been present during the last eddy current inspection undertaken ten months earlier.

EASA AD G-003-01-86 mandates non-destructive testing and visual inspections to identify cracking in the yoke pintle housing on landing gears fitted to Jetstream 31 aircraft. As these inspection requirements did not detect the crack in the yoke pintle before it failed, the following Safety Recommendation is made to the European Aviation Safety Agency:

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.

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