ACCIDENT

Aircraft Type and Registration:	Avro 146-RJ100, G-BXAR
No & Type of Engines:	4 Lycoming LF507-1F turbofan engines
Year of Manufacture:	1997
Date & Time (UTC):	13 February 2009 at 1940 hrs
Location:	London City Airport
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 5 Passengers - 67
Injuries:	Crew - None Passengers - 2 (Minor)
Nature of Damage:	Nose landing gear fractured, internal and external damage to lower forward fuselage
Commander's Licence:	Air Transport Pilot's Licence
Commander's Age:	35 years
Commander's Flying Experience:	4,730 hours (of which 2,402 were on type) Last 90 days - 73 hours Last 28 days - 21hours
Information Source:	AAIB Field Investigation

Synopsis

Following an uneventful ILS approach to Runway 27 at London City Airport, the nose landing gear collapsed as it was lowered onto the runway during the landing. The cockpit and cabin subsequently filled with dense smoke. After coming to a stop, all passengers and crew evacuated the aircraft on the runway. Three passengers were subsequently treated for minor injuries and two were kept in hospital overnight.

The nose landing gear had fractured due to the presence of a fatigue crack in the upper internal bore of the landing gear main fitting. The crack had formed as a result of poor surface finish during manufacture and the incomplete embodiment of Messier Dowty Service Bulletin SB 146-32-150, which the landing gear maintenance records showed as being implemented at its last overhaul in June 2006. CAA Airworthiness Directive 002-06-2000 mandated BAE Systems Service Bulletin 32-158, which referred to Messier Dowty SB 146-32-149; this required repetitive inspections of of the nose landing gear. As SB 146-32-150 was the terminating action for Service Bulletin SB 146-32-149, the operator was not then required to conduct any repetitive in-service inspections designed to detect the onset of fatigue cracks.

History of the flight

G-BXAR was on a scheduled flight from Amsterdam Airport, Holland, to London City Airport. The sector to London City and the ILS approach to Runway 27 were uneventful. After touching down on the main wheels the commander, who was the pilot flying, lowered the nosewheel onto the runway. As she did so, the aircraft continued to pitch down until the fuselage contacted the surface. She then applied the wheel brakes fully as smoke started to emanate from behind the instrument panel; this was followed by the illumination of the ELEC SMOKE warning. As smoke filled the cockpit, the co-pilot transmitted to ATC that they were stopping on the runway, following which the commander transmitted a MAYDAY to ATC which included the intention to evacuate once the aircraft had stopped.

Once the aircraft had come to a stop, the commander shutdown the four engines and ordered an evacuation of the passengers over the aircraft's public address (PA) system. The crew then donned their oxygen masks. The co-pilot operated the engine fire handles in the overhead panel but, due to the density of the smoke at this time, he could not see them and was only able to find them by feel. Having completed their evacuation drills, the commander tried to open the locked flight deck door, first by operating the electric unlock switch at the rear of the centre console then, manually, by attempting to slide the latch handle on the door. She was only able to reach the door by removing her oxygen mask, due to the restrictive length of the supply hose. The commander then leant out of her 'direct vision' (DV) window and saw the Purser who stated that all passengers had safely evacuated the aircraft. The crew then vacated the aircraft via the cockpit DV windows.

Evacuation

The evacuation was executed by the three cabin crew members on board. An analysis of questionnaires submitted to the passengers by the AAIB indicated that all bar one passenger left the aircraft via the rear slides. The Purser, who was seated by the front left door, stated that when she attempted to use the PA she found that it was not working. She subsequently shouted[1] "come this way undo your seat belts and get out" many times, and was surprised that only one passenger used the front left exit. As a result, numerous passengers commented in the questionnaires that there was a queue in the cabin aisle while they waited to exit the aircraft, although the cabin crew members reported that passengers queuing to exit was not an issue. The PA system was subsequently tested and found to be serviceable, but had ceased to operate as it had been deprived of generated electrical power after the engines were shut down, and as a result of damage to the forward fuselage causing the battery to disconnect.

The majority of the passengers who suffered minor injuries had grazed their hands as they came off the escape slide, and some suffered a slight sprain to an ankle or wrist. Two more seriously injured passengers spent a night in hospital.

Recorded information

The aircraft was fitted with a solid-state flight data recorder (FDR) and cockpit voice recorder (CVR). Both were recovered, successfully downloaded at the AAIB and captured the incident landing at London City Airport.

The FDR data confirms an uneventful approach with

Footnote

[1] The operator's Standard Operating Procedures require cabin crew to shout instructions in such an emergency situation.

main wheel touchdown at 19:39:33 hrs. Recorded peak normal acceleration at touchdown was 1.5g after which the aircraft de-rotated from a nose-up pitch attitude of 3.25° at approximately 5° per second. The nose leg squat switch registered that the nosewheel oleo had compressed after which the pitch attitude decreased to below 0° as the nose landing gear collapsed. The CVR recordings confirmed this with the commander issuing a Mayday call as the aircraft came to a stop.

Initial examination

The presence of scoring along the runway, together with a trail of hydraulic fluid, indicated that the nose landing gear had fractured shortly after the aircraft touched down. It came to rest on the runway centreline approximately 500 metres beyond the touchdown point. The landing gear had folded rearwards and penetrated the forward equipment bay. This allowed significant

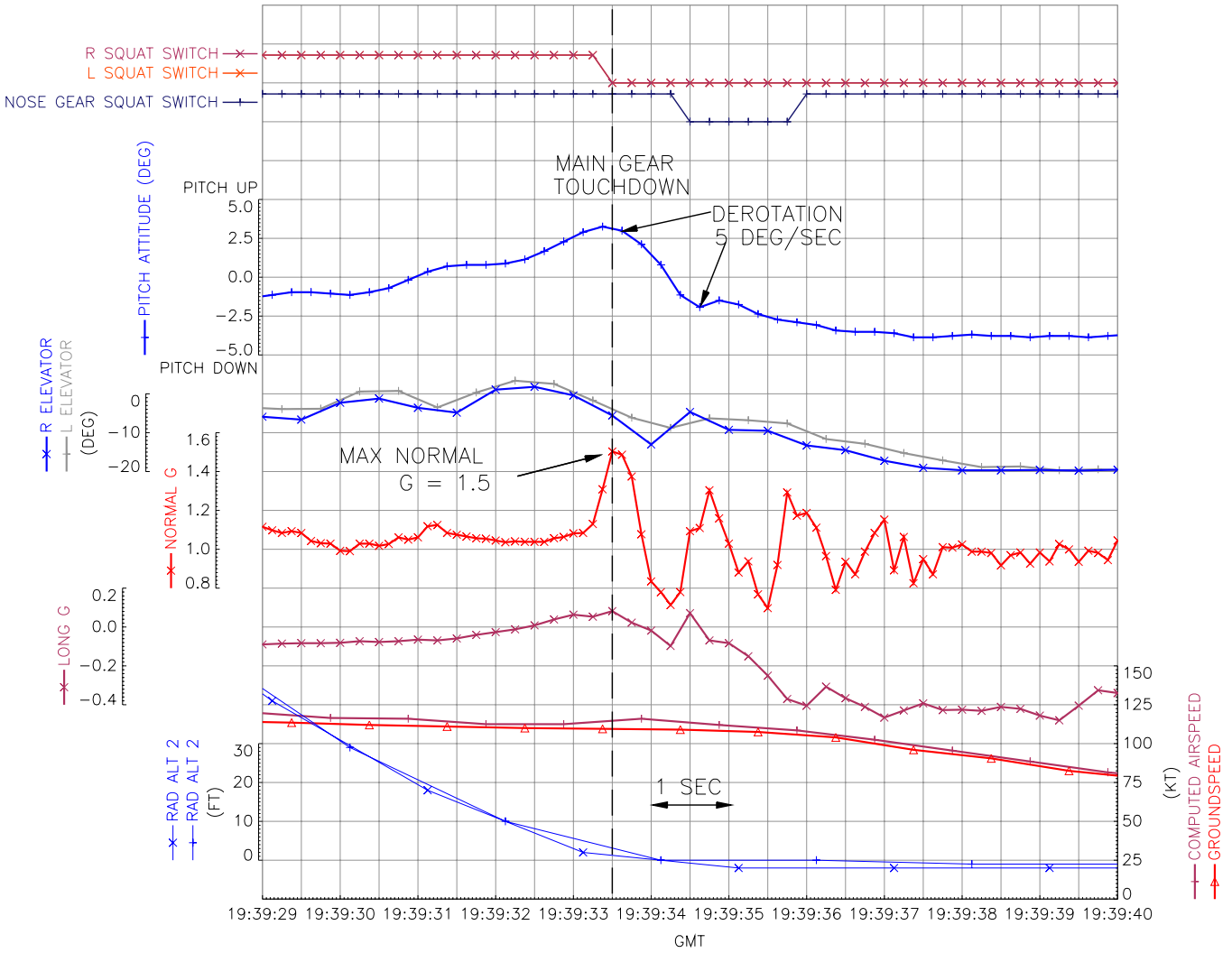

Figure 1

G-BXAR FDR Parameters

damage to be caused to the nose landing gear doors, the fuselage skin and structure immediately aft of the nose landing gear bay and severe abrasion to the forward face of the lower section of the nose landing gear, as the aircraft's lower fuselage scraped along the runway.

The floor of the equipment bay had been destroyed and the aircraft battery had been forced from its mountings, disconnecting one of the battery cables. After jacking up the nose of the aircraft, examination of the landing gear revealed that it had fractured at a point above its pivot and near to the top of the leg, which supports the down and up lock latch, Figure 2.

The retraction actuator and torque links had also broken. The upper portion of the landing gear main fitting was relatively undamaged and visual examination of the fracture surface indicated several relatively small areas of crack progression due to a fatigue mechanism, together with a large area characteristic of a failure in overload.

The nose landing gear was removed from the aircraft for detailed examination by the manufacturer in conjunction with the AAIB.

Figure 2

View showing failed nose landing gear and lower fuselage damage

Cockpit door

G-BXAR is fitted with a manufacturer's approved reinforced cockpit door. When locked, no means is provided to open the door from the passenger cabin. The door can be unlocked from the cockpit either manually, by directly releasing the lock on the door, or remotely, through the use of an electrically operated release switch located at the rear of the centre pedestal. Power for the remote cockpit door release is provided by the aircraft's AC electrical power supply and the loss of AC power renders this door release system inoperative. An examination of the door confirmed that the manual door release mechanism operated normally.

Nose landing gear main fitting

During the certification testing of the nose landing gear main fitting conducted by Messier Dowty, the test specimen completed 360,532 flight cycles without failure. However, a subsequent NDT inspection identified a fatigue crack in the upper section of the internal bore that had propagated partially through the radial wall. The surface finish (roughness) of the inner bore was confirmed as being within the limit specified at production of 3.2 microns. A second fatigue test specimen subsequently failed at 43,678 cycles without fracture before a fatigue crack was identified in the upper internal bore that had propagated fully through the radial wall section. Measurement of the inner bore showed that its surface roughness was 6.95 microns, which exceeded the production limit. Examination of the two test specimens revealed that the high value of surface roughness present in the second specimen had resulted in a significant reduction in the number of flight cycles required to initiate a fatigue crack in the material. As a result of these tests, the manufacturer issued Service Bulletin SB 146-32-149, in June 2000, which introduced a repetitive ultrasonic inspection of the main fitting bore every 2,500 flight cycles (once the main fitting exceeded 8,000 flight cycles since new), Figure 3. This inspection was mandated by CAA Airworthiness Directive AD 002-06-2000.

In addition, Service Bulletin SB 146-32-150 was published which introduced a maximum surface roughness value of 1.6 microns of the main fitting internal bore, together with a shot-peening process, to restore the fatigue life of the main fitting. Incorporation of SB 146-32-150 was introduced into future production and spares manufacture of main fittings, and was recommended to be retrospectively embodied at next overhaul for in-service main fittings. Incorporation of this SB terminated the repetitive inspections introduced by SB 146-32-149 and CAA AD 002-06-2000. The data plate attached to the fitting indicated that the failed unit had been modified in accordance with Messier Dowty SB 146-32-150.

The nose landing gear main fitting installed on G-BXAR had accumulated 18,299 flight cycles from entry into service prior to fracturing, and its maintenance records showed that it had been overhauled by Messier Services Inc. at their facility in Sterling, Va, USA[2] in January 2006, 3,302 cycles prior to failure. The records confirmed that SB 146-32-149 and -150 had been incorporated at that time. Therefore, after installation on G-BXAR, due to the declared incorporation of SB 146-32-150, the operator was not required to carry out further repetitive inspections of the main fitting in accordance with SB 146-32-149.

Footnote

[2] This facility has since closed.

MESSIER-DOWTY

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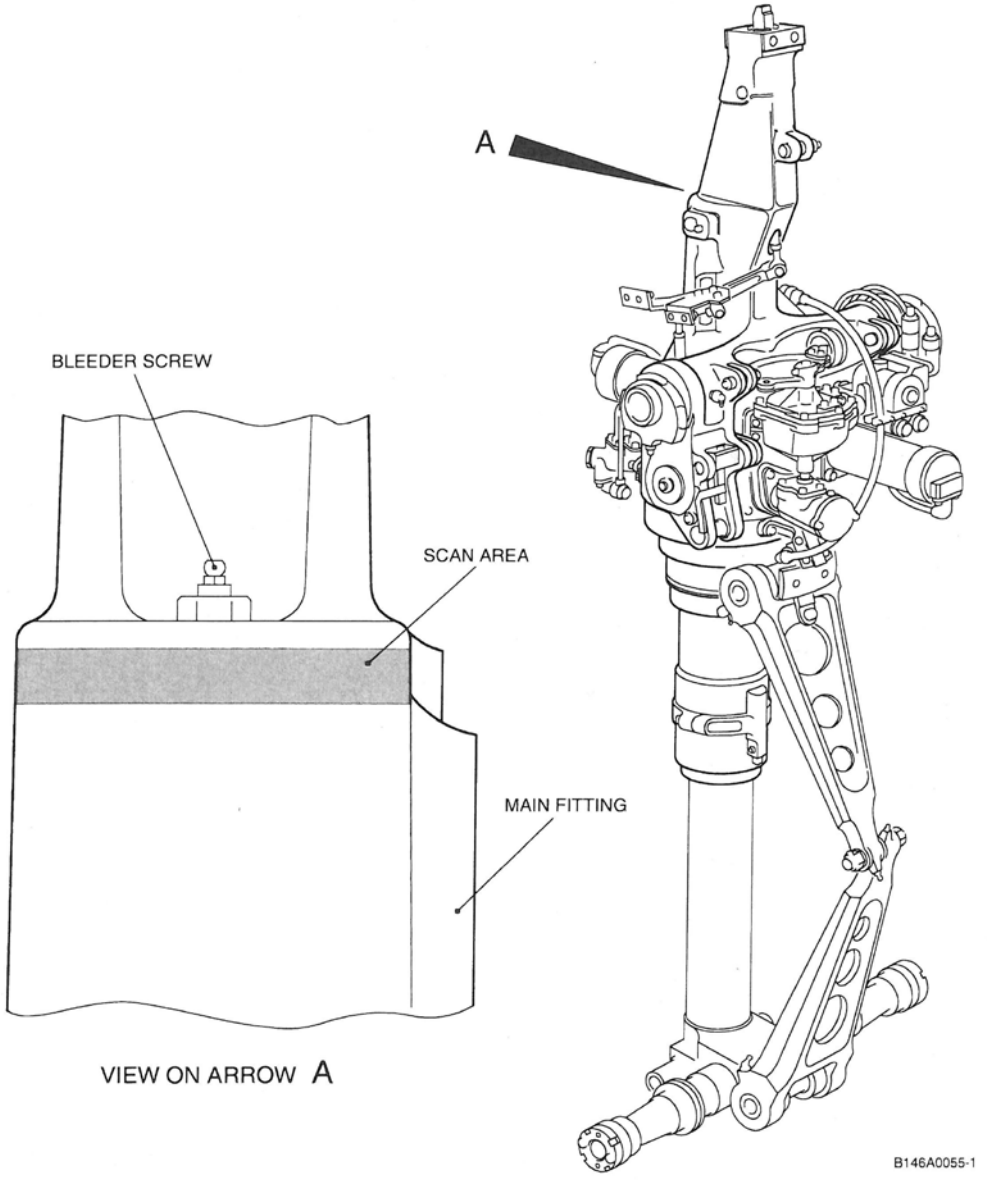
SERVICE BULLETIN



Main Fitting Inspection
Figure 1

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Figure 3

Messier Dowty SB 146-32-149 Inspection area

Detailed examination

Metallurgical examination of the main fitting confirmed that there were no material or microstructure abnormalities. However, examination of the main fitting fracture surface identified the presence of three fatigue cracks, which had become conjoined to form a single crack extending 23.2 mm around the circumference of the upper section of the internal bore, with a maximum depth of 2.21 mm, Figure 4. The location of the fatigue cracks was the same as found on the two fatigue tests.

A count of the striations within the fatigue cracks indicated that crack propagation had occurred for approximately 2,800 cycles prior to failure. The origin of these fatigue cracks was in the trough of a fine circumferential machining groove produced in the bore at the time the unit was manufactured. Smaller cracks were also found along the same groove and in adjacent grooves. Examination of the inner bore confirmed that the shot-peening process had been carried out, in accordance with the requirements of SB 146-32-150, but that the surface roughness close to the origin of the fatigue cracks was 9.5 to 10.1 microns, in excess of the finish specified in the service bulletin.

Examination of the landing gear actuator and torque link confirmed that they had both failed as a result of the failure of the main fitting.

Conclusions

Following a normal touchdown, the fracture of the nose landing gear main fitting allowed the nose gear to collapse rearwards and penetrate the lower fuselage, causing significant damage to the equipment bay and the battery to become disconnected. The penetration of the fuselage allowed smoke and fumes produced by the consequent release of hydraulic fluid to enter the cockpit and passenger cabin. With the battery

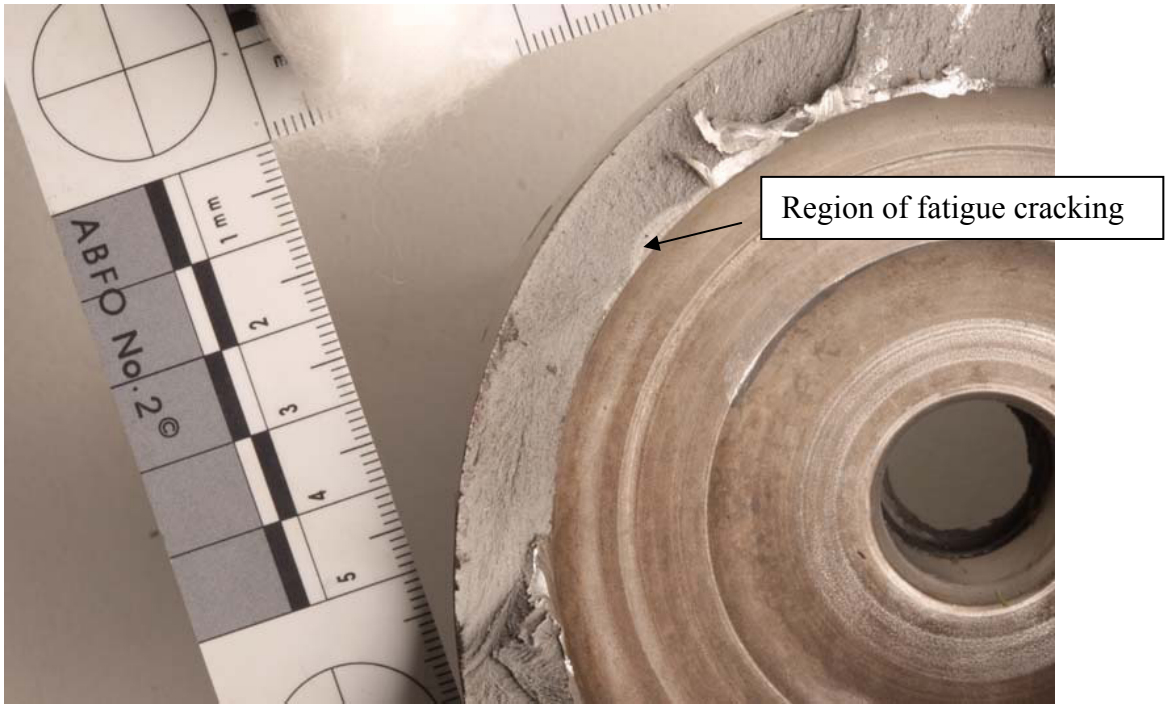

Figure 4

Fracture surface of main fitting

disconnected and after the engines were shut down, all power to the aircraft PA systems was lost and the remote cockpit door release mechanism became inoperative. No pre-accident defects were identified with the manual cockpit door release mechanism or the PA system.

The nose landing gear main fitting failed following the formation of multiple fatigue cracks within the upper section of the inner bore, originating at the base of machining grooves in the bore surface. These had formed because the improved surface finish, introduced by SB 146-32-150, had not been properly embodied at previous overhaul by Messier Services Inc, despite their overhaul records showing its incorporation. The operator had been in full compliance with the Service Bulletin relating to regular inspection of the main fitting, and embodiment of SB 146-32-150 at overhaul removed the requirement for these inspections by the operator.

Safety action

As a result of this accident the following safety actions have been taken:

BAE Systems Alert Service Bulletin A32-180, issued on 25 February 2009, reintroduced the repetitive in-service inspection requirements of Messier Dowty SB 146-32-149 on nose landing gear main fittings that had SB 146-32-150 embodiment claimed by Messier Services Inc. EASA Airworthiness Directive 2009-043-E, also issued in February 2009, mandated this Service Bulletin.

Messier Dowty published Service Bulletin SB 146-32-174 on 26 August 2009, which introduced an improved ultrasonic inspection technique and a shorter re-inspection interval for the affected nose landing gear main fittings, which superseded SB 146-32-149.

BAE Systems subsequently re-issued Alert Service Bulletin A32-180 (Revision 1), which introduced Messier Dowty SB 146-32-174 and canceled the requirements of Messier Dowty SB 146-32-149.

Messier Dowty issued Service Bulletin SB 146-32 173 on 30 September 2009, which required borescope inspection of nose landing gear main fittings overhauled by Messier Services, Sterling, Virginia, to verify the proper incorporation of Messier Dowty SB 146-32-150.

EASA Airworthiness Directive 2009-0197-E, published on 7 September 2009, mandated the requirements of BAE Systems Alert Service Bulletin A32-180 Revision 1, and Messier Dowty Service Bulletin SB 146-32-174.

As the foregoing safety actions have been implemented, no Safety Recommendations are made.