

AAIB Bulletin No: 8/93

Ref: EW/C93/3/6

Category: 1a

Aircraft Type and Registration: Fokker F27 Mark 500 Friendship, G-JEAH

No & Type of Engines: 2 Rolls-Royce Dart 532-7 turboprop engines

Year of Manufacture: 1986

Date & Time (UTC): 28 March 1993 at 20 22 hrs

Location: Bristol Lulsgate Airport

Type of Flight: Public Transport

Persons on Board: Crew - 5 Passengers - 44

Injuries: Crew - None Passengers - 1 minor

Nature of Damage: Damage to fuselage underside, right wingtip, nacelle and propeller, right engine shock loaded

Commander's Licence: Airline Transport Pilot's Licence

Commander's Age: 60 years

Commander's Flying Experience: 17,774 hours (of which 3,298 were on type)
Last 90 days - 184 hours
Last 28 days - 20 hours

Information Source: AAIB Field Investigation

The flight from Belfast Harbour to Bristol Lulsgate took off at 1837 hrs and flew, without incident, to the intermediate approach for an ILS onto Runway 09 at Bristol. As the aircraft descended through about 2,500 feet, with 16° flap and at 150 kt, the landing gear was selected 'DOWN'. The nose and left main gear deployed and locked down, displaying green lights, but the right main gear remained unlocked, displaying a continuous red light. No unusual noises were heard by either the flight deck or cabin crew.

The commander informed ATC that, as he had a problem with the landing gear, he would make an orbit at his present position and asked the first officer to make a quick visual inspection. When the first officer reported that the leg was definitely not locked down, the commander flew to the west, informing ATC that he would 'hold off' along the coast. He then re-engaged the autopilot and referred, together with the first officer, to the Emergency Checklist.

Selection of the 'emergency' system failed to lock down the right gear, as did re-cycling of the 'normal' system. The first officer again went to inspect the gear, this time with a torch, and was able

to see that the drag strut of the landing gear had separated at its top end and was preventing further movement of the leg. Reference to the Flight Manual showed that a normally configured landing could be made, shutting down (in this case) the right engine on touchdown and gradually allowing the wing to sink onto the ground. The commander gave the No 1 cabin attendant some 15 minutes to prepare the passengers and the cabin for the landing and then returned onto final approach. The runway surface was dry and as the wind was 180/11 kt, the commander chose Runway 09 so that the anticipated yaw to the right after landing would take the aircraft into a clear area.

A successful landing was executed and the right wing made contact with the runway at about 60 kt ($V_{AT} = 95$ kt), swinging the aircraft such that it came to rest at right angles to the runway, facing due south. The passengers were quickly evacuated from the aircraft, collected together, counted and taken by bus to the terminal building. ATC closed the airfield until the incident was 'Closed' at 2043 hrs and they had established that the aircraft was clear of the runway 'Surface'.

ATC had declared a 'Full Emergency' and the Airport Fire Service, together with the County of Avon Fire Brigade, were immediately in attendance and assisted with the grouping of the passengers. They also laid foam on the right engine, which was 'smoking', and extinguish a wheel fire which had developed in the left main gear assembly.

The aircraft commander stated that both ATC and the emergency services reacted in a timely and most efficient manner, enabling him to concentrate fully on his own duties.

An examination of the aircraft where it came to rest revealed that the drag stay of the right main landing gear had broken near its upper end, just below the locking link attachment pivot (see diagram). The drag stay was removed for metallurgical examination of the fracture surfaces.

This examination revealed that the initial failure was the result of bending fatigue of the drag stay and that this fatigue had originated at an internal change of cross-section where a machined radius intersects the machined parallel bore of the main tube element of the stay. The fatigue had initiated along a linear origin (there were no discrete origins) on the inner surface of the tube, but did not appear to have progressed quite as far as the outer surface before the fracture mechanism had changed to overload fast fracture over most of the remainder of the section with the final separation as a bending hinge. Even if the fatigue had progressed to the outer surface, a steel clamp ring which supports the lower pivot of the landing gear forward door would have been directly covering the position of the crack.

Investigation revealed that there had been a machining error at manufacture which had resulted in the intersection of the radius and bore not being smooth as intended. The machining sequence for the inside of the tube called for a 'roughing' cut to be taken followed by a finish cut which also formed the

blending radius at the end. The 'roughing' cut appeared to have been made using a large drill, as all examples (several drag stays were inspected as a result of this accident) of mis-machined tubes so far discovered revealed a 42° chamfer running into the intended radiused blend (see diagram). It could not be established whether the roughing cut had been taken fractionally too far, or the subsequent finish cut had not been taken far enough down the bore. In this particular case, the effect of the sharp change of section resulting from the drill shape had been exacerbated by 'undercutting' at the corner of the drill, possibly as the result of swarf being caught up when drill extraction began. This problem might affect any drag stay which was built before about 1983, using the basic tube Part No. 200259300. These tubes may be used in drag stays with the assembly Part Nos. 200485001 or 200684001 which may be found in the main landing gear of Fokker F27 Basic, Rough Field and -500 variants, as well as on Fairchild-built F27 and FH227 aircraft (it may also be used on F50 aircraft).

The drag stay is subjected to significant bending loads during the process of retraction of the landing gear and these loads are at their greatest whilst the gear is up and locked because the air pressure remains, driving the actuator in the 'retract' sense until the gear is selected 'down'. The stressing and test work done by the manufacturer has indicated that the use of air at 1100 psi in the retraction system of the Rough Field and -500 variants (rather than the 1000 psi system used on the Basic variant), would be expected to have reduced the fatigue life of the tubes and, as a result, the drag stays on such aircraft would appear to be significantly more exposed to such a failure. The aircraft 'EH' was fitted with an 1100 psi system and a check of the landing gear pressure regulating valve revealed that it was within the specified limits. The actuator associated with the failed drag stay was taken to its manufacturer and subjected to a production acceptance check which revealed it to be in serviceable condition with nominal damping characteristics.

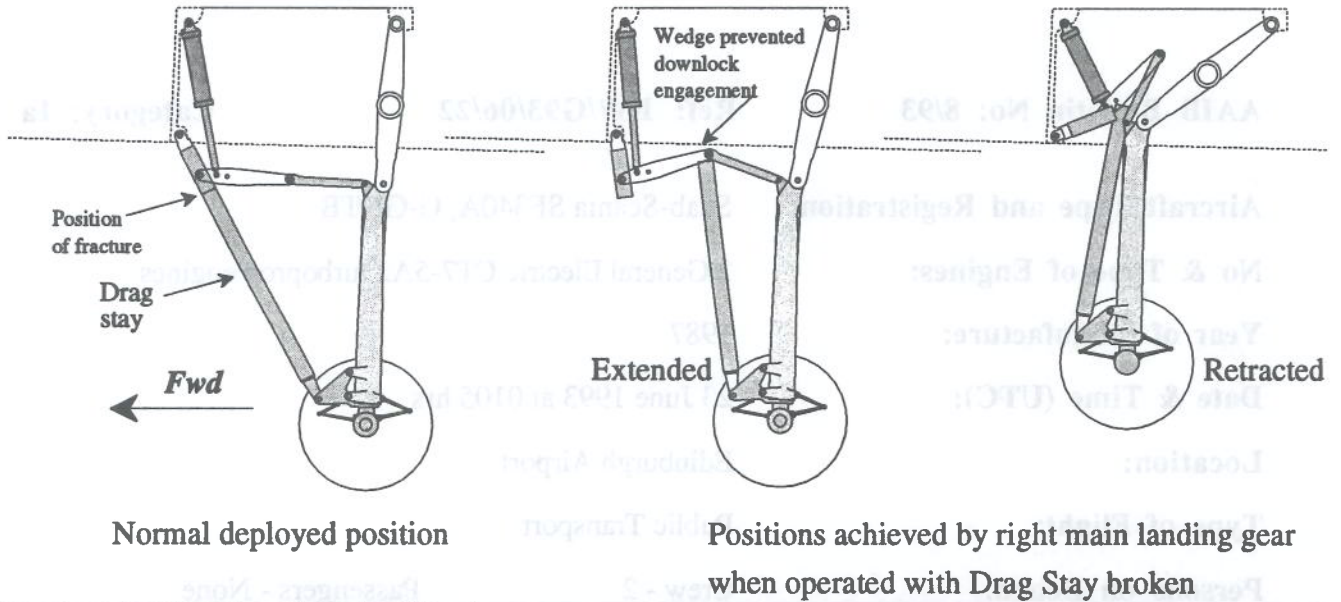
Analysis of the cyclic loading of the drag stay indicated that the fast fracture following the fatigue most probably would have occurred after the landing gear was locked up after the previous take off.

There is an existing Mandatory Service Bulletin, 32-27W, issued by the manufacturer in August 1981 and revised in April 1982, which called for an ultrasonic inspection of this area of the strut. The reason for the issue of this bulletin was tearing cracking of the inner bore of the basic tube during the drawing process and the inspection (in 32-27W) only covered the unmachined portion of the tube where it is exposed to the severest bending loads. The crack in this accident had started at the lower end of this unmachined length and the bulletin warns of the fact that the discontinuity, which has been exploited in this accident, will give rise to a signal in the ultrasonic survey on those stays which have a main tube member with the Part No.200259300.

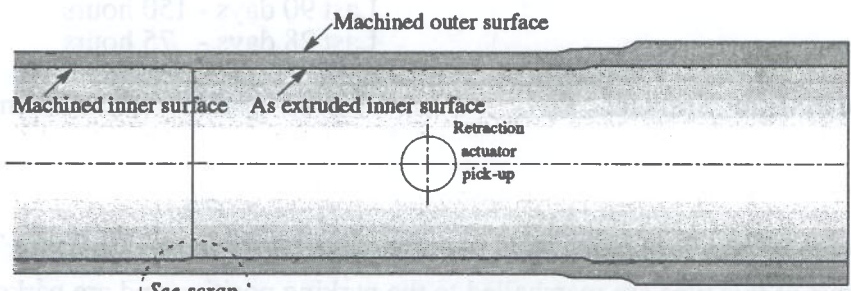
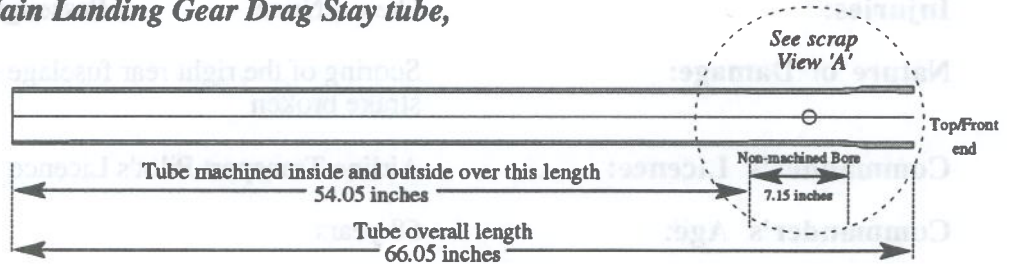
Since this accident, the manufacturer has developed a variant of the inspection called for in the existing Mandatory Service Bulletin, 32-27W. The technique developed will enable operators to determine the

geometry of the intersection between the radius and the bore, and will detect any fatigue crack at this location. The manufacturer has formulated a new Service Bulletin specifying the inspection technique to be used and the variety of actions to be taken in the light of what these inspections reveal. It is anticipated that this inspection will be made Mandatory by Fokker, and RLD, as the Primary Certificating Authority. If this is the case, the CAA has indicated that it will automatically make this Mandatory Service Bulletin an Airworthiness Directive in the United Kingdom, using an established administrative procedure.

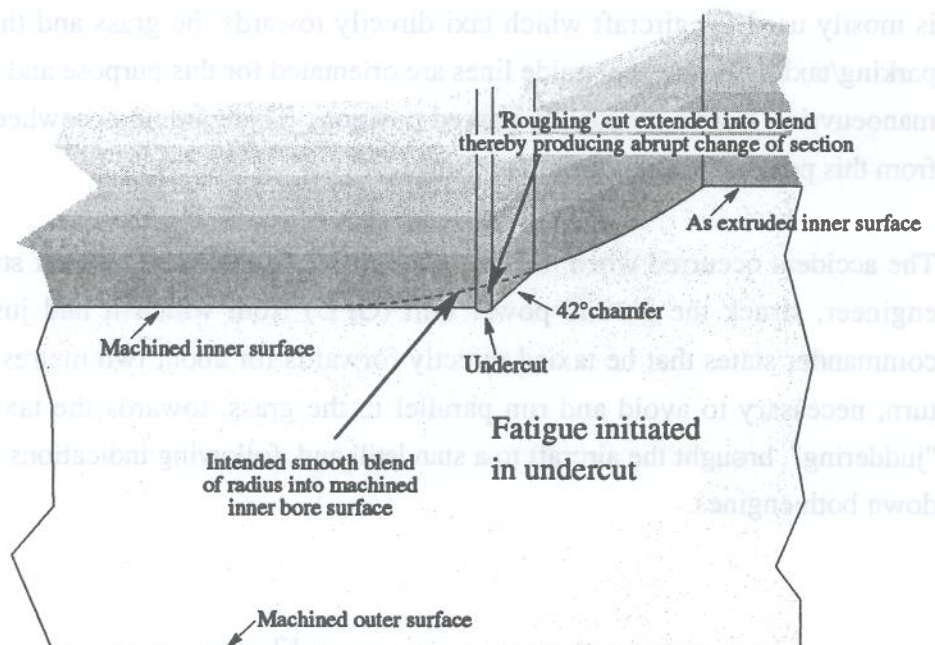
Fokker F27 Main Landing Gear Side views



Section of Fokker F27 Main Landing Gear Drag Stay tube, Part No 200259300



Scrap View 'A'



Scrap View 'B'