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Department of Transport

AIB Bulletin 8/85

No: 8/85 **Ref: EW/C897**

Aircraft type and registration:	Bell 222 G-METB (heavy helicopter, public transport)	
Year of Manufacture:	1981	
Date and time (GMT):	29 November 1984 at 1124 hrs	
Location:	Hatfield Aerodrome, Herts	
Type of flight:	Aerial Patrol	
Persons on board:	Crew — 1	Passengers — 4
Injuries:	Crew — 1 (minor)	Passengers — 4 (minor)
Nature of damage:	Damage to main rotor system (severe), engine, cabin roof structure, sponsons, and left horizontal stabilizer	
Commander's Licence:	Airline Transport Pilot's Licence (helicopter)	
Commander's Age:	34 years	
Commander's total flying experience:	Approximately 4464 hours (of which 1800 hours were on type)	
Information Source:	AIB Field Investigation.	

The helicopter, flown by a single pilot and with four other occupants on board, was engaged in a routine police patrol flight. After about an hour's flying there was a lull in the patrol duties and

ISSN 0309 - 4278

the pilot decided to take advantage of this to make a practice ILS approach to Runway 24 at Hatfield. Radio contact was established with Hatfield ATC who asked the pilot to provide an assessment of height of the cloud base in the area. He therefore climbed to 2000 feet and having completed the cloud base check requested radar vectors to the ILS. A cruise descent to 1500 feet was made while maintaining the airspeed at 100 knots and the downward checks were completed, including lowering the undercarriage and switching on the landing light. At this stage the pilot found that he had difficulty in holding the assigned heading and that the slip indicator was not centralised. He tried using the yaw pedals to re-trim the helicopter but found that this had no effect, and informed ATC that he had a control problem.

A visual check established that the tail rotor was rotating at what appeared to be its normal speed. The pilot therefore decided to conduct a series of handling checks to assess the extent of the problem. He found that full movement of the yaw pedals in either direction had no effect on heading, although their movement was not restricted and pressures felt normal. Adjusting the collective produced a yaw to the left with a decrease in power, and a right yaw when the power was increased. When the airspeed was reduced progressively the aircraft yawed to the left until at approximately 96 kt the sideslip was in the region of 20°. The pilot decided not to reduce the speed further because he felt that the yaw might develop uncontrollably.

In the light of these checks and of his previous training experience in a Bell 222 simulator, the pilot decided to make a high speed approach for a landing on runway 24 at Hatfield. He declared a full emergency to ATC, informing them of his intentions and warning them that the helicopter might roll over during the landing run.

Before attempting a landing the pilot made three approaches and over shoots, each to a progressively lower height while he assessed the best speed to ensure control over the aircraft. During these circuits the passengers were briefed and the cabin prepared for an emergency landing. The operation of the engine shut-down switches was explained to the crewman occupying the co-pilot's seat so that he could operate them if required by the pilot. Finally the pilot commenced a fourth approach, maintaining a speed of 120 knots and from this a firm landing was accomplished with no yaw or drift. The surface wind was from 200° at 13 kt and the touch-down occurred approximately 3000 feet beyond the runway threshold.

Almost immediately after the landing the pilot ordered the crewman to operate the engine shut-down switches. During the ground roll the aircraft started to run gently to the left and although the pilot applied maximum differential braking he was unable to keep it straight. It ran off the left side of the runway into very soft, waterlogged ground approximately 600 feet from the touch-down point. At the point of departure from the runway the aircraft was yawed 15° to the left, but this rapidly increased to 20° and from then on remained constant with the left main wheel running in the trough formed by the nose wheel. Approximately 240 feet after leaving the runway the aircraft pitched forward and rolled right around the nose and right landing gears. One of the main rotor blades contacted the ground causing the aircraft to roll left and the main rotor to detach. The aircraft then slid inverted for 60 feet before coming to rest.

It remained substantially intact with no failures to the seats or the harnesses, and the five occupants suffered only minor cuts and bruises and were able to rapidly evacuate the cabin. The emergency services were quickly on the scene having been stationed close to the runway in preparation for the landing and although there was no fire, foam was spread over the aircraft as a precautionary measure.

Yaw pedal movement on the Bell 222 is transmitted to the pitch change arms of the tail rotor blades via a rod and bellcrank lever linkage. A hydraulic servo jack is interposed in series in the linkage partway along the run to provide reduced pedal forces and prevent transient tail rotor loads feeding back to the pedals. The aircraft was designed with a single jack, but for British Validation of the FAA Type Certificate dual parallel jacks supplied from two separate hydraulic sources were required, as pedal forces in the event of jack failure were considered excessive. This also necessitated a different design of lever to connect the two jack output rams to the linkage (Fig 1). The central arm of the lever incorporates a spigot of 0.562 inches nominal diameter which fits into a socket in the main part of the lever, with a design clearance of

0.0003—0.0013 inches. Both parts are of aluminium alloy. The spigot is installed with an epoxy based adhesive and retained by two 0.25 inches diameter bolts. The lever is supplied by the aircraft manufacturer as an assembly.

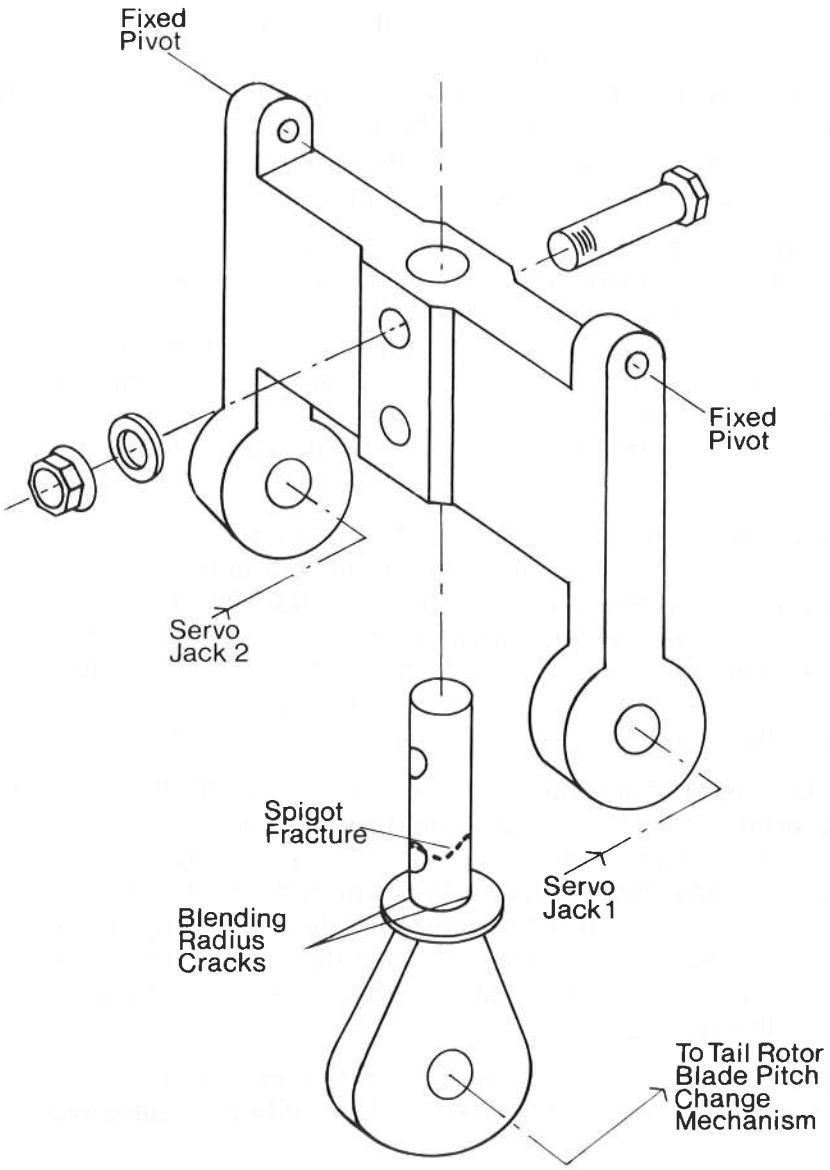
Examination of G-METB revealed that the central arm of this combining lever had failed, completely disconnecting the tail rotor from the rudder pedals. The failure comprised fracture of the spigot at the point where it as penetrated by the lower retaining bolt hole, following propagation of fatigue cracking across almost the whole spigot cross-section from origins at the four corners of the bolt hole. Fatigue cracking was also found at the forward and aft side of the arm in the blending radius between the spigot and flange.

Spigot material properties were consistent with the design specified material, spigot and socket dimensions were within design limits, and chemical analysis confirmed the presence on the spigot of epoxy adhesive deposits. Few traces of adhesive were found on the lower parts of the spigot or socket surfaces, but an even film could clearly not be expected to remain after a cylindrical spigot had been introduced into a tight clearance socket, and there was no reason to suspect that G-METB's linkage was unusual in this respect. The evidence clearly indicated that the spigot had been rocking in the socket in a fore and aft sense during part of the fatigue fracture progression.

The evidence indicated that the lever had been installed at the time of aircraft manufacture, and had accrued 2938 hr from new. Examination of the aircraft and maintenance records did not suggest the the linkage had been subjected to an unusually severe loading environment, except that the maximum allowable vertical vibration level induced in the tailrotor gearbox had been changed by the manufacturer in 1983 from 0.2 to 0.02 in/s. However, it was unclear whether this could have been a factor in the spigot fatigue as the operator had reportedly consistently achieved vibration levels well below the original limit.

All the areas where fatigue cracking had occurred were completely hidden within the socket and there was no requirement for the spigot to be removed for inspection. The lever was an on-condition item, with an indefinite fatigue life predicted by the aircraft manufacturer based on analysis of linkage loads measured during certification flight tests, but it was understood that no fatigue testing had been required for the tail rotor linkage components. It was also noted that although a degree of wear in the various bearings associated with the tail rotor pitch change mechanism was allowable, there was no requirement for measurement of the possible effects of such play on linkage loading.

Insufficient information was available to ascertain whether the fatigue damage experienced could in fact have resulted from the anticipated loads, or whether loads were in fact great than anticipated.


Fixed
Pivot
Fixed
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Servo
Jack 2
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Servo
Jack 1
Blending
Radius
Cracks
To Tail Rotor
Blade Pitch
Change
Mechanism

Fig.1