

AAIB Bulletin No: 5/93

Ref: EW/G93/01/02

Category: 2b

Aircraft Type and Registration:	Aerospatiale AS355-F2 Ecureuil II, G-BOOV	
No & Type of Engines:	2 Allison 250-C20F turboshaft engines	
Year of Manufacture:	1988	
Date & Time (UTC):	6 January 1993 at 1608 hrs	
Location:	Liverpool Airport, Merseyside	
Type of Flight:	Public Transport	
Persons on Board:	Crew - 1	Passengers - 3
Injuries:	Crew - None	Passengers - None
Nature of Damage:	Severe damage to engine bay door, tail rotor and tail rotor drive shaft, secondary damage to airframe	
Commander's Licence:	Airline Transport Pilot's Licence (Helicopter) with Instructor rating	
Commander's Age:	37 years	
Commander's Flying Experience:	3,192 hours (of which 821 were on type) Last 90 days - 99 hours Last 28 days - 38 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot and aircraft inspection by the AAIB	

Flight History

The police helicopter had been airborne for around 55 minutes on its first flight of the day and during this time had responded to a number of incidents, in the course of which the helicopter had been flown at airspeeds varying between 0-120 kt. The commander had experienced no abnormalities in the handling, apart from slightly more vibration at speed than usual, but not to an excessive degree. While transiting towards Liverpool City at about 500 feet agl and an airspeed of around 120 kt the vibration began to increase and the aircraft wallowed, followed almost immediately by a loud bang.

The pilot immediately reduced speed and power. He noted that instrument readings appeared normal, but found that yaw pedal inputs produced no response and declared an emergency. He elected to return to Liverpool Airport as it was only about 3 nm away, he was familiar with the airfield and emergency services were available.

After flying past the Liverpool Airport control tower the pilot was informed that the tail rotor was stationary. He shutdown the No 2 engine, briefed the occupants and ensured the security of items in the cabin before making a shallow approach parallel to Runway 27, intending to land on a grassed area to the north of the runway. The approach and landing were recorded on video. As the aircraft slowed to around 30 kt at 50 feet agl, it began to yaw excessively to the left. The Police Observer in the forward left seat retarded the No 1 engine throttle on the pilot's instruction, correcting the yaw, but with the aircraft now heading for the asphalt runway. As collective was increased to cushion the touchdown on the runway, the helicopter began to yaw to the right and in an attempt to control this the pilot allowed it to touch down in a tail down attitude. The contact on the rear end of the skids caused the aircraft to bounce and make a second touchdown in a nosedown attitude, before sliding on the skids to a stop tracking 70° left of the runway heading. The helicopter came to a halt upright and around 50 metres from the initial touchdown point.

The emergency services were in immediate attendance. The commander shutdown the No 1 engine and remaining services and all occupants evacuated without difficulty, uninjured. It was rapidly apparent that part of the right engine bay door was missing, that a tail rotor strike had occurred and the tail rotor drive system had severed.

Aircraft Description

The Squirrel is provided with an engine bay door and a main gearbox (MGB) bay door on either side of the aircraft (Fig 1), each attached at its top by a piano hinge fixed parallel to the aircraft longitudinal axis and at its bottom by two overcentre catches locating in latch plates fixed to the floor of the bay. The MGB bay doors also have two auxiliary catches along their trailing edge. Both sets of doors are of composite construction; the engine bay doors are curved, 1.2 metres along the hinge by 0.9 metres along the curve. A rubber stop at each catch position locates in a dished part of the latch plate and this tends to hold the doors closed to some degree even when unlatched. Cockpit warning lights provide indication of a baggage bay door not closed, but there is no cockpit indication of the state of the engine or MGB bay doors or their latches.

Following a number of accidents caused by unlatched engine or MGB doors hinging up in flight and being struck by the main rotor, the helicopter manufacturer issued a Service Bulletin (No 53.07, Modification No 07-1447) in 1985 to modify the lower catches on both engine and MGB bay doors by adding a safety flap fitted over each catch (Fig 2). The flap is spring-loaded to the horizontal position and can only be hinged down to the vertical, stowed position, and latched there with a wire retainer clip, forming part of the modification, if the overcentre catch underneath is correctly latched. It was intended that an unstowed flap sticking out from the aircraft would attract attention and prevent take-off with an unlatched overcentre catch. A portion of the flap undersurface (when the flap is unstowed and therefore horizontal) is painted red, but because of the orientation this feature does not greatly add to the visibility of the flap. The modification was incorporated on production aircraft in 1985 and was present on G-BOOV.

This modification did not prevent further accidents caused by unlatched engine or MGB doors and on 2 April 1990 CAA issued an Airworthiness Directive (005-03-90) requiring the installation of a two point restraint on both engine and MGB bay doors. The Directive could be satisfied by incorporating McAlpine Helicopters Ltd (the UK agent for the type) Approved Modification MCH/A/85/111/H which added a restraining cable between the structure and the front lower corner of each door and a folding strut between the structure and the rear corner of each door. The Modification allowed the doors to be opened to permit inspection of the bays but prevented an unlatched door from lifting far enough to contact the main rotor. It had been incorporated on G-BOOV. It was reportedly not intended that the system would need to be in action for an extended period, restraining an unlatched door that had lifted in the airflow, as it was considered that the effects of this on aircraft handling would be apparent to the pilot who could then be expected to land within a short period and remedy the situation.

The exhaust duct from each engine passes through a circular cut-out in the upper part of the respective engine bay door. The duct is in the form of a bend, with the outlet turned towards the rear and so, with the engine operating, the jet efflux would impinge on the composite material of the door adjacent to the cut out, should the door raise to the extent permitted by the restraint system. This had led to failures of unlatched engine bay doors fitted with the restraint modification.

A further CAA Approved Modification (McAlpine Helicopters Ltd A1/90209-100) is available that adds a secondary spring-loaded catch for each engine bay door that acts to hold an unlatched door near to the closed position (Fig 3). With the aircraft on the ground with rotors stopped, lowering the door under its own weight causes the catch to engage, and the catch can be manually disengaged for door opening. The helicopter manufacturer considers that previous experience on other types of helicopter has indicated that a slightly open door is likely to be subjected to significant airflow loads that may be beyond the capability of the door to withstand for long when restrained by a single catch. The modification is not mandatory and has not yet been widely installed. It was not present on G-BOOV.

The UK agent for the type is assessing the possibility of incorporating a cockpit warning light system that would indicate incomplete engine or MGB bay door latching, by means of adding switches to sense if a door is ajar, coupled with minor modification to prevent a door from remaining fully closed unless completely latched.

Aircraft Examination

Inspection showed that the lower aft part of the right engine bay door, comprising approximately 70% of the door and including the two catches and the restraining cable and strut, was missing. Ground and air searches failed to locate the detached parts. The latch plates remained in place, undamaged. The whole of the piano hinge along the upper edge of the door remained in place on the aircraft with the remnants of the door attached, which were severely overheated in the area of the engine exhaust outlet. One blade of the tail rotor was severely damaged, albeit intact, in a manner consistent with a rotational strike of the leading edge with a foreign object. The tail rotor drive shaft had severed in the

tunnel between the engines, consistent with the effects of torsional overload due to excessive tail rotor drag. Other damage consisted of a small dent in the lower surface of one main rotor blade at a radius of around 1 metre from the rotor hub, localised scratching and denting of the tail boom and the fin leading edge and slight distortion of the landing gear skids. The evidence was consistent with the unlatched door, having lifted in the airflow, suffering progressive structural failure due to overheating in the engine exhaust efflux combined with airflow buffeting. This caused parts of the door to detach and strike a main and a tail rotor blade, applying sufficient shock drag loading to the tail rotor to fail the drive shaft.

Engine Bay Door Unlatching

In the absence of the door catches it was not possible to determine positively the reason for the door having unlatched. No information was found to suggest that there had been previous cases of catch failure or unlatching due to service loads, and the evidence indicated that it was unlikely that both catches would have been affected in the course of one flight. The pilot supplied very full information on the circumstances of the preparations for the flight, as well as the flight itself. He had conducted a Check A on the helicopter in its hangar on the morning of the day of the accident but, as latching the doors afterwards would have been a routine matter, he is unable recall for certain either that he did latch them or that he failed to do so. He did note that the Check was interrupted by a phone call. After completion of the Check the helicopter was moved outside onto the apron, where it remained for around 4.5 hours before take-off for the first flight of the day. While outside, a number of tasks were conducted on and around the aircraft, including activity on the right side of the aircraft, both by the commander and by the observers who later flew on the accident flight, but none afterwards recalled having noticed anything amiss with the door latches.

Previous Cases

Evidence was found that there had been 7 other reported cases since 1980 of engine or MGB bay doors on UK registered AS350 (single Squirrel) and AS355 helicopters having opened in flight. Some evidence suggested that there may have been other cases. Available information suggested that in none of the cases was the pilot aware of a door being open by virtue of a change in aircraft handling. In 5 of the cases parts of the door detached and in 3 cases main rotor blades were struck. No definite information was available to indicate which aircraft had had the safety flap modification incorporated. At least 2 of the cases concerned engine bay doors that had the restraint modification incorporated; in one of them the door remained intact, albeit burnt; in the other part of the door detached due to burning by exhaust gases.

Records showed 7 reported cases of in-flight loss of engine or transmission bay doors from other types of UK registered helicopter between 1976 and 1992. A number of these were attributed to failure to latch the door properly before flight.

Airworthiness Considerations

While the evidence was not conclusive, it indicated that a possible cause of the failure was an inadvertent omission by the pilot to latch the door following the Check A, possibility as a result of distraction. Such occasional and understandable human error has reportedly been responsible for a significant rate of similar accidents to Squirrel helicopters in spite of modification action aimed at ensuring that the engine and MGB bay doors will be latched before flight. While it is likely that the modifications have improved the situation, the safety flaps cannot be considered to provide an unmistakable warning. The additional door restraint modification is likely also to have improved the situation. However, it appears to be effective for a limited flight time only, particularly for engine bay doors because of damage that can result from impingement by the engine exhaust flow. It also relies on handling cues prompting an early landing, whereas experience has shown that adequate indication to the pilot that a door is open tends not to be present.

A safety catch would seem to provide a foolproof solution but the helicopter manufacturer has questioned its likely effectiveness for an extended period in view of possible airflow loads in relation to door strength. It seems likely that considerable development may be necessary to qualify such a modification and a significant penalty for door strengthening could be involved. In view of this, an effectively designed cockpit warning light system would appear to be the optimal solution, providing an unavoidable warning to the pilot of an unlatched door before engine start.

Safety Recommendations

As a result of the investigation it has been recommended that the CAA:

93-37 Require, for UK registered AS350 and AS355 helicopters, the fitment of a system to provide unmistakable cockpit indication to the pilot of improperly latched engine or MGB bay doors. (Issued 20 April 1993)

93-38 Consider requiring, for other UK registered helicopters, the fitment of such a system on doors that could constitute a flight safety hazard if not correctly latched. (Issued 20 April 1993)

ENGINE AND MAIN GEARBOX BAY DOORS

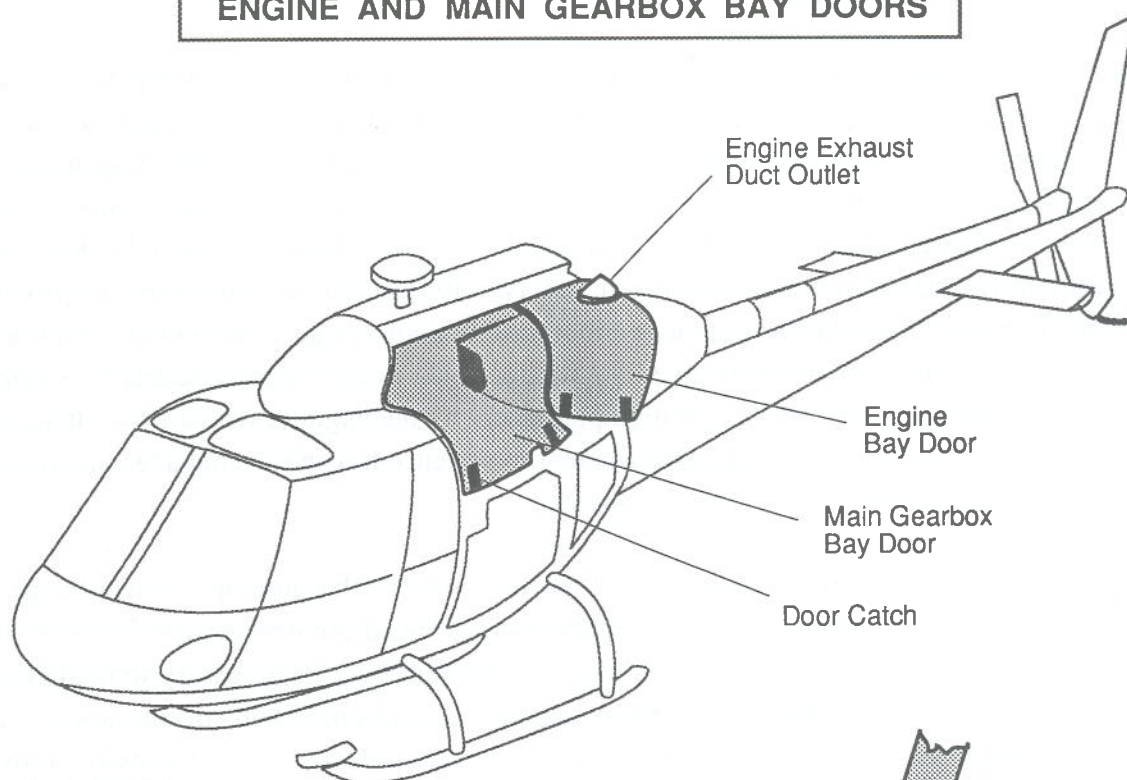


Fig 1

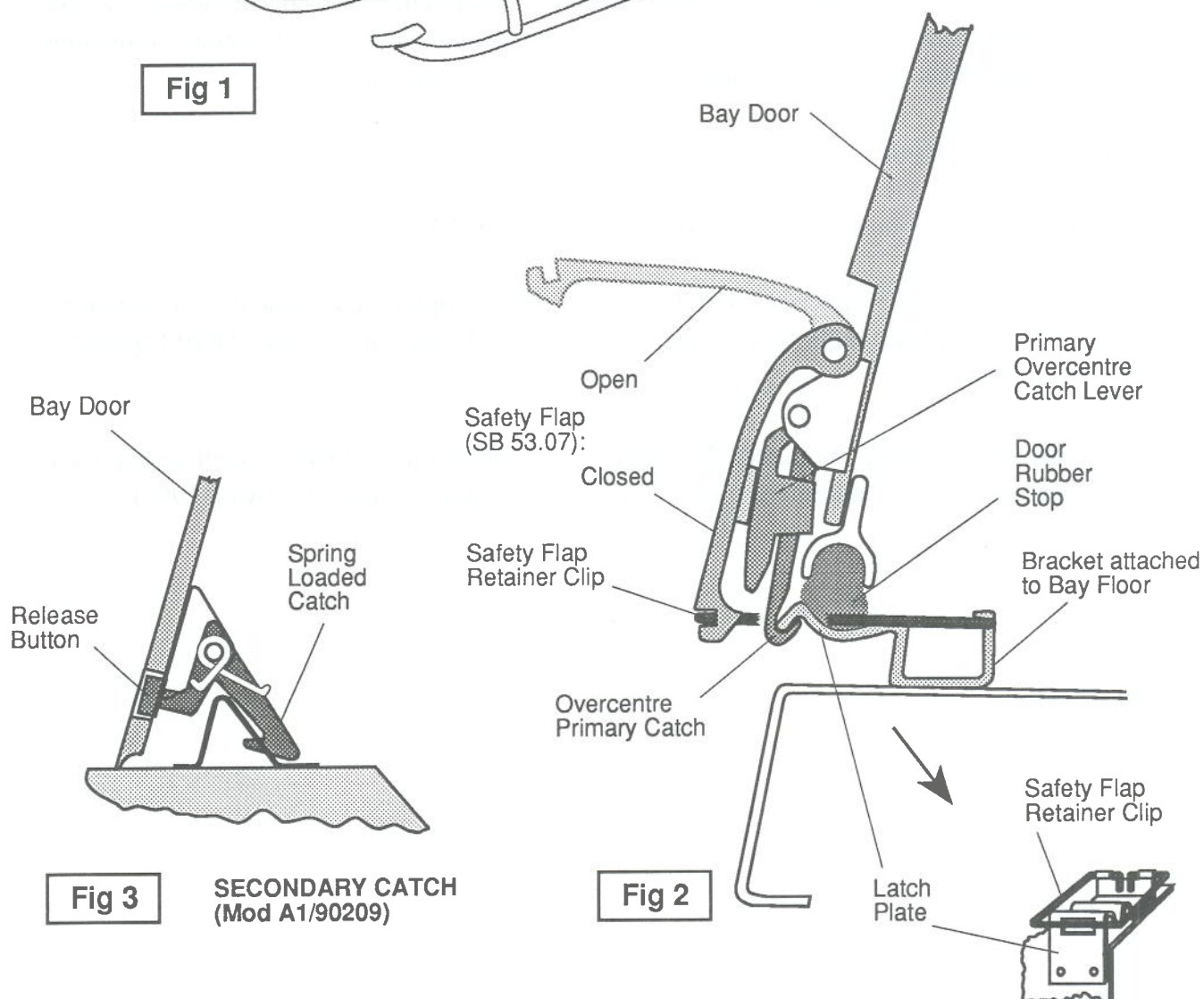


Fig 3

**SECONDARY CATCH
(Mod A1/90209)**

Fig 2