No: 1/92 **Ref: EW/G91/09/06** **Category: 2c**

Aircraft Type and Registration:	Aerospatiale SA341G Gazelle 1, G-TURP
No & Type of Engines:	1 Turbomeca Astazou 3A turboshaft engine
Year of Manufacture:	1977
Date & Time (UTC):	9 September 1991 at 0700 hrs
Location:	Green Acre Farm, Essex
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 3
Injuries:	Crew - None Passengers - None
Nature of Damage:	Deformation of: landing skid cross tubes; tail boom; tail rotor fairing assembly and cabin
Commander's Licence:	Private Pilot's Licence (Helicopters)
Commander's Age:	34 years
Commander's Flying Experience:	108 hours (of which 9 were on type)
Information Source:	Aircraft Accident Report Form submitted by the pilot plus AAIB enquiries and inspection of the aircraft

The pilot completed pre take-off checks from a checklist before lifting off with the intention of bringing the helicopter to a stable hover about six feet above the paved helipad. The AUW was well below maximum; the OAT was +10°C and the wind strength was 2 kt. The stability augmentation system (SAS) which improves roll and pitch stability was engaged before take off.

As the aircraft became airborne it drifted sideways and yawed to the left. The pilot corrected with lateral cyclic and right pedal but the yaw rate increased. Despite the application of full right pedal, the aircraft continued to rotate to the left. There were no abnormal noises or vibrations and the collective lever was raised to a position appropriate for the conditions. After approximately two or three revolutions the pilot diagnosed tail rotor failure and so, in accordance with the flight manual, he lowered the collective and accepted the ensuing rough landing back on to the helipad. The landing was heavy but with skids level. The skid cross-tubes deformed, the tail boom buckled and all four doors burst open. After touchdown the pilot noted that the engine and main rotor were still rotating at normal speeds before he shut down all the systems and evacuated with his passengers. There were no injuries.

Yaw control on the Gazelle is provided by a fenestron, a thirteen bladed fan located within a duct in the base of the fin which is shaft driven by the engine. Horizontal stabilisers with a vertical fin at each tip are mounted on either side of the tail cone just forward of the fenestron. In normal flight the flow through the fenestron is from left to right to counteract the torque of the main rotor which rotates clockwise when viewed from above. The pilot's yaw pedals vary the pitch angle of the fenestron blades and thereby control fenestron thrust. The pedals are mechanically connected to the fenestron blades by a rod, bellcrank and cable system, which incorporates a damper to limit the rate of pedal movement and an hydraulic servo jack to reduce pedal forces. Fuel flow to the engine in flight is controlled by a governor which maintains a constant engine speed. A fuel flow control valve lever mounted on the cabin ceiling near the fuselage centre line provides engine start, idle and normal cruise settings via the fuel governor. Adjacent to this lever is a fuel shut-off cock. Unlike most other single-engined helicopters, there is no twist grip throttle on the collective lever.

Examination of G-TURP revealed no evidence of pre-accident failure or malfunction. The fenestron was undamaged, except for minor tip rubbing consistent with the effects of the accident; the drive to the fenestron remained intact and free to turn; the yaw control circuit remained connected, with no evidence of jamming; and the characteristic of fenestron blade pitch angle versus yaw pedal position was consistent with that measured on another Gazelle on which the control circuit rigging had been confirmed as being correct.

The Gazelle has a history of suffering unexplained loss of fenestron effectiveness, commonly known as 'fenestron stall'. Known previous cases include one accident and one incident to aircraft on the UK civil register (currently totalling 17); one accident and one incident to unidentified aircraft; and 11 accidents plus a further 11 incidents in a military fleet of some three hundred Gazelles during the last thirteen years. In a number of these cases the aircraft came to rest on its side. The majority of documented 'fenestron stalls' have occurred in the hover during an attempted left turn in conditions of significant wind speed (10 kt +) from astern or from the right, but there have also been cases in a variety of other wind and flight conditions.

The fenestron differs from a conventional unducted tail rotor in that lateral thrust is produced not only by aerodynamic forces on the fan blades, but also by a suction force on the duct intake lips created by the fan-induced airflow over the lips. The manufacturer has stated that, under normal operating conditions, about half of the total fenestron thrust is produced from fan blade forces and half from intake lip suction. Available information suggests that the cause of 'fenestron stall' is not well understood. Some reports have suggested that the interaction of the airflow from a horizontal stabiliser fin with the fenestron may be a causal factor. However, it has been shown that when the fan tips reach their maximum coefficient of lift the flow near the duct wall may collapse. This results not only in the loss of a substantial part of the fan thrust when the fan tips stall, but additionally in the sudden loss of most of the intake lip suction thrust, causing the helicopter to yaw to the left under the influence of the main rotor torque reaction. Application of right pedal to correct the yaw may drive the blade tips deeper into stall and cause a further loss of lip suction which increases the yaw rate instead of reducing it. To the pilot the effect is similar to tail rotor failure.

In the case of a helicopter with a twist grip throttle on the collective lever, a loss of tail rotor effectiveness in the hover can be overcome without great difficulty by closing the throttle. This act rapidly diminishes main rotor torque reaction and hence aircraft rotation. The resultant landing may then be cushioned by collective lever application without inducing an uncontrollable yaw. With the Gazelle there is no known easy remedy if fenestron effectiveness is lost in the hover since the pilot has to release the collective to reach the fuel control levers, which are mounted in the overhead panel, at a time when the aircraft is out of control and close to the ground.

Recommended procedures for military operations have included reducing right yaw pedal application until fenestron effectiveness is restored and then reapplying right pedal; attempting to shutdown the engine; and lowering the collective lever and accepting a heavy landing. The civil Gazelle Flight Manual provides a procedure for tail rotor failure, including in the hover, which includes 'Immediately establish autorotative flight by reducing collective pitch; . . .' and 'In the event of failure near the ground, immediately reduce the pitch, even if a very rough landing will result.'

The Ministry of Defence (MOD) is sponsoring a trial scheduled to take place in France in 1992 during which Aerospatiale and MOD test teams will jointly investigate the phenomenon of "loss of yaw control" in the Gazelle.

It has been recommended that the CAA:

1. Liaise with the MOD and Aerospatiale regarding the 1992 trial and, if applicable, invite the manufacturer to suggest a cure for "sudden loss of yaw control".

2. Assess whether any other helicopter on the UK register may be similarly affected.

3. Require the development of flight crew procedures and/or aircraft modifications for existing helicopters, and Airworthiness Requirements for future helicopters, to ensure that loss of yaw control can be handled satisfactorily without requiring the handling pilot to release the flying controls.