ACCIDENT

Aircraft Type and Registration:	Eurocopter SA342J Gazelle, F-GJSL
No & Type of Engines:	1 Turbomeca Astazou XIVG turboshaft engine
Year of Manufacture:	1973
Date & Time (UTC):	8 May 2005 at 1630 hrs
Location:	Ockington Farm Strip, near Dymock, Gloucestershire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - 1 (Serious) Passengers - 1 (Serious)
Nature of Damage:	Damaged beyond economic repair
Commander's Licence:	Private Pilot's Licence
Commander's Age:	63 years
Commander's Flying Experience:	600 hours (of which 12 were on type) Last 90 days - 19 hours Last 28 days - 11 hours
Information Source:	AAIB Field Investigation

Synopsis

After making an approach to hover at a private landing site, the pilot initiated a spot turn to the left. After turning through 90° the rate of yaw increased and the pilot, believing he had lost control of the helicopter due to a strong gust of wind, increased collective pitch. The pilot then became disorientated and reduced collective pitch. The helicopter hit the roof of an adjacent building, the tail boom detached and the main body of the helicopter fell to the ground. Both occupants were seriously injured.

History of the flight

After an uneventful flight from Warminster, the pilot, accompanied by his wife, made an approach to their private landing site adjacent to their house. He had to hover-taxi with a downwind component until the helicopter passed just beyond the paved landing pad. His intention was then to make a spot turn to the left, through 180°, and hover-taxi back to the pad for an 'into wind' landing. The pilot initiated the spot turn slowly and stopped after turning through 90°, with the fin approximately side on to the wind. As he prepared to commence the second half of the turn, but before left pedal was applied, the helicopter yawed rapidly to the left. Application of right pedal did not appear to reduce the rate of yaw, so the pilot pulled up on the collective lever in order to gain height. He also applied some aft cyclic to counter a perceived nose down pitch during the turn. The pilot recalled becoming extremely disorientated and releasing his grip on the collective lever in an attempt to grab his wife's hand. He heard a loud bang as the

helicopter contacted the roof of his house, causing the tail-boom to detach. The helicopter fell to the ground and the pilot, who remained conscious throughout, was able to climb out of the wreckage through the helicopter's roof. He used the onboard fire extinguisher to put out a fire in the engine bay and oil tank, but was unable to extract his unconscious wife from the wreckage. After, unsuccessfully, attempting to disconnect the battery and locate the fuel cut off lever, he telephoned the emergency services who were on the scene within 10 minutes. Both the pilot and his wife were air lifted to hospital.

Pilot experience/training

Although the pilot had been flying helicopters for a number of years, nearly all his flying experience was on the Bell 206 Jetranger. He had only recently acquired F-GJSL and this was his fourth flight as pilot-in-command on a Gazelle. During his conversion training, his instructor had demonstrated landings and various approaches to his private landing site. The pilot was very familiar with the site as most of his previous helicopter flying had also taken place from this location. His instructor had recommended that, when possible, spot turns in the Gazelle should be carried out to the right.

The pilot had completed seven hours of conversion training prior to his skills test and he had not experienced any problems with yaw control. He did, however, admit to some confusion regarding the optimum direction to turn the helicopter if there was a choice available.

Meteorology

An aftercast from the Met Office described a high pressure area to the west of the UK feeding a light to moderate northerly wind over the accident area There was no low level cloud and the visibility was excellent. It was estimated that the surface wind in the area would have been between 320° and 340° at a speed of 12-15 kt. Several local residents reported one or two particularly strong gusts of wind during the late afternoon period.

Aircraft description

The Gazelle, originally designed as a military helicopter, was first flown in 1967. It is configured with a three bladed main rotor and a thirteen bladed tail rotor, located within a duct (termed a 'fenestron') in the base of the fin. The cyclic and collective flying controls, which are servo assisted, vary the pitch of the main rotor blades via a series of control rods, levers and bell cranks. The pilot's yaw pedals alter the pitch of the tail rotor blades, also via control rods, bell cranks and cables, controlling the airflow through the fenestron and hence the side thrust produced. The helicopter is also equipped with an automatic Stability Augmentation System (SAS) designed to oppose motion in roll, pitch and yaw through limited authority hydraulic actuators in the cyclic and yaw control systems. The three channel system senses rate of movement in the appropriate axes and provides a damping effect on helicopter response to both rapid control inputs by the pilot and external disturbances.

Most of the civil manufactured Gazelles were delivered with fronts seats of the 'low back' type. These seats consist of a seat pan with a low flexible backrest fitted to a welded tubular structure. Lap belts are attached to the side of the seat pan but no upper torso restraints are fitted. These were not required for Certification by the French Authorities. Upper torso restraints cannot be fitted to this type of seat. However, a high back version of the seat, which is fitted with upper torso inertia reel harnesses, is available and, according to the manufacturer, may be fitted as a direct replacement if the owner so chooses.

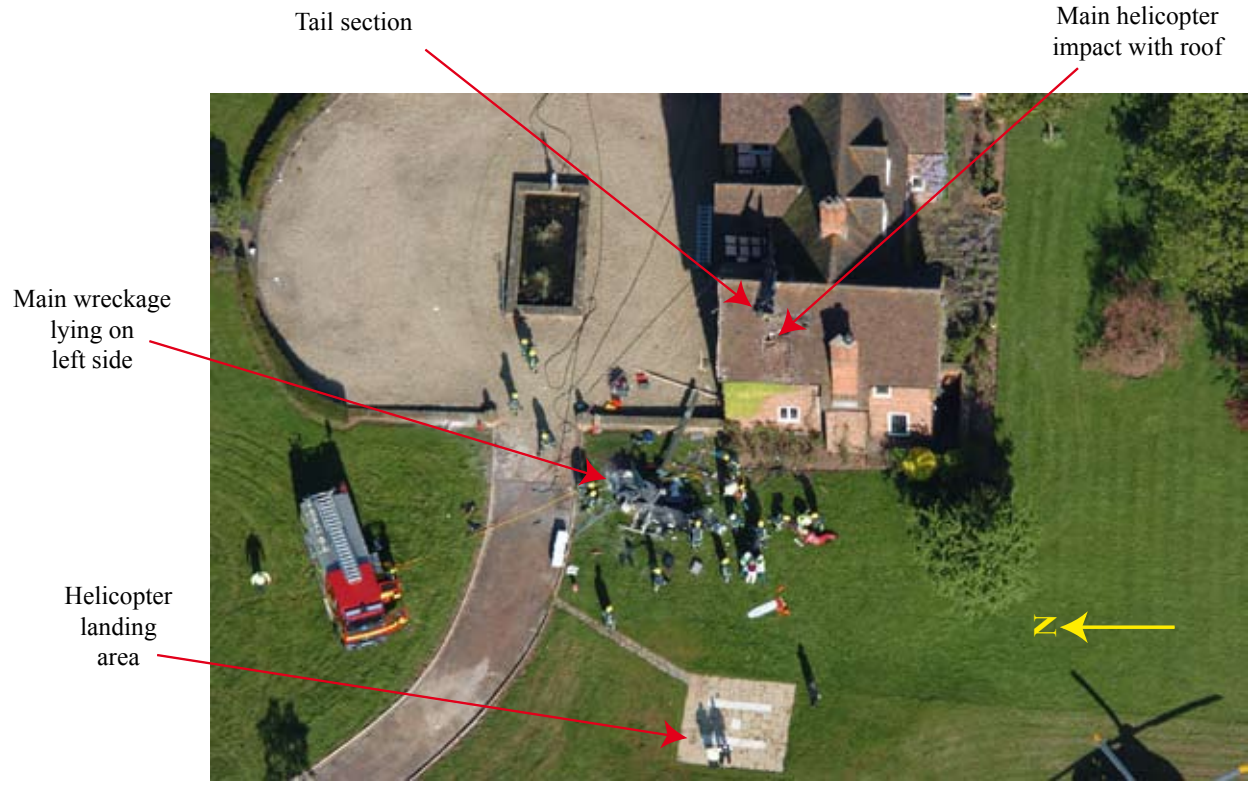
F-GJSL was manufactured in August 1973 as a SA341G civilian model and delivered to the USA. It returned to the manufacturer, Eurocopter, who bought the helicopter in November 1988 to be modified. This involved fitting optimised blades and an upgraded Turbomeca Astazou XIVG turbo shaft engine, converting it to a SA342J model. From February 1989, it flew in France and Canada before being purchased, in March 2001, by an operator in the UK, some 4,984 hours flying time since the modifications. The 342J model of Gazelle is not type-certificated in the UK and, although based within the UK, F-GJSL was maintained on the French Register.

Additional information

The manufacturer also produced the Alouette 2 family and the AS350B Squirrel helicopters without upper torso restraints fitted to the front seats, as this was not required by Regulation. The manufacturer is unable to establish how many remain flying without upper torso restraints but confirms that all models currently manufactured are fitted with such restraints, and point out that many are fitted with crashworthy seats.

Accident site and wreckage examination

The helicopter crashed onto the roof of the pilot's house approximately 16 m to the north of the designated landing area. It struck the pitched roof (Figure 1) with a high rate of descent, whilst in an approximate 30º nose down and right side low attitude, on a westerly heading. The impact had severed the rear structure of the helicopter, comprising the tail boom and fin, which had remained straddled across the apex of the roof. The severity of the vertical impact had caused the rear right skid attachment to be forced up into the fuselage structure. Pieces of the right skid then



Photograph courtesy of Western Counties Air Operations Unit

Figure 1

Impact location and wreckage distribution

detached, falling to the ground at the base of the wall of the house. The remainder of the helicopter, together with the occupants, then fell approximately 25 ft to the ground, impacting heavily on its forward left side.

The main rotor blades had struck the gable end of the roof during the initial impact; one blade had been broken into two parts and all showed evidence of rotation scoring from the impact. The detachment of the tail section allowed the tail rotor drive to become disconnected at the output spline from the intermediate gearbox. The tail rotor drive shaft failed at a location along its length consistent with the position of the impact of the tail section with the apex of the roof. The failure showed evidence of the shaft having been rotating at the time of impact. The tail rotor blades were intact; scoring around the fenestron duct indicated that the tail rotor had been rotating at impact.

Examination of the flying control system did not reveal any pre-accident disconnects or failures in the system. The position of the controls, which run under the cabin floor, had been frozen by the impact which compressed the control rods against the fuselage frames; comparison with a similar helicopter showed a right yaw pedal demand of approximately 75% right and a right lateral cyclic demand. The longitudinal cyclic was in a neutral position.

There had been a small fire around the engine area. The fuel tank had not ruptured and approximately 45 galls of fuel was recovered from this tank.

In summary, examination of the wreckage, both on site and later after its recovery, did not reveal any pre-impact failures or defects within the helicopter.

Helicopter landing area

The centre of the helicopter landing area, shown in Figure 1, was approximately 16 m from the pilot's house. The British Helicopter Advisory Board (BHAB) gives advice, produced in conjunction with the CAA, on setting up an unlicensed helicopter site. This gives a formula for calculating the radius of the landing area within which there should be no obstructions. This is based on the dimension from the forward extent of the main rotor disc to the aft tip of the tail rotor. For the Gazelle, the radius of the landing area was calculated to be 11.9 m; there were no obstructions within this area.

Previous occurrences

The AAIB has reported on six similar events involving loss of yaw control in the hover with civil registered Gazelle helicopters. The most recent was reported upon in Bulletin 10/2002 and occurred to Gazelle G-BZOS on 14 July 2002. Many of these reports contain additional background information relating to loss of directional control with the Gazelle helicopter. A common factor appears to be low pilot experience on type.

The UK armed services have operated the Gazelle helicopter for many years and are aware that high yaw rates to the left can develop. The Gazelle tail fin is considerably larger than most non-fenestron equipped helicopters, making the execution of a spot turn a challenge due to the weathercock effect in windy conditions. The Ministry of Defence Flight Manual (MoD FM) for the Gazelle states that

> *'whenever possible, the first turn should be made to the right to check the maximum rotor torque required'.*

Eurocopter Service Letters

As a result of some of the events mentioned above, Eurocopter produced Service Letter 1518-67-01 dated 26 April 2001, giving advice on apparent loss of tail rotor control. On 4 February 2005, Eurocopter produced Service Letter 1673-67-04 amplifying this advice. It included the following:

> ***'Background***
>
> *From hover flight at take-off at very low speed, the pilot initiates a left turn a few metres above the ground by applying yaw pedals towards the neutral position: the aircraft starts its rotation until the pilot attempts to stop it by applying the right hand yaw pedal.*
>
> *In the various cases which resulted in the loss of control in the yaw axis, the action applied to the right hand yaw pedal was not enough (amplitude/ duration) to stop rotation as quickly as the pilot wished.*
>
> *As the aircraft continues its rotation, the pilot generally suspects a (total or partial) tail rotor failure and decides either to climb to gain speed or get closer to the ground.*
>
> *In the first case, increasing the collective pitch results in increasing the main rotor torque and consequently further speeds up leftward rotation. This results in the loss of aircraft control.*
>
> ***Important Reminders***
>
> *In a quick leftward rotation, if the pilot attempts to counteract this rotation by applying the right hand yaw pedal up to a position corresponding to hover flight, the aircraft will not decelerate significantly.*
>
> *In this situation,* ***immediate action of significant amplitude*** *applied to the right hand yaw pedal must be initiated and* ***maintained*** *to stop leftward rotation.* ***Never hesitate to go to the right hand stop****. Any delay when applying this correction will result in an increase in rotation speed.*
>
> *Intentional or accidental initiation of this rotation phenomena can therefore be physically explained and is in no way connected to tail rotor performance****; in all cases when adequate correction is applied, rotation will stop!'***

Survivability

Both occupants were seriously injured. The passenger seated in the left front seat suffered major injuries to the left side of her body, sufficient to rupture her spleen and diaphragm, fracture several ribs and cause a major contusion to her left lung. The injuries were consistent with the final impact of the left side of the helicopter as it hit the ground. The consultant cardiothoracic surgeon who treated the passenger was of the opinion that the injuries would have been less severe had the helicopter restraint included a bilateral upper body/shoulder (diagonal) restraint.

F-GJSL was certificated to the French Direction General de l'Aviacion Civile (DGAC) requirements and was only required to be fitted, at that time, with lap-belts. These requirements were based on the American Federal Airworthiness Requirements (FAR) Part 27 which, prior to amendment 21, did not stipulate any restraint system. However, FAR 27.2 introduced a retroactive requirement as follows:

> *'For each rotorcraft manufactured after September 16, 1992, each applicant must show that each occupant's seat is equipped with a*

safety belt and shoulder harness that meets the requirements of paragraphs (a), (b) and (c) of this section.

(a) Each occupant's seat must have a combined safety belt and shoulder harness with a single-point release. [...]

(b) Each occupant must be protected from serious head injury by a safety belt plus a shoulder harness that will prevent the head from contacting any injurious object.

(c) The safety belt and shoulder harness must meet the static and dynamic strength requirements, if applicable, specified by the rotorcraft type certification basis.

(d) For purposes of this section, the date of manufacture is either

(1) the date the inspection, acceptance records, or equivalent, reflect that the rotorcraft is complete and meets the FAA-Approved Type Design Data; or

(2) the date the foreign civil airworthiness authority certifies that the rotorcraft is complete and issues an original standard airworthiness certificate, or equivalent, in that country'

In France, there is no equivalent retroactive requirement; however, their regulation in '*Arrêté du 24 Juillet 1991*' stipulates, in Chapter II paragraph 2.4.2, the following:

'For all airworthiness certificated French aircraft having made their first flight after the 1st of January 1983, and for all French aircraft having made its first flight after the 1st of July 1988 .... the flight crew members seats and the forward seats when there is a possibility of collision with the occupant's body and the facing structure, in forced landing acceleration conditions, have to be equipped with a shoulder harness;'

For certification on the UK register the helicopter would, in the past have had to comply with any Additional Requirements for Import (ARI), which would have specifically included high seat backs and upper torso restraints. Under European Aviation Safety Agency (EASA) regulations, the French DGAC requirements valid at the time of Certification prevail, although any existing UK registered aircraft already fitted with the upper torso restraints would not be required to have them removed. This situation is also applicable to other older Eurocopter models.

Discussion

The advice from Eurocopter, which is mirrored in the Ministry of Defence Flight Manual applicable to MoD operated Gazelle helicopters, is that immediate and positive application of right pedal, up to the maximum, must be applied and held to counter a high yaw rate to the left. The pilot of F-GJSL, had only 12 hours on type, including his seven hour conversion course with an instructor. He had 600 hours experience flying the Bell Jet Ranger. He was aware of the advice issued by Eurocopter but believed that he had lost directional control of the helicopter, as he was applying right pedal in an attempt to stop the rotation. As described in the Eurocopter Service Letter, raising the collective lever exacerbated the situation, by increasing the rotation to the left. Immediate and sustained full application of right pedal is therefore required to stop the rotation. There may have been a tendency for the helicopter's nose to dip forwards, due to the centrifugal effect of the high turn rate. Should the pilot have introduced some aft cyclic to make a correction, then this might explain why the helicopter 'backed' onto the adjacent building.

Unlike the Bell 206 Jet Ranger, there is little inherent friction on the collective lever in the Gazelle and, when the pilot released the lever to grab his wife's hand, the lever may have migrated downwards. This would have reduced the pitch on the main rotor blades, resulting in the helicopter descending onto the roof of the building.

Pilots who are inexperienced on the Gazelle need to be particularly aware of this apparent loss of tail rotor control. Unlike several helicopter types routinely used for training, the main rotor rotates in a clockwise direction (when viewed from above) and right pedal rather than left pedal is needed to oppose main rotor torque. Also, the fenestron-equipped Gazelle requires greater pedal deflection than that required for manoeuvring other training helicopters. Additionally, the tail fin is considerably larger than non-fenestron equipped helicopters, leading to more challenging spot turns in windy conditions. In view of these characteristics, the statement in the MoD FM of:

'whenever possible, the first turn should be made to the right to check the maximum rotor torque required'

seems appropriate advice for civil operators to follow in order to avoid, as far as possible, a high yaw rate to the left developing when making spot turns.

The severity of the injuries sustained by the occupants and, in particular, the passenger seated on the left front seat, was exacerbated by the lack of upper torso restraints. Upper torso restraints would have been a requirement had the helicopter been on the UK register; however, the French requirements for this generation of helicopter were only for a lap belt to be installed. As EASA are now responsible for all helicopter design requirements within most European countries, the following recommendation is made:

Safety Recommendation 2006-066

It is recommended that the European Aviation Safety Agency introduce requirements to ensure that upper torso restraints, in addition to lap straps, are installed on all front seats in helicopters for which they have airworthiness responsibility, where such a modification is available from the manufacturer.