

RAF 2000 GTX-SE, G-CBAG

AAIB Bulletin No: 9/2003	Ref: EW/C2002/05/05	Category: 3.0
Aircraft Type and Registration:	RAF 2000 GTX-SE, G-CBAG	
No & Type of Engines:	1 Subaru EJ22 piston engine	
Year of Manufacture:	2001	
Date & Time (UTC):	17 May 2002 at 1634 hrs	
Location:	Black Notley, Essex	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 1
Injuries:	Crew - 1 (Fatal)	Passengers - 1 (Fatal)
Nature of Damage:	Destroyed	
Commander's Licence:	Airline Transport Pilot's Licence, and	
	Private Pilot's Licence	
Commander's Age:	42 years	
Commander's Flying Experience:	7,812 hours (of which 45 were on type)	
	Last 90 days - 91 hours (14 on gyroplanes)	
	Last 28 days - 19 hours (2 on gyroplanes)	
Information Source:	AAIB Field Investigation	

Background

The pilot was an experienced professional pilot on fixed wing aircraft who had commenced training to fly gyroplanes, for recreational purposes, some two and a half years prior to the accident. All of this gyroplane flying had been conducted on the RAF 2000 type. He was the owner of another RAF 2000, registered G-BYDW.

The pilot had become acquainted with another enthusiast who had built G-CBAG over a period of some two years. The accident occurred on the fourth flight since G-CBAG had received its Permit to Fly. Both G-BYDW and G-CBAG were kept at the same farm strip at Rayne, near Braintree, in Essex.

The pilot's colleague had no flying experience other than about nine hours of instruction in the RAF 2000 gyroplane. The pilot was considering the possibility of getting an Instructor Rating for gyroplanes but, after various delays, had only recently gained his own gyroplane licence a few weeks before the accident.

History of flight

On the afternoon of the accident the pilot and his colleague had arranged to go for a flight together in G-BYDW. They took off in the middle of the afternoon from the farm strip at Rayne and spent about twenty minutes flying in the local area. The pilot then took his colleague's wife for a short flight, again in G-BYDW. On their return it was agreed that the pilot would fly once more with his colleague, but this time in his colleague's machine, G-CBAG. The pilot then went on to conduct some solo circuits in G-BYDW, whilst his friend got G-CBAG out of the hangar and completed a pre-flight check and engine warm up.

After landing from his solo flight the pilot put G-BYDW away before getting into the right hand seat of G-CBAG. His unqualified colleague occupied the left-hand seat, which on the RAF 2000 is usually occupied by the pilot flying the aircraft as the blade pre-rotator required during takeoff is only operable from this seat. They then taxied out and took off, flying back over the airfield before heading off in a southerly direction. A witness at the airfield later estimated the departure time as 1600 hrs. Witnesses reported seeing or hearing nothing unusual.

The weather that afternoon was described by witnesses as bright and sunny. Some described the wind as calm, but others estimated that there was a north-easterly wind of between 10-15 kts. One witness commented that whilst it had been generally calm, there had also been some gusts of wind. An aftercast from the Met Office indicated that there was a moderate south-easterly flow covering the area at the time of the accident, with winds up to 1,000 feet being generally easterly at 13 to 20 kt. Stansted Airport, 12 nm to the west of the accident site, had fine weather and an easterly wind of about 12 kt and Andrewsfield, located 4 nm to the north-west, also had an easterly wind of about 13 kt. No gusts were recorded in these reports. However, by convention, no gusts below 10 kt are required to be reported. Hence it is possible that, at times, the wind speed could have been gusting to just over 20 kts.

Several witnesses in the local area reported seeing a gyroplane at various times that afternoon. Most of these sightings were at the time when the pilot was flying G-BYDW. However, there were also some witnesses to the accident itself. These all reported seeing G-CBAG suddenly fall vertically to the ground, shedding parts as it fell, with some able to identify one of the rotors separating.

The aircraft seemed to have been flying normally up to this point, although one witness reported seeing the gyroplane lose height both shortly before and then again immediately before it started to fall. Descriptions of the height at which G-CBAG was flying varied, but it was probably between 500 and 1,000 feet.

There were also varying eyewitness descriptions about the engine noise. Whilst all agreed there had been engine noise up to the point where the aircraft had dropped, there were differences in the point at which witnesses heard the noise cut out. Some reported this to be when the gyroplane had started to fall, some reported it cutting out during the fall and others reported that the engine could be heard until the aircraft hit the ground.

On seeing the crash witnesses close by notified the emergency services and made their way to the accident site to offer what assistance they could. The emergency services were quickly at the scene. Both occupants sustained fatal injuries on impact.

Engineering investigation

The aircraft had impacted almost vertically into a field containing a moderately tall crop, in a tail first attitude. Both rotor blades were detached. One was lying within a few feet of the wreckage, and appeared to have come off as the aircraft had struck the ground, the other was found about 150 feet from the wreckage. That blade had come off in flight, and a section of it about 18 inches long, from the inboard end, was not found although it probably was in the same field. The blade had several marks towards its tip from contact with the propeller, from which it may be concluded that it separated violently during flight while the engine was running. Both blades showed evidence of damage consistent with severe upward bending in flight. Due to the centrifugal forces normally generated by the rotor, this can only occur if the rotor has slowed down or stopped. The composite

propeller had been badly damaged while rotating on impact with the ground, further indicating that engine failure had not occurred at the time of the rotor break up.

During the break up, the rotor had struck the vertical tail. Parts of the vertical tail and rudder had then separated from the aircraft. The tail boom and base of the fin was found in the crop about 180 feet from the main wreckage, and the base of the rudder was found some 240 feet from the main wreckage. Apart from the indication of low rotor speed, no mechanical reason for the loss of control was found. The aircraft was fitted with a pre-rotator mechanism; this appeared to have been serviceable and in particular the clutch seemed to have been capable of engaging and releasing correctly, and no evidence of interference between the pre-rotator mechanism and the rotor was found.

The aircraft appeared to have been well constructed throughout and no pre-impact defects or failures were subsequently found.

Description of the aircraft

The RAF 2000 is a Canadian designed kit-built two seat gyroplane of conventional layout with a pusher engine configuration. The GTX-SE model is fitted with a Subaru EJ22 flat four piston engine as an option. It has a fully enclosed cabin, with side by side seating and a good level of equipment and instrumentation for this class of aircraft. One of its features is a mast design which is claimed to improve handling in pitch. Dual controls are fitted, including dual throttles.

G-CBAG had been purchased as a partly completed project. The owner then stripped it down and completely rebuilt it to a high standard. It was issued with a Permit to Fly in March 2002, and had completed five flights since new, for a total of 5 hrs 30 minutes flying, including two test flights for initial Permit issue, before the accident flight. It carried the constructor's number G13/1296.

Stability of gyroplanes

The investigation has found that the material which has been published on gyroplane stability has, in the past, been largely anecdotal. More recently, Glasgow University has conducted analytical studies and flight testing as part of a CAA project. That work has indicated that the stability of gyroplanes is closely related to the geometry of the thrust lines of the propeller, and to a lesser extent the rotor, relative to the centre of gravity. Using this information, the stability of many gyroplanes appears to be unsatisfactory. Of particular concern are divergent pitch instability modes, which are coupled to rotor speed. This type of instability can be controlled by an experienced pilot, if it has a relatively long time period. However, an inexperienced pilot may find it difficult to control, and the natural responses of an experienced fixed wing pilot may become out of phase, or otherwise inappropriate. This instability mode can be excited in gusting or turbulent conditions. Should such a pitch instability mode become sufficiently large in amplitude, the rotor may become unloaded and a 'power pitchover', in which propeller thrust is the dominant force, may occur. In this situation, if the propeller thrust line passes significantly above the centre of gravity, the gyroplane will pitch rapidly nose down. This phenomenon has sometimes resulted in the loss of control of the rotor, with fatal results.

The RAF 2000 has a relatively high thrust line and this, together with its general geometry, means that it would be expected to have unsatisfactory pitch stability characteristics when assessed against the criteria established by the CAA/Glasgow University studies. It does have a special design of rotor head and mast, which is intended to improve pitch stability but, although a RAF 2000 was offered for trials, it was not used and so the benefits claimed for its mast design have not been evaluated. Like many gyroplanes, it does not have a horizontal tail as standard equipment.

Anecdotal evidence concerning the RAF 2000's stability is widely available. There are a number of after-market tail planes in use around the world, which are claimed to greatly improve the pitch stability. However, none is approved for use in the UK. Whilst some experienced gyroplane pilots consider that the RAF 2000 has particularly poor pitch stability characteristics and that a horizontal tail is a valuable improvement, the manufacturer, RAF, and some other gyroplane pilots consider that a horizontal tailplane can worsen its handling characteristics under some flight conditions such as strong gusts.

There is also some concern about the directional instability of the RAF 2000. The manufacturer has commented that when the RAF 2000 was presented for test for CAA acceptance, the UK pilots had fitted a dual fin stabiliser, with a small horizontal section. The CAA, however, required the acceptance tests to be based on the original test submission and the stabiliser was therefore removed.

Certification issues

In the UK, airworthiness standards for gyroplanes are set by the Civil Aviation Authority and are contained in British Civil Airworthiness Requirement (BCAR) Section 'T'. Section 'T' does contain a dynamic pitch stability requirement. It requires that '*Any short period oscillations occurring under any permissible flight conditions must be heavily damped...*' (para T181(a)). However, most gyroplanes operating in the UK are of foreign design or manufacture, or have been operating in the UK for long enough for them to be accepted on the basis of an adequate safety record, and so have not been assessed against BCAR Section 'T'.

Safety Recommendations

The AAIB considers that the RAF 2000 stability characteristics, with due regard to the local weather conditions, represented a considerable challenge to the two inexperienced (in gyroplanes) pilots on board. Therefore the following Safety Recommendations are made:

Safety Recommendation 2003-01

It is recommended that the CAA should review the pitch stability requirements of BCAR Section 'T' in the light of current research, and amend the Requirement as necessary. The CAA should consider the need for an independent qualified pilot assessment of the handling qualities of different gyroplane types currently approved for the issue of a Permit to Fly against the standards of BCAR Section T, as amended.

Safety Recommendation 2003-02

It is recommended that the CAA should consider retrospectively assessing all gyroplane types currently on the UK register for acceptable pitch stability characteristics.

Safety Recommendation 2003-03

It is recommended that the CAA should assess the RAF 2000 for compliance with the requirements of BCAR Section 'T', as amended, and, if necessary, require appropriate modification to achieve compliance.

Safety Recommendation 2003-04

It is recommended that the CAA consider the introduction of a wind and gust speed limitation for inexperienced autogyro pilots, similar to that already in effect for inexperienced pilots of certain small helicopters.