ACCIDENT

Aircraft Type and Registration:	RAF 2000 GTX-SE, G-CBCJ
No & Type of Engines:	1 Subaru EJ22 piston engine
Year of Manufacture:	2002
Date & Time (UTC):	9 October 2008 at 1755 hrs
Location:	2 nm north of Henstridge Airfield, Somerset
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Fatal) Passengers - N/A
Nature of Damage:	Destroyed
Commander's Licence:	Private Pilot's Licence (Gyroplanes)
Commander's Age:	57 years
Commander's Flying Experience:	Total hours unknown Gyroplane 146 hours (of which 146 were on type) Last 90 days - 5 hours Last 28 days - 5 hours
Information Source:	AAIB Field Investigation

Synopsis

During a descent at close to the never-exceed speed (V_{NE}) the gyroplane rotor struck the aircraft's propeller and rudder. An in-flight break up ensued and, during the impact that followed, the pilot received fatal injuries. No pre-existing defects on the aircraft were identified.

History of the flight

The pilot planned to fly the aircraft from Henstridge Airfield, Somerset to Little Rissington Airfield in Gloucestershire, for its Permit to Fly annual inspection, returning later that day. G-CBCJ departed Henstridge several hours later than intended and arrived at Little Rissington at about 1315 hrs. On completion of the annual inspection, the pilot refuelled the aircraft to full and departed Little Rissington at approximately 1607 hrs. He planned to fly at an altitude of 2,000 ft, at an IAS of 60 mph and expected to achieve a ground speed of 50 mph and a flight time to Henstridge of 87 minutes. Henstridge Airfield closed at 1800 hrs.

Another gyroplane, flown by Pilot B, had accompanied the aircraft on the inbound flight and flew in company with G-CBCJ back to Henstridge. Pilot B recalled that during the return flight the two gyroplanes were flying at an altitude of 2,500 ft and cruising at about 55-60 mph. This resulted in a ground speed of approximately 35 mph and he was concerned about their slow progress. Sunset was at 1730 hrs and Pilot B commented that, from about

1700 hrs, it became very cold and damp and, despite wearing gloves, his fingertips became numb.

Both aircraft were equipped with radios and the pilot of G-CBCJ transmitted all the radio calls, on behalf of both aircraft. Pilot B reported that everything seemed normal when they transferred from the Bristol Radar frequency to the Henstridge Radio frequency. Thereafter, he heard no further calls from the other pilot.

The flight proceeded without incident and, after passing the A303 (a trunk road orientated east-west) and approximately five nm north of Henstridge, G-CBCJ commenced a descent which Pilot B followed. It was about 1750 hrs and getting dark, with unlit ground features becoming indistinct. During the descent G-CBCJ accelerated to about 65 mph and Pilot B matched the descent and speed increase. Pilot B then slowed his aircraft slightly to take up a position astern of G-CBCJ to allow it to land at Henstridge Airfield first. Using G-CBCJ's tail light as a reference, Pilot B then accelerated to maintain his distance. In order to do so, Pilot B had to increase his IAS to 95 mph. Almost immediately, Pilot B became concerned that his airspeed was above the V_{NE} of 70 mph and reduced speed.

Pilot B attempted to call G-CBCJ on the Henstridge Radio frequency but received no reply. Approximately one nm further on he looked towards the airfield and checked his flight instruments before looking again towards where he expected to see G-CBCJ. He could not see the other gyroplane and, concerned that he may have caught up with it, he turned to the right and reduced speed. As he did so, he looked to his left and saw what he believed to be a white blade spiralling down in an eccentric circle at 60-120 rpm. He also recognised the colour of G-CBCJ's airframe and watched the aircraft descend until it reached the surface of the field below. He considered that it was too dark to conduct a safe field landing and continued on to Henstridge Airfield where he landed safely and contacted the emergency services.

Numerous witnesses around the village of Kington Magna reported hearing noises like misfiring or pinking, followed by what sounded like a very large backfire. The witnesses who were immediately below the flight path described seeing a gyroplane much lower and louder than normal, hearing a loud bang and seeing a cloud of debris fall from the sky. Several witnesses went immediately to the large field into which the aircraft had descended, arriving within minutes of the accident. The pilot had suffered fatal injuries.

A witness in the village of Buckhorn Weston, about 1 nm north of the accident site, reported seeing a pair of gyroplanes fly overhead. The witness was concerned that one was "swaying" from side to side. However, based on the witness's description, it appears this was not the accident gyroplane but the one flown by Pilot B. This witness described the accident gyroplane as flying straight and not giving cause for any concern.

Gyroplane description

The RAF 2000 is a kit-built, two-seat gyroplane powered by a 130 hp Subaru-carburetted engine driving a three-bladed 'Warp Drive' carbon fibre propeller. It is fitted with a two-bladed glass-fibre main rotor which rotates in an anti-clockwise direction when viewed from above. The side-by-side cockpit is fully enclosed although, following an earlier Mandatory Permit Directive (MPD 2006-013), the RAF 2000 is required to fly with the doors removed. The throttle is to the left of the pilot's thigh and the pilot's left hand is exposed to the airflow when it is on the throttle. The base of the rotor mast is fixed to a keel beam at the rear of which

is attached the fin and rudder assembly, together with a small tail wheel.

Pitch and roll control is effected by means of a cyclic control stick which operates on the rotor head via a series of control rods; trim springs allow the control forces to be offset. A conventional rudder, operated by pedals connected via cables to the control surface, is used for yaw control.

The RAF 2000 type is not approved for night flying and G-CBCJ had neither cockpit lighting nor illuminated flight instruments. See Figure 1.

Figure 1
G-CBCJ cockpit

Maintenance records

G-CBCJ was constructed in 2002, and had completed 107 airframe hours and 108 engine hours, up to the day of the accident.

Its Permit to Fly, issued by the Light Aircraft Association (LAA), was effective until 9 October 2008. The purpose of the flight to Little Rissington had been to carry out an annual inspection as part the renewal of the Permit to Fly. This had been completed satisfactorily by an LAA Inspector and the Permit Flight Release Certificate signed. A flight test, which could be performed by the pilot/owner, was required as part of the renewal. This had not been completed on G-CBCJ at the time of the accident.

Wreckage and impact information

The gyroplane had struck the ground in an open area to the west of the village of Kington Magna. The impact was consistent with a near vertical descent, with no forward speed. However, there was evidence that the gyroplane had been on a southerly track. The impact occurred with the gyroplane in a nose-up attitude, resulting in the propeller and engine being buried in the soft ground. The tail boom and a portion of the fibreglass fin were found in the same field, approximately 50 m to the north. Further pieces of wreckage, comprising the remainder of the fin and the rudder, were spread along a trail, in a northerly direction from the main wreckage site, up to a distance of 600 m. The tail wheel was found approximately 100 m to the west of the main wreckage. Figure 2 shows the wreckage distribution.

Evidence from ground marks indicated that the rotor blades had not been rotating at impact. However, there was evidence along the length of the blades of multiple impacts with the propeller blades, together with paint transfer arising from impact with the fin and rudder. Reconstruction of the fin and rudder pieces recovered from the wreckage trail indicated that there had been three strikes from the main rotor blade. The first strike had been at the top of the fin/rudder, the second mid-way down, and the third at the base of the rudder, resulting in the detachment of the tailwheel and most of the keel beam. See Figure 3.

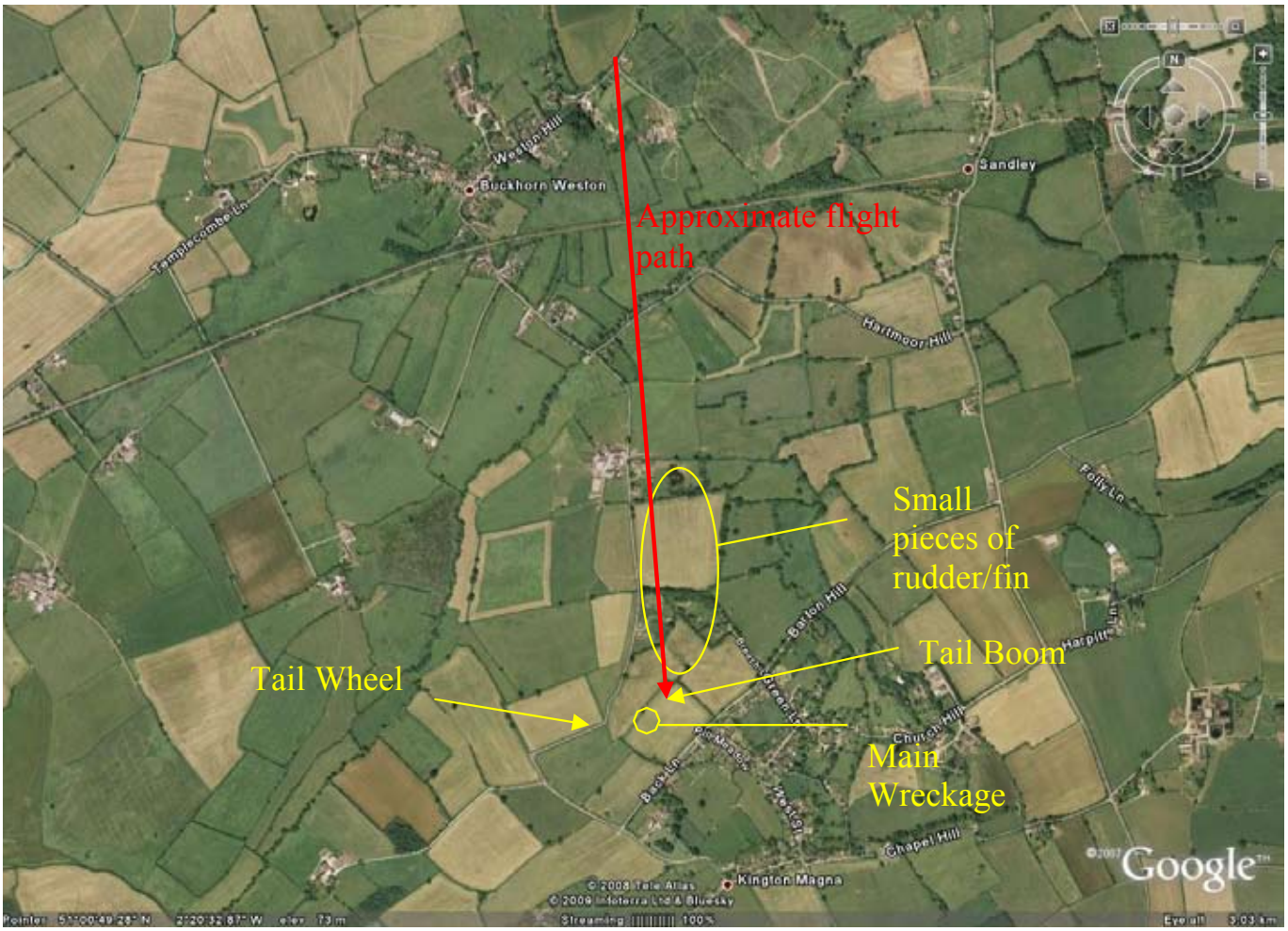

Figure 2

Wreckage distribution
(Copyright Google Earth ™ mapping service/Infoterra Ltd & Bluesky/Tele Atlas)

The gyroplane had been extensively damaged in the impact and the main wreckage was surrounded by pieces of the canopy; the doors had not been fitted. The fuel tank, located beneath the pilot's seat, had ruptured and there was a strong smell of fuel at the accident site.

All the propeller blades were found within the crater formed by the impact, although only one had remained attached to the hub. The propeller blades showed evidence of rotation and impact with the rotor blades and subsequent examination of the engine revealed no pre-impact mechanical damage. The carburettor heat air box on the top of the engine was in the HOT position.

An examination of the flying controls showed that there were no pre-impact disconnections and all the failures were consistent with the impact; the trims were in their mid positions.

Previous accidents

The report on the investigation into the fatal accident involving G-REBA, also a RAF 2000 GTX-SE, (see AAIB Bulletin 9/2007) showed similar damage to G-CBCJ, including:

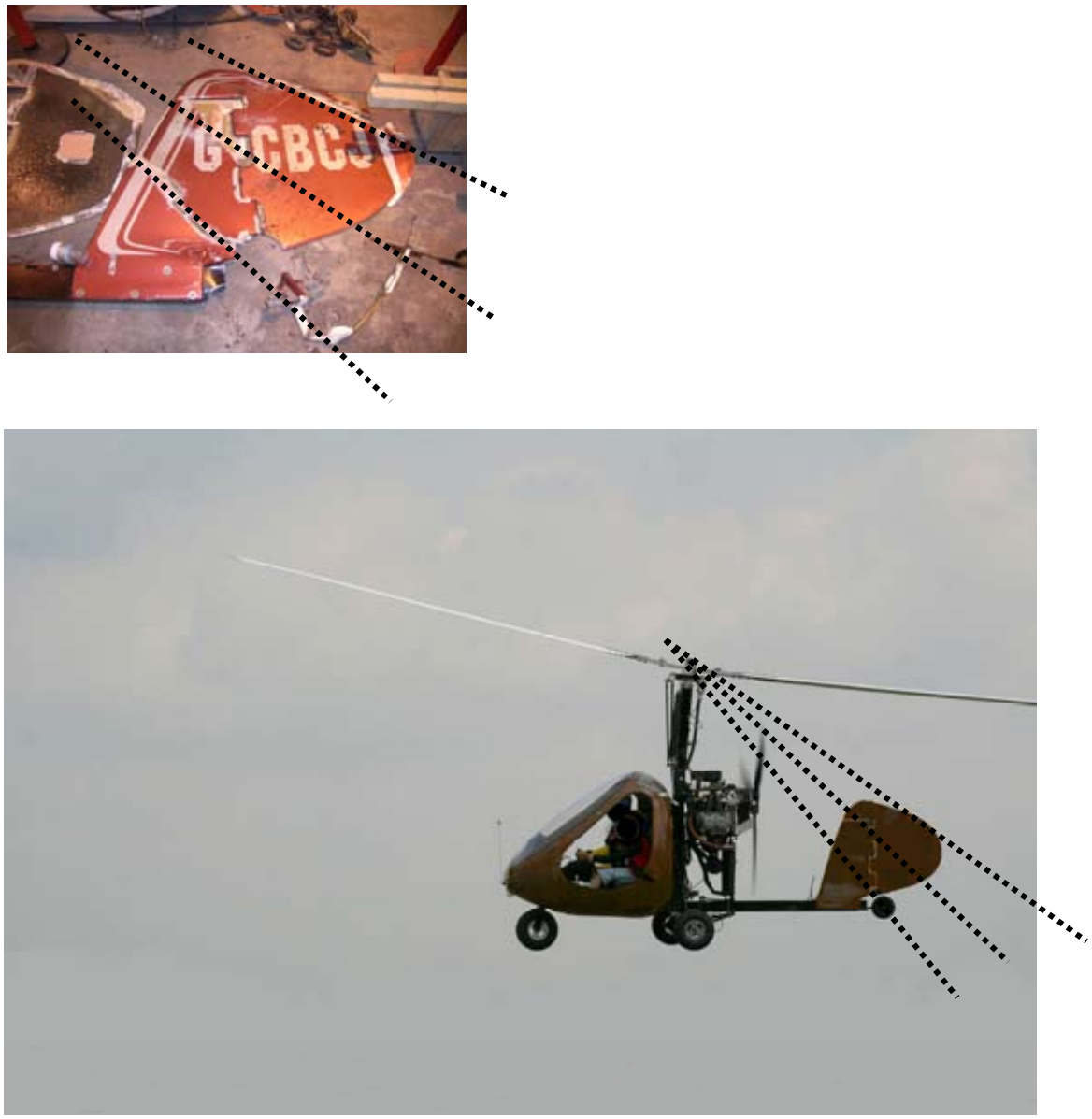

Figure 3

Illustration of the three strikes on the fin and rudder by the main rotor

'When the rudder and fin were reconstructed there was evidence that the tail section had been struck three times by the main rotor blades. The evidence consisted of a clean cut at the trailing edge of the top part of the fin; a shadow along the left side of the fin and an indentation along the rear wheel trailing arm.'

Witnesses to that accident stated that the gyroplane was in steady flight and not executing any violent manoeuvres before:

'It then appeared to be caught in a crosswind, the rotor blades came together above the gyroplane and the engine cut out at about the same time.'

Mandatory Permit Directive (MPD)

Following a series of fatal accidents involving gyroplanes, including two RAF 2000s, G-CBAG (see AAIB Bulletin 9/2003) and G-REBA, the UK CAA conducted flight tests on the RAF 2000.[1]

The tests revealed that, although the RAF 2000 manufacturers claimed a V_{NE} of 100 mph, at 70 mph natural turbulence caused a divergent phugoid which had a period of approximately five seconds and a time to double amplitude of approximately 10 seconds. Testing was curtailed after eight seconds to prevent excessive pitch attitudes being reached. Maintaining a constant pitch attitude ±4° at 70 mph was considered to be *'very difficult'*, requiring continual small (2mm) inputs to the cyclic.

At 80 mph the test pilot rated the handling qualities as six on the Cooper-Harper scale[2]; this is equivalent to:

> *'very objectionable but tolerable deficiencies. – Adequate performance requires extensive pilot compensation.'*

In the report the test pilot commented:

> *'Given poor visual cueing it would be extremely difficult for an inexperienced pilot to fly the aircraft at speeds in excess of 70 mph and momentary distractions to tune radios, IFF, operate trim wheels etc could lead to a large pitch excursion going unnoticed.'*

Following this a MPD 2006-013 was issued by the CAA on 1 December 2006 which, together with other restrictions, limited the RAF 2000's V_{NE} to 70 mph.

Pitch excursions are hazardous to gyroplanes for several reasons. The rotors on a gyroplane are constantly in autorotation and require a relative airflow up through the rotor to maintain Rotor RPM (N_R) As a gyroplane pitches nose-down, the angle of the relative airflow decreases thus reducing the N_R. In a severe case, the relative airflow could pass down, rather than up, through the rotor, causing it to slow rapidly. As the rotor relies on centrifugal force for its rigidity, the slower the N_R the more flexible the blades become, allowing the blades to flex to the point where they can strike the propeller or the tail.

The AAIB report on the accident involving G-REBA stated:

> *'Power pushover*
>
> *Whilst the numerical analysis of gyroplane pitch stability is relatively recent, the gyroplane community has long been aware of what it has termed the 'Power pushover'. This is commonly described as being due to the propeller thrust acting above the vertical CG of the gyroplane and tending to pitch the gyroplane nose down. In normal flight, the lift or rotor thrust developed by the main rotor blades opposes the propeller thrust and balances the nose down pitching moment. If the gyroplane is disturbed in pitch, either by turbulence or control input, this may result in a 'pushover' or 'bunt' manoeuvre. As the normal 'g' reduces, the rotor thrust also reduces proportionately allowing propeller thrust to become the dominant force. If the onset of the*

Footnote

[1] CAA Flight test report FTR12550P.

[2] The Cooper-Harper scale is a set of criteria used by test pilots to evaluate the handling qualities of aircraft. The scale ranges from 1 to 10, with 1 indicating the best handling characteristics and 10 the worst.

bunt manoeuvre is rapid, loss of rotor thrust is also rapid and with a high propeller thrust setting the propeller thrust causes the fuselage to pitch nose down and the tail to rise. If this situation occurs, the main rotor blades may flap back or if the pilot makes a large aft cyclic input to correct the situation, the blades are able to strike the tail surface and the propeller. It is notable that the Glasgow University research has found a strong coupling between pitching motion and rotorspeed, since reduced rotor speed adversely affects rotor disc stability.'

In 2008 the CAA approved a modification for the RAF 2000 that added a horizontal stabiliser to the aircraft. The test pilot reported[3] that, with this modification:

'The aircraft's longitudinal dynamic stability was markedly improved and was stable and compliant with Section T[4] up to 80 mph.'

G-CBCJ was not equipped with this horizontal stabiliser.

Pilot experience

The pilot was reported to have had considerable fixed-wing and flex-wing microlight experience. He had held a Private Pilot's Licence (Aeroplanes) (PPL(A)), which had lifetime validity, since 1994. He commenced gyroplane training in 1998 and flew approximately 50 hours before carrying out his first solo flight in March 2000. He completed the course and was issued with a Private Pilot's Licence (Gyroplanes) (PPL(G)), including a 'single engine' rating, on 21 June 2000, also with a lifetime validity. He flew another 50 hours up to July 2001.

The pilot temporarily ceased flying gyroplanes and restarted training in June 2007. This was recorded in a logbook which only contained his gyroplane flying. He completed a further 30 hours of flying instruction up to November 2007 and, following a break of three months, successfully revalidated his licence in May 2008. His instructor noted that he made satisfactory progress and experienced no particular problems during training. Subsequently, he conducted about nine hours of solo flying before the accident flight.

Of the pilot's total gyroplane flying experience, 60 hours were conducted outside the training environment and he had completed fewer than ten hours of solo flying in the previous seven years.

Medical

An aviation pathologist reported that:

'The autopsy examination did not reveal any evidence of significant pre-existing natural disease which could have caused or contributed to the accident. The pilot held a valid NPPL medical declaration. Toxicology revealed no evidence of drugs or alcohol being present.

While the pilot was wearing a reasonable degree of thermally protective clothing…. (The pilot) *was not wearing any gloves, and it is likely that* (the pilot's) *left hand in particular would have been subjected to a marked degree of convective cooling.'*

Footnote

[3] CAA FTR12746P.

[4] British Civil Airworthiness Requirements (BCAR) section T contains the minimum requirements and constitutes the basis for the issue of Permits to Fly for Light Gyroplanes.

The pathologist further commented:

> *'While it is unlikely to have been a direct factor in the causation of this accident, it is likely that the environmental conditions were such as to have caused cold discomfort of* (the pilot's) *hands which may have produced a source of distraction, and it is recommended that the need to dress appropriately for the anticipated weather conditions in aircraft that do not provide substantial environmental protection be publicised...'*

Weather

Met Form 214, the *UK Low-Level Spot Wind Chart*, for 1800 hrs on 9 October 2008, valid for flights between 1500 hrs and 2100 hrs, gave the latest forecast winds that would have been available before the aircraft departed from Little Rissington. The wind on the aircraft's route, at an altitude of 2,000 ft, was forecast to be from between 200° and 220° at 10 to 25 kt (11.5 to 28.5 mph).

An aftercast indicated that there was a region of high pressure over Northern France resulting in a light to moderate south-westerly gradient over southern England. The estimated surface visibility for the area of the accident was between 25 km and 45 km. High level cirrus cloud covered the region but there was little low level cloud and Pilot B did not recall encountering any during the return flight. The likely average wind for the route, at an altitude of 2,500 ft, was estimated to be 240° at 17 to 22 kt.

An automatic weather observation at 1750 hrs at Yeovilton, 12 nm west of the accident site, recorded a surface wind of 160°/03 kt, greater than 10 km visibility and no detected cloud. The surface temperature was 10°C and the dew point was 9°C.

From observations taken at other nearby airfields, generally the surface winds were less than 10 kt, visibility was 10 km or greater and there was no cloud below 3,000 ft agl.

Flight Planning

An A4 laminated pilot navigation log (plog), an A5 knee board and a CAA aeronautical chart marked with a route were recovered from the accident site. The route covered a return flight from Henstridge to Little Rissington. The return leg log indicated the following:

From	To	Distance	Ground Speed	Time
Little Rissington	N'Leach VRP	6.4	53	7
N'Leach VRP	Junction A417/A429	9.9	50	12
Junction A417/A429	Kemble	5.3	51	6
Kemble	Junction M4/A46	17.6	51	21
Junction M4/A46	Junction A4/A46	7.1	51	8
Junction A4/A46	EGHS	28.4	51	33

(selected columns displayed)

Safety Sense

The UK CAA publishes a series of General Aviation Safety Sense Leaflets. Safety Sense Leaflet 1, entitled *Good Airmanship Guide*, states:

> *'Plan to reach your destination at least one hour before sunset unless qualified and prepared for night flight…'*

Recorded data

There was no recorded primary radar coverage in the area of the accident, no operating transponder on the accident aircraft and its GPS unit was destroyed. The GPS equipment on Pilot B's gyroplane did not record speeds or position and time information from which average groundspeeds could be derived. The data that was available was restricted to the aircraft's ground track. This indicated that, generally, the planned route was followed with minor deviations adding a few track miles to the planned distance.

Although Pilot B stated that he was flying at 95 mph for a brief period, it was not possible to calculate an accurate speed for G-CBCJ during that phase of the flight.

Analysis

The evidence suggests that the pilot had planned the flight with an airspeed of 60 mph, a groundspeed of 50 mph and an airborne time of 87 minutes for the return flight to Henstridge. Leaving Little Rissington at 1607 hrs meant an ETA at Henstridge of 1734 hrs. This would have been four minutes after sunset and 26 minutes before official night flying, which begins 30 minutes after sunset. The forecast wind conditions, which were confirmed by the aftercast, indicated that the aircraft's groundspeed would have been less, at 40 mph, with a flight time to Henstridge of 112 minutes. Thus a more realistic ETA at Henstridge was 1759 hrs.

During the flight the pilot would have had sufficient information to show that the aircraft would reach Henstridge near to the time that the airfield was due to close, 1800 hrs, which coincided with the start of official night flying. The weather was suitable for the aircraft to divert en route and land at a nearby airfield or return to Little Rissington. However, the air temperature and the exposed position of the pilot may have caused a certain amount of discomfort and been something of a distraction.

Pilot B's evidence that he had to fly at 95 mph, while manoeuvring to maintain position astern of G-CBCJ, indicates that the latter aircraft's speed was probably in the region of its V_{NE}, 70mph. Beyond that speed it had been demonstrated that:

> *'Given poor visual cueing it would be extremely difficult for an inexperienced pilot to fly the aircraft at speeds in excess of 70 mph and momentary distractions to tune radios, IFF, operate trim wheels etc could lead to a large pitch excursion going unnoticed.'*

A pitch excursion could potentially cause the rotor blades to strike the tail surface and the propeller.

There was no evidence of any pre-existing fault with the aircraft and witness statements suggest that the aircraft was flying normally approximately one minute before it broke up in flight. The carburettor heat system was found in the HOT position. This could have been the result of a normal selection during descent or in response to a carburettor icing encounter. If there had been any carburettor icing, the engine may have run roughly as it cleared.

It is possible that the pilot was distracted by something, either within or external to the gyroplane, which may have had an affect on his control input. There was, however, insufficient evidence to indicate whether or not this was the case.

The damage to the empennage and distribution of the wreckage was consistent with the main rotor blades having struck the propeller, fin and rudder whilst the gyroplane was airborne and the engine was producing power. The noises reported by witnesses were probably confirmation of this. The damage to the rotor blades and loss in rotor rpm would have resulted in a high rate of descent and near vertical impact with the surface. This in-flight break-up bore strong similarities with the accident involving G-REBA.

Following that and other gyroplane accidents, an optional modification to the RAF 2000 was approved by the CAA. It involved the addition of a horizontal stabiliser which improved the aircraft's dynamic longitudinal stability. G-CBCJ was not fitted with this modification.

Summary

The gyroplane was destroyed by a pitch excursion causing the main rotor to contact the propeller, fin and rudder assembly. The unmodified RAF 2000, without a horizontal stabiliser, has demonstrated dynamic longitudinal instability at speeds in excess of 70 mph. The reduced V_{NE}, applicable in the UK, avoids the most objectionable aspects of its handling characteristics but a loss of control due to a pitch excursion remains possible below this speed. Any distraction or technical problem that could have caused such an excursion to go unnoticed may have been transient in nature and left no evidence. The long, cold flight and impending darkness might also have been a factor.