AAIB Bulletin No: 4/95 **Ref: EW/C95/1/2** **Category: 2.3**

Aircraft Type and Registration:	VPM M16 Tandem Trainer, G-BVRD
No & Type of Engines:	1 Arrow GT1000 2-stroke piston engine
Year of Manufacture:	1994
Date & Time (UTC):	12 January 1995 at 1120 hrs
Location:	Runway 36, Cranfield Airfield, Bedfordshire
Type of Flight:	Acceptance flight for Permit to Fly
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - Minor Passengers - N/A
Nature of Damage:	Extensive damage to rotor blades, landing gear and empennage
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	48 years
Commander's Flying Experience:	5,452 hours (of which 42 were on type) Last 90 days - 15 hours Last 28 days - 1 hour
Information Source:	AAIB Field Investigation

The aircraft was a gyroplane (or autogyro) of a type part-manufactured in Italy and imported in kit form for assembly under the auspices of the Popular Flying Association. This particular aircraft, G-BVRD, had been completed in November 1994 and was being operated on its acceptance test flight to obtain a Permit to Fly. Following the issue of this Permit, the intention was that the aircraft was to be fitted with a suite of onboard test instrumentation for flight testing; the flight tests were part of a programme of research, including computational modelling and wind tunnel tests, sponsored by the CAA and undertaken by the Department of Aerospace Engineering, University of Glasgow.

An attempt at the acceptance flight at Cranfield in December 1994 had been curtailed after 5 minutes because of an excessively rich mixture. On the day of the accident the wind (330°/15 kt) favoured Runway 36, a paved surface. For the first attempt at takeoff, the pilot started to pre-spin the rotor to 190 RPM, using the pre-rotator mechanism driven by a rubber V-belt off the engine. As the rotor reached a speed of 90 RPM the wheelbrakes began to slip so the pilot taxied back for a second take-off run.

On the second attempt, the pilot again pre-spun the rotor to 90 RPM and then, releasing the brakes and the pre-rotator, accelerated gently down the runway, intending to accelerate the rotor at least to 270 RPM, the minimum recommended rotor speed for takeoff. At about 240 RPM, however, the pilot reports that a severe vibration commenced, apparently being fed into the control stick by the rotor and resulting in the stick 'thrashing' laterally. The pilot reports that at this point he was moving the stick forward and that, as he tried to constrain the stick to control the vibration (which seemed to have the rotor's frequency of 1/MR), the aircraft abruptly left the ground. The pilot reports that, having become airborne at too low a rotor speed, he closed the throttle and tried to level and land the gyroplane. The gyroplane rolled left and the pilot was unable, using full right stick, to control the roll before the aircraft struck the ground. Witnesses later stated that the maximum height attained was about 6 feet and that the aircraft was rolling to the left as it descended rapidly onto the runway and slid some 60 metres on its left side (Figure 1). After the aircraft came to rest the pilot was able to switch off the magneto and battery switches, release his seat belt and crawl clear. The pilot received minor injuries and there was no fire.

Technical examination

Examination of G-BVRD and the runway markings after the accident showed that the initial contact with the ground had been on the bottom of the left-hand vertical fin and the aircraft had therefore been nose-high and rolled to the left. The axle of the left-hand wheel had become detached from its landing gear leg and was struck by one of the three propeller blades, which then separated from the propeller hub; the outer portion of the two remaining propeller blades were fragmented by contact with the runway surface.

There had been delamination towards the tip of both rotor blades (Figure 1) as they scraped along the paved surface after the impact with the runway and a length of leading edge balance mass had detached. However, the final position of the balance mass and the nature of the delaminations showed that this had occurred as the aircraft descended onto the ground. The relative lack of damage to the blades, which retained their full length, showed that the speed of the rotor at ground impact was very low and small witness marks on both rotor blades at the radius corresponding to the propeller blades showed that, before the aircraft struck the ground, the rotor had 'flapped back' sufficiently for the propeller tips to touch both blades. This degree of 'flap back' was corroborated by witness marks at the top of the rotor mast where the blade teetering mechanism had contacted the mounting plate.

Discussion

Gyroplane take-off technique requires a careful balance to be maintained between the application of power, to increase the airspeed, and longitudinal stick position to optimise rotor acceleration to flight RPM. There is an effect, described within the gyroplane community as 'over-running' of the rotor blades during the take-off run, characterised by the airspeed increasing with the rotor speed stagnating or decaying before it has reached the minimum rotational speed for takeoff. This effect is generally attributed to excessive inadvertent forward movement of the control stick, thereby placing the rotor at an attitude where the airflow is no longer accelerating the blades. With low rotor speed relative to forward airspeed, blade flapping will tend to increase. At some point the flapping motion of the blades can rapidly become divergent and this violent motion can result in large displacements and forces being fed back to the control stick. If the rotorcraft becomes airborne during this episode the rotor speed will rapidly decay further and the stalling of the 'retreating' blade will result in a rapid roll to that side.

The pilot comments that he believes the most probable cause of the severe vibration in this accident to have been excessive flapping of the rotor and that, during his previous flying of the VPM M16 gyroplane, he had not experienced such severe vibration at the higher rotor speeds used in flight. Having become inadvertently airborne at such a low rotor speed, with considerable forward airspeed, the rotor had entered retreating blade stall and this had caused the uncontrollable roll to the left.

Figure 1 - VPM M16 gyroplane, G-BVRD, at Cranfield, 12 January 1995

(Photographs courtesy of Cranfield University)

Figure 2 - VPM M16 gyroplane, G-BVRD, at Cranfield, 12 January 1995