SOUTH AFRICAN CIVIL AVIATION AUTHORITY

Accident and Incident Investigations Division

Form Number: CA 12-12a

AIRCRAFT ACCIDENT REPORT AND EXECUTIVE SUMMARY

				Reference:	CA18/2/3/9217		
Aircraft Registration	**ZU-RHE**	**Date of Accident**		5 September 2013		**Time of Accident**	1000Z
Type of Aircraft	AutoGyro GmbH (Microlight)			**Type of Operation**		Private	
Pilot-in-command Licence Type		National Pilot		**Age**	64	**Licence Valid**	Yes
Pilot-in-command Flying Experience		Total Flying Hours		723,8		Hours on Type	9,4
Last point of departure		Baragwanath Airfield (FASY), Gauteng					
Next point of intended landing		Baragwanath Airfield (FASY), Gauteng					
Location of the accident site with reference to easily defined geographical points (GPS readings if possible)							
Runway 31 at Baragwanath Airfield. Coordinates: (S 26º15'22.86", E 027º58'14.51")							
Meteorological Information		Temperature: 20ºC; Wind direction: NW; Airspeed: 10km/h; Visibility: good					
Number of people on board		1 + 0	**No. of people injured**	0	**No. of people killed**		0

Synopsis

The pilot, who was the sole occupant, took off from runway 31 at Baragwanath Airfield with the intention of flying circuits. The pilot stated that during the take-off run, he began his rotation with the control stick held in a forward position.

He allowed the rotor to reach 200 rotor revolutions per minute and delayed pulling the control column back. During lift-up, the aircraft rolled over to the left and struck the ground.

The impact damaged the left main undercarriage, fuselage, rotor and propeller, but the pilot was not injured. The engine was taken for functional tests and found to operate satisfactorily.

It was concluded that the cause of the accident was the rotor flapping at high speed during take-off.

Probable Cause

Lost lateral control during take-off

Contributing factor

Poor technique

IARC Date		Release Date	

AIRCRAFT ACCIDENT REPORT

Name of Owner	: Passmore I
Name of Operator	: Passmore I
Manufacturer	: AutoGyro GmbH
Model	: Calidus
Nationality	: South African
Registration Marks	: ZU-RHE
Place	: Runway 31 at Baragwanath Airfield at the coordinates (S26º15'22.86", E027º58'14.51"
Date	: 5 September 2013
Time	: 1000Z

All times given in this report are Co-ordinated Universal Time (UTC) and will be denoted by (Z). South African Standard Time is UTC plus 2 hours.

Purpose of the Investigation

*In terms of Regulation 12.03.1 of the Civil Aviation Regulations (1997) this report was compiled in the interest of the promotion of aviation safety and the reduction of the risk of aviation accidents or incidents and **not to establish legal liability**.*

Disclaimer

This report is produced without prejudice to the rights of the CAA, which are reserved.

1. FACTUAL INFORMATION

1.1 History of Flight

1.1.1 The pilot, who was the sole occupant, took off from runway 31 with the intention of conducting circuits and landings at Baragwanath Airfield in Gauteng. The pilot stated that he commenced the take-off run with the control column held forward until the rotor reached 200 rotor rpm. Approximately 650ft from the threshold, he applied more power for lift-off and pulled the control column fully back immediately, but lost control.

1.1.2 The aircraft lifted slightly and rolled to the left of the runway. The rotor blades struck the ground and the autogyro came to rest on its right side to the left of runway 31, facing in the opposite direction. The accident site was at the coordinates S26º15'22.86", E027º58'14.51" at an elevation of 5 422ft.

1.2 Injuries to Persons

Injuries	Pilot	Crew	Pass.	Other
Fatal	-	-	-	-
Serious	-	-	-	-
Minor	-	-	-	-
None	1	-	-	-

1.3 Damage to Aircraft

1.3.1. The accident sequence caused extensive damage to the main landing gear, nose section, rotor and propeller.

Figure 1: The rotors of the aircraft were destroyed during the accident.

1.4 Other Damage

1.4.1 None

1.5 Personnel Information

Nationality	South African	Gender	Male	Age	64
Licence Number	0271027757	Licence Type	National Pilot		
Licence valid	Yes	Type Endorsed	Yes		
Ratings	Gyroplane, weightshift-controlled microlight				
Medical Expiry Date	13 June 2015				
Restrictions	Corrective lenses				
Previous Accidents	None				

Flying Experience

Total Hours	723,8
Total Past 90 Days	9,4
Total on Type Past 90 Days	9,4
Total on Type	9,4

1.5.1 The pilot was experienced on autogyros. During his aircraft type conversion, he flew a total of 10,8 hours as a student. He performed his solo flight on 18 February 2013 and thereafter accumulated 8,2 flying hours over six-and-a-half months on the type. Between 19 February and 3 May 2013, the pilot did not fly the aircraft, and between 5 May and 9 July 2013, he did not fly at all.

1.6 Aircraft Information

Airframe

Type	Calidus	
Serial Number	C00243	
Manufacturer	Autogyro GmbH	
Date of Manufacture	2012	
Total Airframe Hours (At time of Accident)	27,5	
Last Annual Inspection (Date & Hours)	Not yet reached	
Hours since Last Annual Inspection	AI date not yet reached	
C of A.T.F (Issue Date)	28 January 2013/ 27 January 2014	
C of R (Issue Date) (Present owner)	9 January 2013	
Operating Categories	Part 24 and Part 94	

1.6.1 The AutoGyro Calidus is a tandem, two-seater gyroplane with an all-metal frame, designed and manufactured by AutoGyro GmbH in Germany. The fuselage is made from composites and is a faired teardrop shape to ensure smooth airflow over the propeller, a variable-pitch pusher.

1.6.2 The gyroplane features a single, undivided, glazed canopy that is hinged on its left side and has a locking mechanism on the right. The latter can be operated from both the inside and outside by turning an aluminium lever. The gyroplane is embarked and disembarked from the right while the canopy is held open by a restraint strap. In cases where the canopy cannot be opened, an emergency hammer to the left of the pilot station can be used to break the Plexiglas and evacuate the occupant.

Engine

Type	Rotax 914 UL
Serial Number	7682228
Hours since New	27,5
Hours since Overhaul	TBO not yet reached

Propeller

Type	Ivo Medium VP
Serial Number	219W4, 2125W4, 2119W4
Hours since New	27,5
Hours since Overhaul	TBO not yet reached

1.6.4 The design is noted for its cruise speed of 160km/h (99mph) and range of 800km (500 miles). It was developed into the side-by-side configuration AutoGyro Cavalon. The Calidus is fitted with a steerable nosewheel connected directly to the rudder pedals.

1.6.5 The weight and balance were within limits at the time of the accident. The pilot stated that he performed a pre-flight inspection and took on 10ℓ of fuel.

Rotor

1.6.6 The rotor is a pre-coned, two-bladed, teetering design. Each blade is an extruded section, containing tip weights and end caps. The blades are stamped and etched to match the hub assembly to prevent incorrect assembly. To clamp the blades to the hub bar, 25Nm of nut torque is specified.

Excerpt from AutoGyro Pilot's Operating Handbook:

"*Once airborne, the rotor will maintain and manage its rotational speed to match the load exerted on it. An rpm gauge is provided to enable the pilot to easily see the rpm whilst pre-rotating and making ready for take-off, and as an in-flight monitor.*

*"Gauge markings***:**
- ***0 to 200 amber.*** *Take care in this range; bad handling can result in blade flap at low rpm, which may damage your aircraft!*
- ***200 to 550rpm, green.*** *Full power can be applied in take-off from 200rpm. Normal flight range depends on loading, see 5.1, performance data.*
- ***550 to 610 rpm, amber.*** *In this range the aircraft is pulling in excess of 2.3G. Fly with caution!*
- ***610 rpm red line.*** *Do not exceed. Estimated in excess of 3G loading."*

1.7 Meteorological Information

1.7.1 The following weather conditions at the time and place of the incident were obtained from the pilot's questionnaire:

Wind direction	NW	Wind speed	10kt	Visibility	Good
Temperature	20 ºC	Cloud cover	None	Cloud base	None
Dew point	None				

1.8 Aids to Navigation

1.8.1 The aircraft was equipped with the standard navigational equipment as per the equipment list approved by the Regulator. There were no recorded defects with this equipment prior to the flight.

1.9 Communications

1.9.1 The aircraft was equipped with VHF communications equipment approved by the Regulator. No defects were recorded on this equipment before the flight.

1.10 Aerodrome Information

Aerodrome Location	Baragwanath Aerodrome	
Aerodrome Co-ordinates	S26º20'47.0", E027º46'31.0"	
Aerodrome Elevation	5 422ft	
Runway Designations	31/13	
Runway Dimensions	1 000m x 10m	
Runway Used	31	
Runway Surface	Tar	
Approach Facilities	None	

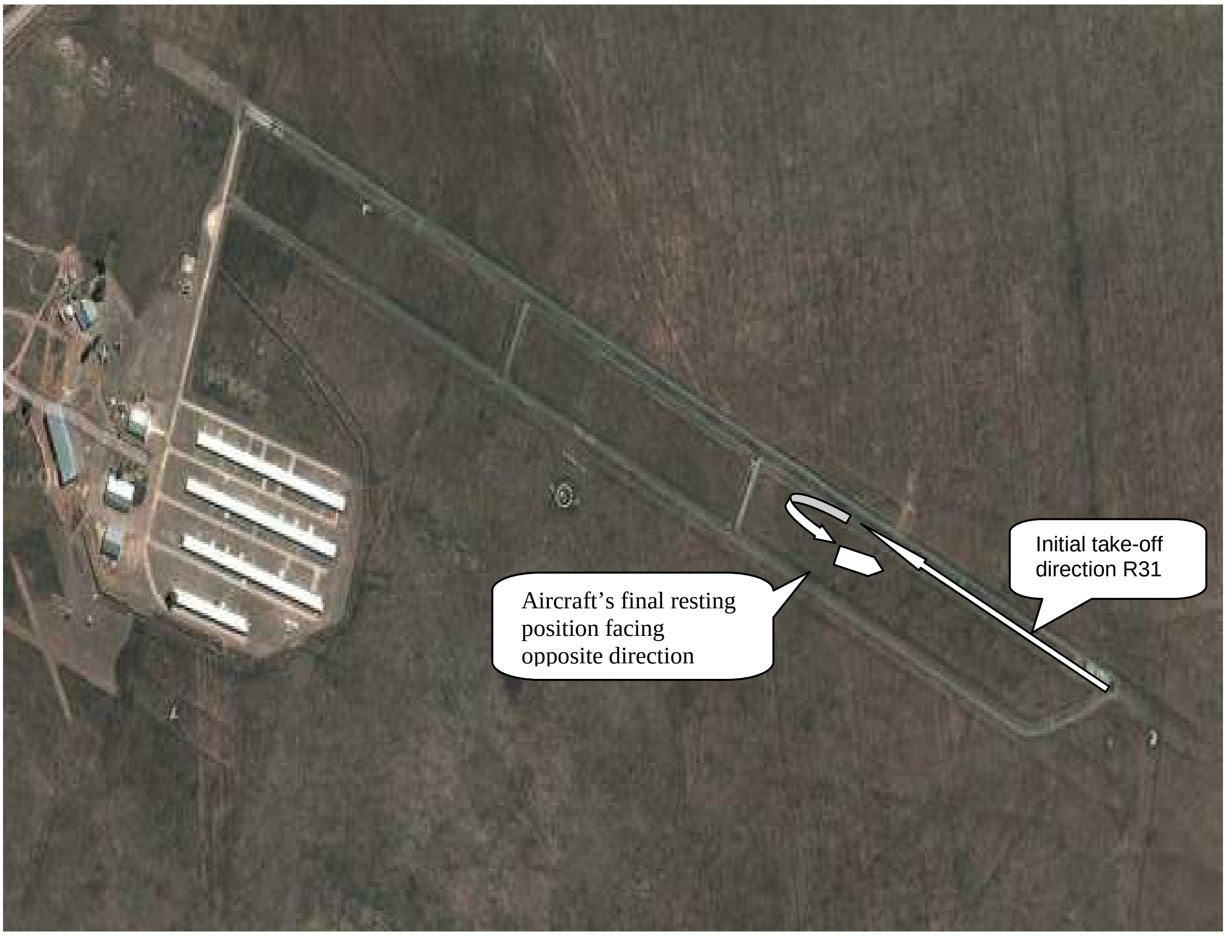

Figure 2: The position of the accident site at Baragwanath airfield.

1.11 Flight Recorders

1.11.1 The aircraft was not equipped with a flight data recorder or cockpit voice recorder. Neither was required by the relevant aviation regulations.

1.12 Wreckage and Impact Information

1.12.1 The aircraft struck the left side of the runway following the rollover during take-off. It came to rest on grass, lying parallel to runway 31 on its right side and facing the opposite direction, at the coordinates S26º15'22.86", E27º58'14.51".

Figure 3: The aircraft was extensively damaged.

1.12.2 The aircraft rolled over during take-off on runway 31, causing the rotor blade to strike the ground. This caused further instability and the pilot lost control. The accident sequence caused major damage to the main landing gear, nose section, rotor and propeller. The wreckage was fairly localised within a radius of 9,84ft. The fuselage structures and powerplant were still attached to the main wreckage.

1.12.3 Damage to the rotor blades and propeller showed evidence that the engine was on a high power setting during the accident.

1.13 Medical and Pathological Information

1.13.1 The pilot's aviation medical certificate was still valid at the time of the accident.

1.14 Fire

1.14.1 There was no evidence of pre- or post-impact fire.

1.15 Survival Aspects

1.15.1 The accident was considered survivable. The pilot was restrained by the aircraft-equipped shoulder harnesses, which did not fail during the accident sequence.

1.15.2 The pilot disembarked the aircraft unassisted through the broken windshield after the accident.

1.16 Tests and Research

1.16.1 During investigation, the engine was subjected to a shock load inspection by Rotax-qualified approved personnel. The results proved that the engine had been functioning normally at the time of the accident.

1.16.2 All other damage was accounted for as the result of the impact during the accident sequence. The turbo control unit (TCU) downloads indicated normal settings for take-off operation with no over-speeding of the engine prior to the accident. (The TCU downloads are attached as Appendix A.)

1.16.3 "**Blade Flap or Rotor Blade Flapping"** is a term commonly used to describe excessive, violent rotor blade motion. This most often occurs when rotor rpm is too low in relation to the forward speed of the gyro during take-off roll. The word "Flapping" by itself is used to refer to the normal in-flight teetering or articulation of a rotor, which helps reduce dissymmetry of lift.

"Rotor Blade Flapping:" in traditional **"Flapping Hinge"** rotor systems, **"flapping"** refers to the normal action of the rotor to allow cyclic action of the rotor – similar to **"Teeter"** for semi-rigid 2-blade rotor systems. The flapping amplitude of the rotor increases with increasing airspeed (forward cyclic input) in order to compensate for the increasing dissymmetry of lift between the advancing blade and the retreating blade. Flapping action also allows cyclic maneuvering inputs to the rotor. In semi-rigid 2-blade rotor systems, the term "flapping" is commonly used to refer to the abnormal excessively forceful teeter action of the rotor impacting the teeter stops upon significant dissymmetry of lift or retreating blade stall – such as on take-off.

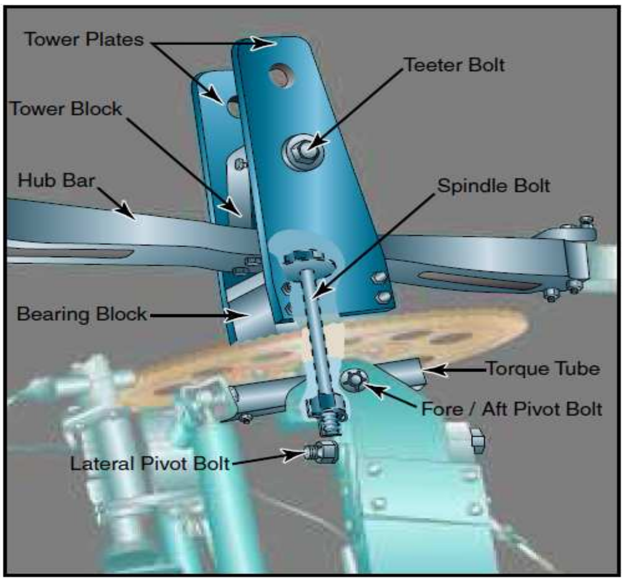

Figure 4: *The semi-rigid, teeter-head system is found on most amateur-built gyroplanes. The rotor hub bar and blades are permitted to tilt by the teeter bolt.*

1.16.4 **"Rotor Systems – Semi-rigid rotor system"** – Any rotor system capable of auto-rotation may be utilized in a gyroplane. Because of its simplicity, the most widely used system is the semi-rigid, teeter-head system. This system is found in most amateur-built gyroplanes. In this system, the rotor head is mounted on a spindle, which may be tilted for control. The rotor blades are attached to a hub bar that may or may not have adjustments for varying the blade pitch. A coning angle, determined by projections of blade weight, rotor speed, and load to be carried, is built into the hub bar. This minimizes hub bar bending moments and eliminates the need for a coning hinge, which is used in more complex rotor systems. A tower block provides the under sling and attachment to the rotor head by the teeter bolt. The rotor head is comprised of a bearing block in which the bearing is mounted and onto which the tower plates are attached. The spindle (commonly, a vertically oriented bolt) attaches the rotating portion of the head to the non-rotating torque tube. The torque tube is mounted to the airframe through attachments, allowing both lateral and longitudinal movement. This allows the movement through which control is achieved.

1.16.4 Blade Flap – On a gyroplane with a semi-rigid, teeter-head rotor system, blade flap may develop if too much airflow passes through the rotor system while it is operating at low r.p.m. This is most often the result of taxiing too fast for a given rotor speed. Unequal lift acting on the advancing and retreating blades can cause the blades to teeter to the maximum allowed by the rotor head design. The blades then hit the teeter stops, creating a vibration that may be felt in the cyclic control. The frequency of the vibration corresponds to the speed of the rotor, with the blades hitting the stops twice during each revolution. If the flapping is not controlled, the situation can grow worse as the blades begin to flex and bend. Because the system is operating at low r.p.m., there is not enough centrifugal force acting on the blades to keep them rigid. The chock of hitting the teeter stops combined with uneven lift along the length of the blade causes an undulation to begin, which can increase in severity if allowed to progress. In extreme cases, a rotor blade may strike the ground or propeller. Refer to figure 7.

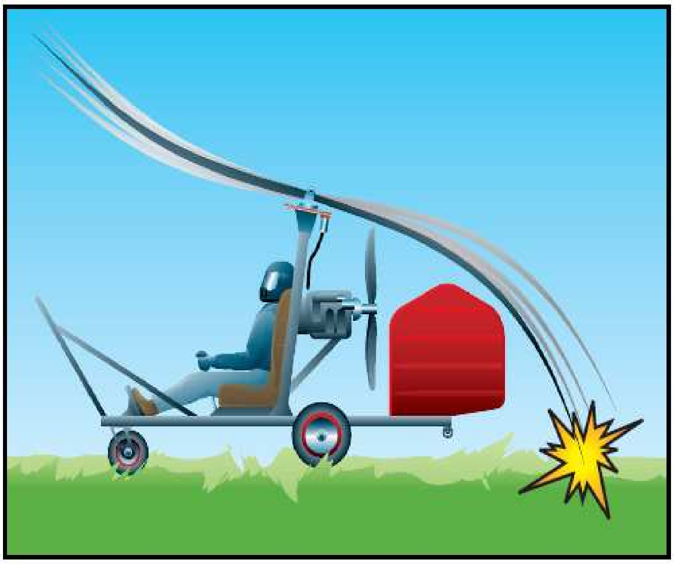

Figure 5: *Taxiing too fast or gusting winds can cause blade flap in a slow-turning rotor. If not controlled, a rotor blade may strike the ground.*

To avoid the onset of blade flap, always taxi the gyroplane at slow speeds when the rotor system is at low r.p.m. Consideration must also be given to wind and direction. If taxiing into a 10-knot headwind, for example, the airflow through the rotor will be 10 knots faster than the forward speed of the gyroplane, so the taxi speed should be adjusted accordingly. When pre-rotating the rotor to accelerate slowly and smoothly, in the event blade flap is encountered, apply forward cyclic to reduce the rotor disc angle and slow the gyroplane by reducing throttle and applying the brakes, if needed. Refer to figure 5.

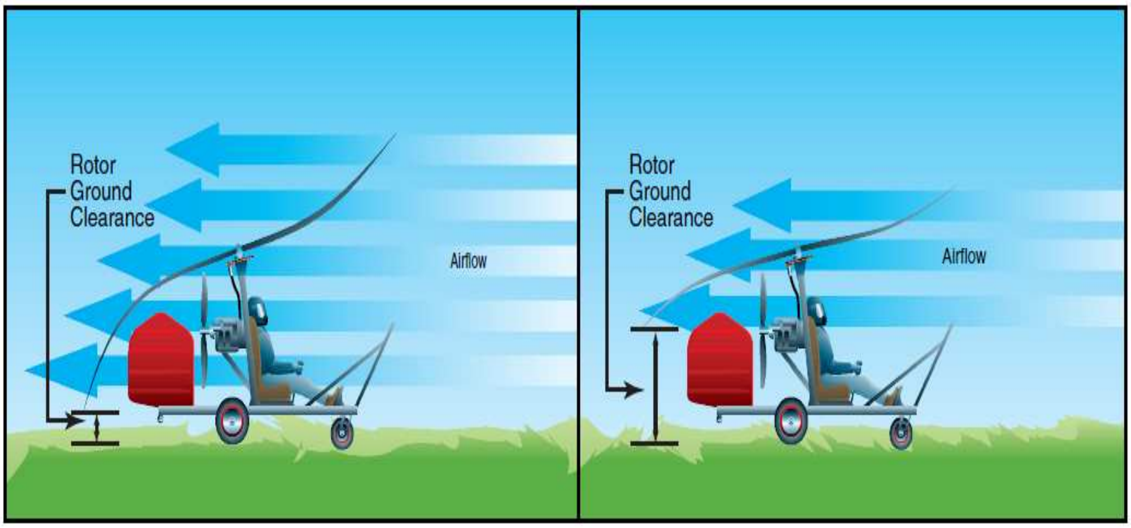

Figure 6: *Decreasing the rotor disc angle of attack with forward cyclic can reduce the excessive amount of airflow causing the blade flap. This also allows clearance between the rotor blades and the surface behind the gyroplanes, minimizing the chances of a blade striking the ground.*

1.17 Organisational and Management Information

1.17.1 The aircraft was a private aircraft owned by the accident pilot.

1.17.3 The aircraft was maintained by an approved maintenance organisation according to existing regulations.

1.18 Additional Information

1.18.1 Take-off Procedure

(Reference: Auto Gyro POH Calidus Revision 2.4. Issued 24 June 2013. Pages 4-6 to 4-9)

- *Check relative wind*
- *Maintain control stick in forward position with right hand*
- *Switch pneumatic mode selector to FLIGHT and return to brake with left hand*
- *Hold wheel brake without having locking pawl engaged*
- *Release trim pressure by trimming full forward*
- *While holding wheel brake, adjust 1 800 RPM with throttle*
- *Activate and hold pre-rotator*
- *Let pneumatic clutch fully engage (stabilisation at about 110 rotor RPM).*
- *If necessary, release pre-rotator button momentarily and press again to maintain engine RPM within green arc, respectively prevent engine from stalling*
- *Carefully increase throttle (~ 20 R-RPM/sec) to 200 R-RPM, max. 220 R-RPM*
- *Release pre-rotator button*
- *Gently move the control stick fully aft (stick travel ~ 1 second)*
- *Release wheel brake with throttle unchanged*
- *Monitor rotor speed and adequately increase throttle to take-off power*

Cautions

"Prior to releasing the wheel brake, make sure that the control stick is fully aft, if headwind component allows. A take-off run with flat rotor system may have fatal consequences.

"With the rotor speed below green arc, relative speed must be built-up carefully to allow rotor speed to increase first. If the situation cannot be corrected, abort take-off run.

"Do not engage pre-rotator at too high engine RPM or until too high rotor RPM, as this will lead to pre-rotator drive damage.

"Avoid overtorquing of the pre-rotator drive! Overtorquing will occur if RPM/ power is fed excessively or abruptly. In case of a stalling engine, release pre-rotator button temporarily. Do not yank the throttle control while the clutch is engaged.* [*Investigator's note: pre-rotor was not damaged.]

"To avoid unintended engagement in flight, the pre-rotator can only be activated with the control stick in its most forward position.

Take-off run

- *Check min. 5 400 RPM for take-off. Otherwise, abort take-off*
- *Minimise lateral drift by applying appropriate lateral control stick input into cross wind direction*
- *Maintain directional control i.e. runway alignment with sensitive pedal input*
- *When nose comes up, allow nose wheel to float at about 10 – 15 cm above the runway by a balanced reduction of control stick back pressure*
- *Maintain attitude until speed increases and gyroplane lifts off*
- *Allow gyroplane to build-up speed in ground effect*
- *VPP**:** When a variable pitch propeller is installed, refer to the respective flight manual supplement in CHAPTER 9 for correct power setting and handling procedure.*

WARNING

"Gyroplanes are fully controllable at very low speeds without exhibiting any signs of wing stall or soft flight controls, as it would be perceived in a fixed-wing aircraft. However, operations 'behind the power curve' may have fatal consequences during take-off, initial climb or in any other situation within ground proximity. Always allow aircraft to build up safe climb speed before allowing it to gain height.

Climb

- *Perform initial climb at safe climb speed and adjust trim*
- *Set power to maximum take-off power*
- *Check engine instruments and respect maximum take-off power time limit*
- *Switch off second fuel pump at safe height*
- *At safe altitude, the climb may be continued with VY and reduced power setting for noise abatement*
- *When desired altitude is approached, level gyroplane and reduce power*

"VPP: With a variable pitch propeller installed, refer to the respective flight manual supplement in CHAPTER 9 for correct power setting and handling procedures.

Blade Flap Hypothesis

"The high-speed blade flapping is a hidden phenomenon that can take any gyro pilot by surprise on take-off, if not understood. It happens in an instant, causing a violent roll-over. The phenomenon applies to all gyros but short-coupled side-by-side machines are more prone to the effect. A rotor must have a positive angle of attack into the apparent wind in order for the auto rotational forces to work. Without a positive angle of attack, the rotor will lose revolution (rpm) and will not fly positively. Once in the air, it is only possible to achieve this state by 'unloading' the rotor. (Negative G's – absolutely forbidden)

The moment-arm of the new-generation gyros is very close to the centre of gravity, resulting in the nose popping up far quicker than in the tandems during take-off. It could that the wider, flattish-bottomed, fuselages/cockpits generate their own lift, adding to total lift up to a point that the rotor takes over all the lift. Thereafter the fuselage is pure drag.

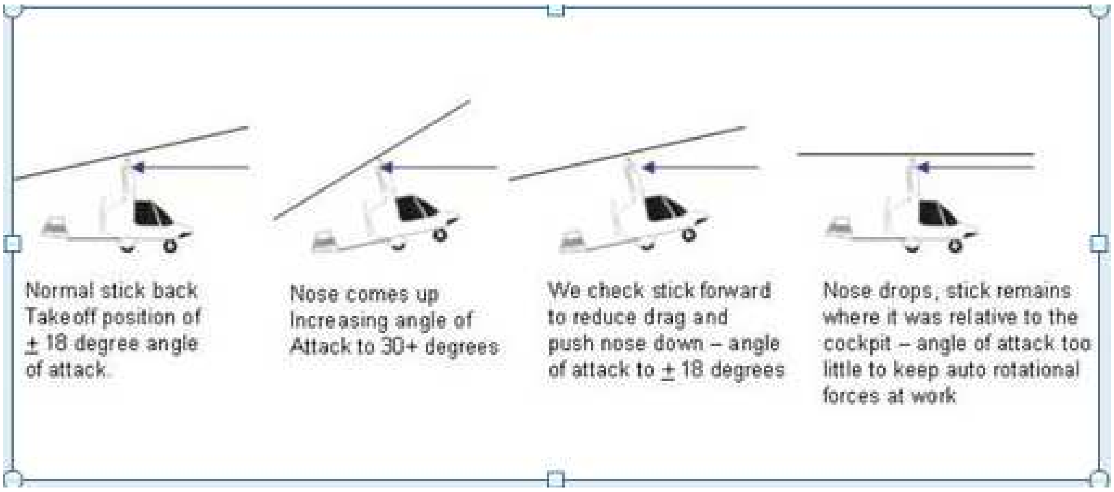

Figure 7: Gyro control stick position.

"In a typical take-off roll, the stick is full back and the rotor is loaded as the drag increases with forward speed. The rotor speeds up to the point that the nose lifts and pilot must check forward on the stick to hold the nose down and to avoid getting airborne behind the power curve. As the nose drops again, the stick position may remain the same relative to the cockpit, causing the angle of attack becoming too small. This is the same as taking off with the stick forward, which will result in blade-flap regardless of rotor RPM. The disc skips along as the airspeed increases rapidly because there is no drag. The rotor is unloaded at this point.

"The safe method of take-off is to ensure that the rotor is loaded throughout the take-off roll until the gyro is airborne, whether it is behind the power-curve or not. In other words, you must feel rotor drag throughout the take-off roll. Once the wheels are off the ground, blade-flap cannot happen in steady flight. The best method then would be to push the nose forward, gain adequate airspeed and only then begin the climb-out.

"Avoid climbing out steeply at the gyro's best angle of climb. Stick to best rate of climb. The reason for this is, again, more pronounced in shortly-coupled side-by-side gyros as opposed to tandems. If the engine fails while in a nose-high attitude, the airspeed will decay very rapidly. Pushing the nose forward to regain flying speed (45mph+) may take too long to avoid making contact with terra firma before

the gyro is 'flying' again and it may not be possible to round-out, flare and land normally. In other words, you may be forced to 'mush' onto the ground hard, resulting in all sorts of gyroscopic effects taking over and spoiling your day.

1.19 Useful or Effective Investigation Techniques

1.19.1 None

2. ANALYSIS

2.1 Man

2.1.1 The pilot did not fly the aircraft frequently enough in the period before the accident flight. Although he had had experience on an autogyro, he was not familiar with the accident aircraft, which was a new and different model. The pilot flew only 8,2 hours on the type in the six-and-a-half months before the accident, with long intervals between these flights.

2.2 Machine

2.2.1 The pilot reported that during the take-off run he pushed the control stick forward and did not pull it back in time for climbing. Although the take-off procedure of the aircraft type specifies that take-off should start with the control stick held forward, holding the control stick like this for a long time allows the main rotor disc to reach a high speed unloaded, causing it to have high resistance for take-off load. When holding the control stick in the forward position, the pilot should also allow for disc loading with relative air flow to avoid disc flapping.

2.2.2 When the pilot attempted to lift off by pulling back the control column instantly after increasing power. The leading rotor blade encountered resistance due to the high load forces of the relative air, causing it to flap in the direction of rotation. The flapping rotor blade pulled the aircraft in the direction of the flapping side. The lagging rotor blade was in a stalled state, which exacerbated the situation by allowing the aircraft to roll to the left. When the rotor blade struck the ground during the roll, the pilot lost control.

2.2.3 The POH provides a technique that the pilot should apply to the take-off procedure. It also advises that, should the pilot experience a high-speed rotor condition during take-off, he must abort take-off and retry with a safe rotor speed to avoid rotor flapping.

2.2.4 The aircraft did not have any defect prior to the accident, and no engine anomalies were encountered during operation before the accident. The engine propeller shock load test and TCU downloads indicated no anomalies during operation prior to the accident.

2.2.5 The mass and balance of the aircraft were within prescribed limits and there was sufficient fuel on board for the flight.

2.3 Environment

2.3.1 The reported temperature was not considered a contributing factor to the accident.

The weather prevailed fine conditions.

3. CONCLUSION

3.1 Findings

3.1.1 The flight pilot was licensed and qualified for the flight in accordance with existing regulations.

3.1.2 The pilot's aviation medical certificate was still valid at the time of the accident.

3.1.3 The pilot's actions and statements indicated that his knowledge and understanding of the aircraft systems were inadequate.

3.1.4 The maintenance records indicated that the aircraft was equipped and maintained in accordance with existing regulations and approved procedures.

3.1.5 The aircraft had a valid Authority to Fly certificate.

3.1.6 The pilot had not been flying the accident aircraft regularly.

3.1.7 All control surfaces were accounted for, and all damage to the aircraft was attributable to the severe impact force.

3.1.8 The damage to and twist of the propeller and rotor were consistent with the engine producing power on impact.

3.1.9 The pilot did not comply with the aircraft operational procedures.

3.1.10 The pilot allowed the rotor to meet the blade flapping hypothesis characteristics which resulted in aircraft rolling over to the flapping direction.

3.2 Probable Cause/s

3.2.1 Lost lateral control during take-off.

3.3 Contributory Factors

3.3.1 Poor technique.

4. SAFETY RECOMMENDATIONS

4.1 None

5. APPENDICES

5.1 Appendix A: TCU downloads results.

APPENDIX A

Turbo control unit downloads results