HANDLINGSENSE LEAFLET 4
GYROPLANE HANDLING AND PERFORMANCE

1 BACKGROUND

a) The safety record of gyroplanes has improved significantly over the past few years. This is generally attributed to the introduction of factory-built gyroplanes complying with BCAR Section T.

b) However, as with all forms of aviation, there will always be mishaps. Fortunately the majority of these over the past few years have resulted only in damage to the aircraft, with most pilots and passengers walking away suffering only minor injuries, if any.

c) In an effort to further reduce the number of incidents, the CAA in conjunction with the Air Accidents Investigation Branch (AAIB) and the British Rotorcraft Association (BRA) continually analyse the causes of these incidents. This analysis indicates that human error remains a key factor. This leaflet is intended to improve and share knowledge of flying gyroplanes to help pilots to achieve greater understanding of their aircraft, and is a distillation of best practice advice from BRA instructors. It gives guidance to gyroplane pilots when considering their take-off, and when handling the aircraft in a variety of conditions. However, the performance information should be regarded as generic, and is currently unvalidated by detailed flight testing.

d) This leaflet is one part of a continuing education process, which also includes:

- regularly reviewing the PPL(G) syllabus and the provision of information to instructors;
- reviewing the content of the gyroplane technical exams and the gyroplane type oral test as part of the examination process; and
- encouraging continual learning, either on an ad-hoc basis, or at the time of the revalidation of the pilot's licence.

e) The three main areas where it is felt that education can significantly improve the safety record for gyroplanes (and which account for almost 80% of all the occurrences between 2006 and 2011) are:

- Understanding of the take-off performance of the gyroplane in the conditions for the day.
- Handling of the rotor system whilst the gyroplane is on the ground and the rotors are slowing down or speeding up.
- Handling of the gyroplane immediately after touchdown on landing.

f) It is vital that the way a gyroplane develops lift and is controlled by the pilot is understood, as this differs from other types of aircraft. There is a risk that a pilot converting to a gyroplane from an aeroplane or helicopter will, in high workload situations, revert to handling the gyroplane in a manner more appropriate to the previously flown type.

2 TAKE-OFF PERFORMANCE

a) The term 'Take-off performance' means how quickly an aircraft can leave the ground and climb safely to clear an obstacle in line with the runway at a given height of 50 ft.

b) A high proportion of gyroplanes are flown from short strips; indeed this is one of the key attractions of gyroplane flying. However, without due care and consideration for the conditions of the day, it is all too easy to attempt to fly out of a strip that is not suitable.

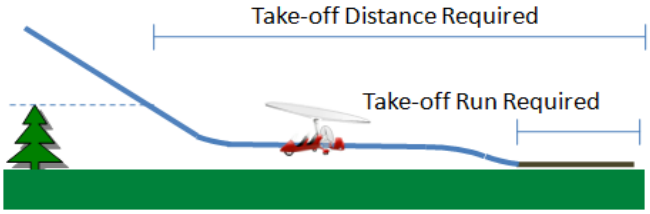
c) It is important for a gyroplane pilot to have a detailed understanding of:

- how to fly the optimum take-off profile of a gyroplane;
- the difference between a 'performance take-off' and a 'rough-ground take-off', and to appreciate that there is no such thing as a 'short field' take-off; and
- the power provided by the engine and propeller combination and how the available thrust changes with air density.

d) The gyroplane pilot must be aware of the above points and go through a mental checklist which should be embedded in the mind of every gyroplane pilot when considering taking off from a strip or marginal operating site.

3 TAKE-OFF PROFILE

a) The gyroplane take-off profile differs from other aircraft types, and must be flown correctly to obtain optimum performance.



b) The gyroplane will run along the ground to achieve flying rotor speed, lift clear of the ground, and then accelerate (transition) a few feet above the ground to achieve the climb speed, and then enter the climb.

The Difference between TORA and TODA

c) There are two separate considerations when deciding about taking off from a field:

- the length of the ground run (TORA: Take-Off Run Available) and the condition of that ground; and
- the distance of the clearance to 50 ft (TODA: Take-Off Distance Available) and what obstacles are in the way.

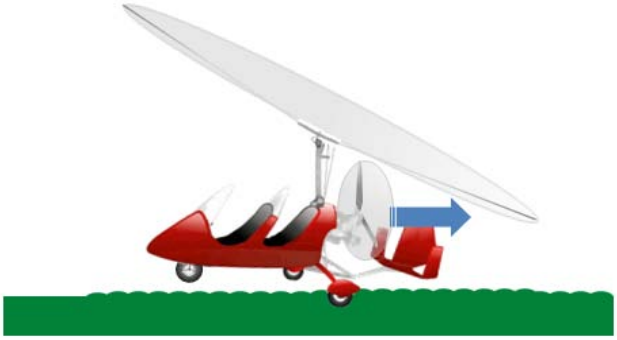
d) The difference between the TODA and the TORA can be considered the '**clearway'**.

e) It is easy to think about the take-off only in terms of the take-off run required and not give due consideration to the **take-off distance required**. As the take-off run required is typically short in a gyroplane it is easy to be led into a false sense of security that it is possible to clear the boundary of a grass strip or similar operating site when in fact obstacles are within the take-off distance required.

To climb from 3 ft to clear 50 ft obstacles will require an additional horizontal distance of about 250 m.

Ground Proximity

f) Helicopters and aeroplanes both gain a performance benefit when flying in close proximity to the ground, and the phenomenon is known as 'ground effect'. A gyroplane during take-off also gains some limited performance benefit when flying relatively close to the surface. On landing, the rotors are tilted back which slows the speed of the aircraft and uses the momentum stored in the blades to provide a limited amount of thrust, and this gain is also more efficient in close proximity to the ground.



g) During a normal gyroplane take-off, once the aircraft has lifted off from the runway the priority is to accelerate to an appropriate airspeed that will allow sufficient power margin for the aircraft to be climbed away from the ground. If the aircraft is climbed before it has reached its best rate of climb speed, it might not clear the obstacles in its path. The need to accelerate as soon as possible, and the limited performance benefit provided by ground proximity, indicate that the pilot should accelerate the gyroplane at as low a height as can be safely flown without any risk of re-contacting the ground.

Accelerate the aircraft as soon as possible after lifting off to achieve climbing speed.

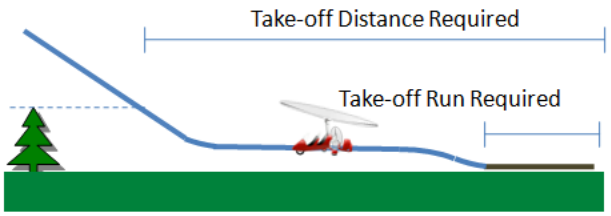
h) The length of the ground-run and the length of the take-off distance are affected by the type of take-off that is performed - these are discussed below.

4 THE DIFFERENCE BETWEEN A PERFORMANCE TAKE-OFF AND A ROUGH-GROUND TAKE-OFF

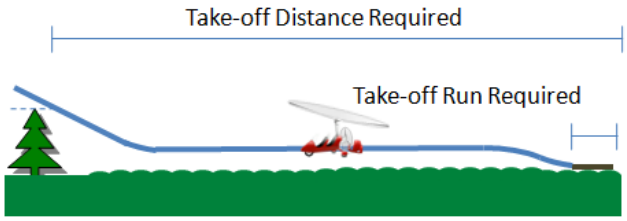
a) Often, people refer to a "short field" take-off, but as described above this is a misnomer. There are two distinct take-off considerations:

- A **performance** take-off will give the shortest distance to a height of 50 ft and is suitable for clearing objects at the end of the runway.
- A **rough-ground** take-off will get the aircraft airborne in the shortest ground-run, and is suitable when taking off from rough ground.

The Performance Take-Off



The Rough-Ground Take-Off



b) Unfortunately, the two take-off techniques conflict with each other. A rough-ground take-off will extend the transition, and therefore requires a greater distance to clear any obstacles. It is NOT possible to achieve a performance take-off and a rough-ground take-off at the same time. To take off from a rough, short strip will require a compromise of both techniques, which will also affect the take-off distance.

The Performance Take-Off Technique

c) The performance take-off technique should be the default method used. It can be summarised as:

- Pre-rotate to the maximum rotor speed allowed by the manufacturer (this may be higher than that used for training or when take-off distance is not critical). As soon as the pre-rotator is released and with the stick held fully backward (ensuring the minimum rotor RPM has been achieved) apply full power.
- Hold the nose-wheel off the ground at the most efficient height – this is likely to be what you have been taught for a normal take-off. If it is held too high, your airspeed at the time you leave the ground will be lower; if it is held too low the rotor RPM will take longer to accelerate to flying speed and your ground-run will be longer.
- As soon as safely airborne, progressively level the aircraft to accelerate to climbing speed as quickly as possible making use of the performance benefit of flying close to the ground.
- As soon as the best climb speed has been achieved, climb holding this speed accurately.
- When above all obstacles on the take-off path, consider accelerating to the speed considered safest in the event of an engine failure; typically this will be slightly faster than the best climb speed.

The Rough-Ground Take-Off Technique

d) The rough-ground take-off technique should be used to get airborne when the ground is rough – but be aware that this will **increase the overall take-off distance**.

- Pre-rotate to the maximum rotor speed allowed by the manufacturer.
- As soon as the pre-rotator is released and with the stick held fully backward (ensuring the minimum rotor RPM has been achieved) apply full power.
- Hold the nose-wheel off the ground as high as possible for the gyroplane, this is likely to put the tail of the gyroplane on, or very close to, the ground. This will accelerate the rotors to flying speed most rapidly.
- As you become airborne your airspeed will be **extremely low** and likely to be at the back of the power curve (explained below). Gently adjust the aircraft attitude nose down, and keep the gyroplane as close to the ground as possible (without contact) whilst increasing the airspeed.
- As soon as the best climb speed has been achieved, climb holding this speed accurately.
- When above all obstacles on the take-off path, consider accelerating to the speed considered safest in the event of an engine failure, typically this will be slightly faster than best climb speed.

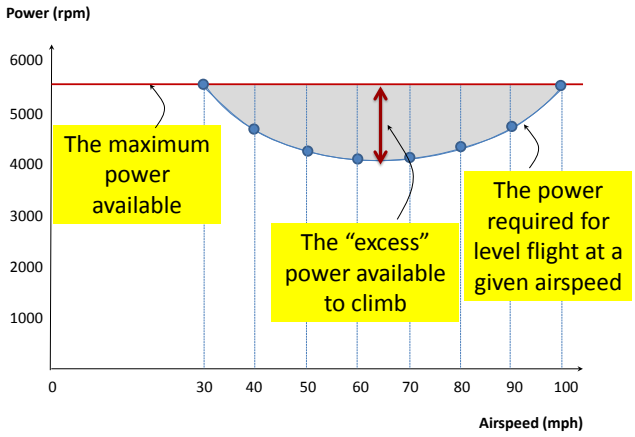
e) If you are in any doubt whatsoever about how to apply these techniques, book some time with an instructor until you are able to fly them accurately, especially the rough-ground technique.

A few circuits practising these techniques with an instructor will be invaluable when you need to use them for real.

5 THE POWER CURVE

a) Getting off the ground and flying the transition is a combination of power and airspeed. Airspeed primarily relates to the stick position and the pitch of the aircraft. A certain power from the engine will be required to fly level at a given airspeed; any engine power in excess of this amount will allow the aircraft to gain height. This is extremely important during a take-off.

b) Every pilot must be aware of the 'power curve'. This shows the power required for level flight at different airspeeds, and also the speed at which the maximum power is available to climb.

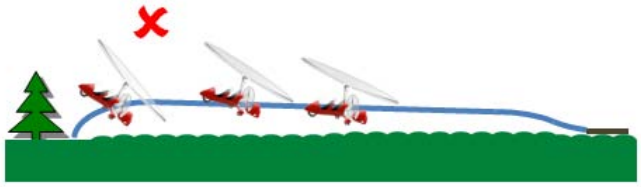


The values in the above diagram are for illustration only – refer to the flight manual for your gyroplane

c) In the above diagram, the sample gyroplane can only gain height if the airspeed is above 30 mph; the airspeed that will give this model of gyroplane the most power available to climb, and therefore provide the best rate of climb, is around 60-70 mph.

d) The airspeed is controlled primarily by the pitch of the gyroplane, corresponding to the position of the stick: the further back the stick, the slower the gyroplane will want to fly. This is an extremely important point to remember and one that a pilot might tend to forget when the workload is high!

The Psychological Fear of Hitting Something, and Pulling the Stick Back to Climb



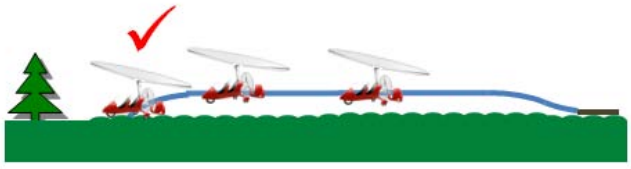
e) If the gyroplane is approaching an object within the clearway whilst still accelerating to best climb speed, it is an extremely natural human reaction to bring the stick backwards to aim the gyroplane over the obstacle. A pilot may try to force the gyroplane to climb over the obstacle. <u>THIS WILL NOT WORK</u>. Bringing the stick back without sufficient airspeed will simply increase the rotor drag and even with 100% engine power the gyroplane will descend, nose high, to the ground.

POWER = HEIGHT and STICK = SPEED.

If you bring the stick back before you have airspeed, you will fly "behind the power curve" and instead of climbing, you will slow down and sink to the ground.

The Correct Action

f) The correct action is to abort the take-off.



6 ABORTING TAKE-OFFS

a) There are three important considerations regarding aborting take-offs:

- Think about it before you start the take-off, each and every time.
- When to abort the take-off.
- How to abort the take-off.

Thinking About Aborting Take-Offs Before Starting the Take-Off Run

b) It is no coincidence that almost every commercial and military pilot will plan the actions required if the take-off is not happening as they intended it, before they start the take-off run. The reason for aborting the take-off may be an engine failure, a warning from a system, or an indication that the correct speeds are not being reached within the correct distances.

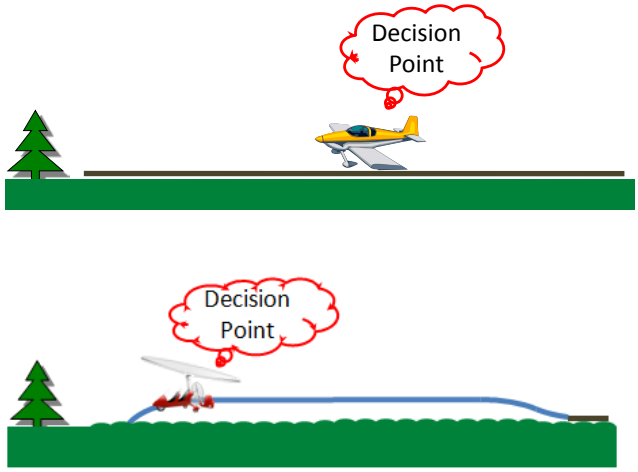
c) Every pilot should develop the habit of putting the actions in the event of a mishap on take-off at the very forefront of their thinking. In the case of the gyroplane pilot, this is immediately before releasing the pre-rotator.

d) Good practice would be for every pilot, on every take-off, to say out loud "in the event of an aircraft malfunction or poor acceleration on take-off, I will abort the take-off by … [e.g. landing ahead, using the field to my right etc.]".

Consider when and how you will abort the take-off <u>before</u> you start the take-off run.

When to Abort the Take-Off

e) A fixed-wing aircraft pilot has a much more limited time available to make the decision to abort a take-off than a gyroplane pilot. The rotor drag of the gyroplane will stop a gyroplane in just a few metres. An aeroplane pilot must make the decision much earlier, because of the ground run needed to slow the aircraft down.



Pilots need to understand their aircraft, including the stopping distance. It is unlikely to be too late to abort a take-off in a gyroplane; most can stop in a matter of metres if flown properly.

Decision Point

f) A pilot should practise the abort procedure and determine what ground distance is required to stop the aircraft from the best rate of climb speed. This 'abort distance' should then be taken into consideration during the planning of every take-off. If a safe take-off cannot be guaranteed by the time the final stretch of runway that would permit a safe abort is about to be over-flown, then the pilot should abort the take-off. For a short strip, a pilot would be wise to pace out this 'abort distance' and ensure some form of lateral marker is in place to help him recognise this 'decision point'; the decision being a pre-determined abort if a safe take-off cannot be guaranteed.

How to Abort the Take-Off

g) The technique for aborting the take-off will depend upon the gyroplane's height when the decision is made. Ideally, the decision should be made whilst the gyroplane is still just a few feet above the ground.

h) If the gyroplane is only a few feet above the ground:

- Smoothly close the throttle.
- Initially hold the level attitude.
- At the correct height, flare as for a normal landing.

i) If the gyroplane is more than a few feet above the ground:

- Remove a small amount of power to initiate a rate of descent.
- Lower the nose to maintain speed, this can be quite steep (this will maintain energy in the rotor system).
- At flare height, flare normally. If you have lots of energy in the rotor system (you are doing things properly) remove all power. If you have lost rotor energy (you have a high rate of descent caused by removing too much power too early) then ADD FULL POWER AS YOU FLARE, this will give the best chance of arresting your rate of decent. As soon as you touch down remove all power.

j) Practise these techniques with an instructor. In particular, gain confidence in the stopping distance of a gyroplane when you abort a take-off – it is usually a lot shorter than you think especially compared to a fixed-wing aeroplane.

Practise the correct way to abort take-off with an instructor.

Train yourself to react properly.

7 THE EFFECT OF THE ENVIRONMENT

a) Mastering the flying techniques alone does not give you sufficient knowledge to safely get out of strips/operating sites. The actual take-off run required and take-off distance required can **vary significantly depending upon the environment**. The factors affecting these distances must be fully understood and considered.

b) Many factors affect the take-off distance. These factors will be different from day to day. You may be attempting to take off from a site that you have successfully used a number of times in the past, but that is no guarantee that you will be able to do it in today's conditions.

Just because you took off from the field yesterday does not automatically mean that you will take off successfully today!

The Effect of Air Density

c) Air density is extremely important to the performance of the **rotor**, the **propeller** and the **engine**. The greater the air density, the better they all perform. Consequently, **low air density** can have a significant **negative** impact on **performance**.

d) The major factors which define the density of the air are:

- The **temperature** of the air: the **hotter** the air temperature, the **less dense** the air becomes.
- The **air pressure**: the **lower** the air pressure, the **less dense** the air. Air pressure decreases with height, therefore the **higher** the gyroplane flies (or the higher the airfield above sea level), the **worse** the performance.
- The **moisture** content (humidity) of the air: the **more humid** the air, the **less dense** the air becomes.

It is easy to remember bad performance conditions, remember HHH:

HOT Temperature, HIGH Altitude and High HUMIDity.

e) However, these components of air density do not all have the same impact. The following information can be taken as a guideline.

f) If the outside air temperature at ground level is:

Normal UK day (approximately below 20°C):

Performance will remain similar.

Warm UK Summer day (approximately 20-30°C):

Performance will be noticeably poorer.

Very hot day (above 30°C):

Performance will be significantly poorer.

If there is rain or mist about:

There is likely to be a noticeable effect especially when associated with very high temperatures.

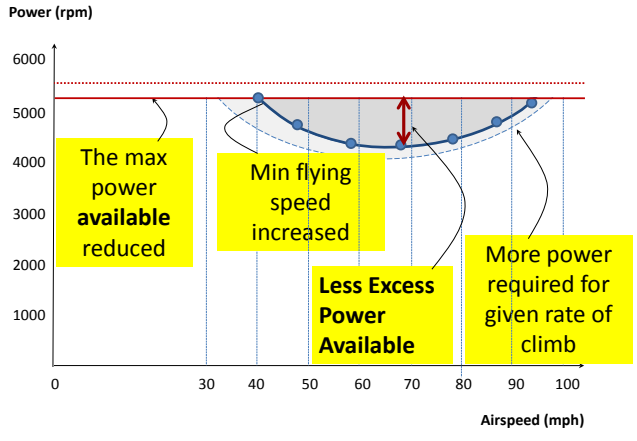
g) In the UK, the highest land that you are likely to take off from is less than 2,000 ft above sea level. Even if the air pressure is low, there is unlikely to be a noticeable effect on take-off. When touring abroad, however, you must factor in the height of the airfield as well as the temperature which may be very high.

Low Air Density Affects the Power Curve

h) Performance is affected in three ways:

1) The lower air density will reduce the performance of a non-turbo-charged **engine**. This means that it will develop less power.
2) The lower air density will reduce the performance of the **rotors** (there are fewer air molecules for the rotors to use - to 'push against' - to create lift). The minimum speed at which the gyroplane can fly level will increase, and the best rate of climb speed may increase slightly.
3) Because of the poorer performance of the **rotors** more power is required for a given rate of climb.

i) The reduced efficiency of the rotor will reduce available excess power (and thus maximum rate of climb), and a reduction in available engine power will further reduce it. Graphically, the 'power curve' will tend to shift to the right and upwards whilst the maximum engine power available will be lower:



j) A decrease in air density will significantly:

1) INCREASE the take-off run required to achieve rotor speed;
2) **INCREASE** the **take-off distance required** to achieve the appropriate climb speed; and
3) DECREASE the rate of climb.

You will require a larger site and clearway on days with low air density than on days with high air density.

Considerations for Rotax 912/914 Engines

k) The majority of gyroplanes produced in the past few years have used the Rotax 912ULS and Rotax 914UL engines. Motor gasoline (MOGAS) can **only** be used in engines where the fuel temperature is **less than 20°C** and where the flying altitude is restricted to **6,000 ft**. Outside these conditions, AvGas (UL91 or 100LL) must be used. If you are flying a gyroplane with one of these engines, you **must** consider the fuel you are using for the take-off.

Considerations Affecting Take-Off Distance

l) A number of considerations are known to adversely affect the take-off distance. The most significant performance penalties relate to the airflow through the rotors. It is extremely difficult to give exact 'factors' to apply to gyroplane performance but the following advice has been drawn from the practical experience of the most experienced UK pilots:

Consideration	Effect on TODR/TORR
Hot temperature	Significant Increase.
High moisture content	Noticeable Increase.
High altitude	Significant Increase.
Crosswind	Significant Increase.
Tailwind	A tailwind has a significant detrimental effect on take-off distance and should not be accepted if over 5 kt – even then it could double distances required.
Weight	Has a critical effect on performance – do not exceed MAUW for aircraft.
Uneven ground	Degrades take-off performance.
Long grass	Degrades take-off performance.
Rain or snow	Degrades take-off performance.
Slope	The slope is less critical than the wind direction but taking off up-slope will degrade take-off performance.
Dirty rotors	Degrades take-off performance.

8 ROTOR HANDLING

a) The gyroplane relies on a good understanding of rotor management if it is to be flown safely. The type of rotors used on a particular type of aircraft can give the aircraft quite different handling qualities. Heavier blades can make the rotor system more stable but can be difficult to accelerate or decelerate on the ground. Equally, lighter blades can suffer from 'sailing' where their weight is insufficient to provide sufficient centrifugal stiffness at low RPM. Unlike a helicopter, the gyroplane rotors cannot be controlled directly; in particular their RPM is governed by external factors creating sufficient airflow to generate the forces to keep them turning despite the aerodynamic and mechanical drag. It is of vital importance that the gyroplane pilot understands how to get the best out of the rotor system – some of the considerations are listed below:

Considerations for Rotor Handling:

1) A gyroplane pilot must always know the wind speed and direction. On the ground this will influence how the aircraft can be safely taxied, the direction of any planned take-off and the potentially increased TODR/TORR. When airborne the gyroplane pilot should always be anticipating his actions in the event of power failure. A gyroplane can be landed with minimal groundspeed and thus quite safely whatever the surface. However, it is important for the landing to be made into wind.
2) Taxiing will generally be safer and easier with the rotors stopped. Consider always stopping the rotors completely after landing, before turning the aircraft out of wind.

3) It is always easier to pre-rotate and accelerate the rotors if pointing into wind. Consider this when choosing a take-off direction. Consider the negative implications of pre-rotating with a crosswind, and avoid this if possible.
4) Be very careful when operating in gusty wind conditions, when the direction and strength of the wind can change rapidly.
5) Be wary of blade sailing. Always be prepared to abort the take-off or rotor acceleration if the stick starts to thrash about, or if the blades appear to be physically sailing rather than following a circular trajectory.
6) Be wary of taxiing on bumpy ground with the rotors turning at low RPM. Again it is safer to taxi with the blades stopped or even tied down. To minimise wear and tear on the blades it may be advantageous to generate some centrifugal force to keep the blades as stiff as possible; in this case the pre-rotator should be used frequently to keep the RPM has high as possible.
7) Always position the stick according to the wind direction. Even a small crosswind component may cause a gyroplane to roll over on the ground if the pilot is not sufficiently attentive. A tailwind can be problematic especially when trying to accelerate the rotors as airflow from above the rotors will always have a negative effect.

Gyroplanes can be at their most vulnerable when in contact with the ground with their rotors turning.

Understand the implications of wind direction and strength on taxiing, pre-rotating, take-off and landing.

9 GYROPLANE FLYING

a) A gyroplane will not stall or spin, and if it suffers an engine failure it is already in autorotation, allowing a near conventional landing to be made with minimal ground speed. However, it is very important for a gyroplane pilot to understand the aspects of flying that can catch out the unwary:

1) The pilot must understand his aircraft's power curve. Flying dangerously slowly can produce an increasing rate of descent. If full power fails to arrest this descent, the pilot must expeditiously ease the stick forward to increase speed until excess power is available. This will initially increase the descent rate. If insufficient height is available, contact with the ground is inevitable; pulling the stick back will only increase the rate of descent. This may occur on a misjudged approach, or perhaps when flying downwind close to the ground, when it is not obvious the airspeed has reduced. **Beware of getting LOW and SLOW**.
2) Modern gyroplanes have increasingly reliable engines, but pilots should always be prepared for a power failure or other emergency. Always consider the terrain being flown over; avoid flying over woods or steeply sloping ground where possible. **Always fly high enough to be able to make an unhurried glide landing into a suitable field.**
3) Consider the weather carefully before and during flight. The gyroplane is restricted to day VMC flight only and pilots require good visual references in order to be able to fly safely. **Always be willing to make a precautionary landing if weather or light levels deteriorate beyond safe limits**.

10 SAFETY RECOMMENDATIONS

1) Read the **flight manual** for the machine you are flying. Know the published performance figures but be aware they are probably based on sea level ISA (15°C) conditions.
2) **Practise** take-offs at different weights, and in different conditions, noting the effect the differences have.
3) Know the **length** of the strip/site you are using and identify all obstacles in the clearway.
4) **Understand** how the temperature, altitude and humidity affect the take-off performance and take them into consideration.
5) **Decide** whether you are going to use a performance take-off technique or a rough-ground technique – remember it is generally **either/or** – it is all about compromise. There is no such thing as a short field technique.
6) Define a **Decision** (**abort) point**, using some natural marker in the field which will be visible during the take-off run.
7) Know your best rate of climb speed.

When taking off from a short strip:

1) Always pre-rotate to the **maximum** allowed for your machine – **it is all about rotor speed**.
2) Always apply **maximum** power as soon as you start moving forward (ensuring minimum rotor speed has been achieved).
3) Keep the transition as **close to the ground** as possible until climb speed has been achieved.
4) If you have not reached best rate of climb speed or are unsure of clearing obstacles by the decision point, **abort** the take-off.
5) When you climb, be **accurate** and maintain **best climb speed**.
6) If you are not going to clear the obstacle, and can no longer safely abort, **turn away from it** – remain at **full power** and remain at the **best climb speed**.

Gyroplanes can safely land in fields that it is not possible to take-off from.

In flight:

1) Beware of flying LOW and SLOW.
2) Avoid flight over hostile terrain.
3) Always consider the wind direction and be prepared to conduct a forced landing.
4) Always consider weather and light levels and be prepared to make a precautionary landing **to live to fly another day!**

Produced by the British Rotorcraft Association in collaboration with the CAA. Refer to www.gyroflight.co.uk.