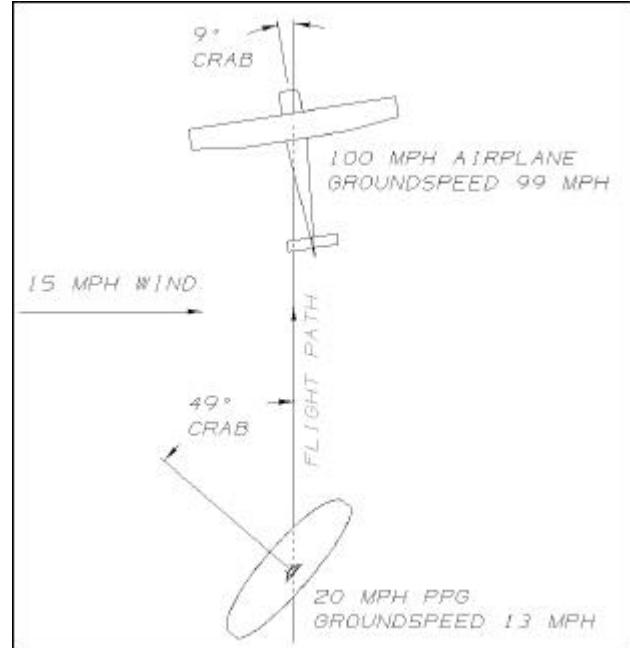


Powered Paragliders and Wind

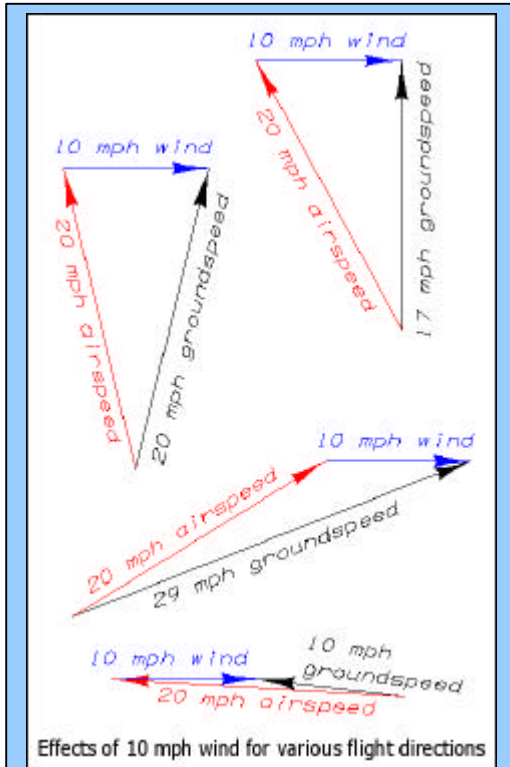
By Dana Hague

One of the major differences between powered paragliders and other aircraft is a result of their uniquely low flying speed: the effects of wind. Few if any airplane pilots have ever flown backwards, but it's quite possible with a ppg to launch, fly upwind for some distance, then climb into stronger winds and get blown backwards past the launch point. The whole thing, including descent to a landing at the launch point, can be done without ever turning once. I once used the wind to help a search for a lost propeller; slowly flying forward at perhaps 5mph groundspeed over the search area, then using gentle s-turns to allow myself to be blown backwards to the start point, over and over again. On that occasion I spent a half hour over an area no larger than a baseball field without ever circling once (no, I never found the prop, but it was great fun to hover almost like a helicopter).

This very thing that gives a ppg such amazing abilities, however, also requires much greater attention to the wind, even light breezes that would scarcely affect a faster aircraft. A Cessna 150, for example, cruising at 100 mph with a 15 mph crosswind, has to correct, or "crab", about 9° into the wind to maintain its desired course, and its groundspeed will still be 99 mph. A 20 mph ppg, on the other hand, would have to crab 49° , so it's going more sideways than forwards, and its groundspeed will drop to just over 13 mph. Increase the wind to 20mph, and the Cessna's crab angle has only increased to 11° and its groundspeed is still 98 mph, but our ppg has turned 90° from its desired course, straight into the wind, and isn't going anywhere! Of course, you would never (I hope!) launch a ppg into a 20 mph (or even 15 mph) wind, but 20 mph or even stronger winds may be blowing just a few hundred feet up while it's nearly calm on the ground... more on this later.



Although perhaps not as dramatic in appearance (no feel of sliding sideways), a straight on headwind has even more effect. The 100 mph Cessna in a 15 mph headwind has an 85 mph groundspeed, which means it



Figuring groundspeed and crab angles for any wind direction, not just the 90° crosswind or straight headwind/tailwind discussed in the text, is a matter of basic trigonometry. The standard pilot's flight computer (either the classic inexpensive E6-B or one of the modern electronic ones) can easily solve these problems if you really need an exact number.

will take 18% more time to reach its destination. The 20 mph ppg, on the other hand, now has only a 5 mph groundspeed, meaning it will take *four times* as long as it would with no wind. Of course, you'll go much faster on the return trip... nearly twice as fast as you would with no wind and *seven times* as fast as the trip out!

Don't think that the headwind and tailwind on an out and back trip will cancel out, though. You lose far more time going upwind than you gain back going downwind. We've seen that the 15 mph crosswind reduces the groundspeed to 13 mph, so if you have an hour's worth of fuel, the round trip of 10 miles each way you could have made with no wind is reduced to 7½ miles each way. With a direct 15 mph headwind in one direction and tailwind in the other direction, you can only go 4.375 miles! (52½ minutes for the trip out with a 5 mph groundspeed and only 7½ minutes for the trip back with a 35 mph groundspeed.)

Of course, the wind also affects the inflation / launch sequence, including the decision whether to do a forward or reverse launch, but this is such a basic part of ppg training that I won't discuss it here.

Practicing Ground Reference Maneuvers

Learning to correct for wind drift so as to make the aircraft go exactly where you want rather than drifting around at the mercy of the wind is a part of every airplane pilot's training, but is often neglected in ppg training. There are a group of "ground reference maneuvers" which airplane pilots must master before soloing, but which, while valuable to ppg pilots as well, are rarely (if ever) taught. *Note: Don't practice these maneuvers too close to the ground, and don't make your turns so tight that you're in danger of stalling!*

The first (and easiest) is the *rectangular pattern*, which is similar to an airport traffic pattern, but at a constant altitude. Pick a straight line on the

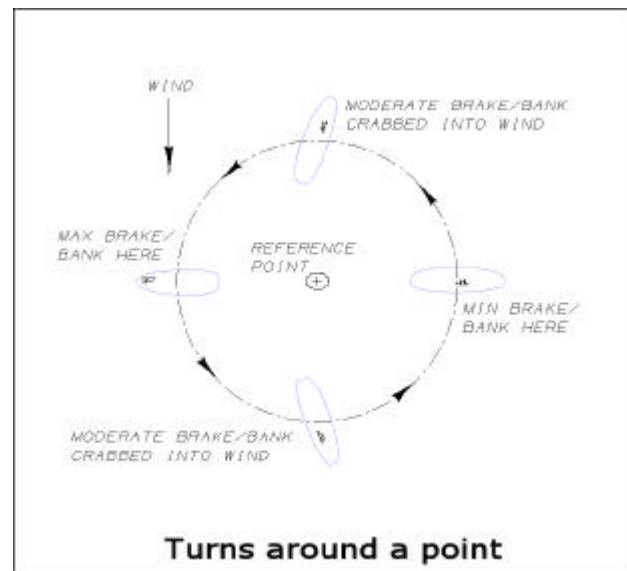
ground (a road, railroad, river, section line, etc.) that's lined up with the wind. Identify two points along the line about ¼ mile apart. If you can find a large rectangular area with all four sides clearly defined, like a large field, so much the better. Fly directly over the line, into the wind, and just as you reach the upwind point, turn left until you're flying straight away from the line. If there is no wind, you'll make a 90° turn, but if there's wind, you'll turn less than 90°, settling on a crab angle that makes your actual path over the ground perpendicular to the first line. The object is to smoothly straighten out on the correct crab angle so the ground track is perpendicular.

Fly along this line for a distance about equal to the length of the upwind leg, then turn left again until you're flying downwind, parallel to the original line. Since you're flying straight downwind there will be no crab angle this time, and because the wind is behind you, the downwind leg will take less time to complete than the upwind leg. As you come abreast of the original downwind start point, turn left again to head straight back toward the original line. This time, you'll have to start your turn earlier, since you're getting blown downwind as you're turning, and you'll have to turn through *more* than 90° to settle on the correct crab angle. Your ground track should be exactly toward the start point while the heading is somewhat into the wind. Finally, turn left again so you're flying back upwind again over the line. Repeat at least twice more.

This maneuver should be practiced in various forms, with both left and right turns, in varying wind conditions, until it becomes second nature to fly straight in any direction you want, regardless of the direction you're actually facing.

The second maneuver is the *turn around a point*. The wind also affects the relationship between bank angle (how tight you're turning) and the actual shape of your turn relative to the ground. Here the object is to fly a perfect circle around a point (a tree, house, road intersection, anything) regardless of the wind. Again, with no wind this is easy, but if there is any wind you will be constantly changing your brake input and bank angle to maintain the perfect circle relative to the ground.

Start by flying straight downwind with the chosen point in front of you and to the left. As you come



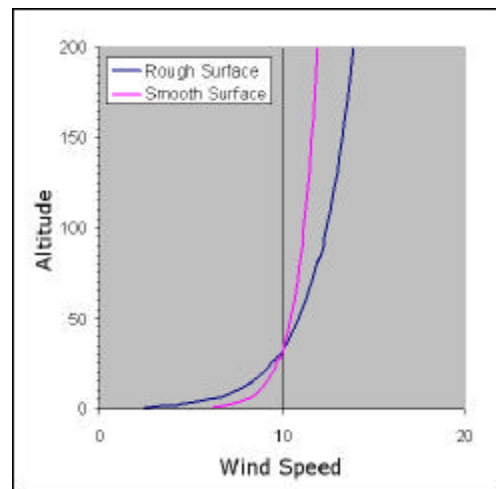
abreast of the point, start a left turn. If there's much wind, you'll need to turn tightly to keep from being blown downwind away from the point. As you move around the circle, you will have to constantly decrease your brake pressure and bank angle to hold a constant distance from the point. Your brake and bank angle should reach a minimum when halfway through the turn, i.e. when you're heading straight upwind, at which point you slowly start to increase your turn until you're back at the starting point. Like the rectangular pattern, you will be crabbed into the wind when flying crosswind. Continue without stopping for two more turns, constantly adjusting your turn as appropriate, before straightening out. As before, repeat this in both directions and in varying winds. Note that engine torque will affect the brake and/or weightshift required for equal turns both right and left.

There are additional ground reference maneuvers in the Private Pilot syllabus which are worth practicing, including figure-8's around two points, S-turns, etc., which add the additional factor of changing from a left to right turn and vice versa, but they're all variations on the same theme so I won't go into detail here.

Wind Gradient

So far we've discussed only constant, steady winds. The subject of flying in shifting or gusty winds is enough for another entire article.

Wind speed usually increases with altitude even on a smooth, steady day. We call this the *wind gradient*. Friction between the air and the ground slows the wind, so the wind blows slower close to the ground. This is why your handheld wind meter may only read 5 mph while the weather service (using a standard 10 meter anemometer height) is reporting 10 mph. Right on the surface, the wind speed is effectively zero. The wind speed increases as we move away from the surface, until at some height it is the same as the free wind speed. The area below this height is called the *boundary layer*. Just what this height is and how the speed increases depends on a number of factors, including the free wind speed and the surface roughness (grass, forest, water, etc.); it can vary from a few dozen feet over a smooth surface to hundreds of feet. Suffice it to say that the wind gradient is greatest close to the surface, and that the rougher the surface (forest vs. water) the thicker the boundary layer and the greater the gradient at the



surface. The graph shows the same wind speed at 10 meters (33') but over different surfaces. Obviously on a calm day there is no gradient, but on a windy day there can be more than 10 mph difference between the surface and 200'.

The wind gradient affects a ppg in a number of ways. Let's say you're making a landing approach in a steady breeze. At 200', everything looks fine; you're higher than you'd be for a no-wind approach, but that's normal, you're lined up fine. As you get lower, however, your glide starts to flatten out until it's obvious that you'll overshoot your target unless you do something to steepen your glide.

What happened? The steep glide angle you established for, say, a 10 mph breeze at 200' now leaves you too high for a landing in what might be a 5 mph surface breeze. I'm not suggesting you start too low; you don't want to land short of the field, after all, but be prepared to bleed off some excess altitude by holding partial brake (not too much, you don't want to stall!), making s-turns, etc.

We can also be affected by wind gradient while flying at a constant altitude. This phenomenon is unique to powered paragliders and powered parachutes, because of the vertical distance between wing and motor. You may notice that flying downwind in a steady breeze at low altitudes requires several hundred more rpm than flying upwind. Or you may turn downwind and find yourself sinking if you don't add power quickly. This has nothing to do with the infamous (and nonexistent) "downwind turn" effect. Rather, it's caused by the difference in wind speed seen by the motor and the wing. This can only occur at very low altitudes where the wind gradient is strongest.

What happens is this: If you're flying very close to the ground, the difference in wind speed between your motor and your wing (which is some 20' higher) can be significant. In this case a difference of less than 1 mph can be significant!

If you're flying downwind (generally not a good idea at low altitudes!), your wing is moving at its trim speed with the wind, and your groundspeed is equal to the trim speed plus the wind speed. Since the wind speed is slower 20 feet lower where you and your motor are (there's less wind "behind" you), the airspeed seen by the propeller is *higher*. To produce the same thrust at the higher airspeed, the propeller has to turn faster. A difference in airspeed of only ½ mph between motor and wing can mean a couple hundred rpm. Adding to this effect is the higher airspeed felt at the motor causing slightly increased drag, requiring even more thrust. Fly upwind and the effect is reversed, so less power is required. At higher altitudes, where there is much less wind gradient, this effect is insignificant, except in the case of wind shear, which is a different condition entirely.

You can use the wind gradient to your advantage, though: Fly the upwind portion of your flight at low altitude, where the headwind is weaker, and fly the downwind portion higher to take advantage of the tailwind. This is also safer, since you won't be flying downwind at low altitudes. It only works if there is enough wind, though; you may burn more fuel climbing than you'd save by catching the tailwind. Don't count on the winds, though. Murphy always seems to dictate that headwinds are stronger than anticipated, and expected tailwinds never seem to materialize. Furthermore, it may be less efficient (and more dangerous!) if you're getting bounced around by low level turbulence than if you're making slow steady progress against a stronger but smoother headwind at altitude.

All of the above discussion concerns the effects of smooth steady winds. Flying in variable or gusty conditions adds an entirely new set of additional variables, while tending to mask (but not eliminate) the effects described above. The behavior of aircraft in gusty conditions is an extremely complex subject, too big for this article.

Happy flying!