TRIGGER POINT OF WIND DETECTION

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Introduction

During flight, without means of measurement or data transmitted by the ground, while exploiting the possible hints (smoke, dust, ripples on water surfaces, etc...), it is extremely difficult to detect and assert the strength and the direction of the wind at ground level, and more precisely the effective wind on track of the selected final leg to an outlanding. It is not always possible to make the few spiral turns that would allow a more precise apprehension of the wind before one has to commit oneself to the beginning of the "downwind leg". If the wind is in the flow of the selected track, only the appreciation of the ground speed allows some kind of pertinent estimation of the true wind.

Having these considerations in mind, it is interesting to determine the precise minimum speed from which the true wind may be detected, and consequently, if it is sufficient to have to be taken into consideration for the safety of the final approach. Our experience, double checking, and the bibliography currently available, have shown that the minimum detected true wind is not less than 10 or 12 kt and may reach 15 kt and even more in the case of some tailwinds when there has been reports of a belated detection of a 20 kt wind.

Reckoning and arithmetic of the influence of the true wind in a final approach

One should first be reminded of one of the specificitions of a glider approach, namely that the final leg which is done on a varying ground slope should be on a constant air slope as nearly as possible corresponding to airbrakes at half maximum effectiveness.

Let us take the cases of three different gliders, all on final approach with an undetected wind, at the Optimum Speed Approach (OSA or V_X) - with no wind correction - which we will set at 25 m/s for the three machines for the ease of calculations.

1) Wood and fabric type with very effective airbrakes e.g. the "Wassmer 30"

2) Modern glass type with very effective airbrakes e.g. the "Pegasus"

3) Modern glass type with less effective airbrakes e.g. the "ASH 25"

Glider number 1 gives the following table:

	Vx	Vz	L/D	slope	angle
Zero Airbrakes	25	1	25	4 %	2.3°
Half Airbrakes	25	2.25	11.1	9 %	5.1°
Full Airbrakes	25	3.5	7.1	14 %	8°

Glider number 2 gives the following table:

	Vx	Vz	L/D	slope	angle
Zero Airbrakes	25	0.62	40	2.5 %	1.4°
Half Airbrakes	25	2.06	12.1	8.2 %	4.7°
Full airbrakes	25	3.5	7.1	14 %	8°

Glider number 3 has flaps and they are used on the final approach, as standard procedure. We will thus consider the position half airbrakes, as being between "zero airbrakes, full flaps" and "full airbrakes, full flaps" (flaps 6). The sink rate induced by the flaps is about equivalent to the one produced by the airbrakes and, at 25 m/s, the L/D being at around 50 with zero airbrakes and zero flaps, we come to the following table:

		Vx	Vz	L/D	Slope	Angle
Zero AB	Zero flaps	25	0,50	50	2 %	1.14°
Zero AB	Full flaps	25	1.75	14.2	7 %	4°
Half AB	Full flaps	25	2.38	10.52	9.5 %	5.4°
Full AB	Full flaps	25	3	8.3	12 %	6.9°

We can now work out with what wind speeds we can maintain the half airbrakes slope with zero airbrakes and head wind, and full airbrakes and tail wind. The wind speed is the difference between the OSA, which we maintain by hypothesis, and the ground speed (GS) which we need for a half airbrakes slope, or Vx - (Vz X half airbrake L/D).

For glider number 1 we have:

25 - (1 X 11.1) = 14 m/s (27 kt headwind)
and 25 - (3.5 X 11.1) = -14 m/s (27 kt tailwind)

For glider number 2 with a better L/D and less penalized we have:

25 - (0.62 x 12.1) = 17.5 m/s (34 kt headwind)
and 25 - (3.5 x 12.1) = -17.4 m/s (34 kt tailwind).

For these two gliders we can absorb equal headwind and tailwind strengths whose values are almost three times what we have agreed upon as being the "trigger speed of wind detection".

For glider number 3, things are quite different, as the flight envelope on each side of the half airbrakes position is much narrower. Effectively we have:

25 - (1.75 x 10.52) = 6.6 m/s (13 kt headwind)
and 25 - (3 x 10.52) = 6.56 m/s (13 kt tailwind)

which means we have just the limit of the undetectable and thus unknown wind.

We can already draw a first conclusion – all gliders have a half airbrakes slope of about 5° but, they do not all have the same capacity to counter an undetected or sudden surge of wind – far from it. The first two gliders have a comfortable margin to work with. The third, which we will now study, is in a much trickier situation, especially if the unknown wind is a tailwind.

However, the pilot may start his final approach at a somewhat smaller angle. and with less flaps. He can even return to the "zero airbrakes, zero flaps" position. (This new setting is quite feasible as an emergency maneuver to make the threshold point safely. At "OSA, zero wind", the glider is far enough from the stall point and near enough to the best L/D point to maintain, and increase if necessary, its speed to counteract an eventual wind gradient.)

In this case the glider can make the field with a headwind of 25 - (0.5 x 10.5) = 19.75 m/s = 38 kt. But with a tailwind, as we have seen, it can do no more than increase its sink rate by 0.62 m/s and counteract a wind of 13 kt!

However, the table shows that if this glider starts its final approach at an angle of 4°, with "zero airbrakes, full flaps" he can reach the threshold by using:

"Zero airbrakes, zero flaps" with a headwind of:
25 - (0.5 x 14.2) = 17.9 m/s (34 kt)
"Full airbrakes, full flaps" with a tailwind of:
25 -(3 x 14.2)= -17.6 m/s (4 kt).

We can also notice that all modern gliders, with or without flaps, which start their final leg with an angle of 4° will make the threshold with a head or tailwind superior to 30 kt (for an old bird it was 21 kt headwind, but still more than 40 kt of tailwind). For the modern glider, with an angle of 5° (slope 8.75 %, L/D 11.4) the limits are 37 kt headwind and 18 kt tailwind, while with 4.5° (a 7.9 % slope, L/D 12.7), the limits are 36 kt headwind and 25 kt tailwind.

Consequently, if a pilot is able to end his last turn at an angle between 4° and 5°, he can be sure to make the landing strip, maintaining his OSA, with a wind, head or tail, much higher than the trigger zone of 10 to 12 kt that we have taken into account.

Approach on a short track with an unknown wind

While in flight, there is no way to know accurately the optimum angle which, in the present conditions, would fit the final leg. By experience we know that high angles are easier to appreciate and to see change than small angles, but to our knowledge the explanation does not exist in any book for glider pilots. We also know that pilots avoid "flat approaches" but to this day, no one has ever defined the very precise angular value from which an approach is named "flat". However the answer to these two questions seems essential for the determination and the control of all the elements of an approach, apart from airports, to a short track with an unknown wind.

The sweeping per degree of attitude we define as the displacement on the ground which is in line with the eye of the pilot and of a mark on the windshield and is significant of the aiming line. The prolongation on the ground of the trajectory is the point of contact and is significant of the line of the trajectory.

Before discussing angles a simple trigonometric calculation can be made.

For angles above 7°, the sweeping is unimportant. It is once the height between 7° and 8°, it is half the height between 10° and 11° and rapidly becomes negligible

Angles	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°	13°
Cotangent		57.2	28.6	19	14.3	11.4	9.5	8.1	7.1	6.3	5.6	5.1	4.7	4.3
Difference	∞	28.6	9.6	4.8	2.9	1.9	1.4	1	0.8	0.7	0.5	0.4	0.4	

beyond that point. In other words, a horizontal shift in the approach will provoke an angular variation all the stronger, and consequently easier to comprehend when the angle is high, and, for a similar angle, all the faster when the distance is short. This is the reason why a landing in a strong headwind, and consequently on a higher slope, presents no particular difficulty regarding its precision, apart from piloting constraints due to turbulence or special topography. It is also the reason why some procedures advise approaches on a trajectory nearer to full airbrakes than half airbrakes.

Moreover, if the wind is known, and the OSA is increased by half the wind strength, the incidence is much superior at the best L/D speed and the variations in trajectory are directly related to the variation in pitch.

Then, and most important, the angular difference between the aiming line and of the trajectory line is of the angle of incidence only, which in this case is small, and these lines are practically very similar. It is thus possible to aim at the "rotation" point with a mark on the canopy. The control of any change caused by a slight shift in the vertical plane remains in the range of the usual piloting corrections.

If, on the other hand, we consider small angles, below 3°, the conclusions are totally different; the sweeping is considerable. Between 3° and 2°, it is 9 times the height. Between 2° and 1°, where most modern gliders stand at maximum L/D, it is 29 times the height and considering the aiming line as the trajectory line, even at a speed above to the maximum L/D speed, has not only lost all consistency, but is almost dangerous.

However a glider pilot is sometimes confronted with the need to exploit trajectories lower or equal to 2° before being able to reach the usual conditions of a final approach at half airbrakes. Let us take the example of a pilot, on a final glide of 2.5% (L/D 40, angle 1.43°) with a safety margin of the same range as the altitude reading error, somewhere between 0 and 50 m, and consequently at best L/D speed. Indeed, at 10 km, for example, in spite of the proximity of the ground which allows him to refine by sight the information given by the altimeter, he cannot, at this distance perceive if the margin is 50 m (3%) or equal to 0 (2.5%). At 6 km, altitude 200 m, he should persevere exclusively in visual flight unless the area between him and the threshold of the track is directly and safely landable.

If the margin is nil, or negative, he will have to open the airbrakes to land safely before the rack when, through an effect of "toppling" (rapid change), his doubts will be transformed into the certainty that "he won't make it". If, on the other hand, the margin is positive, he will perceive it increasing, slowly at first, then faster and faster, until the moment of the "toppling" on the right side, when he gets to the vicinity of the track.

Our example of a final glide with a flat slope (2.5°) and a small margin (50 m), well known to pilots, allows us to determine the most uncomfortable but the most significant case of the "flattest" approach, how and with which values the change in angle is perceived.

In this table we can see that the increase of the slope begins to accelerate towards 5% at 2 km but also that the approach is comfortable only in the last km, when there are only 30 or 40 seconds of flight left, in fact almost at the recommended distance for a "long final leg", and on the recommended slope for an approach with an "unknown wind".

	difference	
At km 6 the height is 200 m or 3.3 %		(1.9°)
	0.2 %	
At km 5 the height is 175 m or 3.5 %		(2°)
	0.25 %	
At km 4 the height is 150 m or 3.75 %		(2.14°)
	0.35 %	
At km 3 the height is 125 m or 4.1 %		(2.38°)
	0.90 %	
At km 2 the height is 100 m or 5 %		(2.86°)
	2.50 %	
At km 1 the height is 75 m or 7.5 %		(4.28°)

On a standard approach we usually come into position from above and considering how hard it is to perceive small angles, there is a great temptation to start the final turn as soon as the final seems secured, with a steeper slope than the one with "half airbrakes". Such a maneuver is much easier than compelling oneself to start it on the half airbrakes slope; but it is unrealistic. Effectively, the half airbrakes procedure fits all ships but it is an imperative one for some modern gliders which demand a stable final approach with precise control of their optimum speed. Consequently, one must constrain oneself to practice at each approach on the home airfield with a weak or zero wind, visualizing the half airbrakes slope which will give us a final leg at the OSA with an unknown wind.

Landing on sloping ground

The difficulty we have to visualize small angles also exists for the appreciation of the slope of fields, which could be selected for an outlanding. Thus the influence of the slope of the terrain is as important as the wind, and soon becomes more important. A landing on a down slope field of more than 5% should not be even considered, and when such a slope has been ascertained with certainty, the landing should be carried out up slope, with an increase in the OSA for the round-up, whatever the direction of the wind is.

If, after the last turn, the pilot is at an angle between 4° and 5°, the final leg still needs his attention, but he should proceed without any more difficulty. It is advisable to plan a sufficiently long final leg. While even an experienced pilot needs a few seconds to determine whether the initial trajectory converges with or diverges from the half airbrakes slope, variations are nevertheless quickly noticeable, and the action of the airbrakes is quite effective in achieving the desired slope. Only an excessive indicated airspeed might reduce the accuracy.

Concluding remark

When reference to the altimeter readings is out of the question, particularly while on the base and final legs, the appreciation of the height, produced by and indisassociable from the appreciation of the distances, is completed by the understanding of the relative motion of all the reference points which are on both sides of the trajectory. This phenomenon appears right from the downwind leg, is intensified with time, and makes it much easier to appreciate "too high, too near" or "too low, too far" while on the base leg. During the short final, this phenomenon totally replaces the appreciation of the slope of descent. It is what happens when a pilot, in his flare out, with an excessive speed, 1 m off the ground at one end of the runway, wishes to stop at the other end, at a distance of 1000 or 1200 m right abeam his hangar. At this moment, the stopping point is seen under an angle of about 1/1000, i.e. totally unusable in a vertical plane. However, the displacement speed and the closing-up speed of all visible elements feed the pilot at every moment with data concerning the relation between the present and the remaining distances, and allow him to set the air brakes precisely and to stop within a few meters of the desired spot.