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WORLDWIDE PARAGLIDING AND PARAMOTORING MAGAZINE. FOR FREE.

SPEED

ON A PARAGLIDER AND A PARAMOTOR

Photo: Parajet

Speed isn't really the strong point of our non-rigid wings. Yet, in XC or cruising we need it. What are the limits for our paragliders and what options do the manufacturers have?

On a paraglider, as with any other gliding aircraft, we can measure three different speeds: the speed along the trajectory, the horizontal speed and the vertical speed. The last, is the famous sink rate and you want it to be as small as possible: You stay in the air longer, and go up quicker in thermals. At the same time, you want to go forward as quickly as possible: The greater the horizontal speed, the quicker you get to the next thermal.

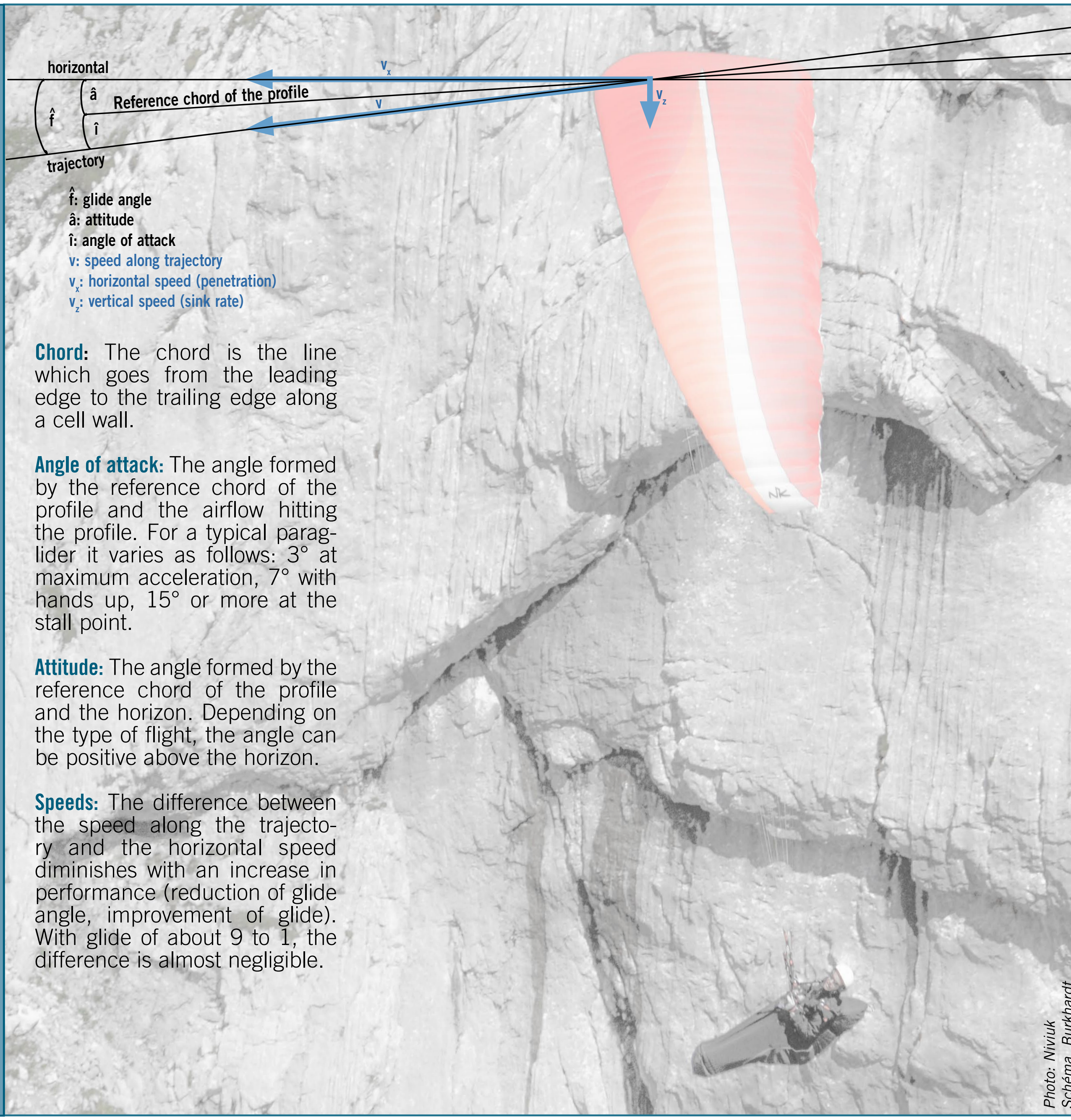
And in a paramotor, the relationship between the horizontal speed and vertical speed, the glide ratio of the wing, determines the power necessary to stay at the same level, and thus the fuel consumption…

The main problem which limits horizontal speed (or rather along the trajectory) of a paraglider is the fragile nature of the non rigid leading edge. By accelerating the paraglider, the angle of attack diminishes up to the point where the air flow is from above the leading edge and, to put it simply without being too scientific, the leading edge folds down and the wing collapses.

But before then, the nose of the non-rigid profile starts to distort and, even if it is still flying, it loses its aerodynamic efficiency. That's where measures like leading edge rods come in. They allow the glider to keep an efficient profile for longer.

Making the pilot more streamlined: A way of increasing the performance, but not really speed…

PARA-WORDS



Chord: The chord is the line which goes from the leading edge to the trailing edge along a cell wall.

Angle of attack: The angle formed by the reference chord of the profile and the airflow hitting the profile. For a typical paraglider it varies as follows: 3° at maximum acceleration, 7° with hands up, 15° or more at the stall point.

Attitude: The angle formed by the reference chord of the profile and the horizon. Depending on the type of flight, the angle can be positive above the horizon.

Speeds: The difference between the speed along the trajectory and the horizontal speed diminishes with an increase in performance (reduction of glide angle, improvement of glide). With glide of about 9 to 1, the difference is almost negligible.

But they don't significantly reduce the minimum angle of attack possible before a collapse occurs. Even the leading edge rods along the whole length of the chord of a paraglider such as the Mantra M6, won't delay it collapsing. The designers at Ozone confirmed that these reinforcements serve just to maintain the shape of the profile of these wings along the whole chord, despite the smaller number of anchor points…

To significantly delay small collapses at low angles of attack, leading edge rods would need to be as thick as tomato canes, confirmed Fred Pieri from Ozone. Otherwise, according to Michel Nesler, you would need to make the A lines rigid because, if you could replace them with metallic rods, that could effectively prevent the leading edge from folding downwards…

The R11, the first SharkNose from Ozone…

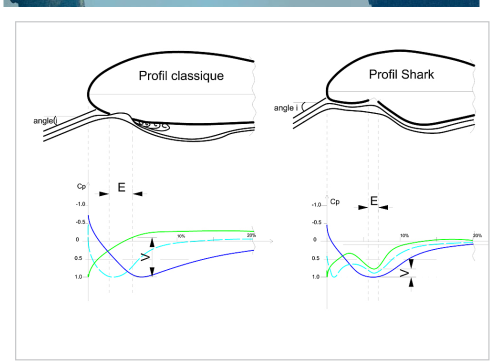
…which was also introduced into the Enzos from the Enzo 2.

THE SHARK COMES TO THE SURFACE

A genuinely efficient solution to making the leading edge more solid is to increase the internal pressure in the wing. Manufactures have been doing this for decades, for example by adding flaps or other valves. However using them can cause other problems like leaks, and can increase production costs.

But a very interesting solution seems to have in fact led to a big advance: The SharkNose. More and more manufacturers are using this special nose shaped profile around the air intakes. The advantage is that, both with high (flying slowly) and low (flying fast) angles of attack, the internal pressure in the wing remains high. The profile is therefore more solid when flying fast: When the designers at Ozone used it for the first time on the R11, they said they had gained 10 km/h at maximum speed, going from a maximum speed of 65 km/h to a new maximum speed of 75 km/h.

The topic SharkNose in the January 2014 edition is of course still available in the archives of our magazine



The problem with a wing flying at these speeds is that it becomes impossible to certify to EN norms because, inevitably at these speeds, the aircraft's kinetic energy leads to violent reactions when it exceeds its flyable envelope. So the Enzo 2, for example, cannot take advantage of all the upward potential and must be trimmed more prudently.

But the concept is spreading more and more, including into beginners wings to give better stability and more comfort at reasonably fast speeds, but also for its advantages at lower speeds.

DON'T DRAG

Another possible way to increase speed is to reduce the parasitic drag by streamlining the pilot and by reducing the lines and their diameter. But in reality you gain more in glide angle and thus performance, but the speed along the trajectory increases very little. If you could get rid of the brake lines, you would gain nearly one point of glide, according to Michael Nesler, but the speed would only increase a little.
Another false hope was to believe that choosing a thinner profile, would increase the speed. But in reality, a thinner profile is more likely to collapse than a deeper one, so the manufacturer can't streamline the wing much more.

Top: Thinner lines and fewer of them: Certainly a gain in performance, but the speed only increases a little.

Middle: Valves to increase the internal pressure when flying fast on a wing from Apco, one of the pioneers of the technique.

Leading edge rods: They make it more aerodynamic at high speed, but they don't give a significant increase in absolute speed.

Photo : Sascha Burkhard

Above: The mini-trimmers from Icaro for making little adjustments in the trim, whilst staying within the confines authorized by the EN or LTF norms.
Left: 3D shaping technology in the leading edge makes the profile more efficient.

REFLEX

With paramotor wings, a new (old) technology appeared less than ten years ago, and is supposed to increase the speed of the wings. The self stabilising or reflex profile has an S shaped curve (the camber line of the profile goes up at the back). The principle has existed for a hundred years and was, above all, developed to stabilise ‘flying wing’ type planes which have neither fuselage nor tailplane, the higher back part of the wing acting like a tailplane.

These profiles had already been rediscovered by paragliding manufacturers decades ago and in the majority of paragliding wings, you find a certain amount of reflex. But it’s Mike Campbell-Jones of Paramania in particular who stands out as the pioneer of full reflex in a paramotor wing. Almost all of his range has a pronounced S curve in the profile. Companies like Dudek also led the way, and then the majority of the other manufacturers integrated this type of profile into their models, especially in paramotor wings. The reflex or self stabilising profiles have the peculiarity that their centre of pressure only moves very slightly and that, unlike a classic profile, they regulate themselves: If the angle of attack decreases, the profile's reflex opposes it by rearing up. If the angle of attack increases too much, it arrests it. Here's a nice visual image to explain very simply how this type of self stabilising profile works: It is like a weathervane which is constantly moving about to stay facing into the wind, the reflex profile always adjusts itself to its favourite angle of attack.

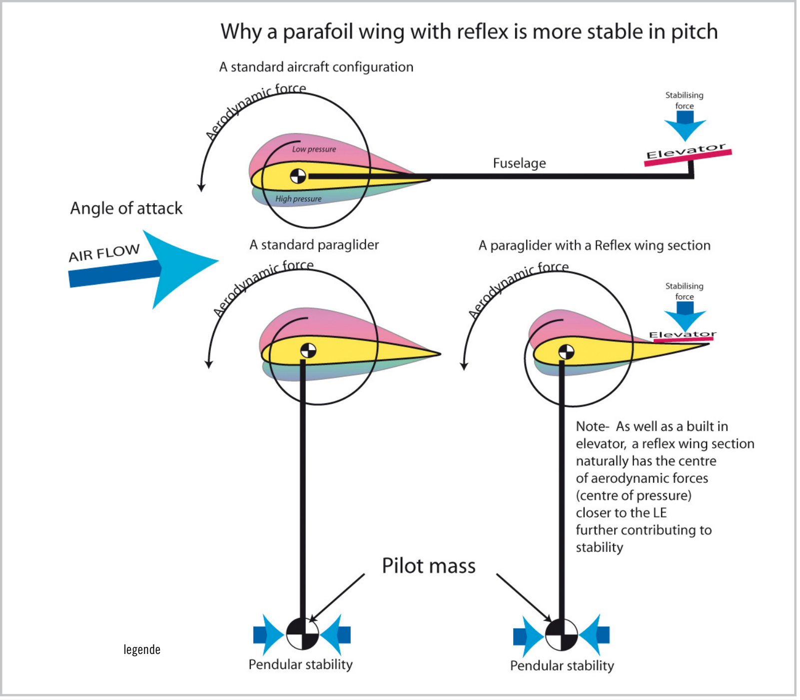
This sort of profile doesn't necessarily give a lower minimum angle of attack than that of a classic profile, but the designer can trim the wing nearer to the critical angle of attack, because the wing will hardly go past the angle expected, whereas a classic profile must be trimmed with more margin. The reflex wing can therefore go faster: Trimmers open and using the speed bar, 60-65 km/h can be reached on most full reflex open models.

In this fully accelerated configuration, the reflex profile fully plays its role. It is impressive to note the extent to which these profiles seem impossible to collapse at this point. Even if the pilot hangs with all his weight on the As, he can't provoke a collapse. It is for this reason that the wings are difficult to certify to EN norms. And recently, it has become even more difficult: If using folding lines to provoke a collapse is necessary, the wing can't have an intermediate classification…

But these profiles have disadvantages: They have more drag, so they perform less well, and are thus less well adapted to thermal flying and are greedier in fuel if used for paramotoring.

The Dudek Nucleon: This full reflex wing has been a big commercial success and has achieved a sort of self-certification over time. It is a very widely known wing which, over the years, has proved the system's efficiency.

Photo : Véronique Burkhardt Pilot: Sascha Burkhardt



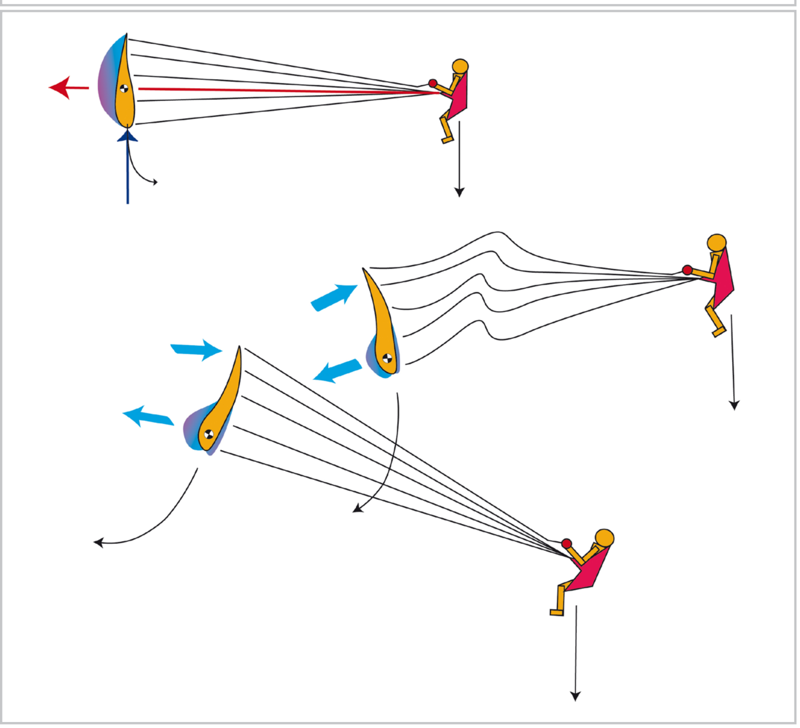
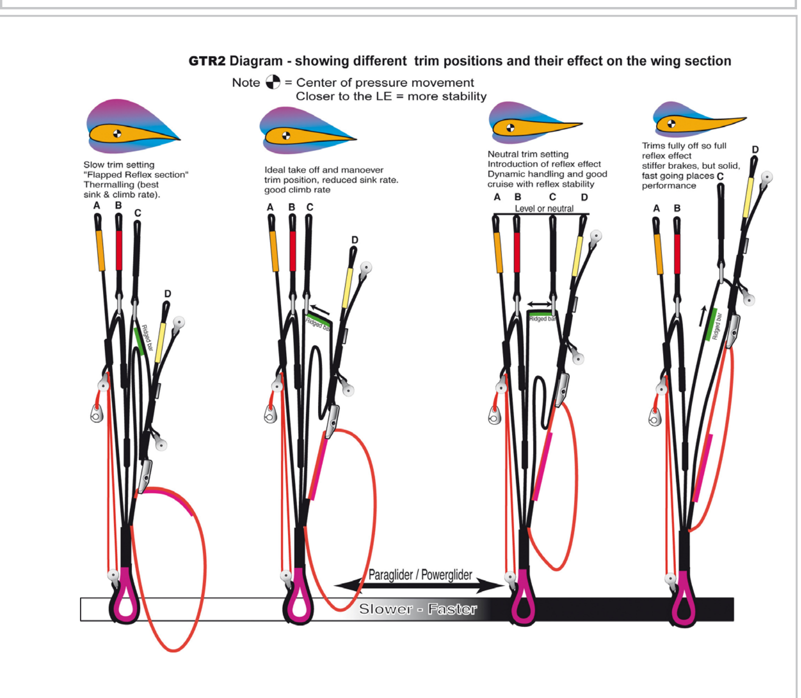
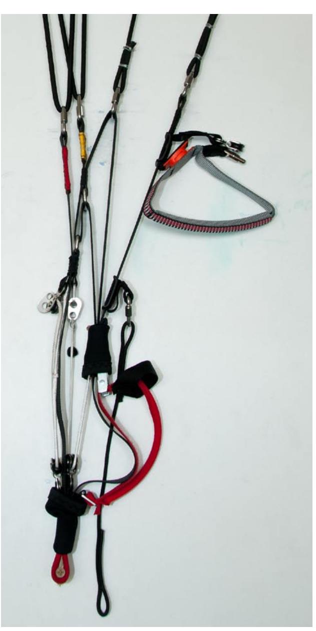


Photo : Véronique Burkhardt Pilot: Sascha Burkhardt

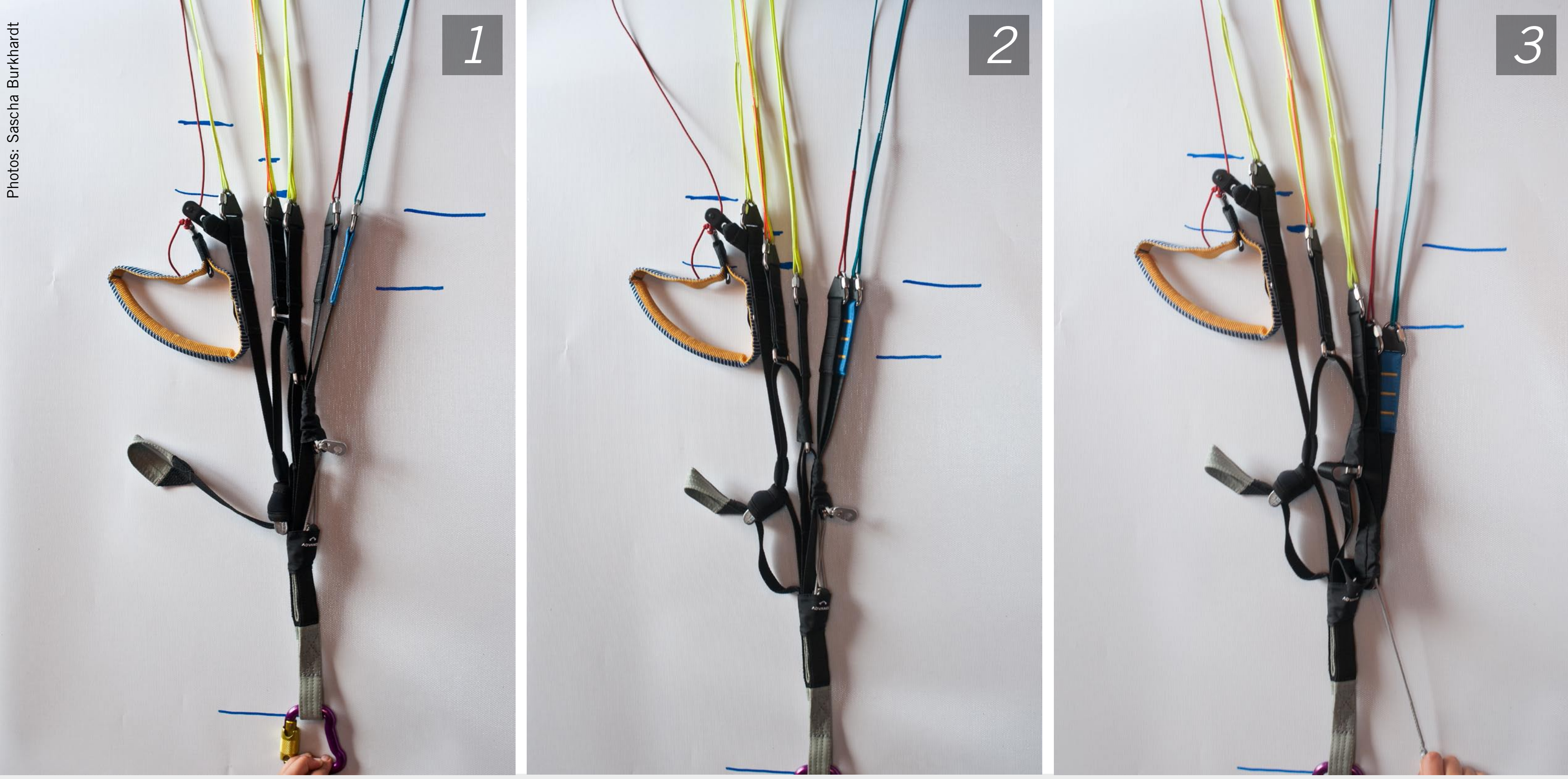


Mike Campbell-Jones from Paramania is the father of the reflex profile in paramotoring. He was the one, eight years ago, who launched the first full reflex models and started spreading the word. Using the diagrams opposite, he was already explaining, back then, the benefits of this technology. Today, most manufacturers of paramotor wings have at least one model with a pronounced reflex profile in their range.



An ingenious system has come out for the first time on Paramania's GTR full reflex wing. The PK-System allows the front and the back to be linked so that everything can be controlled using the speed bar. If you push it right down, it also releases the back as if you were letting off the trimmers. It is especially useful for slalom competitions…

Photos: Sascha Burkhardt



A riser for both paragliders and paramotors from a wing with a classic profile with trimmers and foot operated accelerator. They are made to be used exclusively with one system or the other to increase speed, and it is generally forbidden to use both simultaneously as in the picture on the right otherwise you can have a huge front collapse very easily. Conversely, on full reflex wings, simultaneous usage is perfectly normal. On the other hand, with certain older reflex wings (Paramania Action, Dudek Plasma), it is forbidden to use the foot accelerator if the pilot hasn't taken the trimmers off beforehand!

The Dudek Universal: A wing with a pronounced reflex profile, designed to be used both for free flying and with a paramotor. Following our tests, we still consider it a wing which is more at home with a paramotor.

Photo : Norbert Aprissnig

On the other hand, one of the arguments against the self stabilising profiles, often given for the earliest models, is no longer correct: The difficulty of inflating and the slow handling at takeoff of a paramotor wing has practically disappeared in recent models.

That is perhaps why, at the 2013 Coupe Icare, Dudek launched a wing designed to be as good for free flying as for paramotoring, and whose profile is a full reflex: The Universal. We have been able to test it and we feel that it is still a bit more orientated towards paramotoring than paragliding because while free flying in thermals, it still lacks a bit of manoeuvrability and performance compared to a dedicated paragliding wing, although it is close to being a very good compromise.

Finally one last point about reflexes: Some professional pilots advise completely de-trimming when it is turbulent; it's true that the more you de-trim this type of profile, the more stable it becomes. However, in this configuration, you can no longer touch the brakes as that would break the reflex. You need to fly using the auxiliary controls, present on all full reflex wings. These are lines connected to the stabilo (laterally and/or on the trailing edge at the end of the wing).

But at the same time, we need to remember that despite this incredible resistance to collapses, all non rigid wings can end up collapsing in violent turbulence. Reactions at high speed can thus be 'sporty'. For this reason, the majority of pilots, in strong turbulence, come back to moderate trim: Trimmers slightly open and no speed bar. The wing thus benefits from a certain amount of reflex, but still stays manoeuvrable and allows the pilot to use the normal controls.

Combining two fashions: A wing with a small surface area and a SharkNose, the Zero from Ozone.

SPEED ACCORDING TO SURFACE

There remains another possible way of increasing a paraglider's speed: Increasing its wing loading, by reducing the surface area. It is clearly in the air these days. Over recent years, surface areas have been greatly reduced in one domain with the advent of the mini wings (initially used for speed riding), which are gaining more and more popularity with serious pilots for thermaling and indeed for XC flying… And even in the range of normal paragliders, fashion is moving towards a slight reduction in surface area.

Photo: Véronique Burkhardt Pilot: Sascha Burkhardt

A paraglider with variable geometry: Team 5's Blue Two tandem allows you to change the size between two flights. By simply doing up a zip you lose three cells and the wing changes from 42 m2 to 38 m2. A gain in speed at the all up weight, which was constant during our tests, at about 3 km/h.

An increase in the wing loading gives a noticeably different speed. The simplest way to convince yourself is to increase the weight in flight, which is equivalent to reducing the surface area. A wing whose speed with hands up is 35 km/h loaded with 70 kg, will fly at around 40 km/h with 90 kg.

Therefore why not radically diminish the surface area to increase the speed? Theoretically, a wing scaled down by a quarter, or even half, should keep the same glide angle, whilst gaining speed along the trajectory, thus also gaining speed whilst going into valley winds…

Two years ago, the Kougar introduced a big dose of reflex at Niviuk. During the summer of 2014, the Kougar 2 will make its appearance…

Photo : Karen Skinner/Niviuk

Photo: Gudurn Öchsl/www.profly.org

The ultimate punishment at the limit of angle of attack: A massive collapse shows the speed limit. In the end it isn't as stupid as all that: Like a fuse, this behaviour is a warning that you are going too fast, something which can break the structure of other more solid aircraft due to vibration and resonance…

Photo : Véronique Burkhardt

FreeSpee's speed bar can be adjusted in flight, so you are sure of being able to use the total range, even after changing wings. It is produced with a single or a double step. (Price about 60/64 euros + P&P) http://free-spee.subraumstudio.com

Yes but, in reality, it doesn't work as easily as that. On one hand, air flow around a smaller wing isn't the same as around the same wing on a bigger scale because the viscosity of the air stays the same for both… The parasitic drag of the pilot and the lines doesn't change proportionally either with the reduction in surface.

For small surface areas, and it is even true with an all up weight scaled to the size, giving an identical wing loading, the manufacturers often have more difficulty getting into the certified category they want. In addition, the useful travel of the controls is reduced in smaller wings, which makes controlling their behaviour even more difficult for the pilot. And then you need to consider a more technical take off and a higher sink rate. Even if the glide angle of the wing stays completely unchanged after the increase in wing loading, the sink rate will increase and require a better climb…

INCREASING SPEED: A SUMMARY

We need to find a good compromise when it comes to surface area, the choice of profile, adding ways to maintain performance (leading edge rods)… The fashion is becoming clear: A reasonable reduction in the surface, an increase in the internal pressure (innovations like the SharkNose) and increasing the amount of reflex (including for free flight wings). ■

After several years of R&D and tests, the manufacturer Swing also went for the reflex and brought out the Scorpion in 2012.

Photo: Franck Simonnet

Photos: Sascha Burkhardt

With the 6030 model, Flytec was the first manufacturer to make a vario with a built in pitot tube which could really be used whilst paragliding. Before then, probes were only usable at higher speeds, on a hang glider for example. The tube must be positioned in air flow with a +/-15°accuracy so, it is reasonably tolerant…

MEASURING SPEED

Speed isn't speed: One model gives many values, all correct for maximum speed, even with identical wing loading…

Often, when choosing a new paraglider, pilots compare the speeds very closely, 1 or 2 km/h more claimed for one model can swing the decision of whether to buy or not. Yet, in the tables, the manufacturers don't say under what conditions the measurements were obtained. However, depending on the method used to measure them and the influence of other factors, the results can differ radically… So for a start, you need to know the wing loading when the readings were obtained. For example a 25 m2 wing where the certified all up weight is 80 – 100 kg can theoretically differ, depending on the load, from 51 km/h to 57 km/h.

The actual speed depends on the density of the air, and so it also depends on the altitude, the air pressure on the day and the temperature. The higher we are, the faster we fly. Equally we fly faster if it is hot or if the pressure drops.

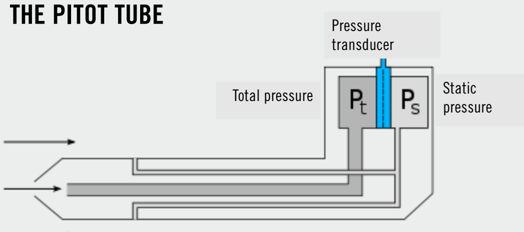
And then there is atmospheric pressure on the day, the altitude, the air temperature, the way it is measured… A wing flying at 50 km/h at sea level will reach 55 km/h at 2000 metres; the difference is about 4.5 % per 1000 metres in a standard atmosphere. If it is colder higher up, the difference is less (about 1.7 % difference per 10° of change).

IAS OR TAS?

And finally, how is the reading obtained? Instruments with cups or rotors like the well known Skywatch, give the real speed, the True Air Speed or TAS. At 2000 metres altitude, they show 55 km/h instead of 50 km/h. Their reading corresponds more or less to that which we can read on a GPS if the wind is zero.

1. Recently the manufacturer Flymaster also brought out an airspeed probe with a pitot tube. When orientating it into the relative air flow, Flymaster claim a tolerance of +/- 20°; within these limits, the error is negligible. In fact, we found during our tests that the speed readings seem very stable and reliable throughout the flight, even when the probe is attached to the risers. The probe measures IAS, which is independent of altitude, temperature and pressure on the day, but the instrument calculates and displays TAS. Displaying IAS is an option which will soon be available.
2. The instrument comes in a little case. The pitot tube is protected by a cover which says "Remove before Flight"; it is like being a grown up with a big plane!
3. The probe is powered by a 1.5 v battery. It communicates wirelessly with all of Flymaster's recent instruments, transmitting speed and a very precise temperature value. The latter will also be used in a 'thermal sniffer' algorithm which will be integrated into a future vario update. As always, the pilot will be able to download it from the internet as soon as it comes out.   .
4. The main opening on the pitot tube.
5. The little hole at the side measures the static pressure.

THE PITOT TUBE



Dr.Wessmann

The cordless speed probe costs 150 euros.
For more information: www.flymaster-avionics.com

Photos : Sascha Burkhardt

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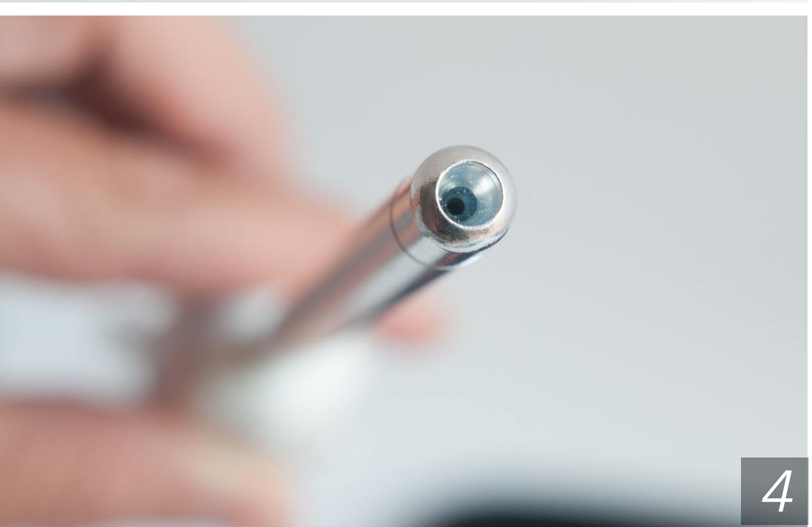

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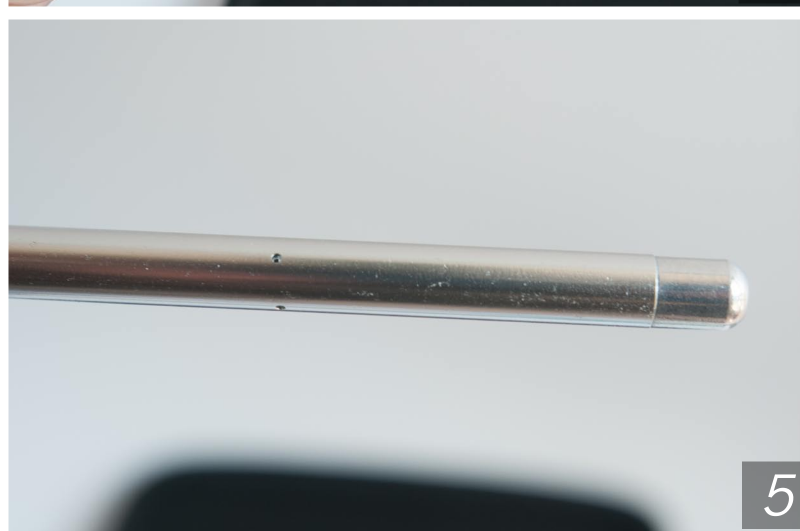

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Photo: Sascha Burkhardt

Top: the original Skywatch from JDC; it was a great help to us 20 years ago! At take off, it gave us the wind speed and, whilst flying, the airspeed. Like all anemometric instruments with blades, it displayed the TAS, the real speed in the air. The higher you are, the greater the speed displayed. When measuring the wind at take off at high altitude, it also shows a higher value. Don't be misled: The pilot can take off with a higher wind speed, because he flies faster…

Left, Skywatch's GEOS 11: A very precise instrument, also used by scientists and the military. Apart from wind speed, it also displays a compass, temperature, atmospheric pressure as well as the dew point.
Its price is, as a consequence, rather high: 476 euros.

For more information: www.jdc.ch

On the other hand, pitot tube instruments that measure airspeed by measuring the pressure induced by the airflow always display, if no correction is calculated, the same maximum speed for a given wing, whether at sea level or at the same height as Mont Blanc, and whatever the temperature and the pressure that day.

The reason can be expressed in a simplified manner: The wing flies faster at altitude because it needs a faster airflow, because the air is less dense, to get the same lifting force in the air. These instruments showing the Indicated Air Speed (IAS) therefore lie, and their measurement doesn't correspond to the real speed of our movement, and therefore not to the progression of our XC flight.

The latest product from Skywatch: The Windoo is compatible with different Apple or Android smartphones, such as the iPhone 5 or the iPhone 4s, the Samsung Galaxy S3, S4, S4 mini, etc…
It is made from anodised aluminium, its rotor is in stainless steel and its case is carbon fibre. It comes in several versions: The Windoo1 measures wind speed and temperature and costs 59 euros, the Windoo 2, for 79 euros, adds humidity and the Windoo 3, for 99 euros, adds pressure.
All the values can be shared via a social weather network which the manufacturer has put in place.

For more information:
www.windoo.ch

On the other hand, as a means of judging the aerodynamic conditions around our wings, the lie is justified: The wing will always stall at the same value indicated, whether at sea level on a winter's day or flying around Mont Blanc in the middle of summer.

Yet the manufacturers of pitot tube paragliding instruments (Flytec, Flymaster) calculate the TAS from the IAS and show us the latter as standard because, during a classic flight, we don't really want to measure the polar curve of our wing, but rather know the speed at which we are travelling over the countryside.

And to know our speed at the stall point, there is no need to measure our airspeed. Contrary to what happens with other aircraft, the static stall point of a paraglider always happens with the brakes in the same position* no matter what the altitude…

* Obviously not true if you are using trimmers…

The Vaavud costs 45 euros and it is compatible with different Apple and Android smartphones.

This instrument doesn't contain any electronics; the rotation of the anemometer is determined due to the magnets in the cups, which modify the magnetic field around the telephone in a cyclical fashion.

As with all instruments with cups, it measures TAS, which changes as a function of atmospheric pressure, temperature and altitude.

www.vaavud.com