SharkNose Technology

Introduction:

In mid-September our patent n° 2972422 was published with the rather long heading "Hollow sail with opening located inside a reinforced part of the leading edge".

This is an opportunity to discuss what we more commonly call the "SharkNose".

In the first part, we'll explain the usual constraints and compromises caused by the placement of the air intakes on a paraglider, and secondly we will reveal the functional advantages and the secrets of the SharkNose.

Finally we will detail our viewpoint on this technology clarify the patent's purpose.

State of the Art :

A paraglider is a flexible air-foil under which the pilot is suspended. In order to enable us to fly, the air-foil has an aerodynamically shaped profile, which generates lift. The lifting forces also exert a force which "stretches" the glider along its span. However, along the chord the aerodynamic forces are virtually useless.

It is the internal pressure in the sail which "stretches" the glider along the chord axis.

We have recently proven, with the XXLite (LINK), that it is possible for a wing to fly without internal pressure (the air-foil being open due to the almost total lack of a bottom surface). During our performance testing with this single-surface design, we tried variances on its angle of incidence.

Varying the angle of attack, of course, allows us to vary the speed of the aircraft.

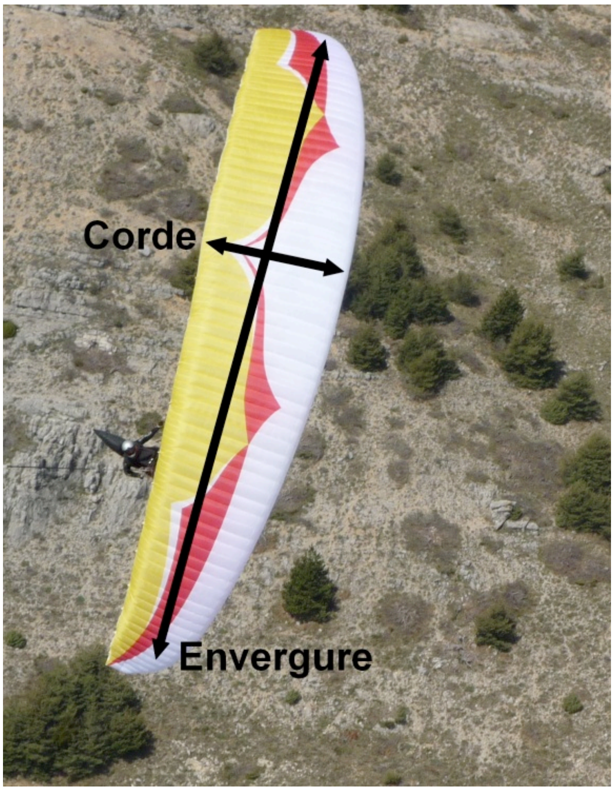

Fig1: span and chord of the glider

The higher the internal pressure, the better the mechanical stability of the sail.

A designer should therefore attempt to maximise internal pressure.

However, internal pressure has a certain limit which cannot be exceeded.

The area of the profile which is perpendicular to the direction of the air particles is called the stagnation point.

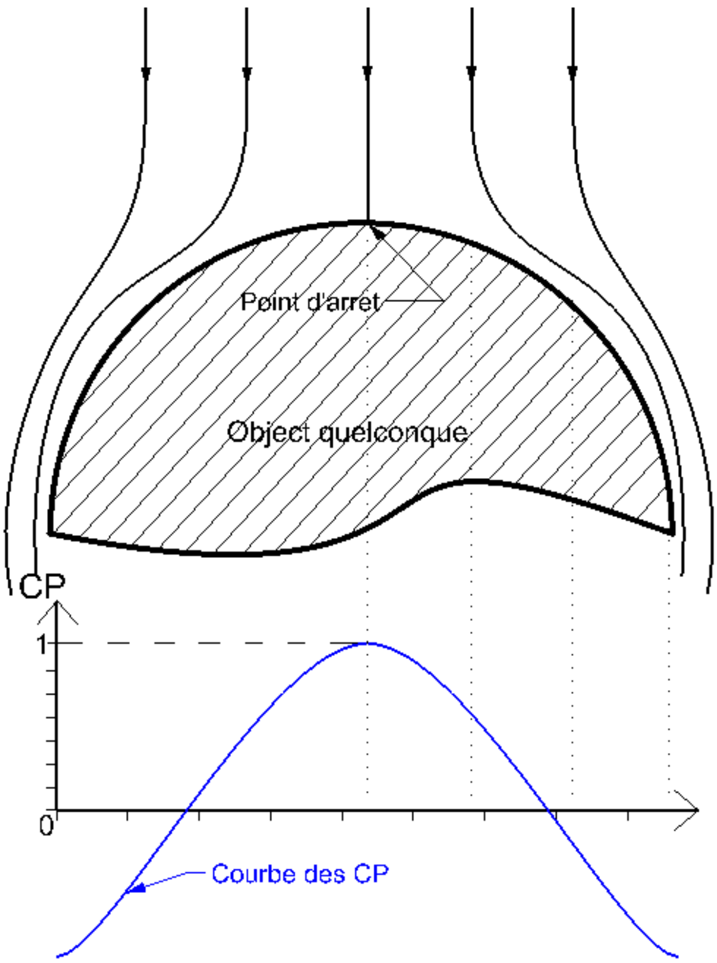

Fig2 : stagnation point and pressure coefficient curve.

It is at that point that the airstream separates into two parts, one part will flow the top surface and the other over the bottom surface.

For a given flying speed, pressure is at a maximum at the stagnation point. This pressure shall be the reference for all other pressures in the rest of this article (and in all literature on the subject for that matter).

Pressure is expressed as a Pressure Coefficient (PC), such that pressure at the stagnation point is equal to 1. PC = 1.

PC = 0.5 means that pressure measured at that point is equal to half the pressure at the stagnation point.

Therefore one needs to place the air intake at the stagnation point in order to get internal pressure with a PC of 1. However the stagnation point isn't fixed along the profile, it moves according to incidence.

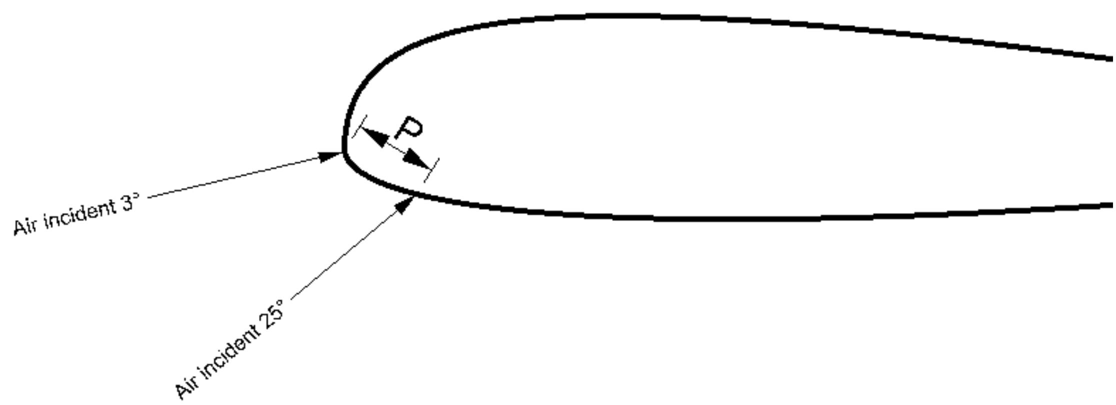

Fig3 : Stagnation point for angles of attack ranging from 3° to 25°. "P" designates the range of travel of the stagnation point.

The compromise is therefore :

- If the air intake is located near the front of the stagnation point range, we get excellent internal pressure at low angles of attack (i.e. accelerated), but not at all at high angles (i.e. when brake is applied); this will produce a glider with poor inflation characteristics and which won't exit parachutal stalls easily.

- If the air intake is located towards the back of the stagnation point's range, it is the opposite: good pressure at high angles with long brake travel. But at low angles of attack pressure will be very low and the sail won't retain its shape when accelerated (meaning a loss of performance) and after a certain angle the air intake will enter a depressurised area and produce a frontal collapse.

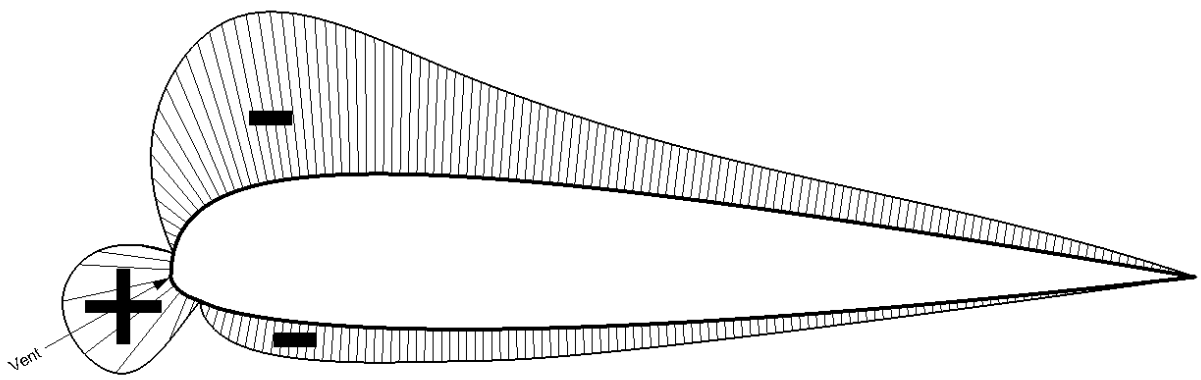

Fig4 : Areas of high and low pressure along the profile for a given angle of incidence..

So what to do?

In most cases the air intake is located in the middle of the range and is rather large in size, which is the accepted compromise most designers live with.

But, let's try to improve on that:

One of the solutions would be to make the intake as large as the range of travel. Unfortunately, pressure inside the glider isn't equal to the sum of pressure at the air intake but more something like the average (in the same way that adding water at 20°C to water at 30°C doesn't produce a water temperature of 50°C). A paraglider with a very large air intake would end up with less internal pressure than a glider with classic air intakes, moreover with bad flight behaviour at high angles of attack: difficult exit from parachutal stalls and full stalls, flat spin tendencies and bad behaviour at low angles: sail deformation and frontal collapses.

Another solution is to use valves, for example two air intakes, with a valve behind each intake which closes when internal pressure is superior to internal pressure in front of the air intake. The idea works very well in theory but is very hard to put into practice, since it often results in air leaks, which makes it difficult and expensive to manufacture. The construction technique also produces drag-inducing folds on the surface of the glider. I think most manufacturers have tried to find a solution with valves, but none have demonstrated any real advantage and often the idea wasn't carried over from one model to the next with only a few exceptions (mostly on acro gliders) perhaps due to marketing rather than technical considerations.

The last option to improve the compromise is to move the inner surface panel towards the bottom, as shown below:

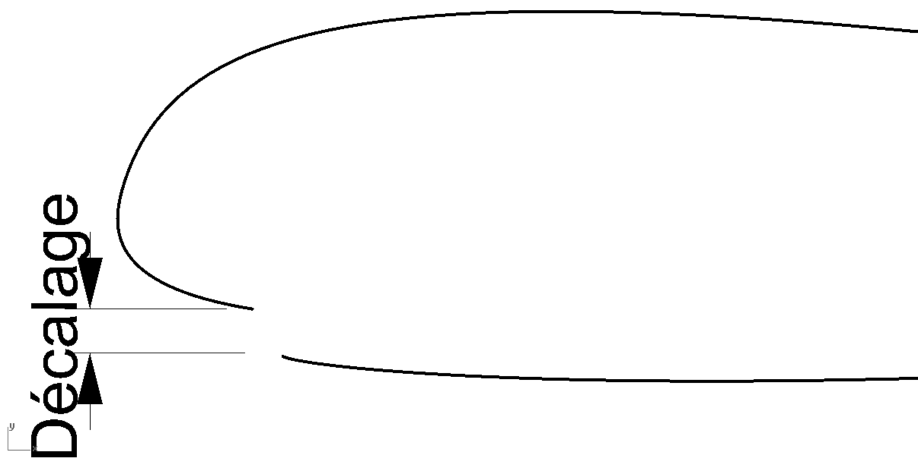

Fig5 : Profile with offset inner surface

This profile shape enables to set back the air intake while keeping a satisfactory amount of internal pressure at low angles of attack. The drawback of this profile is that creates a step in the airflow; it generates increased drag at low angles of attack and in the event of a stall this step will create turbulence at the intake. This does not help recovery.

Here are two explanatory drawings :

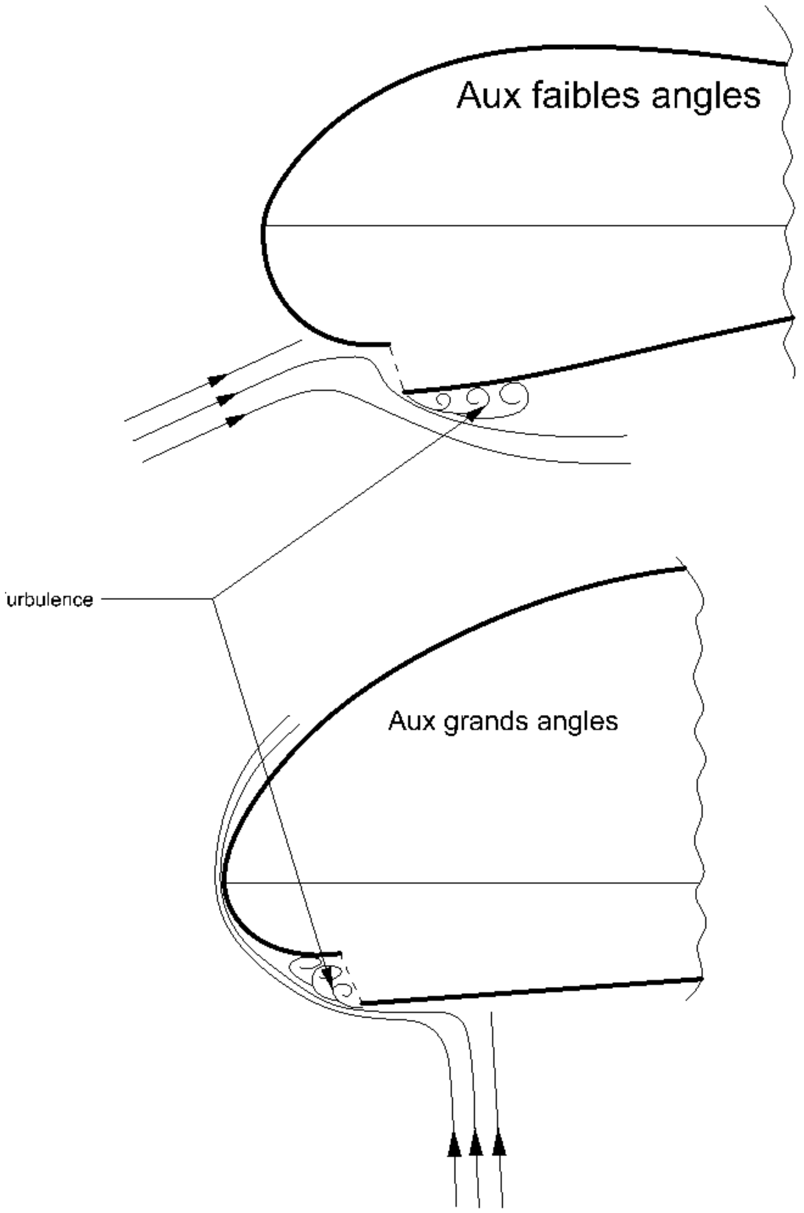

Fig6 : Illustration of high and low angles on profiles with offset inner surface

Shark Nose

The idea behind the Shark Nose is to add a concave part in the usual range of the stagnation point.

This concave part will greatly reduce the size of the stagnation point's range. Before we go any further the following drawing will help visualise the concept :

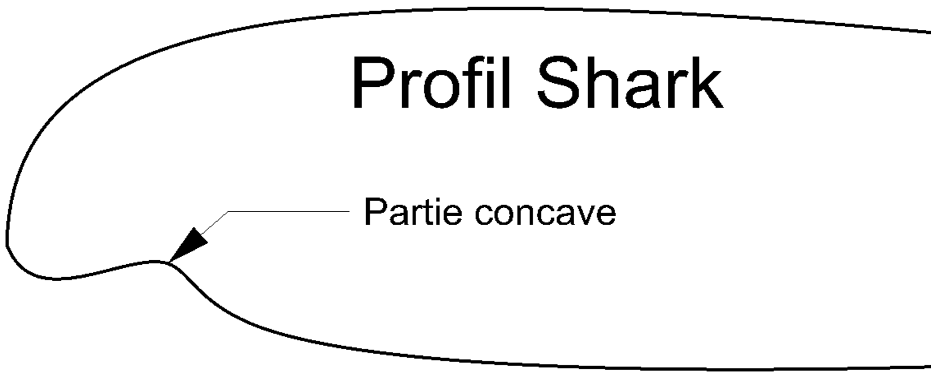

Fig7 : Basic layout of a SharkNose profile.

This concave part shall be considered as an area where the airflow slows down. It produces the opposite effect to a "venturi" by presenting a larger area where the air will flow more slowly, knowing that the more the airflow slows down in a given area, the closer to 1 the PC of this area will be (the extreme case being zero speed at the stagnation point where PC = 1).

One of the big advantages of a Shark Nose lies in its symmetrical shape; it works in exactly the same way whether the airflow in front of the intake goes one way or the other. Same drawing as fig 6, but with Shark profiles:

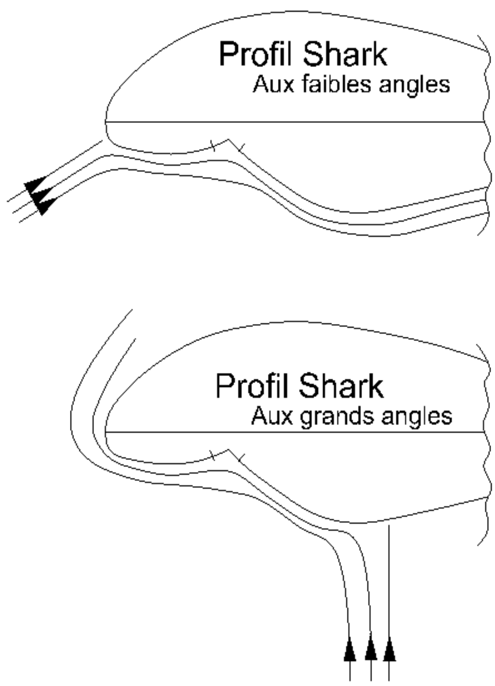

Fig8 : symmetrical airflow situation in front of a shark nose

The symmetrical shape, added to a rounded profile enables a satisfactory behaviour at both low and high angles of attack without added drag.

Moreover, with the stagnation being less mobile, we were able to reduce the size of the intake and therefore to obtain more even pressure in front of it.

Here is a chart showing internal pressure in a traditional profile and in a SharkNose profile according to the angle of attack:

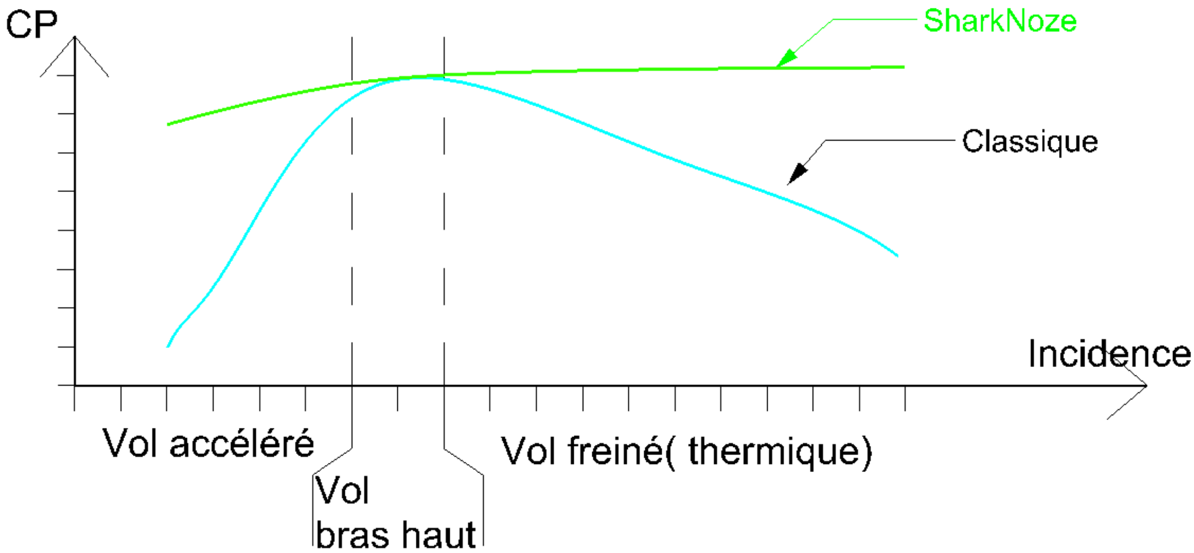

Fig9 : Internal pressure in the glider according to INCIDENCE

Here are two slightly abstract (fig10) but comprehensive graphs, showing pressure along the inner surface according to 3 different angles of incidence for a normal profile and then for a Shark Nose profile.

<u>Key :</u>

In green INCIDENCE 3°, in Turquoise 10° and in Blue 20°

E is the size of the air inlet.

V is the variation of PC at the level of the air intake.

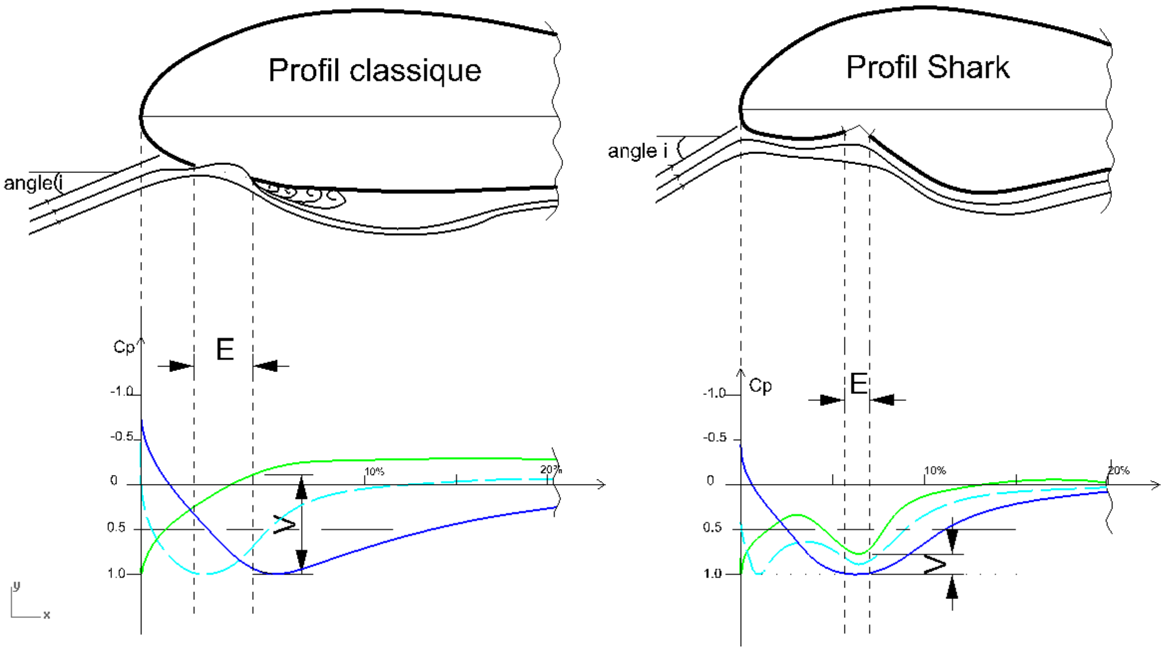

Fig10 : Illustration of CP along the inner surface at three different angles of incidence

The smaller the size of the V range, the easier it is to locate the air intake, the closer the V range is to CP =1, the higher the pressure inside the canopy.

We can clearly see a smaller range for the stagnation point to move along the Shark profile. This is the ideal location for the air intake.

But what are the advantages for the pilot ?

The SharkNose enables :

A glider with greater stall resistance at low speeds and with a longer brake range : this is useful in thermals to give extra speed to the wing in strong lift or when top landing in a tight spot requiring precision.

Added strength for the profile at high speed, the gain in internal pressure allows the R11 to fly at over 70 km/h.

The Shark Nose has allowed the R11 / R12 to become the designs with probably the largest and most useable speed range.

This adds to reduced drag from the air intakes, hence a better glide and, although this is more difficult to link to theory, a better climb rate in thermals.

These conclusions form the basis for our application for a patent.

Let's go over the history of the SharkNose at Ozone.

History and current position.

The first draft of the Shark Nose appeared as we were searching for a profile which would behave properly at low speeds and have high internal pressure at high speed. Having rapidly built an internal rib as a prototype, we validated its technical feasibility and tried simplifying production as best we could.

We decided to build an R10.2 with this profile; having said that, after a week's brainstorming and digital modelling the profile had only the name and origin in common with the first version!

The prototype arrived and after some adjustments to the sail, at last we witnessed the speed improvement we were hoping for, which was in fact much bigger than expected, with bigger brake travel as well. Happiness all around! That is how the R11 project started.

In the meantime we started thinking about writing up the patent.

A few months later, the R11 and the shark profile arrived in the hands of pilots and shortly thereafter, dominated the 2011 season.

Later in the year, politics took over and "Open Class" gliders were banned from competition.

We started working on a certified competition glider: several prototypes were tested, the shark versions flew well but being the first to bring a glider of this type to certification, we decided not to rock the boat: an EN D glider with 2 lines and an aspect ratio of 7.5 was already enough of a shock.

Other brands produced a competition wing, some with their own SharkNose, which displayed the same advantages as ours.

In the meantime at Ozone, research and tests continued at full steam, constantly improving the design. Our patent application at INPI made slow progress in the administrative validation procedure.

Finally we received the validation letter for our patent in November 2011 and it was published in September 2012.

The big question was: what are we going to do with the patent?

In theory a patent provides the holder – under the condition that the technology is made public – with a legal advantage in order to prevent it from being used by a competitor, or to set up a licensing system.

It is worth pointing out that in a patent everything is explained, much like in an instruction manual.

Since Ozone has no wish to seek royalty payments or to get involved in litigation - as our goal is simply to obtain the best designs possible – we have decided to leave the patent free to use but we will simply ask for a small logo to be displayed in the wing.

We are proud to be able to share this innovative design and the fact that it contributes to the evolution of our sport is a source of great satisfaction to us.

From our point of view, we are continuing to develop the SharkNose and we are starting to apply it to other exciting new wings in our range, such as the Delta 2.

Happy flights to all, ☺

Fred Pieri

Glossary :

Chord : this is the line going from the leading edge to the trailing edge along a rib.

Span : distance between the two tips of the glider, perpendicular to the chord.

Shark Nose : the name of our technology explained in this article, obviously coming from the shape of the profile's forward section.