Several years ago we decided to get serious about making an all out high performance canopy that would be a significant step up from anything currently available.

This is not really a comparatively large canopy market but developing a high performance canopy was both a passion for us and an opportunity to prove ourselves in the most difficult and highest profile market in the sport.

It was definitely going to be ZP and Elliptical but after many different prototypes of conventional construction we realized nothing came close to the improvement in performance we achieved years previously with a rectangular ZP Cross Brace Tri-cell. At the time we gave up on this design due to construction, bulk and opening problems. In 1993 technological changes led us to start work on it again.

Background

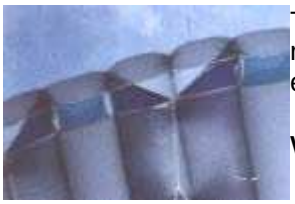
In early 1994 we installed a computerized plotter/cutter and had software customized to calculate the shapes. We were then able to begin computer modeling and building our first Zero P, Elliptical Cross Brace Tri-cell. The ICARUS EXTreme. It flew brilliantly straight off the computer but was far from useable. Another year of development was required to get the design to the stage where we had a viable product and enough testing to release it into the market.

With the successes we were having with the EXTreme we were really motivated to take the concept even further. After watching the canopy in the field for a couple of years we thought there were several areas we could improve on or change without detriment to the design. We had also been experimenting with our canopies in a low speed wind tunnel, (built for testing sails for the America's Cup). This gives us the capability to quantify performance changes very accurately. Using this facility we have managed to optimize several aspects of the canopy with new trims and shaping.

Because a Cross Braced Tri-Cell has a smooth cell structure this has allowed us to enclose the nose of the airfoil to give an almost complete wing. This has the effect of significantly reducing cell mouth drag, which makes up a large proportion of a ram air canopy's drag.

In January 1997 we completed testing and released our latest Cross Brace Tri-cell - The ICARUS EXTreme-FX. The name stands for E lliptical Cross braced T ri-cell (EXTreme - EXTreme-FX)

The ICARUS EXTreme-FX delivers even smoother openings, an even stronger flare, and packs up slightly smaller than the EXTreme. Most importantly, the EXTreme-FX will now give you turf surfing performance that is WAY AHEAD of anything you will get from a conventional canopy.



The EXTreme-FX is not for everybody. It's built specifically for radical maneuverability and is ideal for turf surfing. It is for experienced elliptical pilots only.

What is a Cross Brace Tri-cell?

Cross Brace Tri-cell means the cell is divided into three chambers instead of two and the chambers are diagonally braced to force each cell back into shape.

Normally when you look at a canopy from the front it has a zigzag appearance. The cells are deformed because of the lack of any internal support with only a free floating, non load bearing rib between them. However, if you look at the front of a Cross Brace Tri-cell both the upper and lower surfaces appear smooth.

Where did the idea come from?

PD originated the idea with a parachute called the Excalaber in the late eighties. It was a rectangular Cross Brace Tri-cell made from F-111 and in its day it was awesome. The Excalaber out performed anything else available at the time.
It was eventually superseded by zero-p parachutes which out performed the Excalaber, using only conventional construction.

What are the advantages?

- There is less drag because there are less lines. In effect the canopy is a 7 cell not a 9 cell, yet is almost an 11 cell in shape
- The canopy is more rigid in flight. Due to the triangulation of the cell structure the cells are "locked" into position rather than being free floating and able to breath.
- The canopy surfaces are less distorted. As we know a ram air canopy inflates to form a wing. Ideally it would be smooth and straight like an airplane wing, however as it is not a rigid structure but made from an inflating membrane the surfaces will distort, significantly reducing their effectiveness. There are 3 different types of distortion which occur:

1. Spanwise distortion (bulge and zig zag),
2. Dynamic distortion (on landing),
3. Spanwise consistency (wing tip shape).

Spanwise Distortion

When a ram air canopy inflates the canopy surfaces bulge between the ribs with the air pressure. This both effects the airfoil shape and draws the ribs closer together reducing the span of the canopy (and therefore the surface area). The more ribs we have, the less distortion and shrinkage occurs but bulk and line drag increase. On a conventional canopy not only do the cells bulge they also zigzag up and down between load bearing and non-load bearing ribs, further distorting the canopy and reducing its span/area even more.

To quantify this, bulge distortion alone reduces a 9-cell canopy area by 9% and zig zag distortion by a further 4%. Say you are jumping a PIA measured 100sf canopy, you are actually flying around with 87sf of wing area above your head.

With the EXTreme-FX you still get the bulge distortion (reduced slightly through 21 chambers instead of 18) but zig zag distortion is eliminated completely. On a 100sf EXTreme-FX, bulge distortion will reduce your area by only 8% and that is all. So you

still have 92sf of wing above your head (compared to 87sf), 5% more lifting area and no extra drag (less in fact).

Now that you have this concept in mind, consider this.

Dynamic Distortion

When you look at a photo of a conventional canopy flying on full drive the zig zag appearance is obvious, but look at a landing canopy photo and you will see the zig zag appears much more pronounced - IT IS !

During your flare your canopy is both, slowing down and pulling more load, which is reducing the supporting pressure within your canopy and pulling it further out of shape. In fact, during your flare your zig zag distortion will increase a further 7-9%, to around 12%. Add to this our bulge distortion and our 100sf canopy is now giving us 79sf of lifting area when we land.

Now look at the photo on the cover of our brochure. As you can see, even at the very end of the flare there is no zig zag distortion at all. You are landing with 92sf of lifting area, compared with 79sf. A MASSIVE difference of 16.4%.

Our figures come from physical measurements taken of models inside the wind tunnel and have been proven in practice through building very useable small canopies, to date down to 46sq ft for the VX. Imaging landing a 46 sq ft conventional canopy.

"AH HA !!" you think, why not just buy a 16% larger conventional canopy ? It will still land me softly, pack down smaller and save me a bundle" - and you would be right except for one thing. This larger canopy would also have 16.4% more drag therefore you would fly slower, turn slower and swoop in for landing slower than the EXTreme-FX and (as well as being less fun) this airspeed is what you are using to produce your landing lift.

Spanwise Consistency

On an airplane wing the airfoil usually gets proportionally thinner towards the wing tips to help reduce some induced wingtip drag. On an elliptical canopy the cells are usually the same width right across the canopy. At the wing tips the canopy is shorter meaning the cell is proportionally wider and thus will proportionally bulge more and produce a proportionally deeper airfoil at the tips - exactly what we don't want. Often designers have dealt with this by adding extra non load bearing ribs into the end cells to help contain this distortion.

On the EXTreme-FX we have gone one step further by keeping every cell on the canopy at an equal aspect ratio. If you compare the cells in the center with the wing tips you will see they are narrower and the airfoil depth does remain totally consistent over the span of the canopy.

In summary, the EXTreme-FX will totally eliminate both zig zag and dynamic distortion, marginally reduce bulge distortion and will deliver spanwise consistency to reduce wingtip drag.

What does this mean to you?

As with previous steps forward in parachute design the extra performance is realised by being able to reduce the size of the canopy.

When jumping a similar size canopy you will actually lower your decent rate and therefore fly and turn slower. Although this technically represents an improvement in performance it is not what we were trying to achieve.

Reducing the canopy area by say 10% over your conventional elliptical ZP canopy will give a good benchmark for comparison. With a 10% reduction in area you would find:

1. Descent rate is comparable
2. Forward speed is greater
3. Turn speeds are therefore faster
4. The canopy feels rigid in flight
5. The range of control is greater (the canopy also flies better at slow speeds.)

This all adds up to MORE LIFT.

How noticeable is this extra lift?

On a lightly loaded canopy the extra performance generally isn't that noticeable but when we get to extremes and the canopy is 'heavily loaded' it becomes very noticeable.

This is the same for most performance steps. For example, the difference between an F-111 230 sq. ft. and ZP 230 sq. ft. canopy is not that much but you can imagine the difference when a 95 sq. ft. F-111 canopy is compared with a 95 sq. ft. ZP.

By 'heavily loaded' we don't just mean a big person under a small canopy. When a canopy is being flown hard and the person under it is pulling a lot of G's their weight in the harness is greatly increased. At that time extra little bits of performance really start to add up.

You may have noticed conventional elliptical landing performance starts to drop off at a steady flight wing loading above about 1.7 PSF (pounds per square foot). They are more radical and still easily useable but not as efficient. This is due in part to the parasitic drag of the jumper, and other non lift producing objects. As a canopy reduces in size this drag becomes a larger proportion of the flying unit as they do not reduce relative to the canopy's size reduction. The performance drop on a conventional canopy is also due to the effects of dynamic distortion.

With the EXTreme-FX this landing performance drop off does not start occurring until a steady flight wing loading of around 2.00 PSF is reached. (In testing we have taken them to 3.1 PSF.)

During a landing maneuver you may be pulling 1.5G's, and say 1.2 G's at the beginning of your surf. This is where you realize the extra performance.

Going to a smaller canopy has a compounding effect: Smaller canopy = more maneuverability = greater airspeed = more G's = canopy maintains performance = canopy responds = can go smaller etc....until you reach this performance drop off.

We are not suggesting you load your canopy to 2.00 PSF, but just demonstrating that the "performance envelope" carries further and becomes more noticeable.

If you are wanting to jump a canopy of 1.2 PSF or below then there is not that much of a performance gain. You are probably better off sticking to conventional canopies (we make them too). But if you want to jump a canopy above 1.4 PSF you will notice this

improved performance considerably.

Openings

For us, the biggest hurdle to designing a zero-p cross brace tri-cell has always been the openings. We've had a lot of trouble with them ever since we just about maimed ourselves under the first one we made in 1993. We spent a lot of time getting them first acceptable then improving them to the stage we have them now.

The EXTreme-FX openings are mainly controlled by the nose configuration and are very slow and progressive. As soon as the canopy comes out of the bag it starts to inflate immediately and slowly. You know things are happening straight away and you can monitor the opening as it slowly grows into a full canopy. You won't be screaming earthward with a streamer at line stretch wondering when things are going to happen. Openings take a long time but do not use much too much height as the majority of the opening sequence is waiting for inflation to finish rather than inflation to start.

Most elliptical canopies have a high proportion of off heading openings and the EXTreme-FX is no exception. However by slowing down the opening sequence we have managed to eliminate the steep dive that commonly occurs with conventional ellipticals immediately after opening. With the EXTreme-FX, off heading openings are quite tame as the canopy is either streaming and not flying at all, or is growing and has stopped flicking around, meaning the canopy has time to settle before it tries to fly. Off heading openings on the EXTreme-FX are therefore not such a big problem and will cause less malfunctions, as well as leaving your nerves intact.

Another reason we made the openings this slow is because zero-p canopies tend to get occasional rogue openings (these are sometimes put down to line dump). By slowing down the entire opening sequence we've made those rogue openings acceptable and not a killer. That balances it out.

Overall, the openings are better than under any other ellipticals we've jumped, although not as nice as you would get under a 500 jump F-111 7 cell. The state of the art is not at that stage yet, for any high performance elliptical canopies.

Other flying characteristics

1. Front risering is very heavy as well as smooth and stable with no bucking
2. Canopy stability and pressurization is not a problem
3. Toggle pressure is no different to other ellipticals
4. Overturning is more pronounced than on other ellipticals. Overturning is when the canopy keeps turning after you have finished your turn. You can control it by finishing your turn early (the best technique) or by stopping the turn with opposite toggle. It usually takes people a dozen jumps before they have a 'feel' for it and are adjusting automatically to the amount of overturn.
5. The flare is very powerful but may feel quite late. The "powerband" is deeper into the toggle stroke than on most other canopies.
6. Recovery Arc The size of your canopy's recovery arc is greatly affected by wing loading.

The disadvantage with the small recovery arc many modern canopies have is that you need to (dare I say it) "hook lower" to get the full force of the canopy to carry you down to the ground on full drive. In contrast, the EXTreme-FX has been designed to have a large recovery arc which means you can hook higher, get a lot of speed up from your hook and maintain it longer on full drive until you are ready to flare. You have lots of time to make fine adjustments as you get closer to the ground. Also - the larger the recovery arc, the higher you can do your hook, and the bigger the final height

difference will be between full brakes and full drive. Your hook height will need to be higher but does not have to be judged as accurately or as quickly to remain safe.

When changing from one canopy to another, it is worth getting a serious feel for the flying characteristics of the new canopy before committing yourself to any landing maneuver.

Disadvantages of this canopy design

There are a couple of unavoidable trade-offs with this design. Jumpers went through the same issues when ZP canopies first came out. The pack volume and price will no doubt put a few people off.

1. Pack volume. A regular 9 cell canopy consists of 40 different panels. The EXTreme-FX consists of 53 different panels and an increased amount of material is required to support the cell structure. Consequently a 104 sq. ft. cross brace tri-cell will pack up about the same as a 125 sq. ft. regular zero-p canopy. An approximate 20% increase in pack volume.

You will undoubtedly go down in canopy size but you probably won't want to go down 20% to get the equivalent pack volume (unless you were intending a reduction anyway). So you are more than likely going to end up with a bigger rig than with another canopy.

2. Price. As you can imagine the material and construction time involved is significantly increased when manufacturing a cross brace tri-cell. The EXTreme-FX has more fabric and takes us twice as long to manufacture as a conventional canopy. As there are only 8 line groups the loading is a little higher on each line attachment point so EXTreme-FX reinforcing is sewn throughout the entire parachute

Manufacture

At Icarus Canopies, we computer cut all our canopies with a CAD/CAM (computer aided design/computer aided manufacture) system. We use no patterns or templates and program each order individually into our computer system to customize colors, size and options.

Every model of canopy is available in ANY SIZE you wish. Our cutter marks, labels, then cuts and seals each panel as well as calculating and generating line lengths.

As you can imagine, in an elliptical canopy there are many different shaped panels rather than the same shapes being repeated. With the EXTreme-FX this is even more pronounced as many more panels must be cut and placed to an individual shape and location in order to form a canopy of this structure. To do this by hand would become totally impractical. (Generating the prototype shapes initially took us months of CAD work on a customized canopy design program.)

Each panel is cut to an accuracy of 0.2 millimeters. A high degree of accuracy is required because some of the angles in the cross brace are so acute that if positioned incorrectly the whole parachute will not be shaped correctly. This would defeat the whole purpose of the cross braces pulling the canopy into true.

On all our canopies we use a doubled patch at every line attachment point to eliminate lower surface damage.

Conclusion

The EXTreme-FX is not for everybody - it's not an all round canopy or of much advantage at light wing loadings.

But if you're a bit of a canopy connoisseur who likes flying a canopy and enjoys a radical turf surf then you should definitely consider the Icarus EXTreme

At high wing loadings it will out perform any canopy currently available (with the exeption of the EXTreme VX), it's expensive, it's bulky but it opens well and is a pleasure to fly and land.

This may be the canopy for you

Canopy	Size	Pk Vol	MSW	Weight
	Sq.Ft	Cu.In	Lbs	Lbs
EXTreme-FX 69	69	186	152	3
EXTreme-FX 74	74	200	163	3
EXTreme-FX 79	79	213	174	4
EXTreme-FX 84	84	227	185	4
EXTreme-FX 89	89	240	196	4
EXTreme-FX 94	94	254	207	4
EXTreme-FX 99	99	267	218	4
EXTreme-FX 104	104	281	229	5
EXTreme-FX 109	109	294	240	5
EXTreme-FX 114	114	308	251	5
EXTreme-FX 119	119	321	262	5