Disclaimer - No Warranty

Because of the unavoidable danger associated with the use of this parachute, the manufacturer makes no warranty, either express or implied. It is sold with all faults and without any warranty of fitness for any purpose. The manufacturer also disclaims any liability in tort for damages, direct or consequential, including personal injuries resulting from a defect in design, material or workmanship or manufacturing whether caused by negligence on the part of the manufacturer or otherwise. By using this parachute assembly, or allowing it to be used by others, the user waives any manufacturer liability for personal injuries or other damages arising from such use.

If buyer declines to waive manufacturer liability, buyer may obtain a full purchase price refund by returning the parachute to the manufacturer before use within 30 days from original purchase date with a letter stating why it was returned.

WARNING!

Each time you use this parachute you risk serious bodily injury or death. You can substantially reduce this risk by: (1) assuring every component of the parachute system has been assembled and packed in strict compliance with manufacturer instructions; (2) obtaining proper instruction in the use of this canopy and the rest of your equipment; and (3) operating each component in strict compliance with the operations handbook and safe parachuting practices.

Preface to This Operations Handbook

This handbook is not designed to teach any person how to safely assemble, maintain, or operate this parachute. Persons attempting to jump this parachute without first receiving comprehensive personal training by qualified instructors seriously increase their risk of serious injury or death.

The U.S. Parachute Association (USPA) publishes recommended training procedures for basic parachuting competency, and oversees an international list of USPA Group Members parachuting centers which adhere to its standards. We encourage you to contact USPA at (703) 836-3495 for the Group Member facility in your area.

Because sport parachuting technology and procedures continue to advance, this handbook may contain information that, through time, may become obsolete or otherwise inaccurate. For these reasons, we encourage you to work closely with qualified experts and instructors to help you inspect, assemble, pack, use and maintain this parachute.

Because parachutes are made by people, there is always a chance this product contains human error-based defects. Accordingly, this product must be inspected before first use and before each use thereafter. However, parachute systems sometimes fail to operate properly – even when properly assembled, packed and operated, so you risk serious injury or death each time you use the system.

We also welcome your comments, good or bad, about our products.

For product information/sales/service go to:

Website: http://www.icaruscanopies.aero/contact.htm

This handbook produced by Icarus Canopies, in association with
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Table of Contents

Section 1: Assembly

Your canopy should be assembled by and connected to the harness/container system by a properly rated and certified FAA parachute rigger. The rigger should also agree that your choices for risers, toggles, bridle, deployment bag, pilot chute, harness/ container and other components are all compatible with each other as well as with your new Icarus canopy.

Section 2: Inspection

The better condition your parachute is in, the more likely it is to open properly, fly properly and land properly. Many malfunctions can be reduced or eliminated completely by properly inspecting your parachute to find wear or other damage before it fails during use.

There are three basic inspection levels: Pre-pack, periodic; and rigger/loft.

Pre-Pack Inspection

A parachute system should be inspected each time it is packed. A pre-pack inspection takes only a few minutes and is best done when harness/container and canopy are stretched out prior to packing.

The pre-pack inspection is not a substitute for the more comprehensive periodic or rigger inspections that must be done when the system is first assembled, if damage is suspected, or every 30-90 days.

During your inspection of the entire system, pay special attention to the items listed below. Any damaged or worn parts must be repaired or replaced before jumping the system again.

Main Parachute

The main parachute and its associated components are the part of your system that get the hardest workout and thus are most likely to get worn or suffer damage.

Begin with the pilot chute and bridle. If you don't have a kill-line pilot chute, get one before you jump your canopy– anything other than a kill-line pilot chute is incompatible. Inspect the pilot chute center line for wear, check all sewing for broken stitches, examine the mesh or fabric for tears and wear, and ensure that the pilot chute is securely connected to the bridle. Now inspect the bridle for damage, make sure the pin attachment point is solidly sewn, and that the bridle attachment point is not worn or damaged.

After inspecting the pilot chute and bridle, look at the canopy itself, checking for any tears or damaged seams. Pay extra attention to the slider stops; make sure they are neither damaged nor bent.

Now move down the lines. In particular, check out the lower control lines; they wear out fastest and are sometimes twisted because, unlike suspension lines, they are not anchored. Remove all twists from your lower control lines before packing; this reduces the chance of tension knot/slider hangup malfunctions.

If your canopy is equipped with brake set loops, check them periodically for wear. These finger-trapped loops are especially susceptible to wear and, if not in top shape, can result in premature brake release.

Check the slider for damage; in particular, check that the grommets have no sharp edges. Then check your riser links for tightness – even if you have rubber protectors on them, they can work loose.

After that, examine the risers for broken stitches and excessive wear. Pay particular attention to the 3-ring closing loop condition; be sure it is a) not worn; and b) that it passes over only the small ring. Check the cutaway cable for kinks or other damage.

Reserve container

Make sure the seal is intact and the ripcord pin(s) are seated properly and not bent. The cable must move freely in its housing. The ripcord handle must be properly stowed. If the reserve container is equipped with an automatic activation device (AAD), check it for damage and make sure it still self-tests.

Harness

Inspect the entire harness for broken stitches and excessive wear.

Main Container

The main container closing loop gets the most use and if it is worn out, it can break and result in a premature opening. If there are plastic stiffeners in the main container flaps, inspect them for warping or breakage. Be sure to check your harness-container owner's manual for inspection information specific to that system.

If during your pre-pack inspection you find any excessively worn, damaged or improperly rigged components, bring them to the attention of an appropriately rated FAA-certified parachute rigger before jumping the system again.

A word about “hired” packers

Many jumpers today do not pack their own parachutes; they trust that task to a professional packer. If you choose to use a packer, however, it is important to remember that many of them do not inspect your rig before every pack job. It is still your responsibility to make sure your parachute system is in top shape before you give it to a packer.

U.S. FAA regulations require a main parachute to be packed by either an FAA-certificated rigger or the person jumping it. Other countries may have similar regulations.

Periodic User Inspection

This procedure should be performed during initial assembly and periodically thereafter. It is more thorough than the pre-pack inspection. Take your time doing it and do it in a clean, well-lighted area large enough to spread the parachute out or hang it up.

Inspect your canopy in a careful, systematic way. We recommend starting at the top and working down to the risers, with the canopy attached to the harness/container.

Bridle attachment

Ensure the bridle is correctly attached to the canopy, then check the integrity of the canopy fabric and reinforcement tapes in the area where the bridle ring is attached.

Upper surface

Spread the canopy out on its lower surface and inspect the upper surface for rips, stains, or failed seams.

Lower surface

Turn the canopy over and spread it out to inspect the lower surface for rips, stains, and failed seams. Check the line attachment points and associated stitching for any damage or broken stitches.

Cells and seams

Look inside each cell and inspect each rib from the leading edge to the trailing edge for tears and seam failures. Pay extra attention to line and bridle attachment points.

Suspension lines

Lay the canopy out neatly on one side, stacking each rib on top of the others. Check that all lines in each line group are symmetrical and that the trim differential between each line group is within parameters for this canopy . Check the condition of the stabilizers and slider stops. Check the full length of each line for damage and wear. Look for fraying at all cascades (the Y-shaped junction of two lines) and where each line attaches to the connector link.

Slider

Be sure the fabric isn't torn, that the grommets are undamaged and have no sharp edges, and that they are securely attached to the slider. Be sure every suspension line and both control lines pass through the proper grommet on the slider.

Risers

Be sure the barrels of the connector links are tightened properly (industry standard is finger-tight plus a quarter turn with a wrench. The key here is: a) if you tighten the link too much, you can easily crack the barrel; and b) if you don't tighten the links enough, they can come loose and potentially cause a malfunction. Then make sure the slider stops are properly positioned, and the toggles installed correctly and must match the guide ring and stowage system on the risers.

The rest of the assembly

Follow the instructions in the harness/container manufacturer's owners manual for inspecting the rest of your parachute system.

Rigger/Loft Inspection

Any time your reserve is repacked, your rigger inspects the reserve canopy and container and components at the same time. Many times, people detach the main from the rest of their system. We recommend that you leave your main attached and for an extra fee, your rigger will thoroughly inspect it as well. (NOTE: Be sure to provide your rigger with a copy of this specific handbook, as your copy may be different than another user's handbook).

Section 3: Maintenance

Maintaining your parachute properly is critical to its proper functioning and durability. Poorly maintained parachutes are more prone to damage, poor performance and malfunctions than are parachutes maintained in proper operating condition. Several factors here: Fabric care and storage practices are chief among them.

Fabric Care

Several factors weaken parachutes over time. Parachutes receive wear during packing, deployment and landing. Exposure to sunlight, heat and some household chemicals significantly weaken parachutes. Damage may or may not be obvious.

To reduce the risk of parachute failure and possible serious injury or death, the entire parachute system should be thoroughly inspected every 50 jumps. It should also be inspected whenever it is exposed to a degrading element.

Remember that some chemicals will continue to degrade the parachute long after initial exposure. Regular and thorough inspections are necessary to ensure the parachute's integrity, reliability, and flight characteristics.

Always know the entire life history of every part of your parachute system. That way you'll know no part has been exposed to an element that may weaken or damage it.

Storage

Store your parachute in a cool, dry place in a lightproof container. This will prevent the permanent and hard-to-detect damage caused by ultraviolet light from sunlight and other sources. Certain other agents – notably acids – will quickly cause great damage to your parachute. Do not store your parachute where it might come into contact with such substances (for example, auto trunks contaminated long ago with battery acid have destroyed many parachutes). The same goes for airplane hangars; check your surface to be sure it's free from battery acid or other contaminants from maintenance days gone by.

Section 4: Repair

If your Canopy is damaged, take it to an appropriately rated FAA rigger. Do not try to fix it yourself. It may look like simple sewing, but many other factors are involved and do-it-yourself repairs generally mean trouble, whether they are major –or appear to be minor.

Don’t ignore small tears, broken stitches, or other minor damage. A small problem left untended can become a catastrophic or at least expensive problem if you keep jumping the canopy: Parachute opening forces and flight stresses are significant, so you must always maintain your Icarus canopy in top condition.

Section 5: Packing

Introduction

Today’s airfoil-type canopies are very reliable. If the lines are straight and if it’s assembled correctly, it will usually inflate normally even if packed in unusual ways. Nevertheless, the better you pack it, the more likely it will open properly and without damage.

Icarus Canopies has found through testing a better packing method for airfoil parachutes treated with a coating that eliminates fabric porosity. We have used this packing method for years and found it does two things: First, it makes getting zero-p into the bag easier; and second, it produces consistently sweet on-heading openings.

Pre-pack preparations

‘Where” you pack your Icarus canopy is important. Since sunlight irreversibly damages nylon parachutes, an indoor or shady area is best. Packing in the sunlight is unavoidable at some places, so try to reduce your canopy’s exposure to direct sunlight as much as possible. Cover it with a packing mat or jumpsuit while debriefing your jump.

Packing on concrete, asphalt and even carpet should be avoided; these materials will wear the fabric, lines and fittings of your parachute system. A dry lawn is best.

Also be aware that humidity affects pack volume. Canopies pack much fluffier in the Arizona desert than in humid Florida, for example, and pack volume can even change between the less humid mid-day and the more humid time right around sunset.

Finally, Icarus does not recommend using non-deflatable or bungee pilot chutes. Also, be sure to cock your pilot chute; whether you cock it before or after the rest of the pack job, just be sure it's some part of your personal packing procedure.

Ask For Help

When you're learning to pack, or learning how to pack a new parachute, never hesitate to ask a rigger or your instructor for help. They will show you tips that will make the process faster and easier. Be sure they refer to this handbook, however, as they may not be familiar with the Icarus packing procedure.

The Packing Procedure

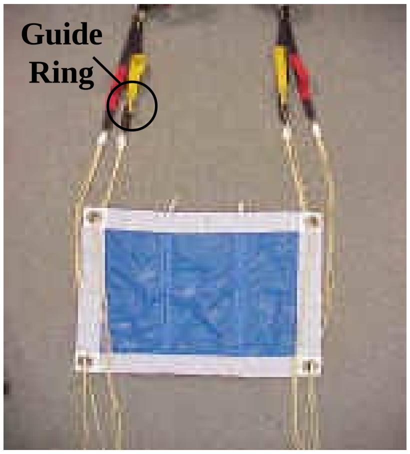
Icarus Canopies, Inc. recommends the use of either PRO-PACK for all its products.

Before you pack

Attach the canopy to the risers; check line continuity and torque connector links to 1/4 turn past finger-tight. Run control lines through guide rings and attach steering toggles. Be sure to also confirm control line continuity. Attach deployment bag and pilot chute. Once assembly is complete, you're ready to pack.

Packing Procedure

The first steps are simply the beginning of a normal PRO pack.

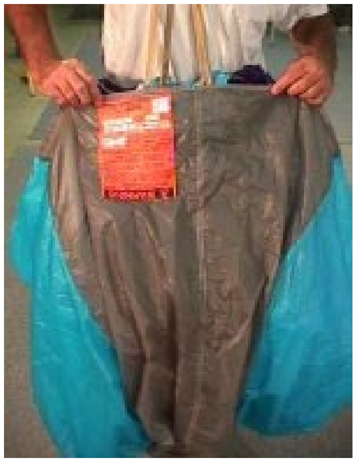


Determine that the suspension lines are straight by separating the four line groups as well as the control lines and clear the lines up to the canopy.

Set the deployment brakes.

Grasp the seven or nine (depending on canopy type) high points of the leading edge (nose) of the canopy with one hand and the C/D (rear) lines with the other. Spread the canopy front to rear, widely, to allow the A, B, C, D, and control lines to separate.

Now place the entire leading edge of the canopy between your knees and hold firmly, then clear the canopy fabric away from the "wind channel" by folding separately the A-B sections, the B-C sections and the C-D sections. The lines should be toward the center, while the fabric should not be. Clear the stabilizers. Allow the slider to fall naturally in the center, making sure that each grommet rests against its appropriate slider stop.



Clear the aft section of the airfoil and pick up the center of the trailing edge, holding it under your thumb. It is not necessary to roll the nose or stuff the leading edge into the cells with this pack job. When you pull the trailing edge around the rest of the canopy, be careful not to bring the “D” lines or control lines around with it or you will invite a line-over malfunction. NOTE: We have never induced a lineover malfunction but we have always packed to avoid it. Common packing protocol dictates that it is prudent to keep suspension lines behind the leading edge.



Lay out the canopy carefully on the floor with the center cell tail facing up. Wrap the center cell fabric around the canopy to form a triangular cocoon shape. Be careful not to pull the D lines from the center while moving the fabric out to the edges to avoid the danger of a line over malfunction.
Keeping tension on the lines, place your left hand under the bottom of the triangle and your right hand on the upper side of the canopy, about 8 inches from the base and in one motion, pull tho top hand toward the harness and the bottom hand toward the top of the canopy, forming an S-fold, while maintaining tension on the lines.

Kneeling on the first S-fold, continue tucking the fabric tighter underneath the canopy until the edges are parallel and the canopy is the same width as the bag. Next, place your arm under the canopy about half to the top and pull upwards making one more fold.
With the fold against your chest, roll the excess top skin fabric into the fold and then carefully compress the canopy down onto itself.

Keeping control of the canopy, place it in the bag with the grommets toward the container.


Finishing Up

Close the bag and stow lines according to container manufacturer's instructions. It is important to use proper stows (Use stow band material specified by the container manufacturer). We recommend making a double turn with all stow bands, to help prevent line dump.

Section 6: Design and Operation

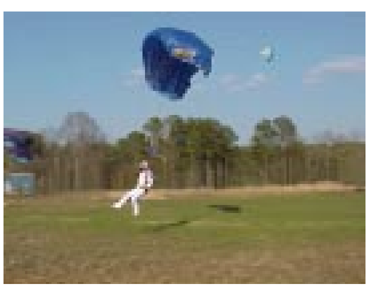
In 1991 Icarus Canopies launched “The Icarus Project”. It’s goal, to produce a new series of superior parachutes for several different applications. It was an ambitious goal, but we are confident that The Icarus Project has resulted in superior products across the experience spectrum.

To reach this goal, we have progressively evaluated every aspect of each and every canopy available in the targeted market segment. We then carefully and deliberately identified the best and worst qualities of each canopy in each segment, then designed, built and refined a superior series of canopies to surpass them.

Icarus Omega, Icarus Safire

These canopies seem generally conventional in design in that they are made from nine two-chambered cells. What separates Icarus Canopies from previous designs is a construction technique that makes them more like a true aircraft wing than a parachute.

Aircraft wings taper toward their tips; height and width (chord) all shrink toward a wingtip noticeably smaller in all dimensions than the wing root. Most airfoil parachute designs, however, simply replicate their center cells three or four times on each side, thereby making rectangular canopies a wing with the same dimensions at the ends as in the middle, and/or elliptical canopies that taper in only one dimension (chord).



All Icarus canopies, have constant cell proportion (CONSTANT CELL ASPECT RATIO): As the canopy chord narrows toward the tips, so does the height and width of those cells. Making the cells proportional makes and maintains the airfoil shape better than the old construction techniques. This creates better balance and symmetry in the canopy, which results in better openings, better control, better performance and nicer overall manners.

Openings

Openings on these canopies are noticeably better because the Icarus constant cell proportion creates a better balanced, more symmetrical airfoil. This makes the canopy’s cells inflate more evenly and efficiently, resulting in more soft, on-heading openings.

These canopies seldomly open off-heading. We’ve also eliminated the steep dives that can occur on elliptical canopies right after opening, making the very few off-heading openings that may occur less radical and more manageable.

Icarus Crossfire

The Icarus Crossfire is a High Performance Elliptical ZP 9-cell canopy designed specifically for experienced ram air pilots. The Crossfire is Highly and Truly elliptical in its planform shaping on both the leading and trailing edges. The cells vary in width across the canopy maintaining a constant cell aspect ratio to control distortion, and drooped wing tips are incorporated to minimize wingtip drag.

Unlike any other 9-cell, the nose is partially formed to give the canopy a more efficient leading edge (much like an aircraft wing). Our nose design not only improves the aerodynamics SIGNIFICANTLY, it also assists in controlling the openings. The structure of the nose also diagonally supports the non-loaded ribs during flight creating further rigidity at the leading edge & reducing distortion during the flare.

A word on openings:

At first your Crossfire openings may feel slower than you'd expect. Don't worry it's designed this way. The openings are very slow and progressive, however, the slowest part of the opening sequence is the last stage of the snivel. As a result, it may feel as though you are chewing up altitude, but in reality, you've already slowed significantly and altitude loss is minimal.

One big problem with HP elliptical canopies to date has been diving off heading openings. Through our development work with the Crossfire we have almost eliminated this completely. The Crossfire openings are among the most consistent and comfortable "stress free" openings available. The turns are snappy and the canopy has a large recovery arc enabling it to dive for a long time and making it very easy to pick up speed. The flare is powerful and only exceeded by Cross Braced Tri-Cell Canopies like the EXTreme FX & VX.

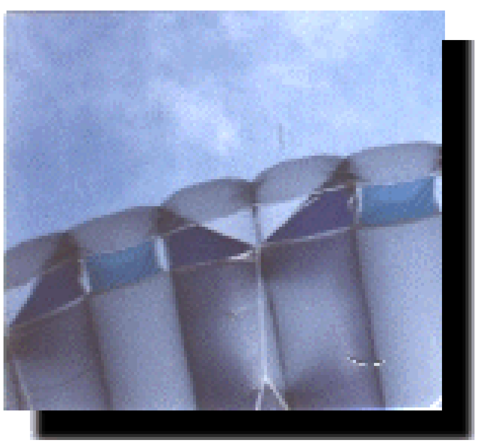
(Note: The Crossfire is NOT cross-braced and does NOT incorporate any valve systems)

Cross-Braced Canopies - Icarus EXTreme FX & VX

The Icarus EXTremes are the undisputed high-speed/high-lift winners that define high-performance in a non-rigid airfoil.

The minimum wing loading on the Icarus EXTreme begins where the others max out (1.3 lbs per square foot), and has been regularly jumped in factory testing and evaluation programs at wing loadings beyond 3.0 lbs/sq ft. (Do not attempt this - Factory test pilots only).

Thus purchasing an Icarus EXTreme is not a decision to be made lightly, as the canopy is capable of approach speeds that can be safely handled by only the most experienced ram-air pilots. We recommend that before anyone considers an EXTreme that they have a thorough knowledge of basic aerodynamics and at least 500 jumps on high-performance canopies such as the Icarus Crossfire, Precision Batwing, PdF Blue Track, Airtime Jedei or Performance Designs Stiletto.



The Icarus EXTreme’s cross-braced tri-cells are the key to its ultra-high performance.

When you look at a conventional canopy from the front, it has a scalloped appearance – the cells are deformed because they lack internal support that keeps them properly shaped and oriented to the airflow.

The EXTreme, on the other hand, is a cleaner design because the cross-braced cells hold both shape and planform integrity significantly better than conventional designs.

In addition to generating more lift and speed, the rigidity and higher internal pressure of the airfoil resists dynamic distortion – the tendency of a parachute to shrink when flared. Flaring forces air from the leading edge, so by the bottom of the flare on conventional designs, the parachute is 10-15 percent smaller than its full-flight size. In contrast, the EXTreme shrinks less than 5 percent because the wing loading creates more internal pressure inside the airfoil, so there's more air to start with and it escapes more slowly because one third of the cells are completely closed (it's the first parachute with a true leading edge).

What does this mean to you?

As with previous improvements in parachute design, this extra performance is manifested in a more efficient wing. An Icarus EXTreme that is 10 percent smaller than a conventional elliptical ZP canopy will give a good benchmark for comparison. With a 10 percent less surface in area, the EXTreme offers:

- Greater forward speed
- Greater airfoil rigidity
- Faster turns
- Longer surfs
- Bigger control range
- Better slow-speed flight
- Comparable descent rates

EXTreme performance and wing loading

Wing loading refers to how much weight the parachute is holding while in flight in relation to wing size. Wing loading is determined by dividing the parachute's size in square feet by its "suspended weight" (jumper and gear). The resulting number is the wing loading for that canopy and pilot.

The Icarus EXTreme is designed to fly best at wing loadings of 1.5 to 2.0. At wing loadings below 1.5, the EXTreme flies much like conventional high-performance canopies. At wing loadings higher than 2.0, the EXTreme is very fast and very radical – and still outperforms conventional high-performance canopies, but does not perform as efficiently as it does inside its performance envelope.

Openings

One parameter to which we gave considerable design attention was opening performance. As a result of that attention, we have incorporated two features into the Icarus EXTreme that improve both opening and aerodynamic performance.

First, there is a variable lip on the leading edge. This lip helps both the in-flight aerodynamics and the openings by reducing canopy opening speed and maintaining internal pressure without using baffles and valves.

Second, the front of every third cell is almost completely closed off, improving low-speed and flare performance because less air escapes from the front, thereby keeping the canopy pressurized and rigid longer. These features also make the openings more progressive than conventional high-performance canopies: Instead of hurtling earthward with a line stretch streamer, you can tell immediately whether the EXTreme is opening normally or not. The partially closed leading edge increases canopy inflation time, resulting in more comfortable openings and longer canopy life because there is less stress on system components.

Most elliptical parachutes have a significant number of off-heading openings and the EXTreme is no exception. However, we've eliminated the steep dives that can occur immediately after opening, making off-heading openings less radical and therefore not as big a problem.

Finally, slowing down the openings also makes it easier to take those occasional rogue openings that plague all high-performance canopies, including the Icarus EXTreme.

A word about high altitude openings

If you jump at drop zones above 5,000 feet or 1500 meters MSL (mean sea level), you may experience harder than usual openings on your Icarus EXTreme. It is not recommended that you do terminal openings on your Icarus EXTreme at altitudes above 20,000 feet MSL.

Other flying characteristics

The EXTreme flare is powerful but may feel quite late. The powerband is also longer, so be sure to extend your arms fully while flaring to take full advantage of the EXTreme's "big bottom end."

The natural recovery arc from aggressive turns is very large. This means you must start your landing turns much higher and your approach speeds can be much higher.

Large recovery arcs also mean more safety and precision. The reason is simple: Starting your landing turns higher means you don't have to gauge them as precisely and you have more time and distance to make corrections. Canopies with shorter recovery arcs don't have this advantage because you need to hook lower to get the full force of the canopy to carry you down to the ground on full drive.

Obviously, the actual recovery arc for a given EXTreme depends largely on wing loading, whether the turns are shallow or sharp, and whether risers or toggles are used to turn.

As with any canopy, get a feel for your EXTreme's recovery arc up high before attempting an high-performance landing maneuvers.

Construction

Each Safire panel is cut to an accuracy of two-tenths (0.2) of a millimeter (less than the width of the sewing thread). This degree of accuracy is required to achieve the precision and resulting performance we required. The Safire also uses a doubler every line attachment point to provide proper load distribution.

Suspension Lines

The Icarus Safire is equipped with Vectranâ suspension lines, a high-performance thermoplastic multifilament yarn spun from Vectranâ liquid crystal polymer (LCP). It exhibits exceptional strength and is, pound for pound, five times stronger than steel and ten times stronger than aluminum.

Icarus pioneered the useof Vectranâ and tested it against Spectraâ and Dacron suspension line material. We found that Vectranâ is by far superior in terms of dimensional integrity. In other words, make 500 jumps with Vectranâ lines and they won't shrink or distort nearly as much as will Spectraâ or Dacronâ lines.

Line shrinkage with Spectraâ is principally caused by the slider generating heat as it moves down the lines on opening. Outboard suspension line and control lines are particularly susceptible to line shrinkage: It is not uncommon to see Spectraâ control lines shrink eight inches and outboard cell lines shrink several inches – enough to influence performance by bowing the canopy and distorting the planform.

Vectranâ does not have as much abrasion resistance as Spectra,â and so the lines will "fuzz out" sooner than Spectraâ – but tensile strength loss due to line fuzz has not shown itself to be a significant problem, especially when compared to the gain in long-term performance.

Another thing about lines made of Vectranâ or any other material; like automobile tires, they wear out long before the vehicle to which they're attached. Unlike F-111 canopies, which wear out about the same time their lines do, properly maintained zero porosity canopies can last through several line sets, regardless of line material. It is recommended that you check line wear regularly. In particular, check out the lower control lines; they wear out faster.

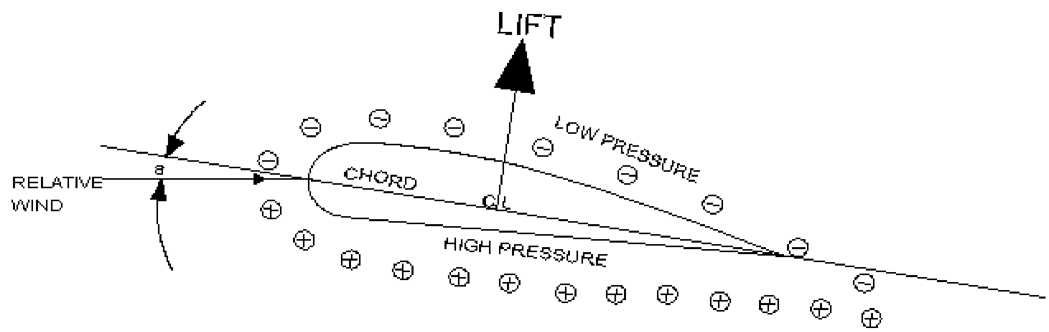
your canopy is equipped with brake set loops, check them periodically for wear. These finger-trapped loops are especially susceptible to wear and, if not in top shape, can result in premature brake release.

SECTION 7: *Basic Aerodynamics*

Introduction

Proficiently handling any airfoil canopy requires knowing and understanding aerodynamics – the basic premises and forces of flight. It's not necessary to be an aeronautical engineer, but Canopy pilots should know aerodynamics at least as well as a private aircraft or glider pilot. Most private pilot manuals and workbooks present very basic aerodynamic information: How lift works, angle of attack, how stalls happen, and how turbulence affects a wing. Unfortunately, not even basic aerodynamics is covered in most current canopy control training, so high-performance pilots have found it necessary to either figure it out by feel or do some outside research.

We've decided to provide some of that outside information in this handbook, because we think it's important that Canopy pilots know and understand basic aerodynamics so they can get more performance out of their parachutes for less risk. Please note: What follows is only part of what you should know, and Icarus strongly recommends that you seek out additional information.



Why parachutes fly – and why they don't

Lift is generated by airfoil parachutes the same way it is by rigid wings: The shape of the wing alters the airflow to create lower air pressure above the wing than below it, resulting in positive pressure – or lift – upward.

The amount of lift generated by a given wing varies depending on its *angle of attack*, which refers to the wing's orientation to the *relative wind*, which is parallel to the flight path, not the ground, horizon or other reference.

The more the wing is tipped so that its bottom surface faces more into the relative wind than the top surface, the higher the angle of attack. The higher the angle of attack, the greater the lift generated – up until the *stall point*.

The *stall point* is the speed at which a wing can no longer generate enough lift to support the weight it's carrying. This stall point varies from wing to wing; more importantly, it varies on all wings depending on how the wing is being flown.

Reaching the stall point is also called *exceeding the critical angle of attack*; it's the point at which the airflow separates from the wing's upper surface and becomes turbulent. This turbulence disturbs the low pressure area above the wing, causing a reduction or total loss of lift.

With an airfoil parachute, pulling both toggles way down can increase the angle of attack to the stall point. When a parachute stalls, it generally collapses. Depending on the type of parachute and how hard and far the toggles are pulled down, the stall may be gradual or very abrupt. In either case, letting up on the toggles is the only way to recover; you have to lower the angle of attack to start generating lift again.

Letting up on the toggles, however, causes the parachute to surge, or dive forward, to recover. During this time, you and your parachute are *falling*, not flying, and if you are too low for it to recover, you will hit the ground in freefall.

Stalling a wing by exceeding its critical angle of attack generally happens at low speeds, but wings can be stalled at high speed too. These *high-speed stalls* are more dangerous for parachutists flying high-performance airfoils because they happen fast and are hard to detect.

High-speed stalls occur during *curved flight* – when a wing turns, pulls out from a dive, or encounters turbulence. The centrifugal force generated during curved flight increases the effective weight carried by the wing.

This effective weight is measured in "*G loads*" – with 1G being the actual weight of the wing and whatever it's carrying. When the G-load increases beyond the ability of the wing to lift it, it stalls, even when it's flying much faster than its 1G stall speed.

The problem for parachutists is: It's hard to tell when a high-speed stall starts. In an airplane, high-speed stalls are detectable because the stall warning horn goes off even when the airspeed is way above indicated stall speed. Parachutes don't have stall warning horns, and high-speed stalls don't deflate the parachute like low-speed stalls do, so it's harder to know when you've quit flying and started *falling*.

Reducing the G-load is the only way to recover from high-speed stalls; you have to flatten out the turn or pullout until the wing can handle the effective weight and start flying again. There is a recovery arc, however, and high-speed stalls have the same consequences low-speed stalls do: If you do them too low to recover, you hit the ground in freefall – and it's faster freefall.

It is important to understand how radically G-loads increase in turns. Turning at a 20 degree bank angle increases the G-load to 1.06 – barely noticeable. A 40 degree bank, on the other hand, increases the G-load to a more significant 1.31, and a 60 degree bank jacks it up to an even 2.0. Crank the wing into an 80 degree bank and suddenly you're asking your wing to support 5.76 times its normal weight.

Now, these figures refer to powered flight and may not be exactly the same for airfoil parachutes, but the pattern is the same and reinforces the point: It's easy to overload a wing when you're cranking turns and the high-speed stalls which may result can get you in a lot of trouble if you do them too low.

Density altitude means: the hotter and more humid the air, the thinner it gets, the faster you go forward and down, the slower your flare works and the less room you have for error.

Density Altitude

Many skydivers do not think about what happens to their parachute performance when it gets hot, and so every spring a lot of them land badly and end up with minor to major injuries because they didn’t think about how air temperature and humidity affect parachute performance.

Enter “density altitude,” or as it is more technically defined: “Pressure altitude corrected for non-standard temperature” (which is defined as 59 degrees Fahrenheit). Translated practically, this means: The hotter and more humid it gets, the more your parachute acts as if it is opening and landing at a higher altitude than your DZ’s actual field elevation. That’s because, the hotter and more humid the air gets, the thinner it gets. The effect on your parachute? Faster forward speed, faster rate of descent, slower flare effect, and less room for error. It has to fly forward and down faster to generate the same lift – and the faster you’re going forward and down, the longer it takes for your flare to have an effect, and the more radically you’ll plummet from the sky in any kind of steep turn.

This is one reason many people biff in every year when it first starts getting hot again. Fortunately, most resulting injuries are fairly minor, but they could be avoided if jumpers would take the time to consider density altitude before they jump.

Pack Volumes

CANOPY TYPE	SIZE	PACK VOLUME	MSW	WEIGHT
EXTreme VX 69	69	221	166	3
EXTreme VX 74	74	237	178	3
EXTreme VX 79	79	253	190	4
EXTreme VX 84	84	269	202	4
EXTreme VX 89	89	285	214	4
EXTreme VX 94	94	301	226	4
EXTreme VX 99	99	317	238	4
EXTreme FX 69	69	186	152	3
EXTreme FX 74	74	202	163	3
EXTreme FX 79	79	218	174	4
EXTreme FX 84	84	234	185	4
EXTreme FX 89	89	250	196	4
EXTreme FX 94	94	266	207	4
EXTreme FX 99	99	282	218	4
EXTreme FX 104	104	298	229	5
EXTreme FX 109	109	314	240	5
EXTreme FX 114	114	330	251	5
EXTreme FX 119	119	346	262	5
Crossfire 89	89	219	161	4
Crossfire 99	99	238	178	4
Crossfire 109	109	257	196	4
Crossfire 119	119	276	214	4
Crossfire 129	129	295	232	5
Crossfire 139	139	314	250	5
Crossfire 149	149	333	268	5
Crossfire 169	169	371	300	6
Crossfire 189	189	409	300	7
Crossfire 209	209	447	300	8
Crossfire 229	229	485	300	8
Safire 99	99	215	178	4
Safire 109	109	235	196	4
Safire 119	119	255	214	4
Safire 129	129	275	232	5
Safire 139	139	295	250	5
Safire 149	149	315	268	5
Safire 169	169	355	300	6
Safire 189	189	394	300	7
Safire 209	209	434	300	8
Safire 209	229	471	300	8
Omega 99	99	246	149	4
Omega 109	109	267	164	4
Omega 119	119	288	179	4
Omega 129	129	309	194	5
Omega 139	139	330	209	5
Omega 149	149	351	224	5
Omega 169	169	372	254	6
Omega 189	189	393	284	7
Omega 209	209	414	300	8
Omega 229	229	435	300	8