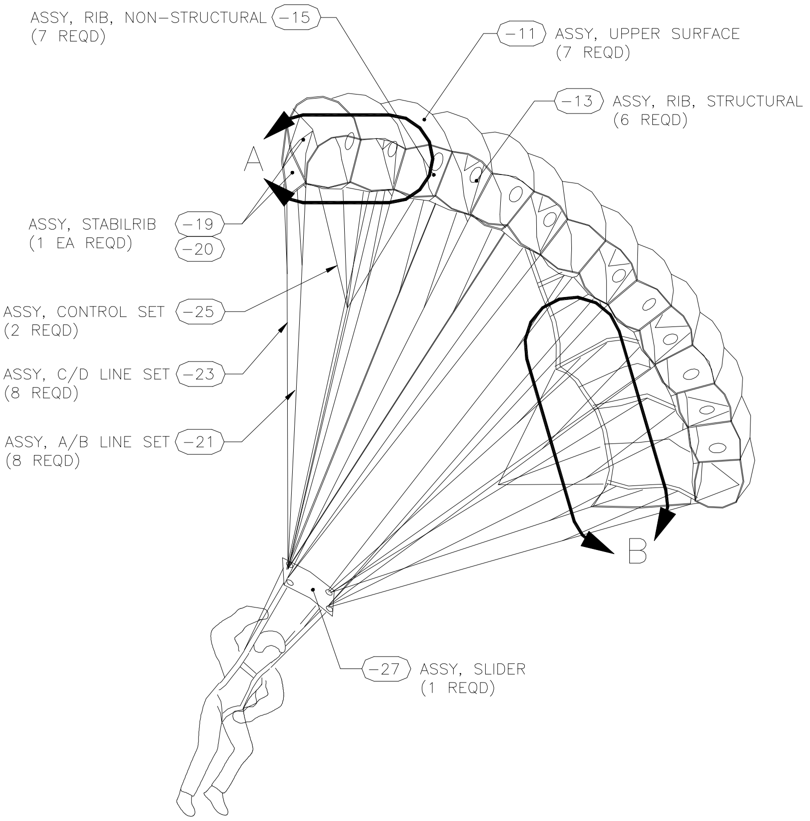


Ram-Air Parachute Owners' Manual and Packing Instructions

Welcome to the family of Precision Aerodynamics' Parachute Owners!

Congratulations. You are now the proud owner of a brand new Precision Aerodynamics' canopy. This manual contains a few things that you need to know about your canopy. Information and education makes us all safer. To assume that one knows everything only brings one closer to demise. Please read ALL OF THIS manual thoroughly before jumping your new parachute, and feel free to contact us if you still have questions not covered here. Although the drawing depicted above on this page is for a typical 7 cell reserve canopy, the contents of this manual describe flight procedures for a broad range of Precision Aerodynamics' canopies including:

Model_______________________________

Serial Number_______________________________

Date of Manufacture_______________________________

WARNING: SKYDIVING IS A DANGEROUS ACTIVITY

Your parachute might not work right and you might die even if you do everything right.

Sport parachuting is a hazardous activity that does, at times, result in severe personal bodily injury or death. Parachutes sometimes malfunction, even when they are properly designed, manufactured, assembled, packed, maintained and used. The results of such malfunctions can be serious bodily injury or death.

The United States Parachute Association reports that during the period from 1999 through 2007, member skydivers in the U.S. made a total of 19,821,728 jumps which resulted in 10,981 medical injuries and 239 fatalities. This data might suggest that the risk of medical injury on any given skydive during that timeframe was about 1 chance in 554 jumps. Similarly, the chances of losing your life on any skydive during the same timeframe might have been about 12 out of a million jumps. While many of these injuries and death are a result of improper use, some are the direct result of parachute equipment malfunctions. The United States Parachute Association has reported that there were approximately 32,000 skydivers in the U.S. in 2009.

While total skydiving experience, currency in jumping, proper training, familiarization with and the correct use of parachute equipment can tend to lower these risks somewhat, nothing can actively reduce the risk to zero. The only possible way to reduce the risk to zero is to not be associated with skydiving or parachute jumping in any way, even as a spectator or as an innocent bystander. Even spectators and innocent bystanders are exposed to many of the inherent risks associated with skydiving or parachute jumping if they are present during jumping activities.

If you use a Precision Aerodynamics' parachute canopy, or if you allow someone else to use it, you are acknowledging that you understand sport parachuting's inherent risks and you are accepting the fact that your parachute equipment may not function properly, and in fact, it may not function at all.

If you are not willing to accept the risks of sport parachuting, or if you are not willing to accept the possibility that your parachute (including any or all of its associated components) may malfunction or perhaps cause you or someone else to be injured or killed, then you may return your Precision Aerodynamics' parachute canopy for a full refund before it is used. Contact Precision Aerodynamics' legal department for details regarding the procedure to exercise this option.

DISCLAIMER - NO WARRANTY

The risks of many types of personal bodily injury and also the risk of death, and many other dangers associated with the use of this or any other piece of parachute equipment is undeniable and unavoidable. Because of the unavoidable danger associated with the use of this parachute system, the manufacturer makes no warranty, either expressed or implied. All of Precision Aerodynamics' parachute products are sold with all faults and without any warranty of fitness for any purpose whatsoever.

Precision Aerodynamics also disclaims any liability in tort for damages, direct or consequential, including personal injuries, resulting from a parachute malfunction or from a defect in design, material, workmanship, or manufacturing whether caused by negligence on the part of the manufacturer or otherwise.

By using this parachute, or allowing it to be used by others, the owner and or user waives any liability for personal injuries or other damages arising from such use. If the owner declines to waiver liability on the part of the manufacturer, the owner may obtain a full refund of the purchase price by returning the parachute system before it is used, to the manufacturer within 30 days from the date of original purchase with a letter stating why it was returned.

About this manual

Parachutes will not fly optimally without proper control input. We want you to be the best canopy pilot you can be. This is why we employ the skills of our industry's leading educators in the field of canopy flight to create, edit, and otherwise contribute to the contents of this manual.

Our wings are carefully crafted to do everything a great canopy pilot needs them to do and more, but they will not make you look good if your piloting technique needs work. We urge you to seek out advanced instruction whenever possible, especially video debriefs of your landings. A weekend canopy flight workshop is the best way to do this. By sitting down and learning all the stuff that you *didn't know you didn't know*, you will expand your reality, and have more fun in the sky. The better you are, the more there is to do up there! Competence makes skydiving more fun!

It is important to remember that we are always on a path to becoming better. Our moments of perfect execution will become more frequent as we continue in our commitment to continuing our development.

General Canopy Information

Canopy Fabric

We use only the finest parachute fabrics available. Solar radiation is the single most damaging element to nylon fabric, and its silent destruction is both cumulative and irreversible. All of our parachute fabric contains a special UV Resistant coating called Solar Maxtm from Invista, but the best way to increase the life of your canopy is to keep it out of the sun as much as possible. With proper care and handling, your canopy's fabric can last for literally thousands of jumps.

Besides ultraviolet exposure, there are a number of other elements that your parachute may become exposed to in normal use. If your canopy is exposed to or becomes stained by blood, sweat, tears, or other body stains that may occur during with normal handling or packing, in many cases the best action to take may be no action at all.

Although it is advisable not to wash your canopy with any sort of agitation, you will definitely need to soak your canopy in fresh water in the event you have a saltwater landing. If your parachute lands in seawater, keep the canopy wet until you can soak it in a bathtub of lukewarm fresh water for several hours to dilute out the damaging microscopic salt crystals from within the weave of the fabric. Soak, rinse, repeat. Then hang your canopy to dry in a place away from sunlight.

Water, in and of itself, is not harmful to nylon in any way. In fact, the fabric in your canopy is exposed to water in several processes before it is ever even cut and sewn into a parachute. Spinning plants, weaving plants, finishing and dyeing plants all use some degree of water in processing nylon from yarn to parachute fabric. In many of these operations, the yarn or fabric is continuously soaked and dried before finally being sold as parachute fabric.

However, there are some instances of water exposure that can and will be damaging to your canopy, including fresh lake water. It's not the water per se that might be damaging, but the unidentifiable elements contained in the water that may cause the pH to be very high or very low. Exposure to low pH water (acid) or high pH water (alkaline) may damage your canopy and render it to be un-airworthy instantly. There is no cure for canopy fabric damage due to high or low pH contact.

Suspension Lines

Depending on the product we use several line materials:

HMA

HMA line is braided from a High Modulus Aramid fiber and is used on our highest performance main canopies. We use a distinctive black fiber to braid for all of our HMA linesets. HMA line is used on all Xaos-21, Xaos-27, Nitron, and Fusion canopies. HMA line is very strong for its diameter and it doesn't stretch or go out of trim like Spectra tends to do during heavy use on a main canopy. The downside to HMA is that it doesn't necessarily show signs of its wear very well, and the first indication that you might need to reline your canopy could be when you break a line on deployment. While breaking a line generally isn't a big deal, it can definitely slow down your weekend. We recommend replacement of HMA linesets approximately every 500 jumps.

Vectran

Vectran is a tan colored fiber which is braided into linesets for our tandem main and tandem reserve canopies. Vectran line is very strong for its diameter, but stability is probably its best property. However stable, Vectran still wears out relatively quickly due to slider friction, and it needs to be replaced every 500 jumps in the tandem main environment. Tandem reserves aren't deployed enough to warrant a replacement lineset.

Spectra

Spectra line became very popular on sport main and reserve canopies beginning in the 1990s. Spectra fiber is strong and when braided into suspension line it is very lightweight for its rated breaking strength, but it has a couple of bad properties for use in main canopies, namely faster openings and linear shrinkage over time due to heat generated from slider friction. Ironically, these bad properties for main canopies are still great properties for reserve canopies, wherein a quick opening is a good thing and few people would ever put enough jumps on their reserve to develop a line shrinkage problem. We use Spectra braid on many of our reserve canopies.

Dacron

Prior to the development of Spectra, HMA, and Vectran, Dacron (polyester) fiber was the preferred choice for suspension line material on ram-air canopies, and was used unilaterally on both on mains and reserves. It has remained popular for some types of canopies since its introduction in the mid 1970s, at which time it replaced nylon as the material of choice for traditional parachutes. One of the reasons it remains popular is because Dacron (polyester) has an excellent memory which means that even though it will elongate during opening shock, it will quickly return to its original specification, unlike nylon. Therefore, although Dacron braid produces very nice openings, and it tends to tolerate slider wear much better than any of the other three types of braided line mentioned above. The downside of Dacron is that it yields a relatively bulky pack volume when compared to Spectra, HMA, or Vectran.

Replacing Lines on your canopy

Just like you must replace the tires on your car, the lines of your main parachute will need to be replaced from time to time. If you keep your canopy out of the sun (except when it is being used, of course), the fabric airfoil section of your parachute will far outlast your lineset in typical use. The primary reason for line wear is due to the friction and the associated heat that is generated by the grommets as the slider descends during deployment.

Some of the key areas that you might notice accelerated wear are the outboard lines on the connector links and also at the cascades. Also, the center cell “D” lines will show wear about a foot below the stabilizers. Keep an eye on these key areas to notice line wear before you start breaking lines during use.

You can extend the life of your lineset by making sure you pack carefully for soft openings, and by keeping your lines clean. Also, any damage to your slider grommets and steering line guide rings will also reduce the number of jumps you can make on your lineset.

Replacing suspension lines on your canopy is considered routine maintenance, but it must be accomplished by an appropriately rated FAA parachute rigger in the US or foreign equivalent in other countries. When replacing lines, it is a good idea to replace the entire lineset rather than individual lines. In the event you break an individual line and choose to just replace the broken line rather than the complete lineset, go ahead and replace the corresponding line on the opposite side of the canopy at the same time.

It is a good practice to replace your slider at the same time you replace your lineset. Although it is possible for many riggers to replace brass slider grommets in the field, most riggers do not have the equipment required to replace stainless steel slider grommets. Replacing stainless grommets requires a specialized cutting tool and a hydraulic press.

If you have any question about whether or not it is time to replace your lines remember the Old Aviator’s Slogan:

**It’s better to be on the ground,
Wishing you were in the air,
Than to be in the air,
Wishing you were on the ground**

Canopy reinforcement tapes

All of our canopies are constructed with an integrated Spanwise Reinforcement System (SRS). This series of load-bearing tapes links up the line attachments like a web or net inside the canopy. This system makes Precision Aerodynamics parachutes among the strongest ever built.

Precision Aerodynamics' reinforcing tapes on the loaded ribs are positioned at optimum angles to the blocks of the fabric, providing the correct weave-bias stabilization, and creating the most rigid airfoil rib possible.

Risers and Toggle Settings

Precision Aerodynamics canopies are designed for 21 inch risers, the standard for the industry. When used with standard length risers, our canopies will have a few inches of slack brake-line in full flight. This is to allow the pilot to apply up to three inches of front riser input without deforming the tail of the canopy.

Long risers (longer than 21") make the stall point more accessible by placing the jumper further from the canopy. Conversely, shorter risers place the jumper closer to the canopy, thereby making the stall-point further down in the toggle-stroke, or even inaccessible. When using very short risers, (19" or shorter), the factory toggle-setting may feel excessively loose, and may require shortening.

Note: The toggle setting referred to here is not the same as the Brake Set Loop. The Brake Set Loop is fixed and should never be changed, regardless of riser length. Everyone has his or her own personal preferences for toggle setting. If you find the factory setting not to your liking, feel free to change them, but only one inch at a time. You'll be surprised how much one inch feels like. Keep in mind that bad landings are almost always due to poor technique, regardless of toggle setting. Before changing anything about your new canopy, please contact Precision Aerodynamics to see if this is the right choice for you.

Pack Volume

Parachutes vary in pack volume slightly, depending on many variables. Choose your container based on the standard for that size canopy, and adjust your closing loop accordingly. Keep in mind that a loop that is too long can allow the pin to slip out inadvertently, and one that is excessively tight can cause a pilot chute in tow malfunction. Refer to your container maker's documentation for proper specification of the capacity and specification for your particular container system.

Wing-loading

Any wing loading guidelines are recommendations, not solid rules. PRECISION AERODYNAMICS leaves the ultimate decision and responsibility of canopy sizing to the customer. We know most of you are quite intelligent and desire to live long and healthy lives. That being said, here is our slogan:

"When in doubt, GO BIG!!"

If a parachute feels too small for you in your mind, it is. Fear and its negative effects on skill are a very subjective issue, and nobody can tell you how you are feeling. If the idea of jumping something smaller than your current canopy feels “off” to you, then it is. Trust your instincts, and ask the opinions of skydivers who are more experienced, ideally folks who have actually watched you land.

For more detailed information on parachute sizing, see the article entitled “Parachute Downsizing Criterion” near the end of this manual.

On Finding the Perfect Canopy

Before arriving at a decision about which canopy you should use, there are many questions to be answered. It is best not draw your conclusion for several months if you want to make the right choice. There can be no rushing if you want to find yourself a parachute you can live with. In order to truly “Love” your canopy, you must arrive at the decision to purchase it based on a very exhaustive process. The beginning of the process is to answer the following questions:

What do I want my new parachute to do that my old parachute does not do?

If smaller pack volume is your sole reason for downsizing, you are making a big mistake. If you are blowing away in the wind because your canopy is a Tank, downsizing will be a step you take soon, but if you are still blowing your flare or your pattern and accuracy, you need to stick with the Love Boat until you figure that stuff out. More speed does not substitute for better skills.

Do I honestly have the skills to handle all of the new responsibilities that this new level of performance will give me?

Be honest with yourself here. We know you believe in yourself, and that is a very good thing. Without the feeling of “The Right Stuff” inside, none of us would be able to get out the door. That aside, where are you in your development, really?

Am I willing to pay the price of the learning process to attain these new skills?

We highly recommend that you further your education as a skydiver by partaking in an advanced canopy piloting course. Didn’t we mention that back on page 3 in “About This Manual?” Good. It is important and can not be overemphasized. We also suggest that you extend your learning process beyond even that, either through written works, video, conversations or formal aerodynamics education. It is that or obtaining the difficult degree from the School of Hard Knocks, where the tuition is very expensive. Take your pick.

How good am I willing to become?

This is the biggie, the one that causes most people to hit a glass ceiling. If you honestly believe you are going to become a great canopy pilot, you certainly can. This entails a commitment to the achievement of this goal. Giving up along the way is not permitted. The ground will weed you out, and it does not grade on a curve.

If you are willing to honestly think about each of these questions, regardless of the specific answers you come up with, you will create the correct choice for yourself. It will be, in fact, incredibly obvious. If it makes sense to you after all that thought and discussion, it is probably the truth for you.

Flight Performance

Whether your new canopy is a reserve or a high performance main canopy, please be careful with it. Your reserve canopy should not be damaged in normal use and we encourage at least one familiarization jump on your new reserve (packed as a main) before stowing it away in your reserve container waiting for an emergency. You may need to have somebody track your main bag and pilot chute on the familiarization, as they will not be attached to your canopy, and check with your rigger regarding appropriate pack volume compatibility with your harness/container system. We recommend at least one familiarization jump on your new reserve canopy, and for your new high performance main canopy make a few jumps with higher than normal openings (7000' AGL or above) to really get the feel for it. Knowing how to fly *a parachute* gives you a general sense of confidence, but knowing how to fly *THIS parachute* is what allows you to fly with pure joy.

Glide Ratio

All of our canopies have excellent glide potential. The glide ratio is further enhanced when the pilot assumes a low drag body position. We have designed our canopies to flatten out even more with a little rear riser input, and minimal pressure is required to hold them down. This effect is improved markedly by pulling the slider down all the way, and pushing the risers to the outside while pulling down an inch or two. This method, applied with the brakes unstowed, is wonderful in all conditions, but is most useful when returning from "short" (down-wind) spots, when you have to fight the wind to get home. If the winds are so strong that you are not making any progress at all, front riser input will be necessary instead, as well as a good "Plan B". Interestingly, if the spot is "deep" (long but on the wind-line), and the uppers are strong, you will do best by holding the toggles at about 90% brakes. This will keep you in the upper winds longer, helping you return to the target with the most altitude possible. If the air mas that you are flying in is already going where you want to go, all you need to do is reduce your decent rate so you can stay in the upper winds longer.

Turns

Your canopy is a high performance parachute, with the capability to turn very quickly. At altitudes above 2000 feet above ground level, feel free to explore all of the wing's flight modes, including steep banks and spiral turns. Notice how much altitude is lost in a single revolution, or even a sharp 180 turn. This will provide you with the essential experiential information for flight below 2000 feet AGL.

Steep turns or dives,
when performed at a low altitude,
can cause you to crash into the ground with staggering velocity
and make you be dead

…or make you wish you were dead

Altitude Awareness does not stop at "pull time"

Be smart.

An essential consideration when turning your canopy quickly is line tension. In aggressive turns, you can make the suspension lines go slack. When this happens, you have opened the door for such dangerous occurrences as unrecoverable line-twists, canopy collapse, or even falling into your canopy. With all of your maneuvers, in order to remain in control you must maintain line tension at all times. Your life depends on it. Maintaining line tension is done by making smooth toggle inputs, and/or using simultaneous opposing toggle input to increase the angle of attack. Also, never reverse direction immediately following an aggressive turn. Such a maneuver can surely spin you into line twists.

Your canopy has the ability to perform level-flight turns, in addition to the descending turns discussed above. Applying simultaneous opposite toggle before, during, or immediately following the turn will increase the wing's angle of attack, decreasing your descent rate. This type of dynamic "flat turn" is often necessary when close to the ground.

Performing a descending turn close to the ground can kill you, or anyone near you.

Over-steer

When flying high performance elliptical canopies, you will find some degree of "over-steer" following toggle turns. This is the tendency for the wing to continue turning a bit even after the input is neutralized. This is even more the case following front riser turns and harness turns. Likewise, the deep brake setting on opening allows for easy "weight-shift' or "harness" turns after opening that exhibit this over-steer characteristic. If the wing begins to turn after opening, simply lean the other direction to stop it from turning, and give a bit of rear riser to counter the turn. If that does not work, try unstowing the toggles to reduce the lift of the airfoil. If none of that works, and the turn begins to develop into a spin, it might be time to try out your rigger's latest reserve pack job. Trust your training. Trust your rigger. Treat both with utmost respect.

The amount the canopy overshoots it's heading after ceasing input varies depending on the aggressiveness of the maneuver. The tendency to overshoot its heading is usually negated by weight-shift in the harness, or by stopping the input prior to the desired heading.

Canopies with a mostly rectangular planform (like your reserve canopy) exhibit little or no over-steer. If however, the pilot leans in the harness toward the inside of the turn, coordinated turn are exhibited. (That is a good thing) More on that in the section entitled "Clean Up Your Turns"

Flare

The landing flare on our canopies, similar to most parachute wings, is most effective when using the "bump-to-the-sweet-spot" method. In other words, make the initial toggle input faster than the second phase of the flare. This braking command will "pitch" the canopy into level flight by swinging the pilot forward of the parachute's center. The quick reduction of the parachute's airspeed allows the pilot's momentum to swing him or her out in front of the canopy, thereby increasing the angle of attack, which is the cause of the increased lift. This method maximizes the speed in the surf, as well as the duration of the level-flight phase of the landing. Flaring too slowly will not significantly effect the angle of attack of the canopy, and is therefore an ineffective method of changing the flight path. By doing this, the only thing accomplished is to diminish the precious airspeed that is so necessary for an effective level-off when the arriving at ground level.

Aim to "surf" within touching distance from the ground. This will prevent the inevitable hard touchdown that comes as a result of running out of airspeed at a significant altitude. Any distance between the skydiver's feet and the ground is the distance that he or she will fall when the stall is reached. One foot of altitude at the end of the landing is still too high, especially on a no wind day.

When it's windy, you can get away with almost anything as long as you keep your canopy at zero bank angle and flare a little. It is the no wind day that separates the Aces from the Jokers. "No-wind conditions" require the pilot to truly "finish" the flare. By this we mean flying the canopy all the way to the stall point, just above the ground, in order to minimize the ground speed at touchdown. When landing in windier conditions, the parachute's ground speed will reach zero when the airspeed becomes equivalent to the wind speed. In other words, when landing facing a 10 mph headwind, the parachute's airspeed only needs to be slowed to 10 mph in order to create a zero ground-speed landing. You will note that your canopy can sustain flight at 10 mph for a longer period of time than it can dwell at the stall point. This will create a longer floating phenomenon at the end of the surf when landing on days with some wind.

During the surf, be sure to consciously control the roll axis, preventing the wing from drifting to one side or the other. Having any roll angle at the end of the surf increases the stall speed, and makes your touchdown harder. Keep in mind that we designed your canopy to curve comfortably in the surf, but only when it still has plenty of airspeed. Applying the explanation described at the end of the previous paragraph, this maneuver is easier in conditions with some wind. This is because the parachute still has airspeed, even when hovering with no apparent airspeed. Having the ability to change your heading during the surf is vital for your safety, as obstacles can appear at the last second. (OK not usually, it's just that we aren't always seeing everything that is there when we are on "Sky-Crack". Practice making slight heading changes in the first part of your surf, when you still have lots of speed, and return the wing to the full upright position prior to touchdown. You will want to master this maneuver up high, though. It is not something you want to mess up, especially when you have an audience.

When changing your heading during the surf, be careful not to over-bank the canopy at low speed. Remember, the higher the bank-angle, the higher the stall-speed. This comes as a result of the increased loading of the canopy when flying at the higher angle of attack necessary to keep the canopy from descending during the turn. The higher the loading, the higher the stall speed will be. What this means is that low-speed high bank-angle turns can lead to nasty stalls close to the ground. Airspeed is the cure for such stalls, but only as a preventative measure. This is why such maneuvers must be performed during the primary phase of the landing, when airspeed is still abundant.

Stalls and Stall Recovery

Every wing, rigid and fabric alike, has a discrete angle of attack at which it ceases to fly. This is called a Stall. When experienced by a ram-air pilot, a stall follows deep brake input or rear riser input, and is followed by a moderate or severe dropping sensation, and backward tilt in attitude. This maneuver, depending on the altitude, method of recovery and duration of event, may be a reasonable safe exploration of the canopy's slow-flight, or a dangerous stunt that risks the pilot's future.

The aggression of a hasty recovery could, in higher performance canopies, cause the pilot to fall into the canopy. A stall, when performed at high altitude and relieved slowly, is a perfectly reasonable activity which allows the pilot to discover the amount of "toggle authority", afforded by the current toggle setting. It also helps give the confidence to finish the flare during landing, without the fear of an inadvertent stall.

When initiating a stall, do so at an altitude which would allow for a safe cutaway in the event that the recovery goes awry. Start by applying the brakes slowly to place the canopy in a "sink". This minimizes the aggressiveness of the stall as well as the recovery. Stalling at high speed is more risky, as the pitch change is far more drastic.

Once the stall is achieved (you will know), **immediately but slowly** allow the toggles up a few inches (or rear risers if that's how you stalled) to the point of recovery **and hold them at the recovery point** until the canopy begins to fly again. Only then is it safe to allow the canopy back to full flight. If the stall is relieved aggressively, the resultant forward surge of the canopy will be immediate, violent and deeply unpleasant.

A good metaphor is the operation of the clutch on a standard automobile transmission. The clutch is let out slowly to the "friction point" and held there until the vehicle starts moving, and then gradually relieved. The same is true of parachute stall recovery.

Dive Characteristic

Many of our highest performing canopies are designed with a somewhat negative "Recovery Arc" when loaded at 1.3lbs/sf or higher. In other words, following a diving maneuver, the canopy will continue to lose altitude until the pilot provides some toggle or rear riser input to level out. This is a conscious design choice on our part, so that you will find it easier to hit the "surf-window". In other words, if you are slowly descending toward the flare altitude with sustained airspeed, you merely have to wait for the right moment to apply the toggles in order to level off.

A wing with a short recovery arc will level itself out after an airspeed-increasing maneuver will do so regardless of the altitude above the ground. If you are at 30 feet when it chooses to level off, that's where you will remain until the airspeed runs out, and then you get an ankle-burner for a landing if you don't work the remaining airspeed with great skill. Precision Aerodynamics canopies will afford you the opportunity to make final approach adjustments on all axes: up, down, and turns. You will learn to love this characteristic when learning how to "swoop".

Essential Aerodynamics for the Ram-Air Pilot:

Laminar Flow

Laminar flow refers to the flow of the relative wind as it follows the curved upper surface of a wing. It is this "bending" of the air that provides the lift that allows a wing to glide, rather than fall. This occurs due to the acceleration of the air molecules following the curvature of the upper surface, and thereby dropping in pressure. This creates a sort of suction that pulls upward, perpendicular to the center cell.

Airspeed = Lift

The faster the wing flies through the air, the more lift you have at your disposal, provided that you have the altitude to use the speed to your benefit. No speed, no lift.

Pitch = Angle of Attack = Airspeed Control   (see Figure 1)

Pitch is the relationship of the pilot and wing to the horizon. In other words, it describes the attitude tilt, fore and aft. Pitch can vary widely, depending on the flight mode. The range can span from pilot hanging directly below the parachute, way out in front, or well behind the center of gravity. The pitch has indirect consequences to airspeed and other aspect of your flight as well. (See Figure 1)

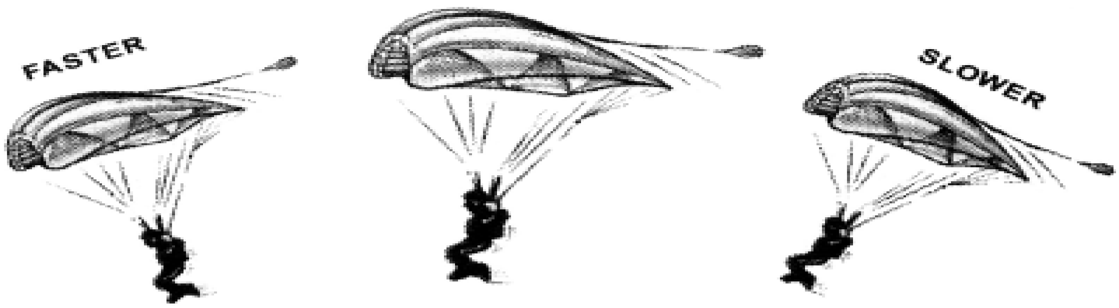


Figure 1

Angle Of Attack

Angle of Attack is the relationship of the wing's "chord" (a line drawn front to back inside the airfoil), to the vector created by the relative wind, or apparent wind created by the parachute's flight path. When the pitch changes, the Angle of Attack changes correspondingly. When the canopy pitches back, this increases the Angle of Attack and vice-versa. (See Fig. 2)

Higher Angle of Attack

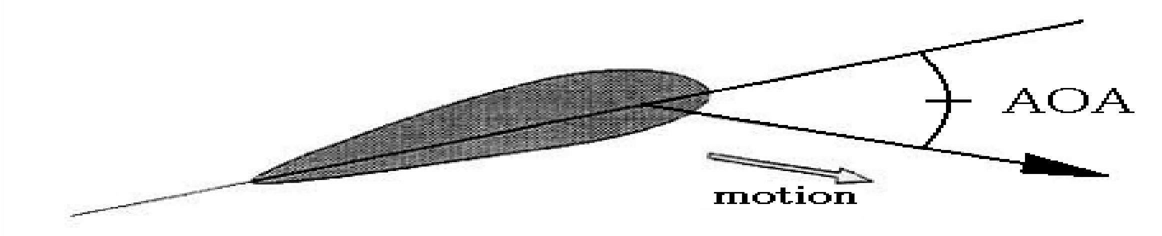


Figure 2

Higher angle of attack results in:

1) more drag

2) less airspeed

3) increased lift and line tension due to increased weight

Lower Angle of Attack

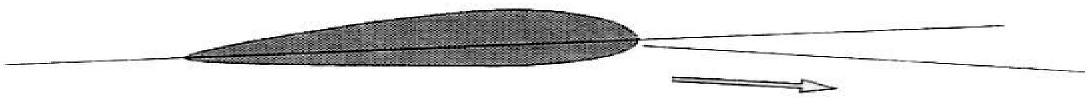


Figure 3

Lower angle of attack results in:

less drag and

more airspeed as lift diminishes and gravity takes over)

Simply put, airspeed is increased when the wing is pointed nose down i.e. pitched forward, which also increases the decent rate. This can be done through the use of front riser input, single toggle input, or the relief of toggle input. When the wing flies with a low angle of attack, it has less drag, so the airspeed increases.

Conversely, airspeed is diminished when the nose of the canopy is lifted. This is accomplished by applying the brakes or rear risers, which slows the parachute's airspeed by increasing the canopy's drag, thereby swinging the pilot forward of center. The net result of such input is a higher angle of attack of the wing, which decreases the decent rate as well as “net “airspeed.

Paradoxical High Angle of Attack

Note the nose-down attitude depicted in Fig 4. This demonstrates that that angle of attack is not the same as “Attitude” (orientation) with respect to the horizon, since this diagram displays a high angle of attack despite the nose-down attitude. Attitude with respect to the horizon is referred to as “Pitch” (Fig 1). In other words, just because you are in a front riser dive does not necessarily mean that you are at a low angle of attack. If your front risers are pulling up hard and you weight a ton, you are flying at a high angle of attack despite being in a dive.

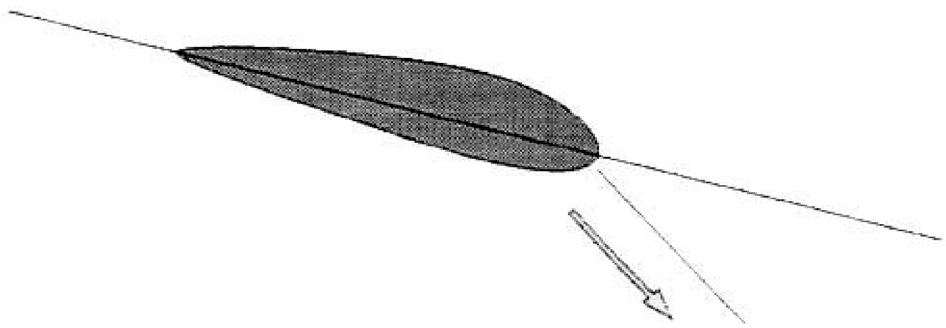
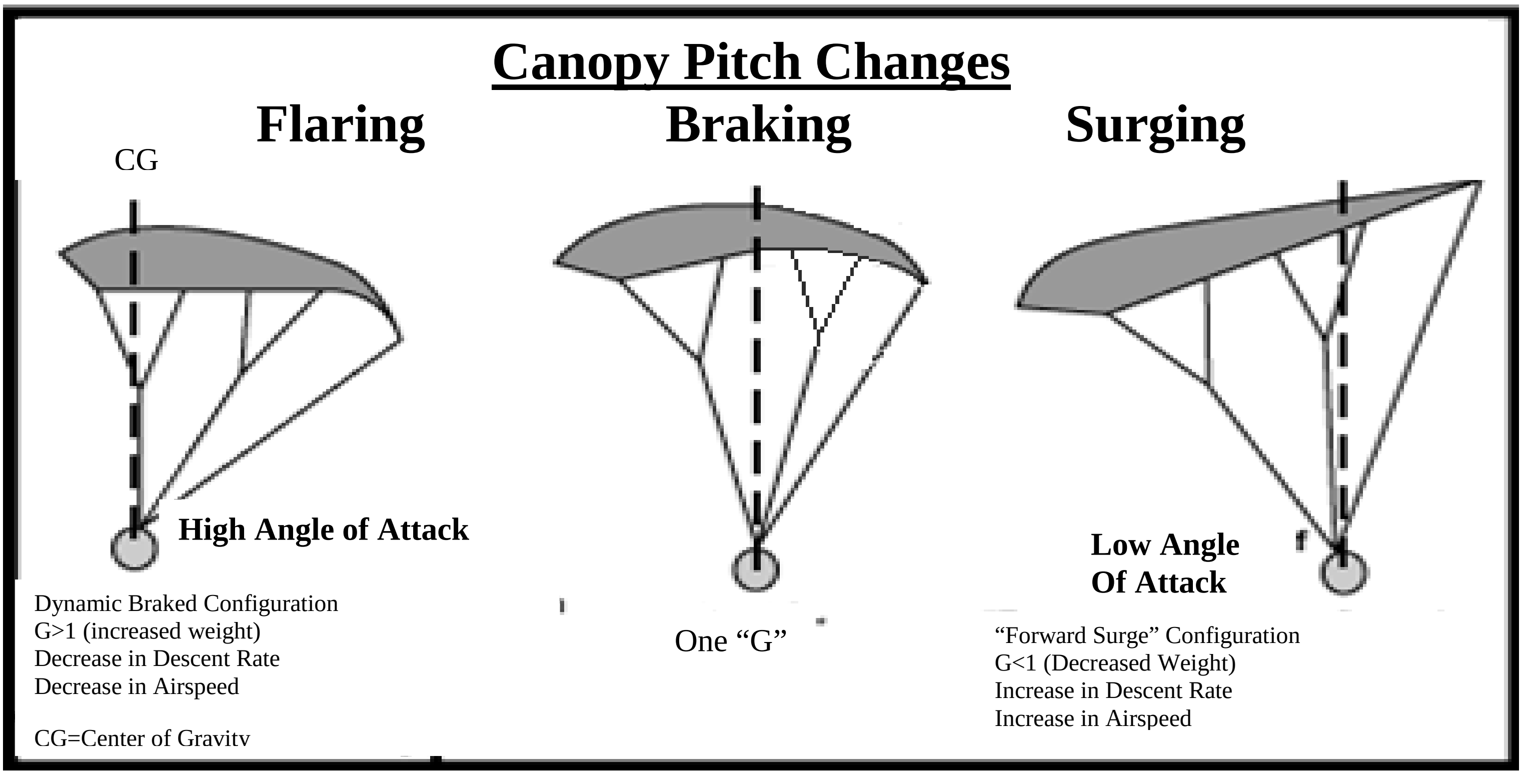


Figure 4

Angle of Attack = “G Force” Control



“G” force is the in-flight weight of the pilot, measured in “G’s” (G is for Relative Gravity). It is your momentary wing-loading. One “G” is equivalent to the pilot’s weight on the ground. Therefore, during a “2G” maneuver, a 150 lb. pilot will effectively weigh 300 lbs.

Pitch, and thus angle of attack, is responsible for the varying “G” load exerted on the pilot. This change in “G” forces also effects the tension of the suspension lines, as the action of the parachute is not intimately connected the pilot due to the reduction in weight. This in turn effects the overall stability of the canopy. If you are weightless, you aren’t energetically connected to your canopy. Bad things can happen on a ram-air canopy if the Lift is not opposing anything. (Fig 6)

As the pilot applies input to decrease the angle of attack (such as aggressive application of the front risers or abrupt relief of brakes), the “G” loading, substantially decreases. Correspondingly, the line tension is reduced. Thusly, the parachute becomes less stable and less rigid, and thereby more apt to collapse due to turbulence as well as opening the door for self-induced line-twists. Further, rapid decent close to the ground is not quickly arrested when the lines are slack, and the “G” load is low. This means that you will be unable to pull out of a dive before making a divot in the grass. Yea, ouch.

When the pilot increases the angle of attack by applying brakes or rear risers, the “G” load on the pilot is increased. Accordingly, the line tension increases in direct proportion to the “G’s” felt by the pilot in the saddle. In other words, the more the pilot performs high “G” maneuvers, the more stable the canopy will be in flight. Maintaining a high airspeed, when combined with a positive angle of attack, will result in the high “G” loading that will allow you to maneuver quickly in any way you see fit. If you feel heavy, do whatever you want. If you feel light, do not attempt to turn aggressively. Wither wait for the line tension to return, or induce lift by applying some brakes to pitch the canopy to a higher Angle of Attack.

If you are flying at a relatively high airspeed, with positive weight, you are in command of your wing. When the ground comes, a short burst of ¼ brake is more than enough to achieve level flight. If the “G’s” need to be increased further, bring the nose up by applying more brake input, sharply, but not all the way to stall.

“G” force is the effective weight of the pilot, measured in “G’s”. One “G” is equivalent to the pilot’s weight on the ground. Therefore, a 150 lb. pilot will effectively weigh 300 lbs. during a 2 “G” maneuver.

Pitch, and thus angle of attack, is responsible for the varying “G” load exerted on the pilot. This change in “G” forces also effects the tension of the suspension lines, as the action of the parachute is not intimately connected to the pilot due to the reduction in suspended weight. . This in turn effects the overall stability of the canopy. If you are weightless, you aren’t energetically connected to your canopy. Bad things can happen on a ram-air canopy if the Lift is not opposing anything. (Figure 6)

As the pilot applies input to decrease the angle of attack, or dive the canopy, “G” load, or net wing loading decreases. Correspondingly, the line tension is reduced. Thusly, the parachute becomes less stable and less rigid, and thereby more apt to distortion or line-twists. Further, rapid decent close to the ground is not quickly arrested when the lines are slack, and the “G” load is low.

When the pilot increases the angle of attack by applying brakes or rear risers, the “G” load on the pilot is increased. Accordingly, the line tension increases in direct proportion to the “G’s” felt by the pilot in the saddle. In other words, the more the pilot performs high “G” maneuvers, the more stable the canopy will be in flight. A nose high attitude isn’t always a high “G” flight mode. If the “G”s need to be increased further, bring the nose up more with toggle input.

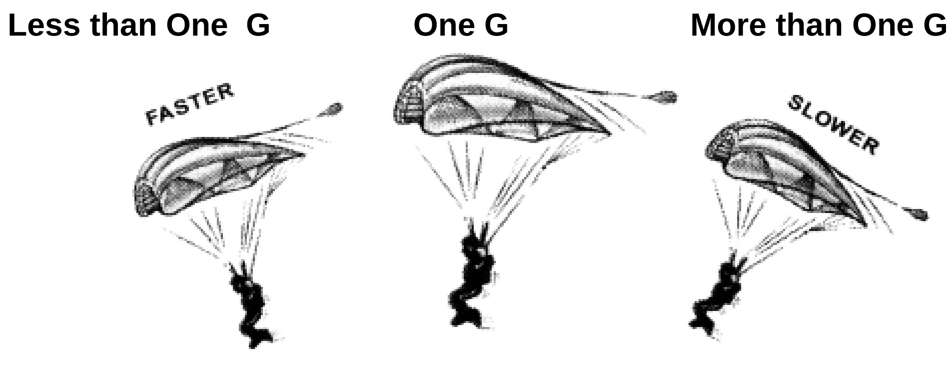


Figure 6

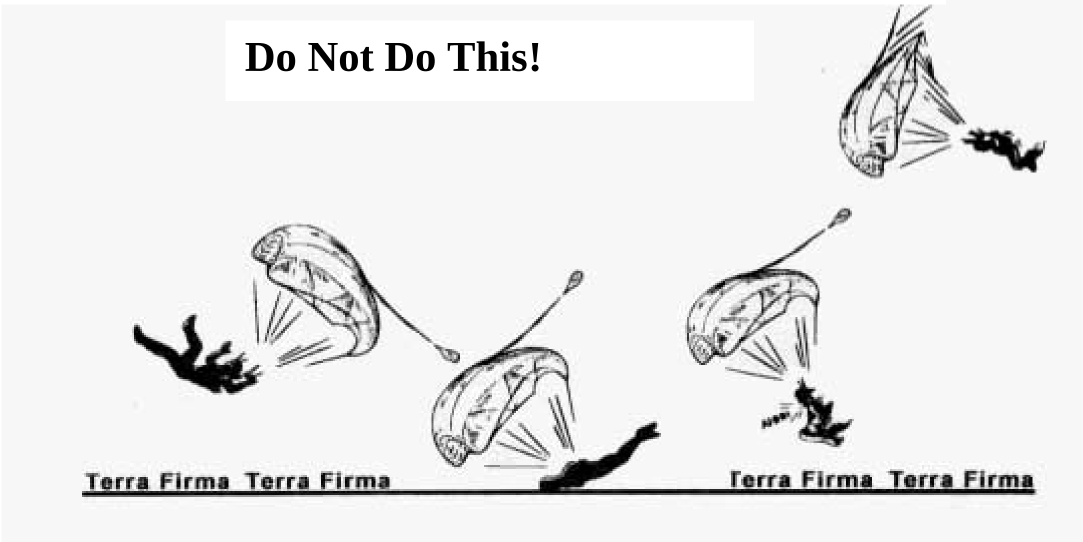
Recovery Arc (Pendular Stability on the Pitch Axis)

Much like a pendulum, the pilot hanging under a parachute has a natural tendency to return to the “neutral” position, directly below the canopy. This principle assumes many important factors including airfoil design, line length, type of maneuver, maneuver aggressiveness, density altitude, and wing loading. Parachutes vary with respect to Pendular Stability, based on design, type of maneuver and wing loading.

A parachute that has a slight negative tendency to recover from a dive will be easier to land.

With this in mind, it is important to perform final turns fairly high above the ground in order to level off with minimal toggle input. This is because it is optimal to allow the canopy’s natural pendular stability to return you to the neutral pitch position prior to reaching final level-off altitude.

If you have to pull your toggles down below your shoulders to recover from your last turn, you have executed your last TOO LOW, period!



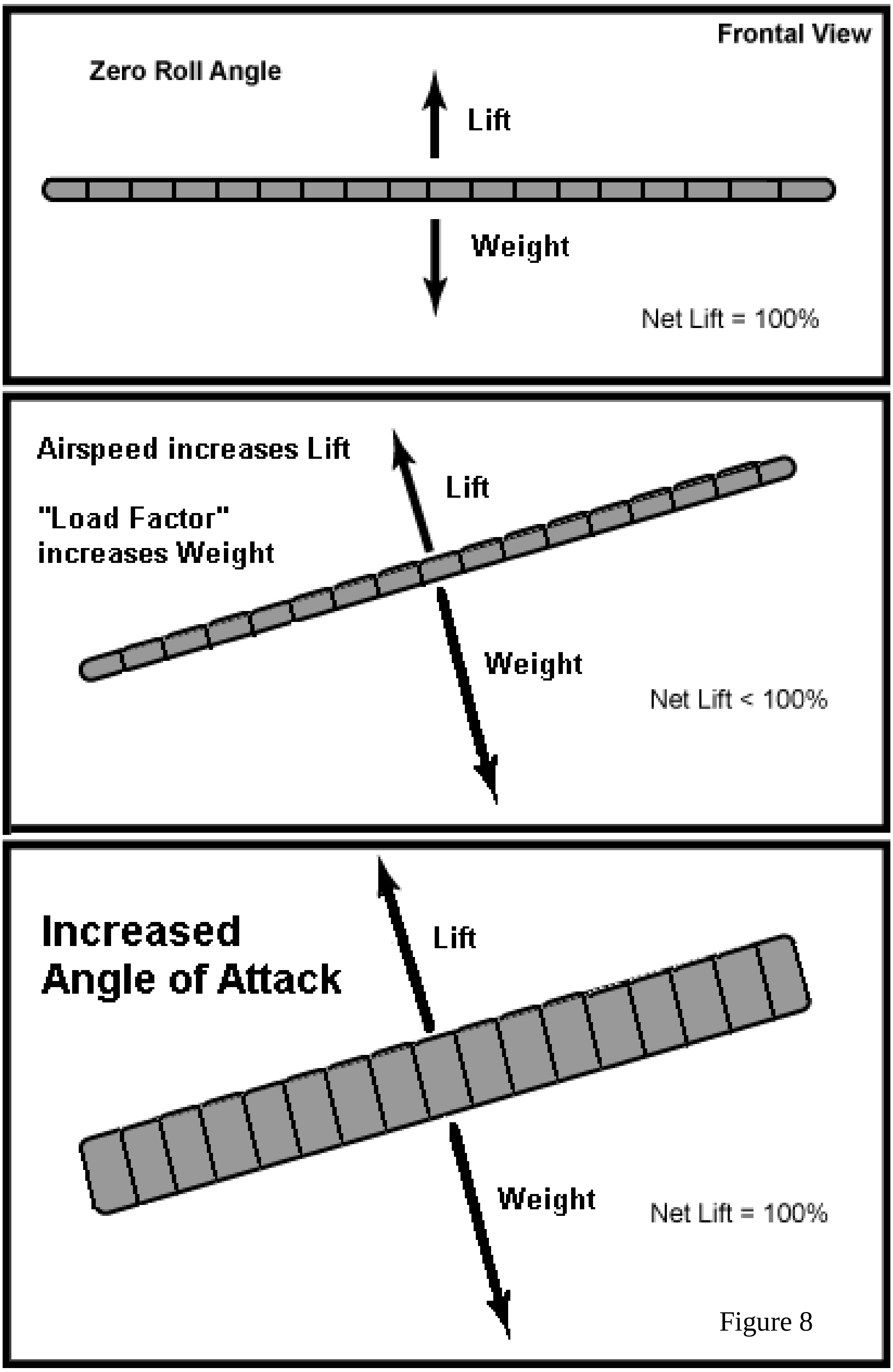


Figure 8

Roll Axis

"Roll" or "bank" is another axis of flight that must be consciously controlled, especially during landing. When the canopy is banked to one side or the other, the lift vector, which is always perpendicular to the center cell, is changed such that it is lies at an angle to gravity. This reduces the effectiveness of your canopy's lift against gravity, which in turn increases your decent rate. Touching down with any bank angle will serve to reduce your canopy's net lift, making your landing harder, due to the increased wingloading generated from the turn. (see Figure 8)

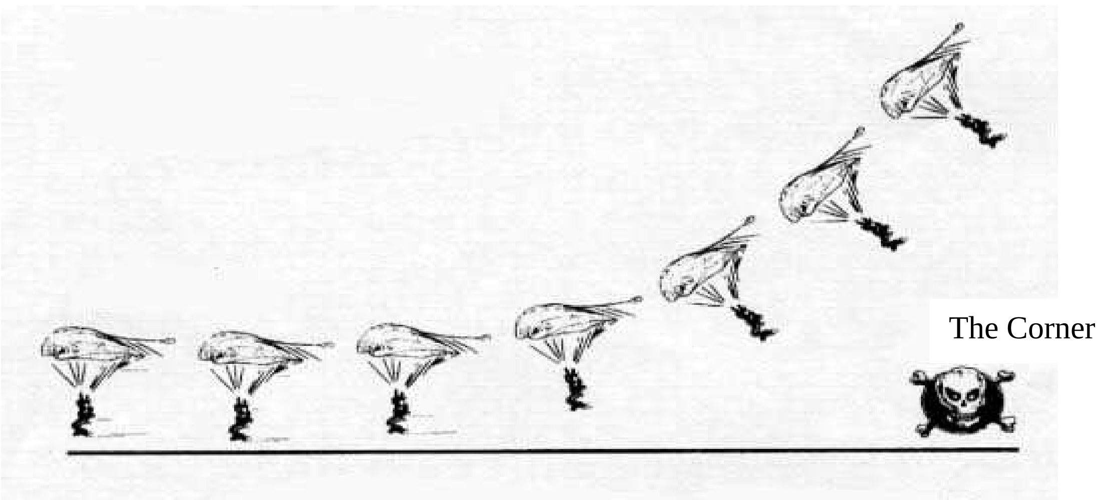
Roll, however, is what creates heading changes in flight. By producing lift in a more horizontal direction, the wing experiences a force that changes its direction of flight. This is important information when considering turns at low altitude. This understanding allows the pilot to realize that, when flying at full speed, bank is integral and essential for heading change or "yaw". Without bank there is no yaw.

With this in mind, turns requiring little or no altitude loss must begin with bank, but a higher angle of attack is necessary to limit the decent rate. Start the turn with harness input (create roll), then add the single toggle input to deepen the turn (create yaw), and ***then*** pull the opposite toggle as well to increase the angle of attack. This places the pilot further forward of the wing and increases the "G" forces during the turn. If you feel heavy in the maneuver, you are doing it right.

It is essential when performing such a level-flight turn, to initiate the maneuver with significant amounts of airspeed. This is due to the increased "G" load on the canopy that comes as a result of the higher angle of attack. As the load increases, so does the **stall speed** of the wing. This means that it is crucial to recover the wing to the overhead position on the roll axis before the airspeed drops below the critical stall speed.

High Speed Approaches

It is true that the faster a wing flies the more lift it can produce. This assumes, however, that there is sufficient altitude and angle of attack to convert the speed into lift prior to smashing into the ground. If we sound too direct in this point, it is out of necessity. Airspeed increasing maneuvers close to the ground have become a blight on our sport. Hundreds of incidents, both fatal and non-fatal occur each year. It is our belief, at Precision Aerodynamics, that it is not the maneuver that is the problem, it is the pilot. Education is the answer



Very few experienced swoopers have avoided incident and injury.

That's why they're called: "Experienced".

Stay out of the dreaded "Corner". A shallow entry is a safe entry.

A properly executed airspeed-increasing maneuver affords a reasonable amount of safety for the pilot. (see Figure 8) This is, however, the result of years of practice coupled with a deep understanding of the parachute. Inexperienced pilots attempting to swoop across the ground at high speed is a formula for disaster for everyone involved, including bystanders.

It isn't necessary to accelerate the canopy above its natural full flight airspeed in order to achieve a safe and soft landing. Doing so clearly increases the risks, plain and simple. Errors in judgment, or variances in the flying environment can lead to impact forces beyond your imagination's ability to foresee. Your ego will cloud your ability to picture the consequences, so don't foster its function. Ego represents a blindfold that shields us from reality. Facing reality is the only way to be safe in this sport.

Knowledge, discipline and humility are the only salvation from the carnage that plagues our sport. With this reminder of the potential hazards in mind, let's look at some thoughts that may help you survive high-speed approaches.

You don't NEED to swoop on this jump

One must approach the earth with an attitude of "maybe". Sure, it would be nice to get a great swoop. If the conditions are not perfect, however, you must refrain. This kind of discipline is not easy, or common. Our lives ride on an archetypal decision between willingness and willfulness. Loosen your grip on your swoop.

Plan your abort

One must have options before going out on a limb in life. Make sure that any maneuver you perform below 1000 feet is one which can be quickly negated. Aggressively slinging yourself way out to the side in order to pick up speed leaves a period of time during which you cannot save yourself. Practice carving maneuvers so that you can level out immediately in the event that you find yourself too steep too low. In the case of turning approaches, consider the direction and location of your turn carefully. Every degree of your turn should have a safe avenue for an aborted approach. Avoid boxing yourself in such a manner that only a successful execution of the plan will allow you to survive.

Rehearse your abort

Execute the diving approach at high altitude over and over, including immediate arrest of your dive. A quick, strong application of the brakes will put you in level flight very quickly, but the action pattern must be natural. The physical behavior must be second-nature, but mental visualization is also essential. Picture yourself reacting quickly to a self induced emergency, stabbing your way to survival.

Learn to recognize the signs of a dive gone awry early, before it's too late. During the dive we rely exclusively on our sight to guide our actions. A good pilot notices that he or she is in trouble early enough to bail out and land safely. A great pilot recognizes the same problem even earlier, and makes adjustments such that the landing looks totally normal and in fact graceful.

If The Approach Feels Scary, It Probably Is!

The shape of an ill-planned and executed approach is angular; forced in energy. It is the embodiment of "willfulness" rather than "willingness". Instead of going with the flow, we muscle the turn, the dive, and the recovery. Consequently, the experience is uncertain of outcome and thereby provocative of fear. Further, it looks scary, even to uneducated observers.

The perfect high-speed approach is a thing of beauty. It flows like water, fluid in both shape and energy. There are no sharp corners, no abrupt changes in momentum. As a result of flowing with the "Tao" (Chinese concept of Flow), the experience of the perfect approach is one of comfortable, relaxed grace. There is nothing scary about it at all. When you do it right, you will know because the whole thing feels SLOW.

Dive Techniques

Front Riser Approaches: Straight In

Pulling on your front risers, in unison or asymmetrically, will change the center of gravity of your canopy toward the nose, increasing your airspeed and decent rate. This is a stable maneuver on many parachutes, affording the pilot a good chance of recovery in the event of an excessively low dive. This is due to the fact that the canopy is producing lift throughout the dive, and will generally begin to recover immediately after the front risers are released.

Caution: Not every canopy will respond in this manner to front riser input. Many parachutes will buck wildly when the front risers are pulled down. This may be due to brake lines that are too short (flutter in the C-D section), or much worse, instability in the design of the parachute. If the front riser pressure drops significantly as the airspeed increases, or in turbulence, your parachute might not be stable in this flight mode. Keep in mind that front risering in turbulence is a risky endeavor with any parachute. If you feel a sudden loss of front riser pressure, or an abrupt dropping sensation, release the riser(s) immediately and apply the brakes.

Straight front riser approaches will be an easier method for learning to swoop than turning approaches. This approach limits the number of variables we need to keep track of, simplifying the experience. Basically, it's a waiting game. Face into the wind, toward a clear area, and pull down on the front risers. A few inches is generally enough to increase the speed, so avoid excessive application. Too much input will pull your tail down, as your toggles are still in your hands. Keep your eyes open and wait for the right moment to release them and level off. Don't forget to breathe.

Never let go of your toggles in order to pull on your front risers. Creating speed without the means to recover quickly is quite simply a very bad idea. It is absolutely essential that you experiment with this maneuver at altitudes at least 2000 feet above the ground. Your canopy's response to such input will vary depending on many variables including: wingloading, length of brake lines, pilot chute size and type, riser length, weather conditions, design of the canopy, and condition of the canopy and line-trim. If your experiments display any instability at all, don't even consider this as a viable alternative near the ground.

It is crucial that you apply front riser input smoothly. Pulling the front risers aggressively can present the top-surface of your wing to the relative wind, making it more susceptible to structural deformation due to turbulence. In such situations, the canopy may experience line-slack, and loose precious altitude quickly. Recovery from such situations requires immediate brake application to the half-brake position.

The location at which you grab the front risers is also important. Holding on to long "dive loops" that are located low on the risers will force you to pull your tail, as previously discussed. Pulling the tail is contradictory input, as you are attempting to increase your speed, not loose it. It's a bit like naming your dog "Sit". Imagine trying to call him…"C'mere, Sit"… you'd drive him crazy! This is why many swoopers leave their toggle attachment point a bit long, so that their tail is straight and aerodynamic during the dive. Also, consider holding your front risers as high as your hands can reach, which will accomplish the same goal.

As you recover from the dive, make the transition as smoothly as possible. The change from dive to level flight must be gentle and gradual. If you hear a "popping" sound you simply dropped the front risers, probably because you were too low and got scared. Release the dive high enough that you can enter the surf with minimum toggle input. A good swoop is like skipping rocks on water. Enter the swoop at a shallow angle, rather than straight at the ground. It's that or make a big splash...

Heavy Riser Pressure

On many canopies, the front riser pressure is too high to allow many pilots to pull them down. Initial front riser pressure can be relieved, however. Hold 1/4 brakes before initiation and then release them just prior to riser application. The load factor is then reduced, thereby reducing the pressure on the risers. This must be done in one fluid motion and moderately at that. An aggressive flare, release and front riser sequence is a dangerous and unstable maneuver that may promote a full frontal collapse. However, a gentle “over-the-hill” kind of maneuver can be a pilot’s best friend on a canopy with heavy front riser pressure.

“It’s Ballet not Boxing”

Front Riser Approaches: Turning

The most common method for accelerating the canopy’s airspeed prior to landing is the front riser turn. There are advantages of this method over toggle turning approaches. As mentioned earlier, aggressive toggle turns can promote line slack, which can lead to impacting the ground at high speed. Also, toggle turning approaches do not afford the pilot the option of continuing the dive straight ahead in the event that the maneuver was performed too high. Front riser turns, while more physically demanding, have none of these potential problems, and allow the pilot to adjust every aspect of the approach throughout the dive.

Aim to execute your dive too high, And most of the time you will be right on. Once in a while you will plane-out too high, But you will walk away.

A high speed approach has many ways in which it may unfold. No two “hook turns” are alike. Sometimes you will find yourself high, sometimes a little low. The key is, adjust before it’s too late.

Too High

Sometimes you complete your front riser turn too high, realizing that you are about to plane-out well above surf altitude. This is the safest of the errors that you can make, and is exactly what you should aim for when learning. It is rare that a pilot who turns too high gets hurt.

On aggressive front riser turns: Once you get more comfortable with front riser turns for landing, it can become terribly tempting to throw the turn around with all your might. By doing this, the Load Factor is markedly increased. This means that the weight carried by the parachute is heavier than your body weight, making the front riser pressure heavier. This can result in leveling off too high, as the pressure on the risers may be too much for you to bear.

Too Low

The key to surviving a low approach is early recognition of your situation. As mentioned earlier, just because you have started your approach a bit on the low side doesn’t mean that you can’t salvage a great landing. If you are really low and really steep, hitting your breaks RIGHT AWAY is your only option for survival. Those who hesitate will inherit the earth.

Rubber Necking

When flying your canopy, you must be acutely aware of the other canopies in the air with you. This is especially true when executing aggressive approach methods. By diving your canopy in the pattern, you can rudely enter someone else's airspace, or even collide with them. "Drive Preventatively". The term "Defensive" driving is too strong a word, and it suggest that being scared will somehow help. It won't. Have fun, dig into it, and keep your eyes wide open.

Remember: "Low canopy has the right of way" Keep your eyes mobile. Look above, below and all around. You may need to abort your hook altogether. The best hook is the one that you didn't do when conditions were questionable.

Awareness: The Mind of the Swooper

When your adrenaline begins to subside through repeated exposure, your awareness will begin to increase. This will allow you to make all kinds of adjustments during your dive. We call this process "waking up". Most skydivers think that they are awake. This is only natural, as our minds manufacture a reality that makes us comfortable enough to jump. The truth is, very few pilots are calm enough to be truly aware of the situation all of the time.

Waking up is a continual process in which the enlightened skydiver returns to the present moment. The present moment is reality, and reality is where all of life's decisions are made. Ego, and all of its presupposed assumptions about what is, takes us from what truly is. Our lives are a journey toward wakefulness, toward bare attention of the present moment, whatever it holds.

Awareness can be noticing that someone's chest strap is not hooked up, even though they are ten feet away from you. Awareness might be seeing another canopy below you before starting your front riser turn for final approach, and aborting the swoop altogether. Wakefulness is all these things and more, and it truly is the key to our survival.

Awareness is the answer

*The chart is based on *"**Total Exit Weight**"*: [Jumper + Equipment]*

Parachute Downsizing Considerations

By BrianGermain.com

 # Top: Middle of Range (recommended)

(#) Bottom: Smallest Allowed (only with advanced skills training)

Jumpers with fewer than 500 skydives must not downsize beyond this chart.

**Jumpers are welcome to use a larger parachute than the chart suggests*.

Absolute limitations are placarded on every individual canopy and must never be exceeded.

Exit Weight (lbs) / Jumps	110 sf	121	132	143	154	165	176	187	198	209	220	232	243	254	265
1	190 (170)	190 (170)	190 (170)	190 (170)	190 (170)	190 (170)	210 (178)	210 (189)	230 (200)	230 (211)	230 (222)	260 (230)	260 (230)	260 (230)	260 (230)
20	170 (170)	170 (170)	170 (170)	170 (170)	190 (170)	190 (170)	210 (176)	210 (187)	230 (198)	230 (209)	230 (220)	230 (230)	230 (230)	230 (230)	230 (230)
40	170 (150)	170 (150)	170 (150)	170 (150)	170 (150)	190 (160)	210 (171)	210 (182)	230 (192)	230 (203)	230 (214)	230 (224)	230 (230)	230 (230)	230 (230)
60	170 (150)	170 (150)	170 (150)	170 (150)	170 (150)	190 (156)	190 (166)	210 (177)	210 (187)	230 (198)	230 (208)	230 (218)	230 (229)	230 (230)	230 (230)
80	170 (150)	170 (150)	170 (150)	170 (150)	170 (150)	190 (152)	190 (162)	210 (172)	210 (182)	230 (193)	230 (203)	230 (213)	230 (223)	230 (233)	230 (230)
100	150 (135)	150 (135)	150 (135)	150 (135)	170 (150)	170 (150)	190 (158)	190 (168)	210 (178)	210 (188)	230 (198)	230 (208)	230 (217)	230 (227)	230 (230)
120	150 (135)	150 (135)	150 (135)	150 (135)	150 (135)	170 (145)	190 (154)	190 (164)	210 (174)	210 (183)	220 (193)	230 (203)	230 (212)	230 (222)	230 (230)
140	150 (135)	150 (135)	150 (135)	150 (135)	150 (135)	170 (141)	190 (151)	190 (160)	190 (170)	210 (179)	210 (188)	230 (198)	230 (207)	230 (217)	230 (226)
160	150 (135)	150 (135)	150 (135)	150 (135)	150 (135)	170 (138)	170 (147)	190 (156)	190 (166)	210 (175)	210 (184)	230 (193)	230 (202)	230 (212)	230 (221)
180	150 (135)	150 (135)	150 (135)	150 (135)	150 (135)	150 (135)	170 (144)	190 (153)	190 (162)	210 (171)	210 (180)	210 (189)	230 (198)	230 (207)	230 (216)
200	135 (120)	135 (120)	135 (120)	135 (120)	150 (123)	150 (132)	170 (141)	170 (150)	190 (158)	190 (167)	210 (176)	210 (185)	230 (193)	230 (202)	230 (211)
220	135 (120)	135 (120)	135 (120)	135 (120)	135 (120)	150 (129)	170 (138)	170 (146)	190 (155)	190 (163)	210 (172)	210 (181)	210 (189)	230 (198)	230 (207)
240	135 (120)	135 (120)	135 (120)	135 (120)	135 (120)	150 (126)	150 (135)	170 (143)	190 (152)	190 (160)	190 (168)	210 (177)	210 (185)	230 (194)	230 (202)
260	135 (120)	135 (120)	135 (120)	135 (120)	135 (120)	150 (124)	150 (132)	170 (140)	170 (148)	190 (157)	190 (165)	210 (173)	210 (181)	210 (190)	230 (198)
280	135 (120)	135 (120)	135 (120)	135 (120)	135 (120)	135 (121)	150 (129)	170 (137)	170 (145)	190 (154)	190 (162)	190 (170)	210 (178)	210 (186)	230 (194)
300	135 (120)	135 (120)	135 (120)	135 (120)	135 (120)	135 (120)	150 (127)	150 (135)	170 (143)	170 (150)	190 (158)	190 (166)	210 (174)	210 (182)	210 (190)
320	135 (120)	135 (120)	135 (120)	135 (120)	135 (120)	135 (120)	150 (124)	150 (132)	170 (140)	170 (148)	190 (155)	190 (163)	190 (171)	210 (179)	210 (186)
340	135 (120)	135 (120)	135 (120)	135 (120)	135 (120)	135 (120)	135 (122)	150 (129)	150 (137)	170 (145)	170 (152)	190 (160)	190 (168)	190 (175)	210 (183)
360	135 (120)	135 (120)	135 (120)	135 (120)	135 (120)	135 (120)	135 (120)	150 (127)	150 (135)	170 (142)	170 (149)	190 (157)	190 (164)	190 (172)	210 (179)
380	135 (120)	135 (120)	135 (120)	135 (120)	135 (120)	135 (120)	135 (120)	150 (125)	150 (132)	170 (139)	170 (147)	170 (154)	190 (161)	190 (169)	210 (176)
400	135 (120)	135 (120)	135 (120)	135 (120)	135 (120)	135 (120)	135 (120)	135 (122)	150 (130)	150 (137)	170 (144)	170 (151)	190 (158)	190 (166)	190 (173)
420	135 (120)	135 (120)	135 (120)	135 (120)	135 (120)	135 (120)	135 (120)	135 (120)	150 (127)	150 (134)	170 (142)	170 (149)	170 (156)	190 (163)	190 (170)
440	135 (120)	135 (120)	135 (120)	135 (120)	135 (120)	135 (120)	135 (120)	135 (120)	150 (125)	150 (132)	150 (139)	170 (146)	170 (153)	190 (160)	190 (167)
460	135 (120)	135 (120)	135 (120)	135 (120)	135 (120)	135 (120)	135 (120)	135 (120)	135 (123)	150 (130)	150 (137)	170 (143)	170 (150)	190 (157)	190 (164)
480	135 (120)	135 (120)	135 (120)	135 (120)	135 (120)	135 (120)	135 (120)	135 (120)	135 (121)	150 (128)	150 (132)	170 (141)	170 (148)	170 (155)	190 (161)
499	135 (120)	135 (120)	135 (120)	135 (120)	135 (120)	135 (120)	135 (120)	135 (120)	135 (120)	150 (126)	150 (132)	150 (139)	170 (145)	170 (152)	170 (159)

*Size must be **Increased** as Necessary to reflect "Relevant Variables"

*See footnotes and explanations (next page)

Footnotes and Explanations

The chart on the previous page gives two different values:

A) Top Number: “**Middle of Range”** (Square Feet)
*Not an absolute figure. See “Relevant Variables” (above)

Due to individual differences in natural ability, judgment and demonstrated in-air awareness, there must be allowances for variability with the recommended size. To fit every canopy pilot into a finite formula is not reflective of the true nature of the situation.

B) Bottom Number: **(Smallest Size Allowed)**

Although some canopy pilots are ready to downsize beyond the recommended limitations of this chart, there must be absolute limits. Most parachute manufacturers prescribe a Maximum Wingloading for a given parachute design, implementation of these limitations requires further elaboration. The purpose of the bottom number is to establish a ”Wingloading Never Exceed”, or WNE, defined in Pounds per Square Foot, rather than a wingloading number. This allows for careful selection of each subset category of the wingloading range, reflective of the non-linear nature of parachute performance as it relates to wingloading and canopy size.

Applicability of Chart

The parachute size to which the Chart suggests pertains to the Smallest Parachute of the dual parachute system (main or reserve).

Density Altitude Compensation

Surface area should be increase to reflect increases in density altitude. Increase the recommended size by roughly 10 square feet for each increment of 2000 feet above sea level. This adjustment is subject to adaptation based on the proficiency exhibited with regards to the “Essential Maneuvers” (see below).

Currency

Add approximately 15 square feet for less than 100 jumps per year

(i.e. 120 becomes 135)

Add approximately 30 square feet for less than 50 jumps per year

(i.e. 120 becomes 150)

Canopy Design

Add one size for Fully Elliptical Canopies

-F.E.C. = More than 20% wing taper

-Fully Elliptical Canopies are not permitted for jumpers with less than 300 jumps.

-Prior to transitioning from a non-elliptical to elliptical planform, all jumpers should make at least 100 on a non-elliptical parachute of the same wingloading, or as dictated by the Canopy Transition Course Instructor.

Rounding Sizes:

The parachute sizes prescribed by the Chart do not always coincide with the sizes available for a specific canopy model. Given this, jumpers should use the size closest to the prescribed number if the number is not a standard size. If the canopy is elliptical or radical in design in some other way, this may or may not suggest increasing the size further. The best course of action is usually to err on the side of safety.

Rounding Weight

Use the weight and size to the right of your numbers. If your weight is above the number on the chart, round up to next the higher number.

Skipping Sizes and Planform Type

It is not advisable to change planform type and or size simultaneously in the transition process. Skipping sizes or changing planform type is a judgment call of the Canopy Transition Course Instructor based on the skills demonstrated by that canopy pilot, and the best course of action is to err on the side of safety.

Beyond 500 Jumps

After a canopy pilot has exceeded 500 jumps, the only limitation on wingloading, size and planform is to be based on the Specific Canopy Manufacturer's Recommendations for that design and of the Safety and Training Advisor or equivalent instructional staff.

Probationary Period

The initial jumps on a new canopy are a probationary period. This is an opportunity for the pilot to focus complete attention on the flight characteristics of the new canopy. Therefore, the first 5 jumps on a smaller or more agile parachute should be made solo, opening no less than 5000 feet AGL.

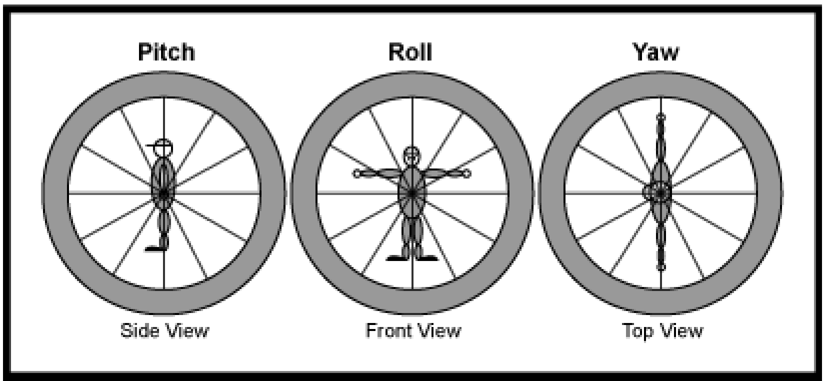
Frame of Reference

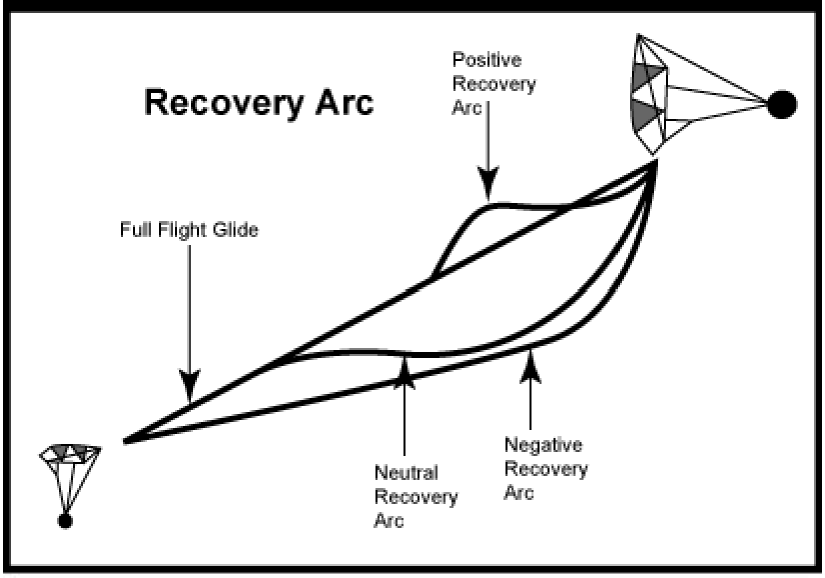
Depending on the jumpers previous experience, currency and individual ability, the canopy transition course instructor may chose to allow accelerated downsizing or skipping sizes.

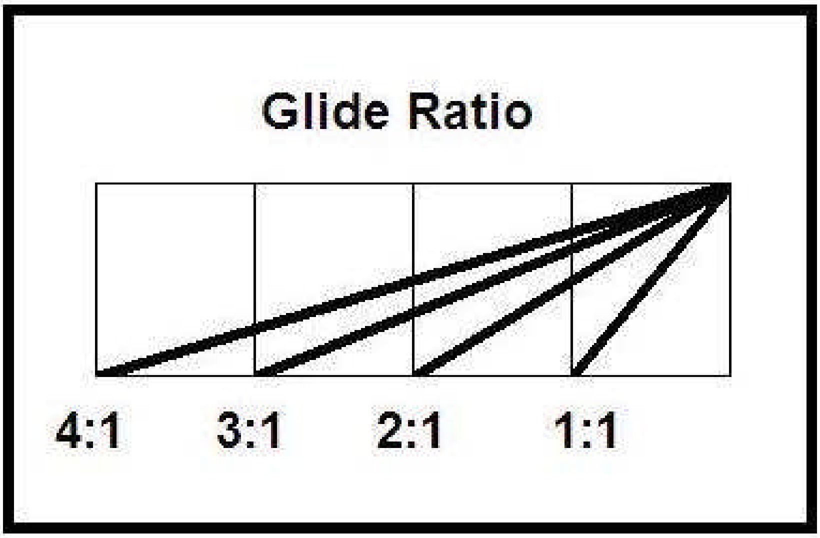
Non-Linear Nature of Parachute Performance

Due to effects relating to the balance of drag between the suspended weight and the parachute, the same canopy design of varied sizes will perform differently with the same wingloading.

Larger wings tend to have more Roll Axis Stability, shortened Recovery Arc and superior True Glide Ratio*.



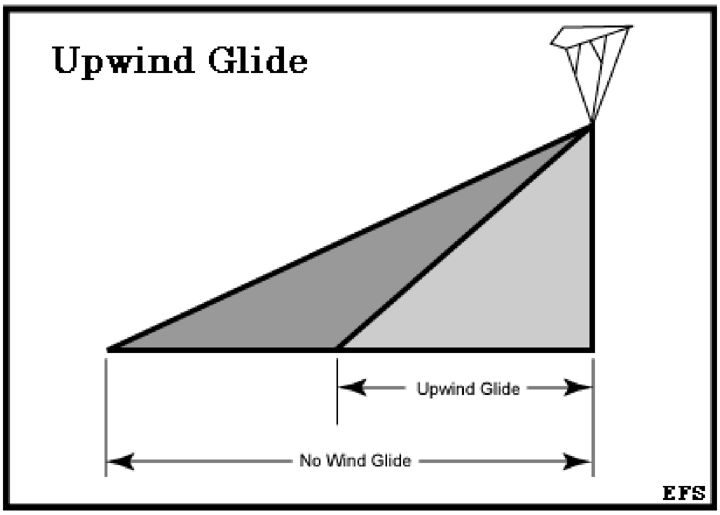


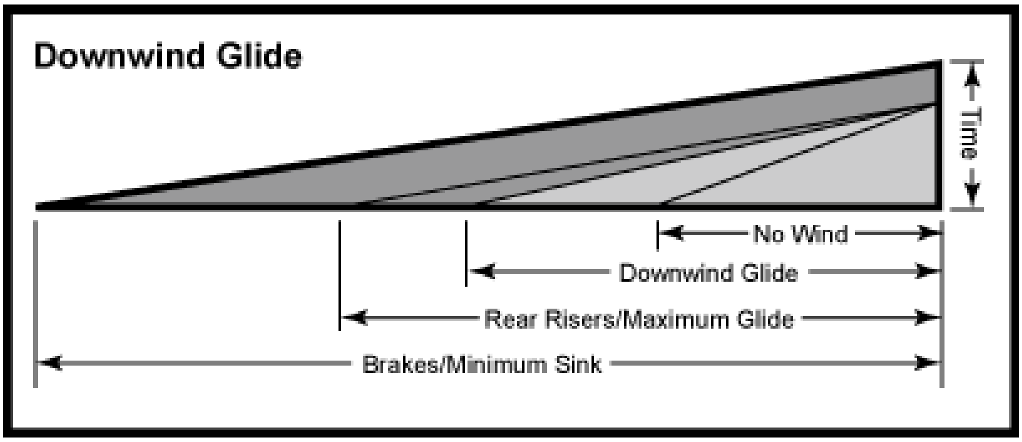


While a 170 square foot canopy may perform in a docile manner at 1.0 lbs per square foot, a 107 of the same design will be much more responsive at the same 1.0 wingloading. Therefore, the Chart skews the data in a non-linear nature, suggesting a more gradual downsizing progression for lighter pilots and a more aggressive paradigm for the heavier jumpers.

Relative Glide Ratio and Wingloading

Although **Upwind Relative Glide Ratio** is further enhanced with increased wingloading, **Downwind Relative Glide** is more a function of descent rate than airspeed. Therefore, the best way to enhance Downwind Relative Glide is in the deep brake mode on a small canopy, or through the use of a larger parachute.





Smaller parachutes have several advantages when flying in high wind conditions, as well as in turbulent air. Further, heavily loaded canopies tend to perform more like fixed-wing aircraft, enhancing the extrapolative learning process. Nevertheless, downsizing prior to attaining the necessary skills and judgment is unwise and potentially very dangerous. Therefore, the following set of performance standards establish a baseline for a canopy pilot as they prepare to downsize. Without demonstrating the following survival skills prior to switching to a smaller canopy, the increased airspeed, descent rate and roll axis instability are a set-up for failure.

Essential Maneuvers

The following is a list of in-flight maneuvers essential to safe flight. These tasks must be preformed regularly, so that the pilot will have the ability to perform these maneuvers without thinking. "Learned Instincts" must be developed for such tasks, so that when situations arise requiring immediate action, the programmed responses will be the correct ones.

***All exercises should be performed above a safe cutaway altitude, in the event that the pilot inadvertently induces line-twists and loses control of the parachute.**

***All exercises should be performed on the current size and planform before downsizing or transitioning to a more responsive design.**

***All exercises should be performed on dedicated jumps, opening above 5000 feet AGL. Opening high following a relative work freefall may allow sufficient time to perform the maneuvers, but dedicated jumps are preferable as a learning experience.**

***Video should be used whenever possible for debriefing and evaluating landings and in-flight maneuvers.**

Pitch Control Exercises

Manipulate the canopy on the pitch axis using the brakes.

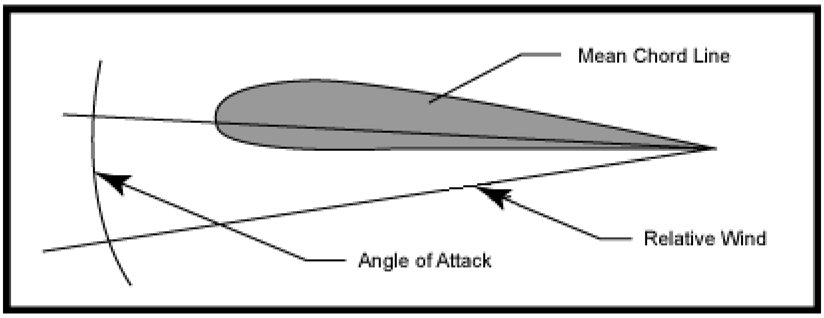
Look at canopy to notice the amount of pitch axis change.

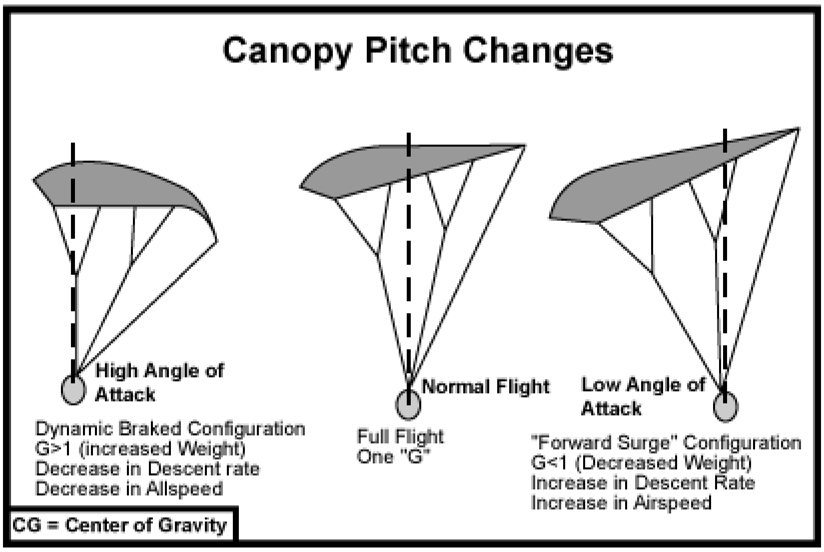
Notice the difference between “soft” and “sharp” inputs:
{slow application vs. quick}

Notice the amount of slack in the brake system when in the full flight mode.

Why?

Controlling the pitch angle is how we manipulate the Angle of Attack of the wing. Without a dynamic change to the angle of attack, the pilot will be unable to increase the lift of the parachute enough to change the direction of flight from its normal full flight glide to level flight. This maneuver is therefore essential for safe landings.





Stall Practice

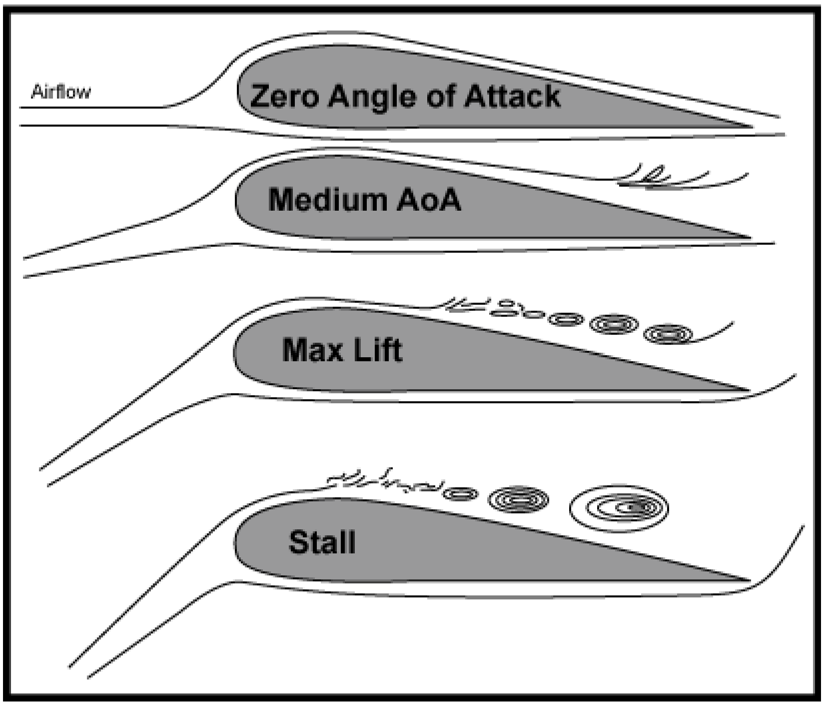
- Find the stall point using both the brakes and the rear risers
- Recovery with minimal altitude loss and loss of heading

- Controlled recovery must be demonstrated, using a slight reduction in the angle of attack, rather than an aggressive release, which can result in a collapse of the wing or line-twists.
- Any modern parachute design is capable of stalling and recovering safely with proper technique.

Why?

The stall point represents the highest angle of attack that a particular wing can utilize prior to a loss of control. This discrete angle of attack, when approached slowly, also represents the slowest airspeed available to the pilot. When landing in no-wind conditions, it is necessary to diminish the airspeed as much as possible in order to achieve the lowest possible groundspeed for the touchdown. On smaller, high airspeed parachutes, this ability is essential.

Further, deep brake flight is often necessary for approaches into small landing areas. If the pilot is unfamiliar with the flight characteristics of the parachute in the high angle of attack mode, there is significant risk of a stall or spin at low altitude. By rehearsing slow flight and beyond to the full stall condition, the pilot becomes more comfortable with dynamics of the canopy in the steep descent flight mode. If the parachute stalls, quick recovery has become a learned instinct, increasing the chances of survival significantly.



Slow-Flight Practice

- Place the canopy in 90% brakes and hold for 60-90 seconds.
- Make controlled heading changes of 45-90 degrees.
- Notice the difference in responsiveness as compared to full flight turns.

- Notice that lifting a toggle on the outside of the turn reduces the risk of stalling the wing on the inside of the turn.
- Notice the diminished roll axis stability in the deep brake mode, requiring smooth control inputs and slow recovery of the roll angle.

Why?

Most pilots spend the majority of their canopy ride in full flight. This means that the feeling of the canopy in this mode is most comfortable to most people. It also means that flying in deep brakes places many out of their comfort zone. In other words, most people are somewhat uncomfortable just prior to putting their feet on the ground on every single jump.

Anxiety in slow flight often causes pilots to hold their breath which diminishes their cognitive capacity due to oxygen deprivation. The impatience caused by the discomfort usually results in looking down and offsetting the steering toggles toward the end of the landing in order to get to the ground sooner. They simply want this part to be over.

In order to land with great consistency, we must become intimately aware of the flight performance of our parachutes in very deep brakes. The more time we spend in this flight mode, the more comfortable we will be.

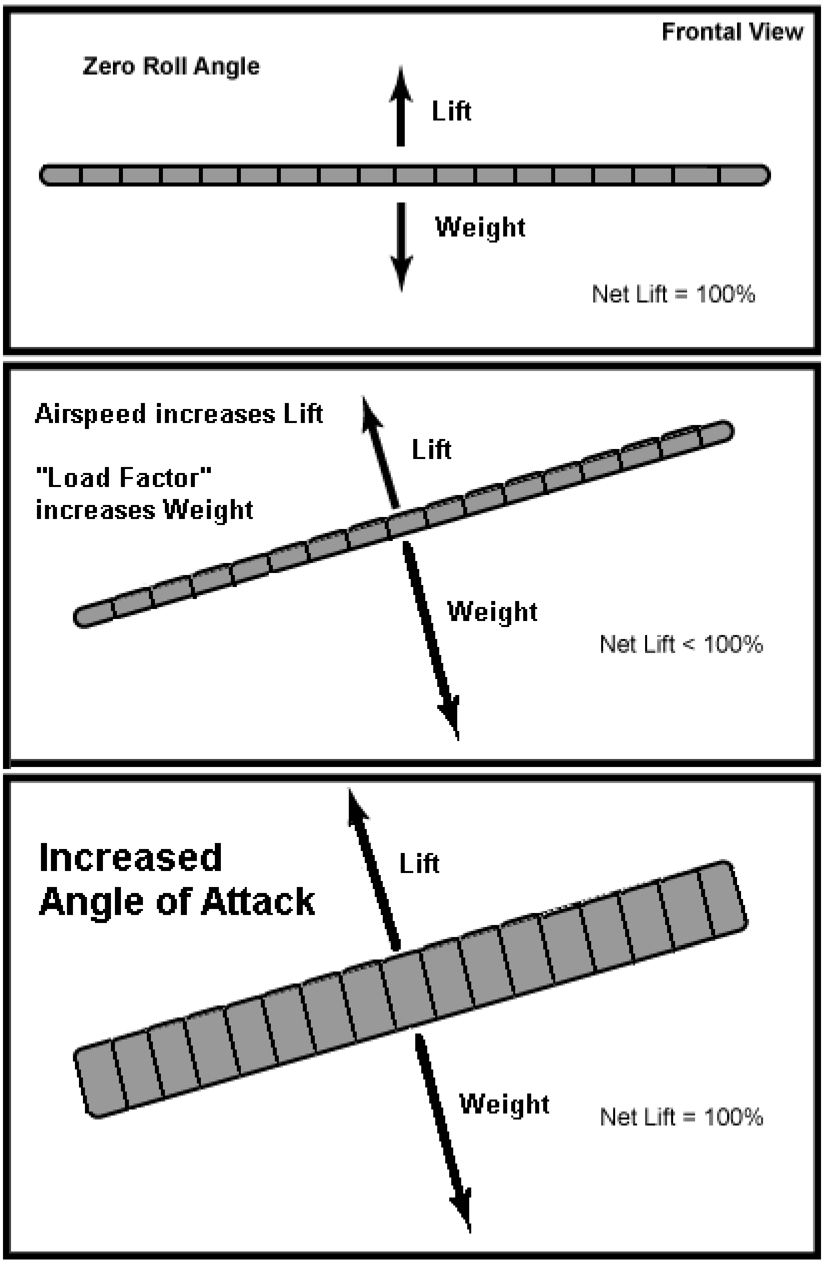
Pitch Control with Bank Angle

- Begin a turn using a single steering toggle
- Apply the opposite toggle while still in the turn
- Experiment with soft versus sharp inputs to negate decent.
- Look at canopy to notice pitch changes with respect to the relative wind.
- Recover bank angle to zero **As Gently As Possible**, as roll axis stability in high angle of attack flight mode increases the likelihood of overcorrection in the recovery of the roll angle.
- Exercise should be practiced alone, as well as with a relative reference such as another canopy, altitude reading or clouds.

Why?

Having the ability to control the pitch axis while in a bank is what gives the pilot the ability to control the decent rate while in a turn. The natural tendency is to lose altitude in a turn, but this is not necessarily the result of turning with bank angle. By increasing the angle of attack while in a bank, the pilot increases the amount of lift that the parachute is producing, and can alter the flight path to zero descent rate flight despite significant bank angle.

The goal of this maneuver is to cultivate the ability to arrest the descent rate while in a turn, rather than relying on a reduction in the bank angle to negate descent. This technique can be utilized during low altitude emergency evasive action. It is inevitable that parachutists will encounter situations requiring a change of heading close to the ground. This method allows such actions without significant risk, given sufficient rehearsal.



Dive Arrest: Toggle Turns

- Begin maneuver above 3000 feet AGL
- Place the canopy in a spiral dive using a single steering toggle.
- Arrest the dive as quickly as possible by sharply applying the opposite toggle while maintaining toggle input on the inside of the turn.
- Roll out of the turn at a high angle of attack without oscillation or overcorrection.

Why?

While turning too close to the ground is the preliminary cause of injuries in parachuting, it is not specifically the bank angle that causes the accident; it is the Descent Rate. Although bank angle tends to be coupled with a loss of altitude, it is the low angle of attack that causes the descent. The descent rate of any turn can be eradicated through the application of collective brake pressure in a turn when sufficient airspeed is maintained throughout the maneuver.

Unfortunately, most canopy pilots assume that bank angle must be eliminated before arresting the dive. This leads many to waste valuable time and altitude in the process of leveling the roll axis of the system prior to the flare. In situations with very little altitude remaining, this may delay the collective brake application until it is too late. Further, the release of the single brake input allows the canopy to surge forward in the window, causing a decrease in the angle of attack.

By rehearsing a transition to zero decent while still in a bank, the pilot becomes accustomed to applying the toggle on the outside of the turn as a learned instinct, reducing the chances of a turn leading to serious injury. The process of “Carving” out of a turn, rather than allowing the canopy to follow a diving recovery is perhaps the most important skill available to the modern parachute pilot.

Turn Reversal

- **“Pause and Reverse”** (wait for line tension returns prior to reversing direction of flight)
- **“Aggressive Reversal”** (apply collective toggle input prior to reversing direction of flight)

Why?

It is often necessary to reverse the direction of a turn to avoid traffic. Without sufficient rehearsal, a pilot may inadvertently induce line-twists and lose control of the parachute. By practicing turn reversal, the pilot is able to change direction almost instantly, decreasing the risk of canopy collisions.

Rear Riser Flight

- Perform rear riser evasive turns immediately after opening with the brakes stowed.
- Perform rear riser turns with the brakes released.
- Perform rear riser flares and stalls.
- Apply collective rear riser input to flatten glide without a significant loss of airspeed.
- The benefits of such exercises are significantly enhanced by having a relative reference such as clouds or another parachute flying in no contact formation.

Why?

In the event of traffic after opening, there is little time to alter the canopy’s heading, and the process of releasing the brakes requires time. Having the ability to safely maneuver the parachute with the brakes stowed is essential to safe parachuting. Experimenting with the performance tendencies of each parachute brings to light individual issues relating to over-steer and allows the pilot to take precise evasive action.

Performing rear riser turns with the brakes released prepares the parachute pilot to properly deal with a broken steering line. Further, by rehearsing rear riser flares, the pilot will be better equipped to handle such situations. Attempting to land a parachute using the rear risers with no prior high altitude rehearsal is unadvisable and may lead to injury.

Lastly, application of collective rear riser input allow the pilot to increase the True Glide of the canopy, reducing the risk of off-field landings, as well as altering the flight path to improve accuracy.

Front Riser Input

- Perform straight front riser dives.
- Perform single front riser turns.
- Perform offset double-front riser turns.

Special Considerations:

Front riser input should be applied with the toggles in the hands. Given this, this maneuver requires forethought and planning on exactly how to hold and release the risers without risk of inadvertently dropping a toggle. The risk of dropping a toggle near the ground can be significantly reduced by inserting all four ringers into the toggles and tightly grasping the toggle with the pinkie and ring finger at all times. This allows freedom of the index and middle finger for insertion into the front riser dive loops.

Front riser pressure increases as a function of airspeed. Therefore, attempting front riser application in full flight or faster is extremely difficult or impossible. In order to reduce front riser resistance, application and subsequent release of ¼ brakes is usually sufficient to diminish the resistance to within workable limits.

Why?

Reduction of the angle of attack is necessary for many flight maneuvers including: upwind penetration (improving relative glide ratio), canopy relative flying, accuracy, as well as high performance approaches.

Dive Arrest: Front Riser Dive

- Place the canopy in a dive using the front risers.
- Rehearse dropping the front risers and quickly stabbing the brakes.
- Rehearse both straight front riser dive recovery as well as turning dives.

Why?

What keeps pilots alive is the judgment and skills necessary to save them when they dive too close to the ground. If a pilot rehearses the solutions to the dangers, the likelihood of a dive resulting in serious injury is dramatically reduced.

Dropping the front risers allows the pilot to keep their hands down, ready to stab the brakes aggressively to arrest a dive. A short, sharp, “nudge” on the brakes is usually all that is necessary to place the jumper back under the wing, and to the higher angle of attack that saves their life.

Harness Turns

- Harness turns with the brakes stowed
- Harness turns in full flight
- Harness turn follow-through after other inputs
- Harness turns to adjust the flight path on final approach

Turning on the harness is accomplished by leaning to one side or the other, and lifting the leg on the outside of the turn. The capacity for the harness to load the canopy on one side is limited by chest strap tightness as well as canopy design and wingloading. Utilizing asymmetric harness input in order to effect a turn is only effective on parachutes of sufficient wingloading and elliptical taper.

Harness input can be used to initiate a turn as well as enhance or extend the heading change of another type of input such as toggle, rear riser or front riser.

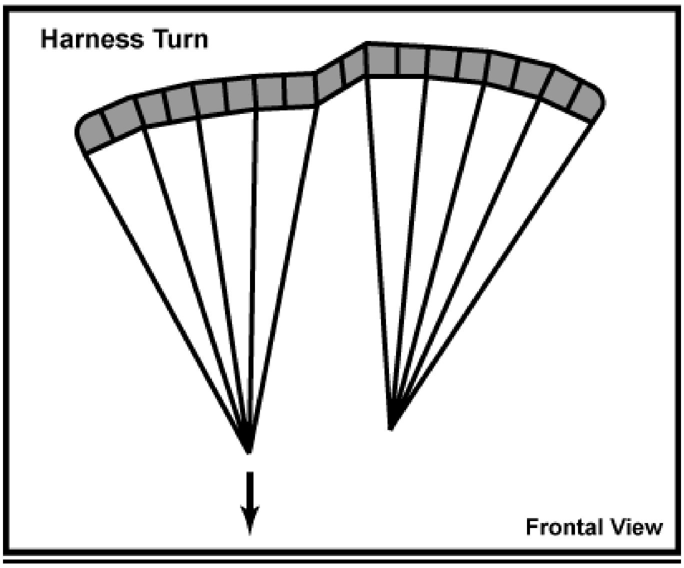
Why?

Immediately after opening, the harness can be utilized to steer away from traffic or toward the landing area prior to unstowing the toggles. Although the turn is not as fast about the yaw axis as a toggle or rear riser input, the immediate access of this kind of turn makes it a useful technique.

Another use of the harness turn is for heading changes in turbulent conditions. While all other methods of turning distort the airfoil and alter the pitch axis of the wing (which effects many variables such as airspeed and decent rate), the harness turn is neutral in this regard. This makes the harness turn the safest method in turbulence, reducing the chances of an abrupt decrease in the angle of attack resulting in a loss of control and or collapse.

Harness turns can also be used to enhance or extend the effects of other turning methods. While front riser turns may become difficult as airspeed increases, the heading change may be continued with the harness even after the pilot is forced to let off of the front riser input.

On final approach, adjustments to the heading should not affect the glide angle. Unlike toggle inputs, harness turns will not result in pitch and roll axis oscillations. Therefore harness maneuvering can be a superior control input to other options.


Harness Turn
Frontal View

Precision Landing Pattern

- Enter the pattern with sufficient altitude for the decent rate and glide ratio of the specific canopy.
- Fly a semi-linear **Downwind, Base and Final Approach** with minimal adjustments so as to coordinate with other traffic in the pattern.
- Demonstrate the ability to appropriately adapt the approach pattern to reflect the specific needs of the opening point or other issues that may affect the safety of the flight.
- Demonstrate sufficient Situational Awareness while in the pattern, not only of location and altitude, but of traffic as well.

Approach technique will vary depending of type of parachute, the pilot's experience level, as well as situational variables. While flying the pattern in full flight may be appropriate for some pilots under certain conditions, others may find more success by flying a braked approach during the Downwind and Base leg of the pattern.

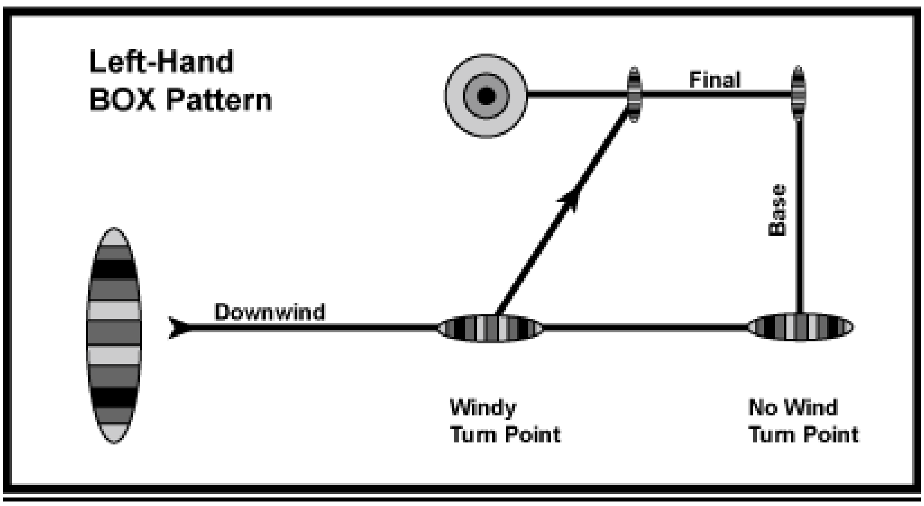
Deep brake approaches can deprive the system of the airspeed necessary for a safe landing, especially on heavily loaded canopies. Final approach, then, should be primarily flown in full glide with only subtle corrections.

*The smaller the canopy, the more altitude is necessary for a safe landing pattern. This is due to the higher descent rate, and increasing the pattern entry altitude allows for a similar amount of time in the pattern for all canopies regardless of size.

Why?

Consistency in the landing process allows a pilot to notice differences and make necessary changes to the flight path early enough to ensure safe landings. Further, by flying a predictable pattern into landing, other traffic will better be able to expect the next change to the flight path, thereby reducing the chance of collisions.

The accuracy method referred to as "S" turns are useful for approach adjustments in the absence of traffic, but create a dangerous situation when multiple parachutes are landing at the same time. Therefore a standard "Box Pattern" creates a safer situation in the landing area, and is an important skill prior to downsizing or changing planform.



Accuracy Landings

- 30 **Stand-Up Landings** within 10 meters of the target center, consisting of:
- (10) No wind/light wind accuracy
- (10) 5-10 mph
- (10) 10-18 mph
- Full Flight Approach
- Braked Approach (5-10 mph wind, no turbulence)

The ability to land precisely in a planned location is essential for safe parachuting. This allows the pilot to negotiate constrained landing areas in the event of an off-field landing, eliminating the need for last minute corrections due to a faulty approach. Such missed approaches in tight landing areas often result in accidents.

Replication of the approach in varied conditions is also an important part of the demonstration of this skill, and is required for the fulfillment of this skill category.

Landing hard on target is not the goal of this exercise. Therefore it is also part of the requirement to land softly without the need for a PLF. This requires a more advanced understanding of the parachute so that the descent rate can be negated prior to landing. A “Flared Landing” requires accommodation of the horizontal “float”, so the target of the approach must be downwind of the actual landing point.

Depending on the size of the landing area, a full speed approach may or may not be appropriate. Therefore it is necessary to demonstrate the ability to make steeper brakes approaches as well. Such a method becomes crucial for small landing areas.

Heading Changes in the Landing Surf

- Set up a final approach approximately 45 degrees off the windline
- Achieve zero descent rate within 5 feet of the ground
- Roll and Yaw the canopy into the wind
- Recover the bank angle to zero without overcorrection about the roll axis
- Complete the flare for a soft, stand-up landing

Special Considerations:

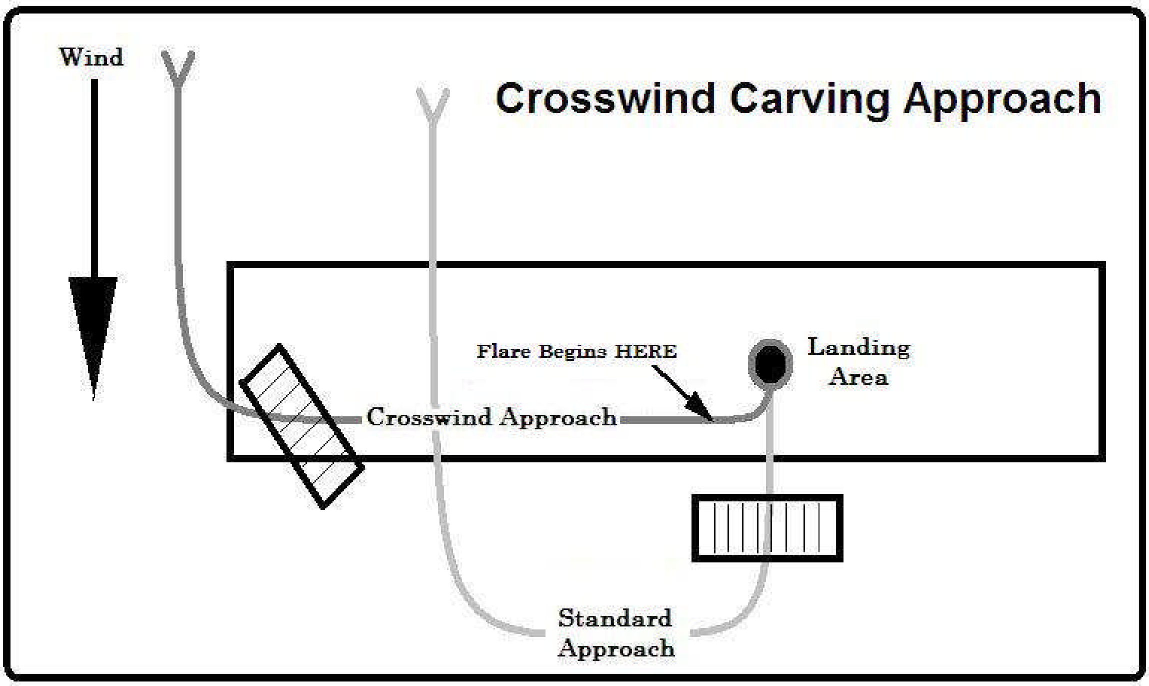
Airspeed is necessary for the performance of a level flight turn. It is not necessary, however, to accelerate the parachute beyond full flight glide in order to perform the maneuver.

It is essential that this maneuver be rehearsed numerous times at altitude prior to attempting it close to the ground. Roll axis wobble due to overcorrection can result in hard landings, and practice is the only way to become comfortable with the roll axis instability experienced at a high angle of attack.

Why?

Controlling the heading throughout the landing process is essential for safe canopy flight. The increased airspeed and groundspeed exhibited by smaller parachutes causes longer landing surfs as well as a longer period of time in this phase of the landing. This increases the risks of colliding with obstructions on the ground as well as other canopy traffic. The skill of controlling the parachute's heading while maintaining level flight is therefore even more important on parachutes with higher wing loading, and for pilots working on advanced approach techniques.

In the event that the landing area is narrow and off the wind line, the ability to make a crosswind approach allows the pilot to reduce the risk of hitting an obstacle on the ground by overshooting the landing site. Making a heading change back into the wind during the landing flare reduces groundspeed substantially, as well as the distance covered across the ground.



Crosswind Landings

- Set pattern and final approach 45 to 90 degrees off the wind-line
- Complete Level-Off within touching distance from the ground
- Complete the landing flare for minimum groundspeed landing
- Slide or PLF landing should be performed, rather than attempting to run.

Special Considerations

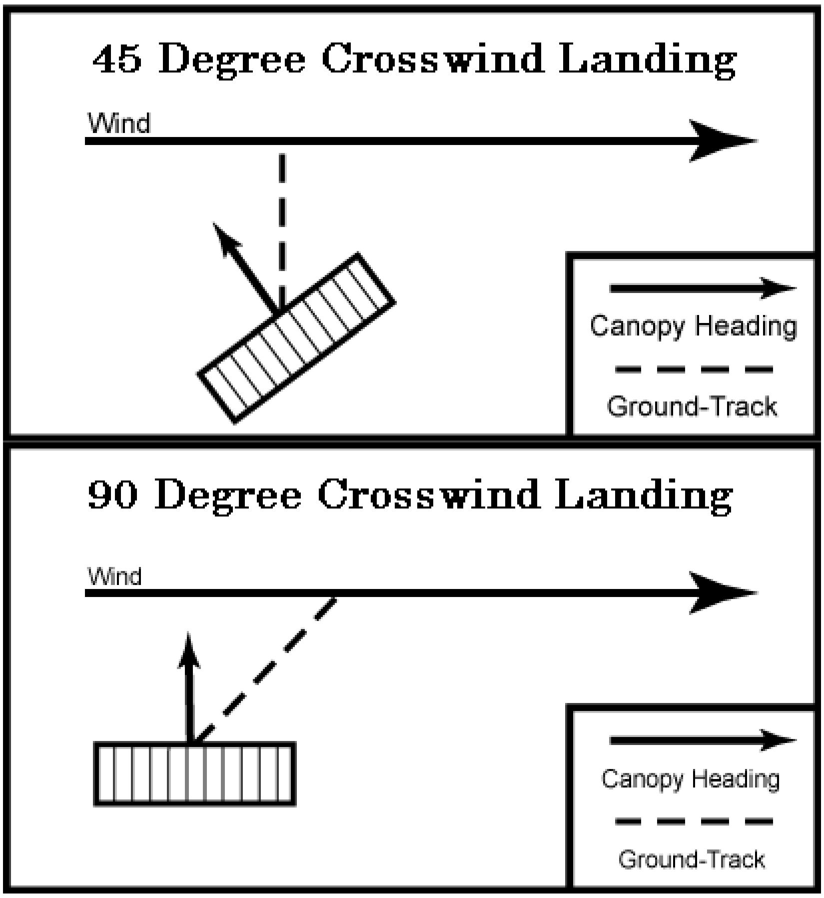
Attempting to run out a crosswind landing significantly increases the risk of injury. The jumper must place the heels on the ground first facing the direction of motion, and then gradually ease back onto the butt toward the completion of the landing. It is also important to continue the flare while sliding for the lowest possible groundspeed.

Do not attempt the crosswind landing exercise above 10 miles per hour ground wind velocity. In the event that the jumper is forced to perform a crosswind landing in high winds, it is advisable to carve the canopy into the wind during the landing flare as much as possible, without touching down with significant bank angle.

Crosswind landings must always be performed away from the normal landing area so as to avoid creating a traffic hazard. Further, the site chosen for this maneuver should be clear of rocks or other obstacles, and should be level terrain.

Heading changes may be necessary on any landing, and looking forward toward the direction of flight is crucial.

***Do not attempt to land more than 90 degree off the wind-line while practicing this exercise.**



Why?

If a pilot is not accustomed to landing with high groundspeed, they will be more likely to attempt to make a dangerous low turn to face into the wind. If, however, they have practiced landing crosswind, they will be prepared for the additional challenges with this type of approach.

No Contact Formation Flight

Flying relative to another canopy at altitude presents an unparalleled learning opportunity. While exploration of a parachute's flight modes is essential training, in order to truly understand the results of the control inputs, a pilot needs a relative reference. Although such drills are very important in the cultivation of canopy flying skills, there are a number of safety concerns that must be addressed prior to the jump.

1) Only fly with one other canopy at a time. Losing sight of another parachute presents the greatest risk in formation flight. Do whatever is necessary to remain in visual contact with your wingman. If you lose visual, maintain your flight path until you re-acquire the other canopy.
2) Never approach another canopy head on. The closing speeds of two parachutes flying toward each other can be staggering, leaving little time for evasive action.
3) When flying within 200 feet of another canopy, match heading and descent rate prior to moving closer. This reduces the risks that both pilots will attempt to manoeuvre closer at the same time.
4) Establish a Base. When flying in close proximity, it is important to have one canopy remain still in order to create the best possible learning environment. The whole point of the exercise is to establish a relative reference, and a base that is moving around will make things much more difficult, and quite possibly more dangerous.
5) Know where you are. It is easy to lose track of your location when engrossed in relative flying. Therefore it is essential to take periodic glances at the ground to determine if a course correction is in order. Landing off DZ in formation is not the goal.
6) Know how high you are, and have an obvious break-off signal above minimum cutaway altitude. An audible altimeter is a very useful asset for this, but ultimately it is our eyes that tell us how high we are.
7) Never look away from your wingman for more than 1 second when in close proximity. In the time that it takes to check an altimeter or ground reference, the distance between the parachutes can disappear. Maintain your global awareness of the situation as a sidebar to your relative flight. Landing off the DZ is less dangerous than a wrap.
8) Have a plan in the event of a canopy wrap. Although no-contact flight almost never results in a collision, the possibility remains. Think your procedures through carefully.

Helpful Hints:

1) In the event of mismatched airspeed and descent rate due to disparate wingloading, have the slower canopy open 300-500 feet lower.
2) When the other canopy is stuck behind you, turn your parachute 90 degrees to reduce the closing distance.
3) When in close proximity, make all your course corrections slowly and predictably.
4) Communicate clearly and concisely. Have hand signals or air-to-air communications. The ability to talk increases the value of the exercise immeasurably.

No-Contact Drills

1) Matching Flight Path (Slow, Medium and Full Glide modes)

- It is crucial that a stable no-contact formation be established before moving on to more dynamic drills.
- Becoming accustomed to being in close proximity to another canopy is useful in preventing undue stress on the pilot on final approach in the event of traffic.
- Do as little as possible to maintain relative proximity.

2) Synchronized turns of 45 degrees or less.

- Maintain proximity
- Maintain relative altitude
- Use any and all control inputs to maintain proximity.

3) Synchronized turns of more than 45 degrees

- Switch to other side of formation to cut down closing distance
- Maintain levels
- Do not look away during the turn

4) Dive, Pause, Rebuild.

- When one canopy dives down and then resumes full glide, they provide a base that the chasing canopy can target.
- This drill allows the chase-pilot to practice "Dive Arrest" in the event that they are going low.
- This is the same skill necessary for preventing low turn injuries.

Complex Approaches on Small Canopies

When learning to fly any parachute, all kinds of approaches must be rehearsed. This includes increased airspeed approaches. If a pilot is only comfortable with full flight airspeed, they are likely to panic and make mistakes in the event that they are forced to increase the airspeed as a result of an unexpected evasive maneuver. It is therefore a part of the learning process to cultivate the skill of steep, high speed approaches.

Clean Up Your Turns

By Brian Germain
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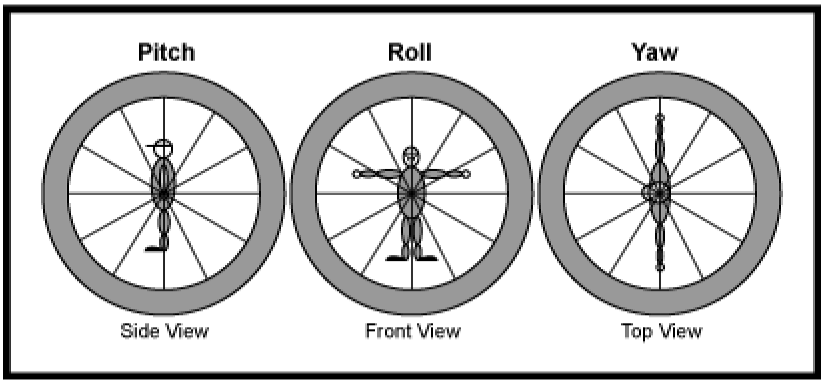
"Turn coordination" is a topic that, until recently, has been mostly unapplied to ram-air parachute aerodynamics. In simplest terms, this refers to the degree to which a flight vehicle is aligned to the relative wind during a turn. Another way to look at this is the degree to which a turning aircraft is pointed at the relative wind with regards to the yaw axis.



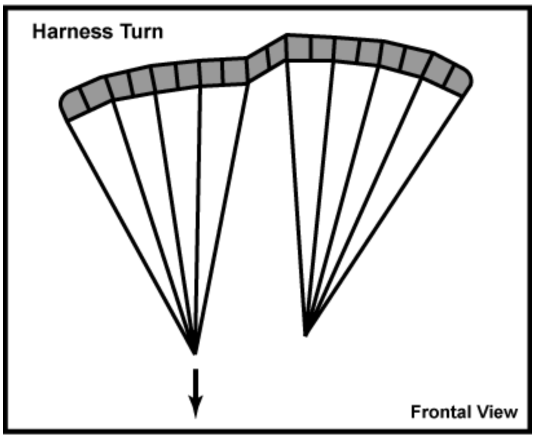
A "clean turn", from an aerodynamic perspective, is one that keeps the nose of the aircraft pointed at the relative wind throughout the turn. When flying airplanes, this prevents the passengers from spilling their drinks, as well as saving fuel and preserving airspeed. In parachutes however, this aspect of turning has mostly been ignored. As parachutes become faster and faster, the time has come to begin thinking about this aspect of our canopy flight for several very important reasons.

The first has to do with the ability of the pilot to level off at any point during the turn. Lets face it, sometimes the ground creeps up on us. Flying an aerodynamically sound turn increases the likelihood that you will be able to convert your airspeed into lift in a timely manner. If you are sliding sideways through the sky because you are simply jamming a toggle down, you are not prepared to interface with the planet. The relative wind is jumping across the bumps on your parachute, creating turbulent flow, while the suspension line load is getting shifted to one side of your canopy. When you attempt to stab out of an uncoordinated turn, there is a hesitation before the parachute begins to change direction and level off. If the ground gets to you before this happens you may find yourself watching Oprah in your hospital bed for a while (not that I have anything against Oprah).

The second reason for flying a coordinated turn has to do with overall parachute stability. In an uncoordinated turn, the nose of your parachute is not pointed at the oncoming relative wind. It is sliding sideways. This means that the pressure in your wing is being compromised, in addition to the wingtip on the outside of the turn being presented to the relative wind. If you hit turbulence during this kind of "sloppy" turn, you are much more likely to experience a collapse of this side of the parachute. In other words, if you are turning right, your left wing more likely to fold under. Interestingly, when an aggressive, uncoordinated toggle turn is released, the opposite tends to happen. When the right toggle is released, the right wing surges forward as the drag is released and it is presented to the relative wind, opening the door for a collapse on right side of the parachute. Either way, this can result in way too much daytime TV.

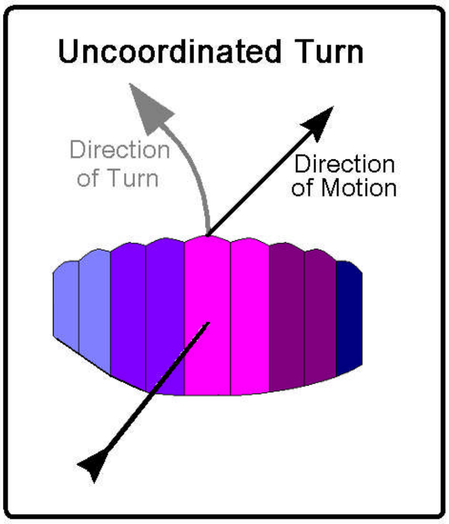
There is a fundamental problem with the way in which most of us were taught how to turn our parachutes. They said: "if you want to turn right, pull down the right toggle." Simply pulling on a toggle increases the drag on the right side of the parachute, retreating that wing tip. At the beginning of the turn, it is purely "yaw" energy. It is like the pilot of an airplane stepping on the rudder pedal. As a discrete action, steering toggles are an incomplete input. We need some "roll" energy.

The harness is more than a way to attach the jumper to the parachute. It is also a way to manipulate the canopy itself. If the right leg reaches for the earth as the left hip reaches for the sky, the parachute will turn to the right. It is true that smaller parachutes will respond quicker to such inputs than larger ones, with elliptical canopies responding the quickest, but harness input will have an affect all parachutes. Most importantly, when used at the initiation of a turn, harness steering converts a toggle turn into a coordinated maneuver. This is true if you are under a Lotus 190 or a Samurai 95.



When flying an airplane, all turns begin by initiating roll energy with the ailerons, (rotating the yoke), followed by an application of the rudder to coordinate the turn. The old airplanes had a string on the cowling (hood) to show the direction of the wind-flow, while newer ones have slip indicators on the instrument panel. If only we had such information while we were flying our canopies. Ah, but we do…

Trailing behind your wing is all the yaw axis coordination data you will ever need. It is called your pilot-chute. If you are flying a coordinated turn, your bridle will remain parallel to the ribs of your canopy throughout the turn. If at any point it goes slack, whips around like a snake or drifts off to one side, you are not flying a clean turn. You are not carving your wing through the sky; you are skidding out of control. The relative wind is not following the valleys of your ribs; it is hopping over the bumps, tumbling into chaos.



Try this on your next jump. Look up at your canopy while you are flying straight and simply yank a steering toggle down to the ½ brake position. You will immediately see what I am talking about as your pilot-chute swings off to one side. Next, lean in your harness, lifting one leg-strap to yield direct roll axis input. It may turn and it may not, depending on the wing. This is not important. Then, while holding the harness input, pull the steering toggle to turn toward the direction of your harness input. You will notice that the pilot-chute is trailing straight back, even in a sharp turn.

Once you have experienced your first real coordinated parachute turn, it is time to develop new habits. This takes time. I find that when learning a new skill like this, it is best to have a simple way to remember the process. In this case, try using the following sequence for every turn you make**:**

1) **LOOK**
2) **LEAN** and
3) **TURN**.

This is mnemonic was taught to me by a great paragliding instructor and skydiver, J.C. Brown. Rather than thoughtlessly jamming a toggle down, ***look*** where you are about to go, ***lean*** in the harness to establish the roll, and finally, ***pull*** the toggle down to flow deeper into the maneuver.

When you play with this kind of turn, you will find that the parachute simply feels better; that you feel more in control over the wing. You will also find that you can better bump both brakes down during the turn in order to reduce your decent rate, or even level off completely. While practice is necessary to perfect the technique, all parachutes have the ability to transition from a descending turn into a level flight turn, into a soft beautiful landing. If you know how to carve your way out of a low turn, there will never be a reason to hook into the ground, ever.

Although many skydivers still think of their parachute simply as a means to get back down to the ground after a skydive, learning how to use the system the way it was meant to be used will increase the chances that you will get back down to the ground safely. Gravity pulls equally on those who love canopy flight as those who abhor it. From twenty years of teaching parachute flight I have learned this: you can only become great at something that you love. The more you understand, the more you will explore. The more you explore, the more you will feel control. The more in control you feel, the more you will love it. And that, ladies and gentlemen, is what it is all about.

The Long Haul

by Brian Germain

There are many areas of this sport in which we can invest ourselves, so many avenues in which to excel. By focusing heavily on a single discipline, we are able to achieve significant notoriety in a fairly short period of time. By utilizing the superior training techniques, personal coaching and wind tunnel rehearsal, modern skydivers are able to reach significant prowess in just a few months of participation in the sport. Although the speedy gratification of our desires is tempting and rewarding in the short term, there is a larger, more important goal. We must survive.

Photos: Brian Germain

I asked Lew Sandborn what he thought was the biggest problem in the sport today. With very little hesitation he stated that what concerns him the most is "new jumpers trying to make a name for themselves before their skills are ready for them to have that name". We want to get it all in one shot, and instantly achieve all of our goals. In a pursuit as complex as skydiving, it is impossible to get all the necessary information in a short period of time. We have to keep learning, and hope that our knowledge bucket fills up before our luck bucket runs out.

It is difficult to see the big picture of our lives from where we are at any given moment. We forget that the medals we strive so hard to achieve will not mean much when we are older. They will just represent more stuff to box up when we retire to Florida. In the end, the things that matter most pertain to the choices that we wish we could take back. Twisting an ankle today might seem like a small issue, but in fifty years from now, it will be something that effects whether or not we can ever jump again.

Picture yourself forty or fifty years from now. Are you still skydiving? Do you have pain in your joints from a bad landing? The quality of your life in the future is dependant on the choices you make today. If that wise old geezer that you will someday be could somehow communicate to you in the present-day, it might sound something like: "Stop trashing my body!"

We are insecure when we are young. We are so uncertain of who we are that we feel a need to prove ourselves at every opportunity. We think that who we are is based on our most recent performance. We go to great lengths to show the world what we can do, and often pay a hefty price for our impulsiveness. Short-sighted goals neglect to take into account anything that does not achieve that goal. If looking cool and wearing the right gear is your highest priority, you may find yourself joining the dead skydivers club before too long.

I hate sounding like an old fart. People assume that being safety oriented means that you have to be boring. Not true at all. We can have fun; we just need to keep the throttle below 100% thrust if we are to control where we are going. The long-term survivors in this sport all seem to have this perspective; whether or not they talk about it. We sit around in trailers at boogies, shaking our heads at the ridiculous behavior that repeats itself over and over. We watch people eat it in the same ways that they did last year, and twenty years before that. It’s like the message did not get out or something. The message is: "Pace yourself, this is a long journey".

On every jump there is a way for your life to end. No matter how many jumps there are in your logbook, the Reaper is watching for the moment that you stop paying attention. He is looking for the one thing for which you are not prepared. This fact does not require your fear, it requires your attention. If you are to be there at the Skydivers Over Sixty Swoop Competition, you must let go of your grip on trying to prove yourself, and stay focused on the stuff that really matters.

The real identity of a skydiver is not in how many medals they win or how stylishly they swoop. It is in how long they jump and how safely. There simply are no Skygods under the age of sixty. If you want to prove yourself, stay alive.

BSG

In addition to being a highly experienced skydiver with over 14,000 jumps, Brian Germain is the author of several books including The Parachute and Its Pilot, Transcending Fear, Vertical Journey, and Greenlight Your Life. Brian also runs canopy flight workshops worldwide, in addition to his “Heroic Leadership Training” Seminars that he describes as:”High Intensity Emotional Intelligence”. For more about Brian’s Books, Seminars and Parachutes, visit his websites: www.BigAirSportZ.com and www.TranscendingFear.com

Packing Tips

The best opening on our canopies seems to be as a result of either the traditional "Pro-Pack" or the incredible "Psycho-Pack", although some customers have found success with other methods.

Regardless of the method you choose, remember that asymmetrical pack-jobs tend to open asymmetrically. Further, we have found that the highest frequency of on-heading openings tend to be associated with pack-jobs that leave the nose alone, in the center of the bulk, with no stuffing or rolling whatsoever.

*For a more detailed description of the Precision-Pack, see the article at the end of the packing section, written by company President and Founder, George Galloway.

Riser Symmetry

Elliptical parachutes, being designed for quick turn response, have a higher frequency of off-heading openings. Symmetrical packing of the lines help your canopy to inflate evenly, improving your odds of a straight opening. We recommend tying your risers together at the 3-ring to limit the amount of offset possible during packing.

Slider: Flaking and Placement

We recommend flaking the slider in four equal parts to maximize the surface area during initial inflation. Pulling the entire slider in front of the nose of the canopy opens the channel of air to the bottom surface, typically allowing the parachute to open sooner. Also, please pay careful attention that the slider stays pressed against the slider stops on the stabilizers. Even one inch of distance between the slider and its stops can cause a harder opening on any canopy. By allowing a significant distance between the slider and the slider-stops, the possibility exists for "slider rebound", in which the slider bounces aggressively back against the stops and then down the lines. This happens at the moment when the canopy's lines become taught and the canopy is towed back to the freefall speed. Checking your slider's location should be the last thing you check before closing your deployment bag.

Slider: Drawstring/Kill-line

Your slider is equipped with a drawstring "kill-line" for stealthier flight. Please always remember to pull this back to the OPEN position prior to packing it. Your parachute will open VERY HARD if you do not do this! Be sure to pull the slider apart to the fully open position. By fully retracting the drawstring, you are much less likely to have the tab on the end of the line snag in a suspension line cascade possibly causing a malfunction.

Stowing your slider is not your highest priority after parachute opening.
Fly your canopy!

Looking around for other canopies and checking the operation of your own canopy are much more important tasks after opening. Keep your priorities straight. Lastly, please never tie the drawn strings together around your neck. If you have to cutaway, you'll be very, very sorry.

Line Stows: Types of Elastics

Use line-stow bands that will do their job. That is to say, if the elastic is unable to exhibit 7-10 pounds of drag before it releases, it isn't slowing the bag's ascent from your container. Small, sturdy rubber bands on all the stows seems to be the best way to achieve this holding power, while tubular elastics allow the lines to roll off too easily. Further, the size and condition of the closing stows that pass through the grommets in the deployment bag are essential in the prevention of "line-dump", which is directly related to extremely hard openings.

Very heavy elastics that won't break, however, can and do cause bag lock malfunctions. As this is a terminal velocity malfunction, it is among the most serious and dangerous. Precision Aerodynamics does not recommend the use of such excessively strong elastics.

Line Stows: Location of Stows

We highly recommend using "Inboard Line Stows" on your bag. In essence, having the lines stowed closer to the center of the bag will help to reduce the chances of "bag spin", and therefore line twists. Most riggers can do the modification, but we'd be happy to modify your bag right here at Precision Aerodynamics. The turn-around time is usually just a few days.

Pilot Chutes: Size

Your pilot chute size and type will significantly affect your parachute's opening characteristics, as well as the flight. An excessively large pilot-chute will cause hard openings, or even line-dump, which can cause catastrophically abrupt openings. A pilot chute that is too small may not lift the bag off your back at all, or may allow line-twists to occur as the bag is lifted lazily off your back. We recommend pilot chutes between 26 and 30 inches in diameter proportionate to the weight of the canopy. Freefliers beware: ZP pilot-chutes can slip out prematurely!

Pilot Chutes: Kill Lines

An inflated pilot chute trailing behind your canopy can distort your wing, as it will continuously be pulling back on the center cell. The extra drag also diminishes flight performance, and may be the deciding factor as to whether or not you make it back from a bad spot. Therefore, a collapsible pilot chute is mandatory equipment for any of PRECISION AERODYNAMICS' canopies.

We do not recommend the use of bungee pilot chutes, however, as they tend to allow the pilot chute to periodically re-inflate under canopy, and may delay inflation during low speed aircraft exits. The kill-line method is excellent, although carelessness in resetting the kill line during packing may also cause pilot chute in tow malfunctions. Further, a spectra kill line will shrink with age, preventing you from cocking your pilot chute fully. Eventually, this will lead to pilot chute in tow malfunctions. Lastly, is a #8 grommet on the deployment bag. This will allow the bag to invert and slide down the bridle to pilot chute, collapsing it. This is the safest method to collapse your pilot chute, requiring no "cocking" during packing, although the wearing on the mesh of the pilot chute may expedite its replacement. This method also usually causes the pilot chute to spin up under canopy.

Stowing the Toggles

Please stow the toggles and the excess brake line in a manner approved by your container's manufacturer. Leaving the excess line free opens the possibility of entanglement, particularly with your helmet or camera. This is not merely the recommendation of an over-protective manufacturer; it is a precaution based on experience. A brake-line that is entangled with some part of your body will prohibit you from jettisoning your main canopy.
"Toggle-Keepers" are also a necessity on all Precision Aerodynamics parachutes. This is an elastic or fabric loop that holds the tip of the toggle above the guide ring. Toggle-Keepers reduce the chance of a malfunction due to a brake-release during deployment.

An Easy Way To Pack a Zero-P Canopy

by George Galloway 1995
President, Precision Aerodynamics
Board of Directors, Parachute Industry Association
Former Director, United States Parachute Association, Southern Region

It was many years ago when we received the first Strato-Star in our area, complete with rings and ropes, and you never would have guessed that our small group of riggers had a combined experience of several thousand skydives, not to mention as much rigging and packing experience as most anybody else in the world. We must have really looked strange, the way we inspected, fondled, fumbled and speculated how this thing was supposed to go into that little backpack kind of thing that the manufacturer shipped with it. Of course, we hadn't yet considered looking at the Owners Manual; we wanted to figure it out by ourselves.

We all knew of the Barish Sailwings, and the Volplanes with hydraulic reefing. Some of us had even jumped the Para Sleds and Baby Planes, but none of us really knew anybody who had a lot of experience packing these things. These newfangled things. Back in those days, there were no packing videos. Very few companies published packing instructions with photographs. The ones that did, left it up to your own interpretation as how you were to get the canopy from "photo_A" to "photo_B". Many of the canopies which we used for both mains and reserves were simply packed as instructed, "pleat the gores in the normal manner", a phrase commonly quoted by many manufacturers in their instructions to riggers.

I remember one company that published its packing instructions on a little fold-out leaflet, so you could kinda carry it in your helmet to make sure you had it handy when it came time to fold the thing back up (the parachute) and put it into the container. The instruction sheet was harder to fold up than the canopy.

There were deployment devices such as sleeves, pods (para-opening-devices), bags, and slags (half sleeve/half bag). There were cones and grommets, and spring loaded everything, from pilotchutes to pack opening bands. There was no such thing as a pull-up cord, and I distinctly remember a kinda half hitch arrangement packed into the lines of one canopy to hold the bag closed which was referred to as the "dead-man knot". I know there are still a lot of people around who remember all of these things, but there are an awful lot of you who might not have a clue what all this mumbo-jumbo is about.

It's about packing canopies, of course, and mostly about packing square canopies in particular. Ram-air mains started catching on in the late 70s. Ram-air reserves started catching on in the early 80s. There have been as many different ways to pack a ram-air parachute as there have been models to choose from.

I personally know three different people who claim to be the inventor of the "propack", a method for packing ramairs which has become popular in recent years. I don't really have anything against the "propack", but what does that term really mean? If you ask ten different people to show you how to "propack", I will give you a dollar for each one who does it the same as the last. The "PRO" in propack is said to have been an acronym for "Proper Ram-air Organization". Maybe it should have stood for "Proper Ram-air Orientation" referring to the fact that for the first time a ram-air canopy was actually going into the container the way it was intended to come out. (You see, the early squares were packed by laying them on their sides before folding, a packjob which is still used quite successfully by many people. Some people erroneously think this "side-pack" method induces a 90 degree off heading opening. It's not true.) As I remember it, the original idea of the "propack" was to keep everything on heading, in theory, that is. That was a significant idea, and I agree that it worked to a degree, as long as aspect ratios were hovering around 2.0 and there were no coated fabrics or complex airfoils.

In the early days of pro-packing, there was no mention of awkward techniques like stuffing the leading edges into the center cell to "reduce opening shock", or rolling the nose past the "B" lines to ease the pain induced by the parachute opening sequence. These bastardizations to an otherwise pretty good packjob came along to help skydivers deal with more complex airfoils and fabrics. Talk about producing an off-heading opening! Some of the things we hear and see about how people are currently packing out there in the real world are a true test and testament to the reliability of the ram-air parachute.

Parachute packing procedures have continued to develop along with the development of new canopy designs. When we first started flight-testing higher performance non-rectangular canopies, I wanted to create a pack job which produced consistent openings, of course, but it also had to be a packjob which wasn't such a hassle to get into the bag.

I started out by thinking I might have modify the parachute design to accommodate the problem of getting the trapped air out of the Zero-P canopy, but then, that didn't really make much sense. I had gone to a great deal of effort and calculation to design this airfoil, so why would I want to go and cut it full of vents just to get into the d-bag? What I needed to do was to develop a method of folding the canopy which exhausted all of the air out of the airfoil where it entered in the first place, at the leading edge.

A "regular" propack might have been OK, except that there was always this huge bulging bubble when I laid the canopy down on the ground. You all know what I'm talking about. There ought to be a name for this thing. I'll call it the "bubbulge". It is (was) a problem.

Another problem was that contortionist procedure thing I always had to do in order to get the canopy all stacked up so I could smash it down into this little bag. After the canopy is finally crammed in, the bag always looks like it is about half as big as it needs to be. That's because all that fabric is in there, slipping around on itself, trying to fill back up with air, and you don't have a new rubber band in your pocket! Damn!

What I ended up doing to remove all of this frustration is really simple. I will attempt to put it down into words, although I might run the risk of just confusing you more.

I have to say at the outset, that while this packjob has worked successfully for us in thousands of documented deployments over the years, never forget that it is YOU who is responsible for any parachute packed by you. At Precision Aerodynamics, we pack all of our demo equipment this way, and we base the reputation of our product on its consistent results. You have to realize that your interpretation or misinterpretation of these words may lead to canopy damage, bodily injury or death.

You must pack your parachute any way you want to. It's your canopy and you are the one who is jumping out of the airplane. Accept the risk and be responsible for yourself. Having said that, I will cautiously continue to try to describe the procedure.

It is always important to inspect the entire assembly and determine that the system is airworthy. Make sure that the canopy's direction of flight is correctly oriented to the harness. For the purpose of this article, I am going to simply focus on the "canopy folding procedure" which has been so very successful for us.

Lay the container on the floor, harness down, and stow the brakes in accordance with the container manufacturer's instructions. Split the line groups and run the slider up toward the canopy, observing that the leading edge of the canopy is hanging at your knees with the trailing edge of the canopy away from you. Work the fabric which is between the line groups to the outside of the lines, and continue for all sections of the canopy. This "accordion folding" A-B section, the B-C section, and the C-D section is intended to minimize fabric/line friction during extraction from the bag, as well as minimize the pack volume as a result. The idea here is to keep all of the line attachment points toward the center of the packjob, with the fabric folded to the outside.

It is important that you pay particular attention to the location of the "D" lines and the "control lines" in particular. It is imperative that you maintain the relative position of these and all lines throughout this process, or you might end up with a malfunction caused by these lines migrating up to and in front of the leading edge of the canopy during the rest of the process. The leading edge is neither rolled nor stuffed. Just leave it there exposed, even with convicted "hard-opening" canopies. We have seen this packjob tame even the baddest of the bad.

The slider is neatly "cloverleafed" into position so that it is quartered into the hanging canopy and against the slider stops. Bring the center of the trailing edge up and hold it under your thumb while you roll up the hanging sections of the trailing edge. So far, this resembles what is commonly referred to as a "propack".

Here is where everything changes. Flip the canopy around now, so that you are actually inducing a 180 degree line twist into the packjob. Continue to roll the canopy up at the trailing edge, which now overlays the leading edge. You are really creating a pretty tight cocoon. Now you should be standing there with the canopy hanging from your right hand, with your right hand still controlling the slider's position and the trailing edge, and your left hand controlling the cocoon. The bag and pilot chute are hanging from the bridle attachment point, and as you swing them out of the way, you flop the cocoon to the floor, retaining control over the position of the "D" lines and control lines with the placement of your left hand as the bundle hits the floor. You have maintained line tension with your right hand through this process, and the only difference in this and an otherwise "normal" propack is that now the container is looking down and the canopy is looking up. Don't worry about that for now.

Replace your right hand with your right knee and your left hand with your left knee to continue control of the bundle. You now have a triangular shaped bundle with the rolled trailing edge facing up, covering the leading edge of the canopy. Fold the "ears" in so that the entire canopy portion is slightly less than bag-width. Pull the bridle attachment point out to one side or the other, and start to roll the canopy up like a sleeping bag from the top to the bottom. Keep the roll tight, and maintain the roll to be the width of the bag. The bridle ring needs to be pulled far enough out from the center of the roll (the axle) that it can be wrapped around the outside of the roll and maintain contact the grommet in the bag. This is important.

When you roll the bundle all the way down to the point where the lines come out of the canopy fabric, it is quite easy to see that you can control this small bundle/roll with one hand, holding it like a football. While holding the canopy roll in your right hand, it is easy to slip the deployment bag over the roll, but make sure that you place the bag on "upside down" because, remember, the canopy is still 180 degrees out relating to the container. Now with the canopy in the deployment bag, you will notice that there is absolutely no tendency for the bagged canopy to fill with air. It is not trying to escape from the bag. It is not sliding all over itself making your life miserable.

This is the point at which people say, "What if you forget which way you turned it?", referring to the 180 degree half-twist you put into the lines a few minutes ago. Well, simply stated, just don't forget, because now is the time to take that half twist out by rotating the bag back to normal. (Note: if you accidentally do turn the bag the opposite direction, it should be very obvious that you have a severe line twist in your packjob.) Simply rotate it back the other way. If you have maintained sufficient line tension during the rollup process, this will not be a problem. If you are completely confused, start over.

Now close the bag, stow the lines, and close the container "in the normal manner".