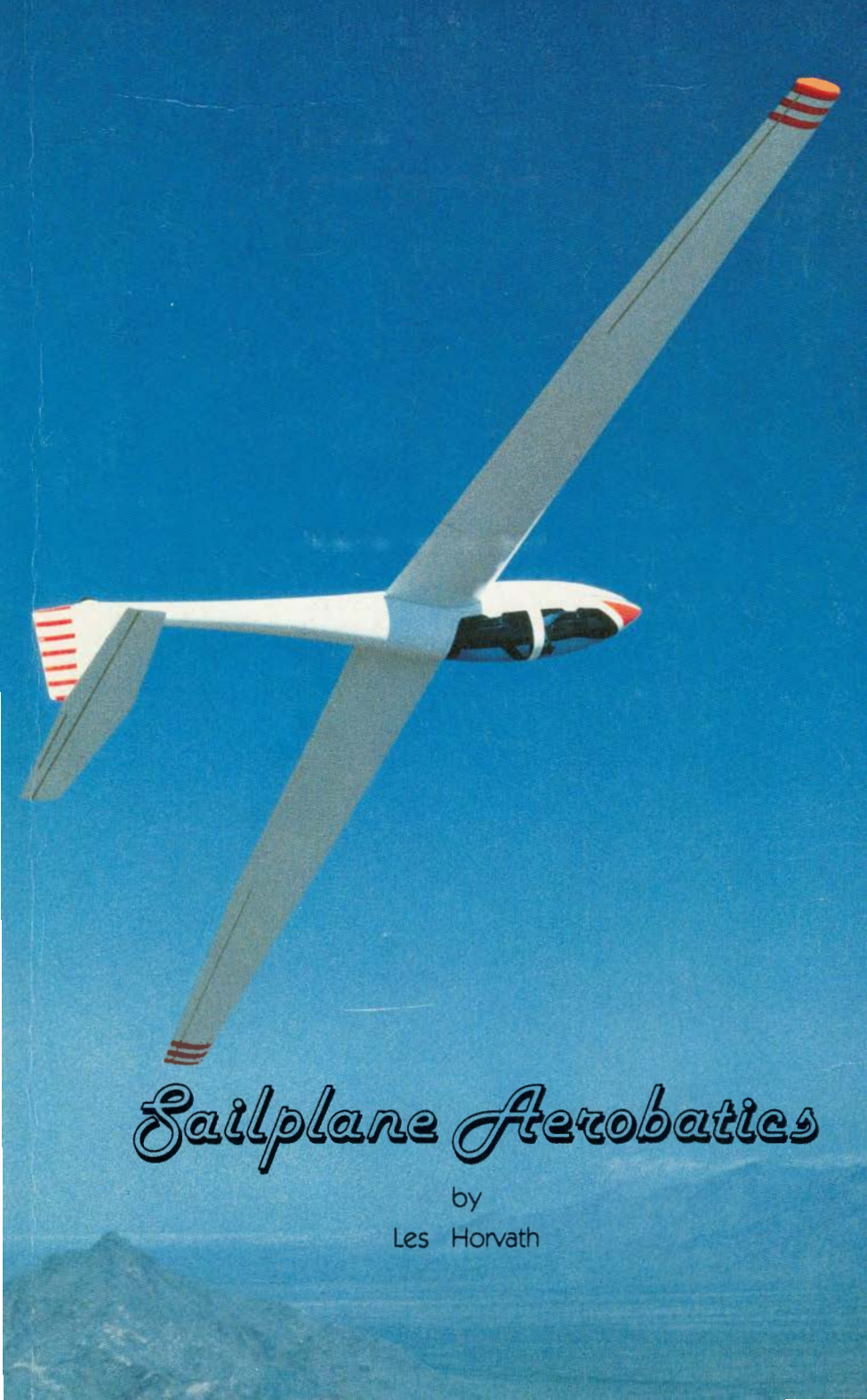


Sailplane Aerobatics

by

Les Horvath

SAILPLANE AEROBATICS

by

Les Horvath

This is not a book for self taught aerobatics.
Use as a supplement to an Aerobatic Course only.

Printed in the United State of Americo.

ACKNOWLEDGMENTS

This has been a "forthcoming" book for a number of years, but somehow things kept getting the way. Being a soaring school owner/operator means that I am, among other things, a full time businessman, safety officer, personnel manager, professional sailplane pilot, weather forecaster, and line chief; part-time I become secretary, janitor, all-round maintenance man, and so on.

Even so, I've found the time for sailplane aerobatics, learning along the way that I will never stop learning along the way. I'm fortunate to have a number of people who've helped me make time for learning, practicing, and teaching aerobatics. They've also hounded, inspired, and helped me to write this book. I would like to thank:

My crew at Estrella - for being ready when I want to fly.

Nancy Blank, a sailplane aerobatic pilot - for always being ready to type and do research and nudge me on.

Judy Lincoln - for help in editing this book.

The countless pilots who've come to me for aerobatics and taught me more as they were learning.

Most of all, I thank my dear wife Betty - who has made the best things better, and has had many lonely hours as I've explored a different world.

Les Horvath
Estrella Sailport
July 1985

CONTENTS

APPENDICES:

WHY SAILPLANE AEROBATICS

It was one of those beautifully clear Autumn days with strong and turbulent thermals above the hills. I was in second heaven! I was thermalling, soaring, sight seeing...There were red, yellow and gold colored leaves on the trees far below me. A brisk stream of air whistled through the air vent. This was the freedom of soaring; "Today I can do no wrong," I thought. Moments later, this idyll was shattered in horror. I had been more tourist than pilot, and suddenly the Blanik turned itself upside down, then seemed to aim itself at the fall-colored trees below, and began rotating as if to flaunt the scenery. I was merely along for the ride.

At first I couldn't react - I didn't know what had happened. "Thermalling one minute, and now...what's this?" I wondered. For lack of a better idea, I tried a spin recovery. To my great relief, the rotation slowed, airspeed gradually increased, and I was able to return to normal flight. I continued the flight, but the "joy of soaring" had been replaced by fear. Will THAT happen again? When?

I landed and spent some time trying to decide what had happened. Finally, I reasoned that the second half of the escapade must have been a spin, and that I had been disoriented by an "over the top" entry passing through inverted flight. Of course I had done spin entries before, in the controlled environment of basic training: slow the ship, increase back stick pressure, stomp the rudder. Recovery was just a series of control motions learned by rote. Spins had never been comfortable maneuvers for me, but they had always been predictable. Until then. Long after this incident, soaring was just not the same for me. Fear and hesitation persisted.

Years later, flying in the 1978 Standard Class Nationals in Arizona I had a somewhat similar experience in an ASW-19. Returning from the last turnpoint one day, I joined three higher sailplanes thermalling in the lee of the Sierra Estrella. Light winds seemed to dictate that rotor turbulence was unlikely, and the thermal was a good 600-800 fpm. In the northwest quadrant a strong bump pegged the vario at 1000 fpm, indicating that I had not

centered the strongest lift. Cautiously I adjusted each circle to the northwest. The thermal seemed to have such a narrow core that I remember thinking, "If I adjust too much, it'll just kick me out!" After two or shree slight corrections, I still wasn't satisfied, so I made one more move. WHAAMM! I was inverted.

I held this attitude momentarily, concerned about other gliders I may not have seen as they entered the thermal below me. I cleared the area and found that the nearest competitor lower than me was about ½ mile away, so I proceeded with an uneventful recovery and then continued thermalling. My comment to myself was, "Well, I'll be darned!" And, though the incident did seem to rattle other competitors who'd seen it, my own flying and concentration were not affected. This was a totally different handling of similar circumstances: where fear and anxiety had been my reaction to the Blanik incident, I was able to respond in a calm and calculated manner in the ASW-19. The easy answer is that I had hundred more hours of flying time...True! But more importantly, the most valuable of those hours were spent learning aerobatics.

At least part of the reason I decided to get involved in aerobatics was directly tied to the Blanik incident: How could this nice sailplane DO that to me? How could this thermal, which I have so carefully tried to center, throw me over like that? And, how come I couldn't figure out - until afterwards - what happened? I knew that being "pilot in command" was not a spectator event, and decided to learn more about flying. I decided to learn aerobatics so that I could fly the sailplane, not just watch as it flew me around.

Sailplane aerobatics are a relatively new sport worldwide, and as in other aspects of sailplane design and manufacture, the West Germans are in the lead. Since the mid 70's, West Germany has held annual FAI sanctioned sailplane aerobatic championships. For a number of years, single seat sailplanes dominated the aerobatic scene: some versions of the metal Pilatus B-4 suffered as the result of some unfortunate accidents, while the

wood construction Lo-100 and the fiberglass Salto are good examples of sturdy aerobatic ships.

Now, with the advent of the stronger modern fiberglass two seaters (ie. the G-103 ACRO and AS-K 21) the time for sailplane aerobatics has really arrived! With an experienced sailplane aerobatic instructor on board, any pilot can learn sailplane aerobatics safely. Though the individual pilot may not choose competition or airshows as his goals in aerobatics, the training can and will produce safer, more competent pilots in any soaring arena.

So, "Why Sailplane Aerobatics?" Because you can achieve

... a higher level of competence and safety in flight

... a better understanding of sailplane AND pilot limitations

and you can turn a lift-less day into a beautiful (and fun) aerobatic experience. It's a reward worth the challenge!

WHY NOT SELF-TAUGHT AEROBATICS?

Never, in my 14 years of learning sailplane aerobatics, practicing for airshows and competition, or in teaching aerobatics have I found any books to replace a competent aerobatic instructor. This book is no exception! I have written this book ONLY to be used in conjunction with a complete Sailplane Aerobatic Course, or as a refresher for pilots who have completed such a Course.

Based on my experience is teaching sailplane aerobatics, I find an alarming truth: unsupervised or self-taught pilots, including those with previous experience in power plane aerobatics, HAVE or WILL put themselves into flight attitudes from which recovery below Never Exceed Speed (Vne) is impossible. I believe the reasons for this are worth exploring. Without competent instruction, several facets of sailplane aerobatics can be dangerously confusing:

- There is an inherent lack of familiar, useable reference points on the sailplane during aerobatic flight.

- Beginning students have 'tunnel vision,' and will not recognize subtle but critical safety concerns.

- The sailplane's direction and attitude at different points in an aerobatic maneuver are often different than perceived by the pilot.

- Sailplanes in general are "slippery." Though some pilots may "get away" with poor technique right side up, self-taught aerobatics can easily "get away" from ANY pilot.

Therefore, the self-taught aerobatic pilot can be a real risk to himself, to his equipment, and to innocent spectators. These risks far outweigh any imagined benefits. A competent SAILPLANE AEROBATIC INSTRUCTOR is able to give a great deal of his experience to the student in only a few flights, and at the same time can create a SAFE learning environment.

THE AIRCRAFT

SAILPLANE DESIGN FACTORS

I'll concentrate here on two major items that need to be considered in terms of their impact on aerobatics — the wing profile (or airfoil) and the wash-out or twist of the wing.

Airfoils

Even without an extensive background in aerodynamics, any pilot can see that wing profiles differ among sailplanes. As a generality, most modern sailplanes designed for cross country soaring are NOT safe for inverted flight, due to the relatively flat lower surface of the airfoil. If such a "flat bottomed" airfoil is forced inverted, the pilot can maintain inverted flight only as an inverted dive at very high speed. Any attempt to flatten the dive angle would result in an inverted stall and loss of control.

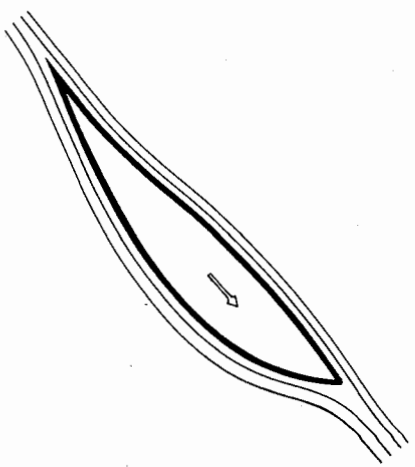


Illustration 1. INVERTED DIVE

The pilot can keep the airfoil of a modern racing sailplane flying in inverted flight by establishing a steep inverted dive. Safety is in question, as Vne will be reached in seconds!

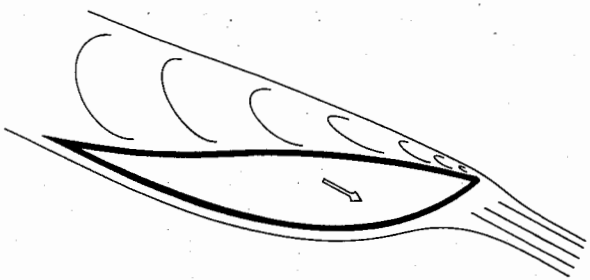


Illustration 2. INVERTED STALL

If the pilot attempts to hold a normal inverted attitude in a modern racing sailplane, an inverted stall will result.

The next logical question is, "how does an aerobatic sailplane manage to fly inverted?" The simple answer is that the airfoil is curved not only on the top, but also on the bottom and this enables it to fly upside down.

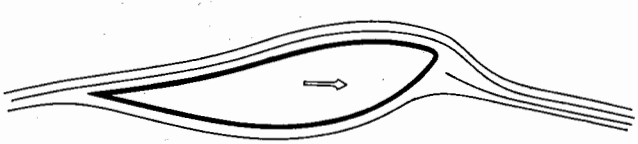


Illustration 3. AIRFOIL CAPABLE OF INVERTED FLIGHT

This type of airfoil will have about 50% higher stalling speed flying inverted as opposed to flying right-side-up.

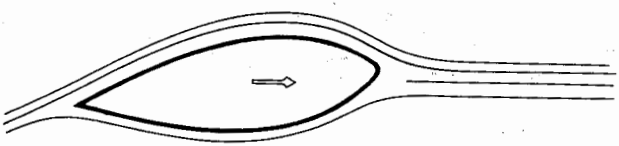


Illustration 4. IDEAL AIRFOIL FOR AEROBATICS

This airfoil simply slices the air. It makes no difference which way you fly it.

Wash-Out

In addition to covering the basics of airfoils in cross-section, we must also consider a span-wise design factor. "Wash-out" (a certain amount of twist) is built into the sailplane wing so that in non-aerobatic flight, there is a relatively higher angle of attack at the wingroot, and lower angle of attack at the tip. In non-aerobatic flight, most of the aerodynamic loads are carried by the wing area closer to the root. This area is structurally engineered to handle the anticipated loads; the higher angle of attack ensures that this area of the wing will produce greater lift capable of supporting these loads.

Considering aerobatics, however, "outside maneuvers" (those producing negative "G" forces, including inverted flight) will put most of the load onto the wingtips, since the angle of attack is now relatively higher there, and more lift is being produced. This is probably why some sailplanes, such as the Blanik L-13, are NOT allowed to be flown inverted with two pilots on board — the extra weight results in exceeding the stress limits of the wings.

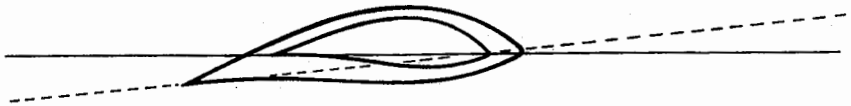


Illustration 5. WASHOUT: NON—AEROBATIC FLIGHT

The wingroot, represented by the larger airfoil, has a higher angle of attack in flight, and creates more lift compared to the wing tip. The wing root, which is carrying most of the load, will stall before the tip.

Illustration 6. WASHOUT: INVERTED FLIGHT

The wing tip, represented by the smaller airfoil, has a higher angle of attack in inverted flight, and creates more lift compared to the wing root. The wing tip must be structurally strong enough to bear the increased load.

SAILPLANE LIMITATIONS

Unfortunately, some pilots either ignore or don't know the limitations of their aircraft. Practicing aerobatics is a terrible time to become a self-appointed test pilot, whether deliberately or out of ignorance. Before beginning aerobatic training, carefully study the flight manual for the sailplane you'll be flying. Pay particular attention to sailplane limitation speeds and load limits.

Limitation Speeds

Indicated Air Speed (IAS) vs. True Air Speed (TAS) is a comparison that deserves special attention. In the cockpit, the airspeed indicator shows the IAS in flight. Often, however, placards, factory installed airspeed indicator markings, and the sailplane flight manual ALL refer to limitation speed in terms of TAS. The only time that IAS and TAS are the same is when the aircraft flies in the so-called "standard atmosphere." That is, at sea level, barometric pressure 29.92" Hg, temperature 15 degrees Centigrade.

Obviously, a lot of flying is done in other than standard atmospheric conditions. To be accurate, the E6B computer commonly used in power flying can be used to determine TAS. Alternatively, some sailplane flight manuals include tables of maximum speeds in IAS at various altitude ranges.

If all limitations are provided in terms of TAS, the pilot should at least be able to use this common rule of thumb: TAS will equal IAS plus 2% of IAS for every 1,000 feet Above Sea Level (ASL). For example, if you're flying at 10,000 feet ASL and have 100 kts IAS (a common entry speed for a loop) your TAS is 120 kts. In the Grob 103A and AS-K 21, never exceed speed (Vne) is only 14 kts higher.

Safe aerobatics at high elevation airports (above 4,000-5,000 feet ASL) require a great deal of discipline; that discipline may mean that certain aerobatic maneuvers must not be done! The penalties for ignoring the sailplane's never exceed speed (Vne) can include: high speed flutter, structural damage to the control

surfaces, and possibly disintegration of the sailplane in flight. Frequently in modern "slippery" sailplanes, flutter is a very real threat which can occur only a few knots above the never exeed speed.

Load Factors

In aerobatics, we will intentionally change the load factor on the sailplane as we use the entry speeds and control inputs needed to perform various figures; in many maneuvers, you will be aware of the curved flight path that creates centrifugal force. The total load on the aircraft can be measured in "G's" or units of force measured relative to the acceleration of the force of gravity. Therefore, it is not acceptable to do aerobatics without an Accelerometer (G-meter) to measure the total loads. It simply isn't enough to recognize the difference between positive G forces and zero-G or negative G forces.

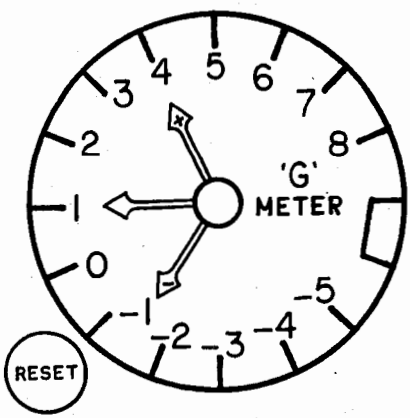


Illustration 7. TYPICAL ACCELEROMETER FACE

The center hand shows real time G forces, while the positive and negative hands record the respective maximums in flight. The reset button returns the recording hands to positive 1 G.

ATTITUDE REFERENCES

Right Side Up

All sailplanes are designed for soaring! They are efficient, have great visibility ... and as we all recall from basic training, in-flight references are obvious. Considering a straight glide:

Sailplane pilots learn early to relate indicated airspeed to pitch attitude, keeping an eye on the horizon, and its angle relationship to the sailplane's longitudinal axis. At speeds of 100 kts or more, this angle will be between 10 and 20 degrees in higher performance ships. The resulting flight path is neither as steep as the nose-low attitude nor as flat as horizontal.

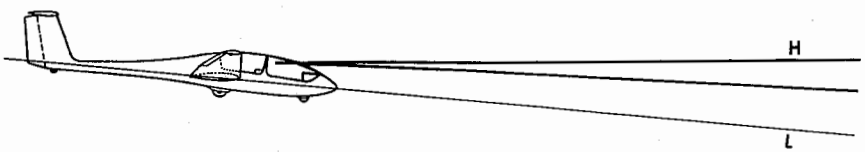


Illustration 8. STRAIGHT GLIDE

Great visibility for soaring! Top line points to horizon, line L shows the longitudinal axis, and the middle line is the flight path.

Upside Down

Now consider the same glider flying in an inverted attitude. In order to maintain inverted flight, the pilot must establish a high angle of attack, creating aerodynamic lift. He must compensate for the fact that the angle of incidence and the wing itself are designed for flying right-side-up. It quickly becomes apparent that a sailplane flying inverted will have a very high nose attitude and THAT attitude is NORMAL for inverted flight! (Illustration 9.)

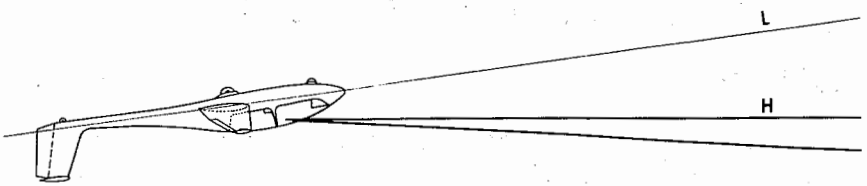


Illustration 9. NORMAL INVERTED FLIGHT

Notice the lack of pitch references for aerobatics? Line H points to the horizon. The longitudinal axis, Line L is necessarily aimed at a point well above the horizon. The bottom line shows the resulting flight path.

On paper, we can explore a common trouble spot by rotating our "Normal Inverted Flight" drawing (Illustration 9.) clockwise, such that the sailplane's nose is aimed 10-20 degrees below the horizon. This inverted attitude may look "right" to the pilot — since this angle relationship would be acceptable right side up, and old habits die hard.

However, illustration 10 shows that what may look OK to the pilot is really a very steep inverted dive. In this attitude, when the pilot realizes he has a problem, he is only seconds away from going through Vne.

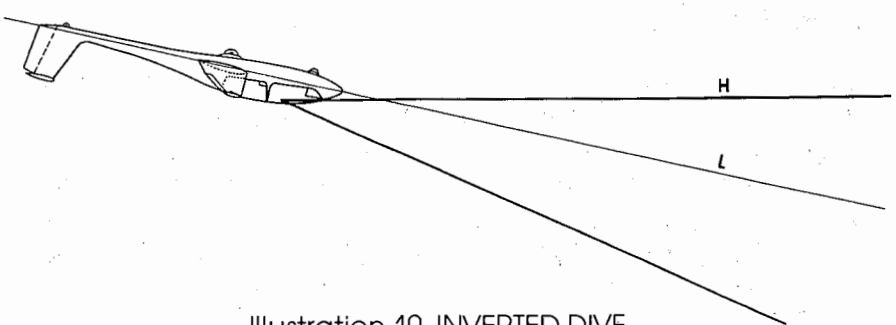


Illustration 10. INVERTED DIVE

An inverted dive is frequently the result of using incorrect references to establish pitch attitude. This example will occur if the pilot lines up the top of the instrument panel on the horizon — a common error made by pilots experienced in powered aircraft.

Weather or air pollution will play an important role in the actual inverted attitude of the sailplane versus what is seen by the pilot. On a day with five mile visibility the pitch attitude relative to the horizon may look the same as on a day with twenty five miles of visibility, however, the direction of flight is drastically different! (Illustrations 11 & 12)

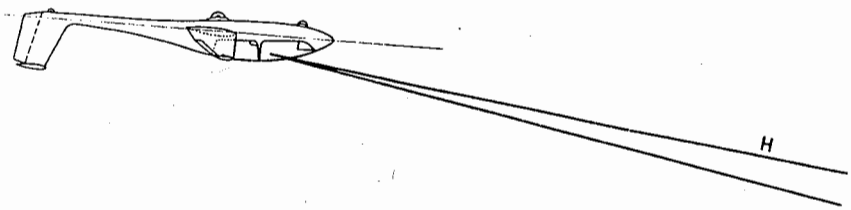


Illustration 11.

Line H points to horizon as seen by the pilot with 5 mile visibility. Bottom line shows the flight path of the sailplane. The result is an inverted dive.

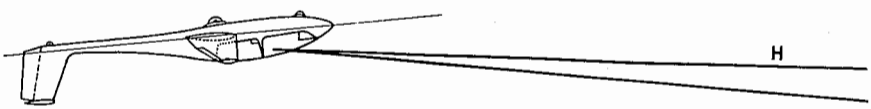


Illustration 12

Line H points to horizon as seen by the pilot with 25 mile visibility. Bottom line shows the flight path of the sailplane. The result is normal inverted flight.

FACTS FOR THE PILOT

In the previous section, the sailplane was our focal point. Now, let's concentrate on some equally important matters: pilot response to aerodynamic load factors, airspace considerations, and a short list of do's and don'ts.

"Gray-out"

The first time I experienced the loss of my sight in flight, I thought it was all over! I had been flying for about two hours at the time, using weak thermals to regain altitude lost in practicing a few aerobatic maneuvers. I was getting pretty tired and kept forcing it. After an extended time of inverted flight I finished the sequence with a "split S". Completing the figure with the normal positive 4 Gs, I was suddenly in big trouble — I lost my eyesight completely in a dense gray fog! I did manage to gradually reduce the G loads, and at least I was right side up ... but going where? I knew I was close to the southernmost tip of the Sierra Estrella Mountain, but couldn't remember how close. My mind was racing, trying hard to recall my exact position relative to the "White Spot," a familiar reference near the crest of the ridge. I clearly remembered that the indicated altitude had been 2,000 feet AGL, and I knew that the White Spot was 300 feet higher.

In seconds that seemed an eternity, the "fog" lifted, and I could finally see the horizon to the side, and the White Spot looming a few hundred yards in front of me. Fortunately, a simple 180° turn was all I needed to head away from the mountain and back toward the Sailport. Obviously, I learned from this experience that the scenery is great, but better appreciated from a safer distance! The gray-out, I hoped, was just a fluke.

After this incident though, I experienced "graying out" in flight again and again. In fact, as time went by and I became more skilled at aerobatics, I noticed that this was happening more often. It really bugged me that I had these "graying out" problems, and I even thought about quitting acro altogether! I happened to mention this to a friend who was a military pilot,

experienced in some of the high-G maneuvers involved in jet training. He asked, "How relaxed are you during aerobatics?"

"I am very relaxed," I nearly bragged, "I don't even have to hang on any more. Except for this graying out, aerobatics are comfortable for me."

"That's the problem!" my friend continued, "comfortable is fine, but by relaxing, you're allowing the blood to drain from your head — and you lose your color vision or even all vision for a short period of time in the positive G maneuvers. Try tightening up your leg, stomach, chest and neck muscles as you add the positive G's and you can probably have better control over the graying out." Then he added, "You know, to prevent this problem in the fighters: we wear G-suits!"

G-suits may be the ultimate answer for the military (and they, perhaps, are the only ones who can afford them). In sailplane aerobatics however, the extent to which a pilot can control his responses to G loads is his own limitation. Refer to Appendix C of this book, and be aware that:

- Done correctly, the maneuvers in this book will involve load factors between negative 3 and positive 4 or 5 G's. More negative G's are both uncomfortable for many pilots, and can cause a "red out" vision problem as blood rushes to the head.

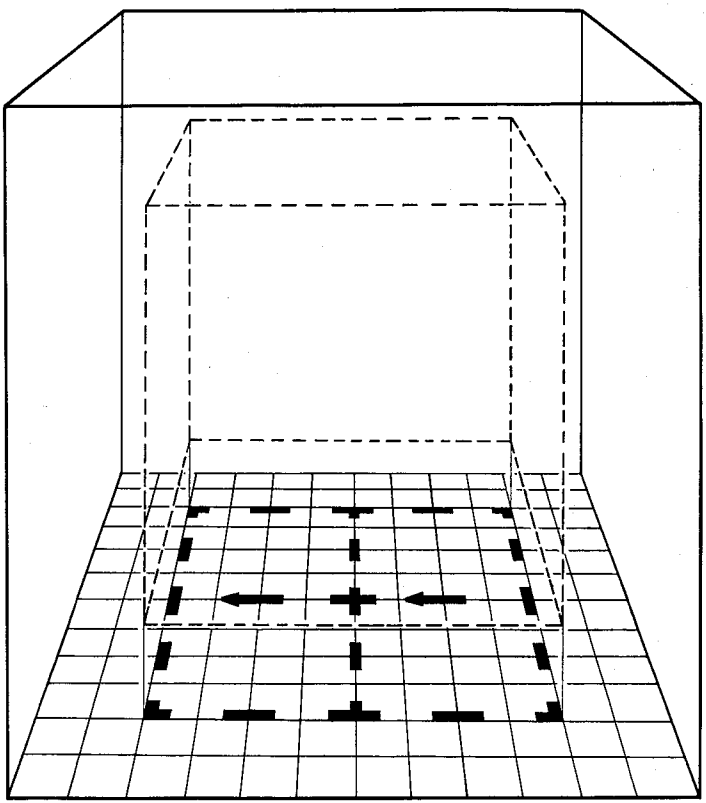
- Most pilots can withstand 4 to 5 G's for several seconds. (Many pilots can tolerate brief positive G loads of up to 10 — but the aircraft may not!)

- Eating a large meal results in increased circulation to the digestive system, and therefore somewhat less blood flow elsewhere. Eat only lightly in the hour or two before aerobatics.

- Aerobatics can be strenuous; good overall health and adequate rest are important.

AIRSPACE

The best place to practice aerobatics is an area specially protected from through traffic, and dedicated to aerobatic use. At Estrella Sailport, we are fortunate to have a cubic mile of airspace called an "aerobatic Box." (See Appendix B: FAR's and WAIVERS for important information.)



THE AEROBATIC AND COMPETITION BOX

The Estrella Aerobatic Box is used for practice and competition. The dimensions of the smaller FAI competition Box are "1 km x 1 km x 1 km" and it begins 600 feet above the ground. Its horizontal dimensions are indicated by ground reference marks. Since most pilots don't have one of these in the backyard, coordinate with your airport manager and the local FAA to carve out some airspace for aerobatics!

DO'S AND DON'TS

DOs

1) DO drink water or fruit juice within 30-40 minutes before your take-off. Even in winter time you can get dehydrated.

2) DO aerobatics first thing, while your body's energy level is high. Avoid aerobatics after a soaring flight.

3) DO aerobatics on a day with good visibility and less than 500 ft/minute turbulence.

4) DO advise everyone of your position and intention of doing aerobatics.

5) DO continuously look around to clear your airspace.

6) DO use stick pressure instead of stick movement during aerobatics.

7) DO observe minimum altitude requirement.

8) DO quit at first sign of tiredness, confusion or forgetfulness.

and DON'Ts

1) DON'T SHOW OFF!

Special Considerations

Reference books sometimes seem to imply, "Follow these simple instructions and nothing can go wrong!" Particularly in aerobatics though, even the "simplest" maneuver involves some aerodynamics; some physics, and a lot of attention to detail; precise use of certain control pressures in a certain order and your ability to avoid disorientation are required. Very simply, things CAN go wrong!

The figures are presented in order of difficulty. Descriptions of the more advanced figures assume that the pilot can safely perform the maneuvers described before them. Safe and proper execution of each maneuver requires that the pilot has received dual aerobatic instruction and understands proper abort and recovery options.

Entry speeds for each figure are shown in the required Indicated Air Speed using a Grob 103 ACRO and assume maneuvers are done below 6,000 ASL. G forces involved in each figure are a general standard useable in most sailplanes to ensure proper completion of the maneuver. Consult your aerobatic instructor and the appropriate sailplane flight manual for any variances your sailplane may require.

Whether putting familiar figures into a new sequence, or practicing aerobatics in a new sailplane, even highly skilled pilots will sometimes make mistakes. In order to keep your proficiency "up," fly with a sailplane aerobatic instructor periodically — make sure that your figures and recovery procedures are safe for the sailplane and for YOU!

THE AEROBATIC FIGURES

WINGOVER

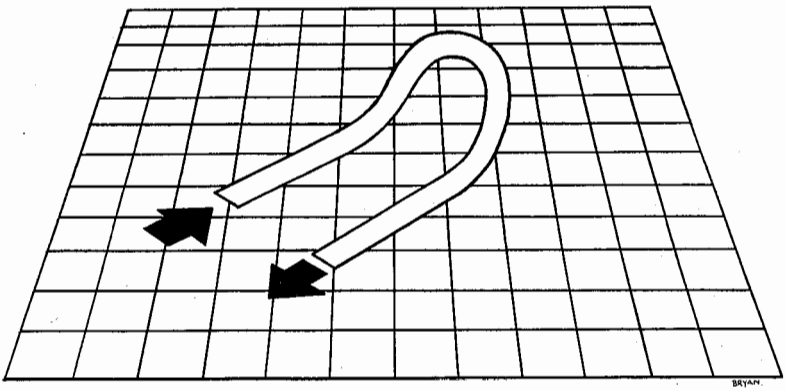
A wingover is considered by many to be a "mild" aerobatic maneuver, since it does not involve an inverted attitude or high G loads. As effortless as a good wingover might look from the ground, however, it's difficult to do correctly.

Enter from normal flight as follows:

First, find a straight line reference — a road, field or section line. Align the sailplane directly over this reference, parallel to it, so that you can use this same reference throughout the wingover's 180 degree turn. Your original heading will be your "0 degree" heading reference.

Set the elevator trim for a comfortable 50 kts, and then put the sailplane into a 45 degree diving pitch attitude. As entry speed (60-65) is reached, allow the trim to help raise the pitch attitude toward the horizon. As the nose approaches the horizon, begin to add bank in the desired direction. (At this point 70-80 kts is normal.) Coordinate pitch and bank such that you reach a 90 degree heading change at a minimum flying speed, in a 90 degree bank. At this point, the nose should be pointing at the horizon. Apply top stick and bottom rudder as needed to maintain coordination.

Going "downhill" is a mirror image of going "uphill". Remember what various control pressures were at different points during the climb, and try to repeat them in reverse order going down the hill. At the end of the wingover, you should be lined up parallel to your preselected reference line, at about 70-80 kts on the reciprocal heading from the original.



THE WINGOVER

CAUTION!

1) In early practice, use about 60 degrees as a maximum bank angle. As you practice wingovers "back to back," pick up the rhythm of alternating directions, and progressively increase the bank angle to a maximum of 90 degrees.

2) At no time in a wingover should the pitch attitude exceed 45 degrees up OR down; bank angle maximum is 90 degrees, and the maximum forces involved are 2 positive G's.

3) This maneuver can't be done safely by watching the sailplane's wingtip rolling under!

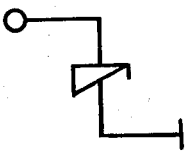
NOTES ...

1) All control pressure changes should be made smoothly and without any abruptness. The "airflow direction indicator," (yaw string) should stay in the center at all times.

2) The sailplane comes close, but does not actually stall in a true wingover.

3) Pitch and bank attitudes must change at constant rates.

THE SPIN



A spin, according to FAR definitions, IS an aerobatic maneuver. In practice, a spin may inadvertently occur when another maneuver is done incorrectly. Never attempt to practice this maneuver in a sailplane placarded against spins. Make sure you are familiar with the flight manual's recommended recovery technique.

To practice a normal spin entry, trim the sailplane for minimum controllable airspeed ("slow flight"). Increase the angle of attack, and just BEFORE the stall, apply rudder in the direction of rotation you want, and add full back stick pressure. The nose drops down and sideways, toward the bottom rudder. In some sailplanes, it may also be necessary to apply and hold top aileron to maintain a spin.

Over The Top (OTT) spin entries are not recognized in aerobatic competition, and are difficult to perform predictably. However, they can occur accidentally (as I found out) in gusty or turbulent conditions when the pilot was maintaining what he thought was a safe thermalling pitch attitude. In an OTT entry, the sailplane passes through the inverted position, the nose describes an arc of about 270 degrees. The sailplane spins in the opposite direction compared to the intentional angle of bank you HAD last time you recall. This and the quick look at inverted flight are disorienting to many pilots. However, once the spin is stabilized, recovery is normal.

Spin Recovery:

In general, the important thing to remember is that the sailplane spins when one wing is stalled and the other is flying around it. Recovery requires that you reduce the angle of attack below the critical angle. Usually, rudder pressure opposite the

direction of rotation is initiated immediately before forward stick pressure. However, in most sailplanes rudder pressure alone will not entirely stop the rotation. Safe recovery requires that the ailerons are held neutral until AFTER the stalled wing is fully recovered.

Some Variations:

In some sailplanes (i.e., 1-26, 2-33) recovery may only seem to rely on relaxing rudder or elevator pressure. Practicing this technique does NOT prepare you for spins in other ships.

Different tail group configurations can play a role in spin recovery: flying tail, external elevator trim tab (and where it's set), ships with extremely large AND ships with extremely small control surfaces can all involve slightly different recoveries from normal spins.

For example, spinning in a 2-32 with the trim full aft, there may be some pitch oscillations; in recovery, even full opposite rudder will have little if any effect in slowing the rotation, and it may take both hands on the stick to budge it forward. The same ship with the trim full forward spins beautifully, and recovers without hesitation if opposite rudder pressure is begun slightly before using forward stick.

CAUTION!

1) The sailplane MUST be flown within the proper CG limits. Failure to do so may mean that recovery is difficult or impossible, or that excessive altitude is lost in recovery.

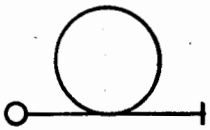
2) Large aerodynamic elevator trim tabs can be a problem both with spin entry and recovery. By setting the tab to help you to fly slowly, you are reducing the elevator's surface area and may not be able to enter a spin. However, this trim setting will aid recovery. Of course with trim set full forward the problem is with the spin recovery. (Possibly because of its "flying tail" the 2-32 is an exception to this.)

3) There may be some problems with spin recovery even if the

CG is OK: BIG wingspan, HEAVY gliders with SMALL control surfaces like to SPIN, and may have a tendency toward flat spin profiles. If the spinning sailplane's nose is high relative to the horizon, rotation slower than normal, and this condition is stabilized, the ship may not respond to normal rudder and elevator pressures for spin recovery. If there is no response to normal spin recovery technique, try to INCREASE the rate of rotation: rather abruptly use full rudder and aileron in the direction of rotation. If the nose drops and rotation speed increases, proceed with normal recovery. If the spin remains flat, you may have to try changing the CG position FORWARD by shifting your weight forward and simultaneously attempting the spin recovery. If these attempts do not work, you have run out of options, but hopefully not altitude. An irrecoverable flat spin is not very common, but should be considered a worthwhile reason for using the emergency parachute. JUMP.

4) Do not confuse a spin with a spiral dive! Using the wrong recovery for the wrong maneuver will compound the problem. In a decent spin, airspeed is constant within a few knot range, angle of bank is constant, and G forces are constant. Review the development of and recovery from spiral dives with an instructor.

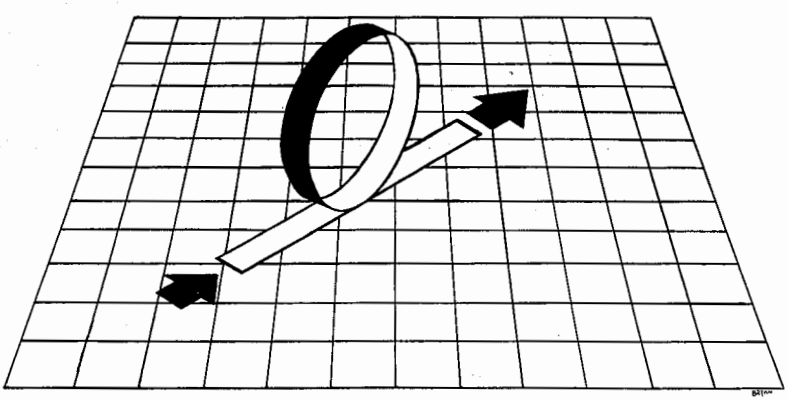
THE LOOP



Enter from normal flight as follows:

First put the sailplane into a 45 degree dive and hold this attitude until the sailplane reaches 100 kts, then add back pressure on the stick firmly, but not abruptly to +4 Gs. Maintain constant back pressure until the sailplane approaches the inverted position and then slowly reduce stick pressure to near neutral, so that the G forces approach 0. From the top of the loop, allow the sailplane to glide into an increasingly nose down attitude, then start to add back pressure again as the sailplane reaches 45 degrees nose down. The bottom of the loop should have +4 Gs and be nearly 10 kts slower than entry speed.

Continue to pull up until the climb attitude is 45 degrees, then leave the loop on tangent to regain altitude. As the speed lowers to 70 kts, normalize pitch attitude.



THE LOOP

CAUTION!

1) An unintentional inverted stall or a dangerous tailslide may occur if:

- the entry dive angle is less than 45 degrees nose low OR
- the required speed is not reached before the pull up OR
- back stick pressure is added too slowly in the pull up OR
- the pull up yields less than positive 4 Gs.

2) If the outcome of the maneuver is in doubt BEFORE reaching the vertical pitch attitude, the pilot must push forward on the stick to return to normal flight attitude.

3) If the maneuver must be aborted when the pitch attitude has reached or exceeded the vertical, the pilot MUST increase elevator pressure using full back stick and wait for normal horizon to come into his view. AN UNINTENTIONAL TAILSLIDE MUST BE AVOIDED, since this can seriously damage the sailplane.

Reference points:

1) To assume the 45 degree dive angle; look at the wing tip and change the pitch attitude down until the chord line points 45 degrees below the horizon.

2) Now, divide your attention between the point on the ground ahead of the nose and the airspeed indicator. Oppose the nose pitch up that occurs with increasing airspeed.

3) As soon as entry airspeed is reached, focus attention on the "G" meter adding back pressure to reach the +4 Gs.

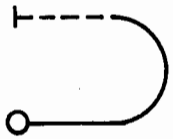
4) Next, while maintaining the constant back pressure, look at the horizon to check that no bank attitude change is being introduced in the pull-up.

5) As the horizon disappears below the nose, look above and behind for the rising inverted horizon. A slow, smooth transition

from high positive Gs to 0 G begins when you sight the inverted horizon. Check and/or correct the bank attitude at this time.

6) On the back side of the loop, allow the nose to slowly approach 45 degrees down, then start increasing the back stick pressure and look for the normal horizon.

INVERTED FLIGHT (½ loop entry)



The sailplane is designed with superb right-side-up stability; you can let go of it at any time and it will continue to fly. It can't turn upside down on its own. Once upside down the sailplane is very unstable, wanting to right itself, and it takes the pilot's hands-on flying to keep it upside down! However, right-side-up or upside-down the basic priorities still apply:

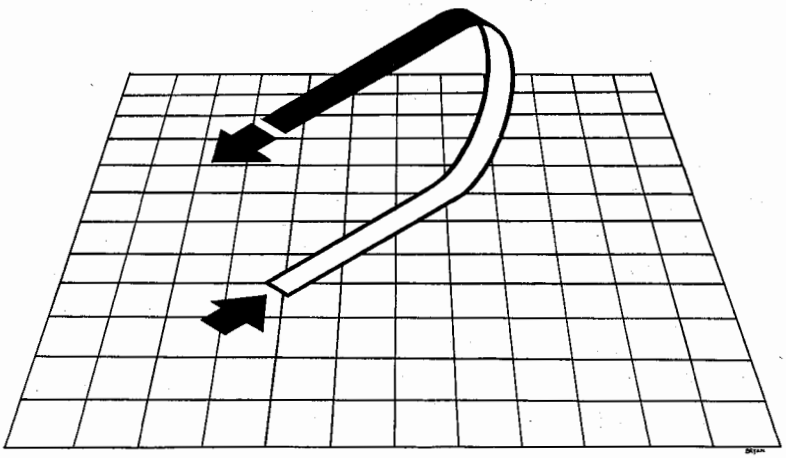
1) pitch control

2) coordination (must be rudder only)

3) bank control

Enter from normal flight as follows:

First put the sailplane into a 45 degree dive and hold this attitude until the sailplane reaches 105 kts, then add back stick pressure firmly, but not abruptly to +4 Gs. Maintain the 4 Gs until the sailplane is in the inverted position, then set the pitch attitude with forward stick pressure to 70-80 kts. The yaw-string is maintained in the center by the use of rudder only.



INVERTED FLIGHT from ½ LOOP ENTRY

Recovery from inverted flight:

1) change pitch attitude slowly to well above the horizon, then as the sailplane approaches an inverted stall, apply back stick pressure to pull through to normal flight attitude.

2) if the sailplane stalls inverted, apply back stick pressure to pull through to a normal flight attitude.

CAUTION!

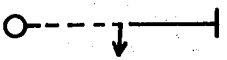
1) Always THINK in terms of PITCH ATTITUDE and BANK ATTITUDE rather than in terms of the reversed stick controls or in terms of left and right.

2) At the first moment of disorientation in an inverted attitude:

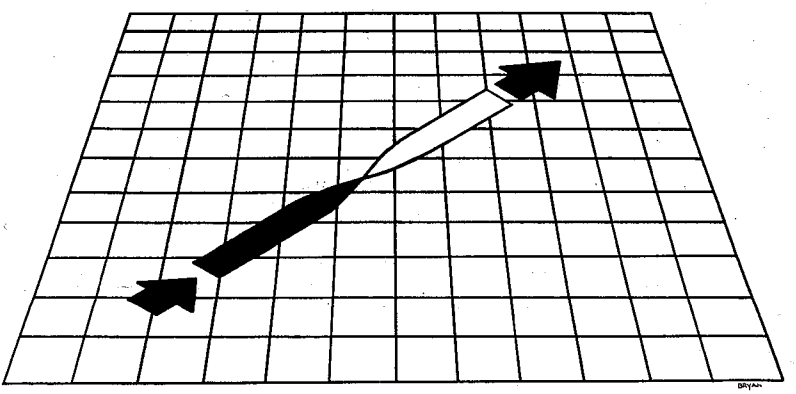
- open spoiler and apply full aileron WITHOUT rudder. DO NOT apply forward or back stick pressure!

3) Attempting to learn inverted flight without the on-board supervision of an acro instructor WILL RESULT in an uncontrolled dive, screaming past Vne!

½ ROLL from INVERTED FLIGHT (beginner)



In inverted flight, adjust pitch attitude for about 70 to 80 kts, add forward stick pressure decisively and at the same time full aileron with opposite rudder for coordination. As the sailplane rolls past a 90 degree bank, slowly reduce bottom rudder. At a point about 30 degrees before completion of the roll-out reduce the forward pressure and add top rudder as needed to maintain direction. Neutralize the aileron as bank angle approaches zero and then normalize pitch attitude.

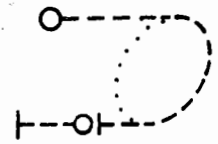


½ ROLL FROM INVERTED

CAUTION!

1) Without decisively raising pitch attitude in the inverted position and maintaining the forward pressure, it will not be possible to maintain direction at the completion of the roll-out.

INVERTED TURN



You already know that the sailplane is unstable in inverted flight, and that more care is needed in maintaining the proper pitch relative to the horizon. Now, let's complicate things by adding the basic aerodynamics of a turn.

In inverted flight, set up a pitch attitude that produces 80-90 kts. The turn is accomplished by lowering the wing toward a chosen point. (Just like right side up ... but it's HOW you do this that differs!) Very simply, move the stick AWAY from that chosen point. As the bank develops, a considerable amount of additional forward stick pressure is needed to maintain the proper pitch attitude. Use rudder as needed to keep the yaw string centered. Coordination becomes extra important because a "simple" inverted side slip can quickly degenerate into knife-edge flight followed by loss of control.

To stop turning, apply aileron pressure in the direction of the turn —that is, TOWARD the center of the turn — again using rudder to coordinate the maneuver.

CAUTION!

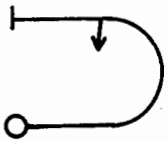
1) Always THINK in terms of PITCH ATTITUDE and BANK ATTITUDE rather than in terms of the reversed stick controls or left and right.

2) At the first moment of disorientation in an inverted turn:

- open spoiler and apply full aileron without rudder. DO NOT apply forward or back stick pressure!

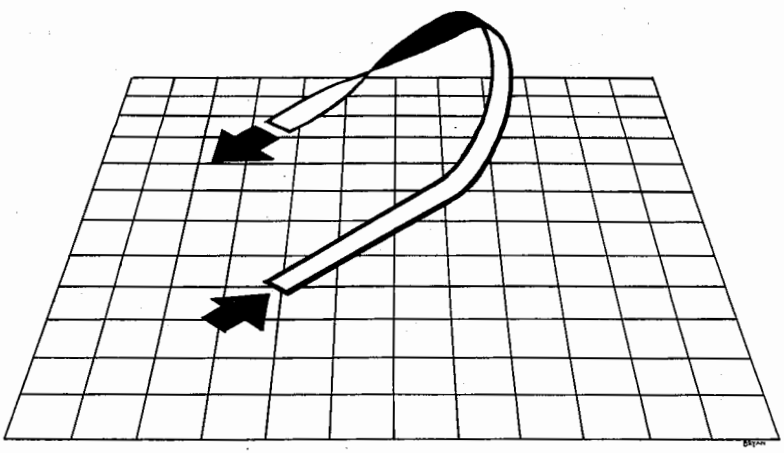
3) Attempting to learn inverted turns without the onboard supervision of an acro instructor WILL RESULT in an uncontrolled dive, screaming past Vne!

IMMELMAN (½ roll at top of a ½ loop)



Enter from normal flight as follows:

First put the sailplane into a 45 degree dive and hold this attitude until the sailplane reaches 110 kts, then add back pressure on the stick firmly, but not abruptly to +4 Gs. Maintain constant back pressure until the sailplane's nose is about 20 degrees above the horizon in an inverted flight attitude. Then stop pitch change with forward pressure and add full aileron with opposite rudder for coordination. The ½ roll is the same as in "½ ROLL-OUT"from inverted flight. The extra 10 kts is needed for the ½ roll at the top.



IMMELMAN

CAUTION!

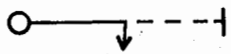
1) An unintentional inverted stall or a dangerous tailslide may occur if:

- The entry dive angle is less than 45 degrees nose low OR
- the required speed is not reached before the pull up OR
- back stick pressure is added too slowly in the pull up OR
- the pull up yields less than positive 4 Gs.

2) If the maneuver must be aborted BEFORE reaching the vertical pitch attitude, the pilot must push forward on the stick to return to normal flight atttiude.

3) If the maneuver must be aborted when the pitch attitude has reached or exceeded the vertical, the pilot MUST increase elevator pressure using full back stick and wait for normal horizon to come into his view. AN UNINTENTIONAL TAILSLIDE MUST BE AVOIDED, since this can seriously damage the sailplane.

½ ROLL to INVERTED (beginner)

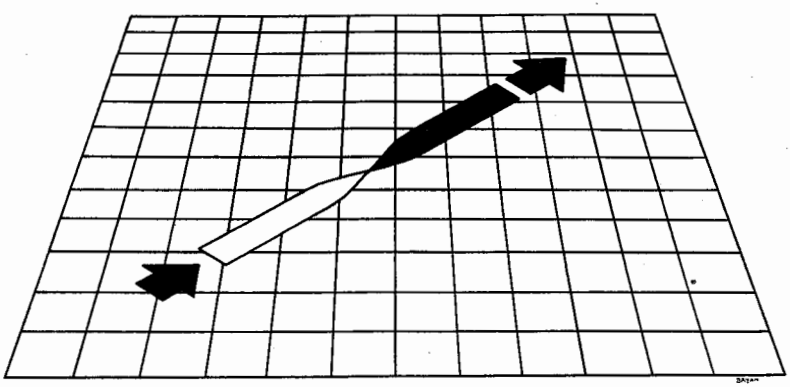


Enter from normal flight as follows:

Put the sailplane into a 45 degree dive and hold this attitude until the sailplane reaches 95 kts, then add back pressure to +2 Gs.

(So far you have done a slower than normal Loop entry, with a mild pull up ... Imagine the "ARC" this scribes in the air.)

Raise the sailplane's nose slightly above the horizon and reduce back pressure to leave the "ARC" on the tangent. Add and hold full aileron without changing the forward or aft pressure on the stick. As the angle of bank approaches 90 degrees, slowly apply top rudder. Next, when actually rolling through a 90 degree bank angle to inverted, start adding increasingly more forward stick pressure, with top rudder to coordinate. Neutralize aileron and rudder as you establish inverted flight, and adjust the inverted pitch attitude to achieve 70 to 80 kts.



½ ROLL to INVERTED

CAUTION!

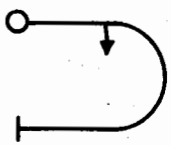
1) Because of the unusual dangerous attitude and the inherently false visual references, attempting to learn this maneuver without the onboard supervision of an acro instructor WILL RESULT in an uncontrolled dive, screaming past Vne!

2) Modern racing sailplanes CAN'T fly in an inverted attitude and therefore they should not be rolled inverted!

NOTES:

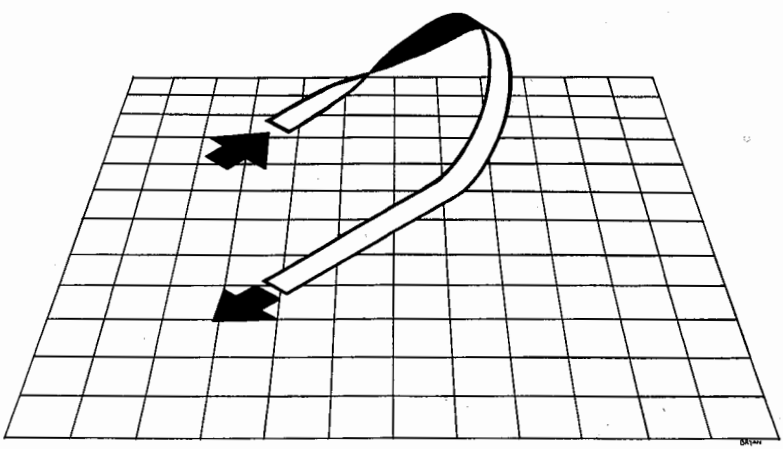
1) The over use of rudder will make the rolling very difficult.

SPLIT-S



Enter from normal flight as follows:

Put the sailplane into a 45 degree dive and hold this attitude until the sailplane reaches 95 kts, then add back stick pressure to +2 Gs. Raise the sailplane's nose slightly above the horizon and reduce back pressure to leave the "ARC" on the tangent. Add and hold full aileron without changing the back stick pressure. As the roll approaches 90 degrees, slowly apply top rudder, and when rolling just past 90 degrees, start adding increasingly more forward pressure and top rudder. Neutralize aileron and rudder when inverted and establish an increasingly nose high attitude. As you approach an inverted stall, allow the sailplane to glide into an increasingly nose down attitude, starting to add back stick pressure again as the sailplane reaches 45 degrees nose down. The bottom of the loop should have +4 Gs and nearly 100 kts.



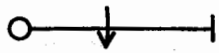
SPLIT-S

CAUTION!

1) It is vital that you get near inverted stall speed before starting the ½ LOOP or high speed Gs may result ...

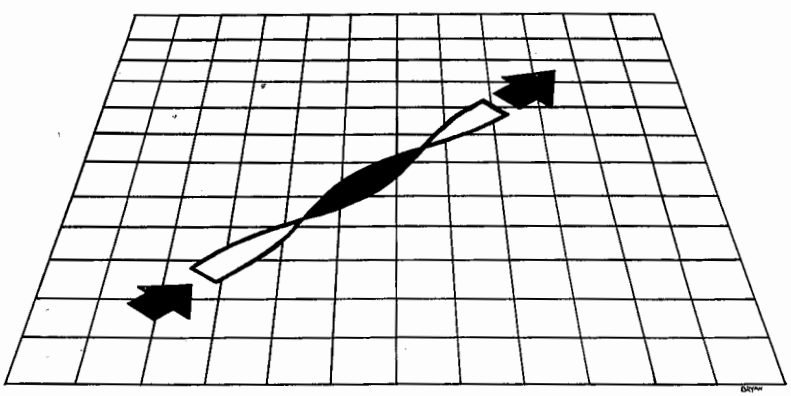
2) Allow the nose to slowly approach 45 degrees down, then start increasing the back pressure to +4 Gs and look for the normal horizon.

360 DEGREE ROLL



Enter from normal flight as follows:

Put the sailplane into a 45 degree dive and hold this attitude until the sailplane reaches 90 kts, then add back stick pressure to +2 Gs. Raise the sailplane's nose slightly above the horizon and reduce back pressure to leave the "ARC" on the tangent. Add and hold full aileron without changing the back stick pressure. As the roll approaches the first 90 degree bank, slowly apply top rudder. As the roll continues just past the 90 degree bank start adding increasingly more forward stick pressure and top rudder for coordination. As the sailplane approaches the 270 degree bank, slowly reduce bottom rudder. At a point about 30 degrees before completion of the rollout add top rudder as needed to maintain direction. At the time the top rudder is added, slowly reduce the forward stick pressure as well. Neutralize the aileron as the bank angle approaches zero and then normalize pitch attitude.



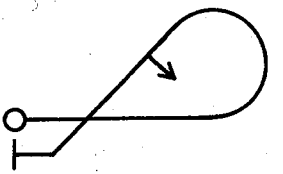
360 DEGREE ROLL

CAUTION!

1) Without decisively raising pitch attitude in the inverted position and maintaining the forward pressure, it will not be possible to maintain direction at the completion of the roll-out.

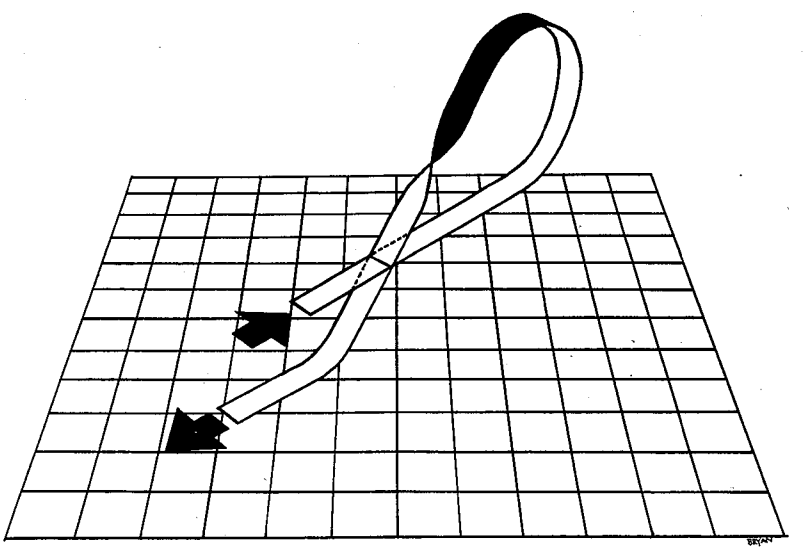
2) Attempting to learn this maneuver without the onboard supervision of an acro instructor WILL RESULT in an uncontrolled dive, screaming past Vne!

½ CUBAN-8



Enter from normal flight as follows:

First put the sailplane into a 45 degree dive and hold this attitude until the sailplane reaches 105 kts, then add back pressure on the stick firmly, but not abruptly to +4 Gs. Maintain constant back pressure until the sailplane approaches the inverted position, slowly reduce the back stick pressure so that the G force almost reaches 0 G. Allow the sailplane to glide in an increasingly nose down attitude; as 45 degrees below the inverted horizon is reached maintain constant pitch attitude. A second later start a ½ roll from inverted to normal on a 45 degree down line. When the ½ roll is completed, recover to normal attitude. At this point you should have made a 180 degree directional change.



½ CUBAN-8

By putting two ⅝ loops with ½ rolls back to back you'll end up with a CUBAN-8!

CAUTION!

1) Start with a 30 degree down line at first, limiting the speed built up during the ½ roll. As you become more comfortable with the ½ roll, progressively increase the angle towards the 45 degree down line. In either case, keep the speed below 110 kts.

CLOVERLEAF LOOP (LOOP with a ½ ROLL on the way up)

NO symbol for this maneuver

Enter from normal flight as follows:

First, put the sailplane into a 45 degree dive and hold this attitude until the sailplane reaches 100 kts, add back pressure on the stick firmly, but not abruptly to +4 Gs. Maintain constant back pressure and as the nose reaches the horizon apply aileron.

Coordination between back pressure and aileron pressure is important because the ½ roll and ½ loop should be finished at the same time.

At the top of the loop the sailplane should be pointing 90 degrees away from the original direction, having completed the ½ roll. As the inverted position is approached, slowly reduce the back stick pressure, so that the G force almost reaches 0. Allow the sailplane to glide into an increasingly nose down attitude, then start to add back pressure again as the sailplane reaches 45 degree nose down. The bottom of the loop should have +4 Gs.

Continue back stick pressure to pull up until the climb attitude is 45 degrees above the horizon, and leave the loop on tangent to regain altitude. As the speed lowers to 70 kts, normalize pitch attitude.

Four of these figures back to back (without leaving the loop on the tangent) will make an impressive looking airshow maneuver!

Reference points:

1) To assume the 45 degree dive angle; look at the wing and change the pitch attitude down until the chord line points 45 degrees below the horizon.

2) Now, divide your attention between the point on the ground ahead of the nose and the airspeed indicator. Prevent the nose pitch up that occurs with increasing air speed.

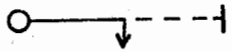
3) As soon as entry airspeed is reached, the attention is focused on the "G" meter adding back pressure to reach +4 Gs.

4) Next, while maintaining the constant back pressure, look at the horizon to check that no bank attitude change is being introduced in the pull-up.

5) As you start the roll at the horizon, look 90 degrees to the side in the direction of roll, and end up pointing your sailplane in this direction as you reach the inverted flight attitude. Check and or correct the bank attitude at this time.

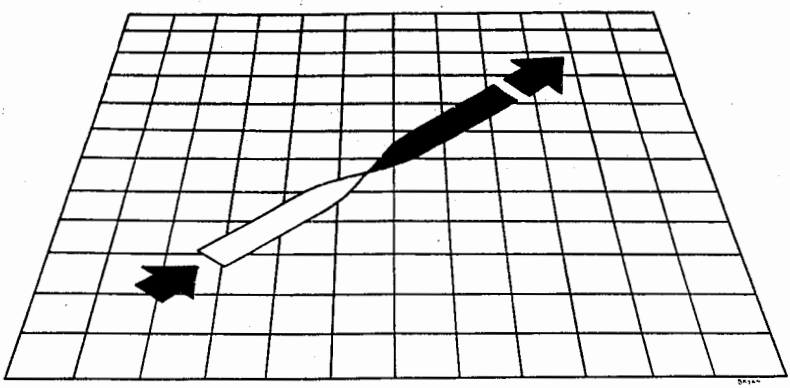
6) Allow the nose to slowly approach 45 degrees down, then start increasing the back stick pressure and look for the normal horizon. Return to a normal attitude.

½ ROLL to INVERTED (advanced)



Enter from normal flight as follows:

Put the sailplane into a 45 degree dive and hold this attitude until the sailplane reaches 90 kts, then add back stick pressure to +2 Gs. Raise the sailplane's nose up to the horizon and reduce back pressure to leave the "ARC" on the tangent. Add and hold full aileron without changing the back stick pressure and through the first 45 degrees coordinate with bottom rudder. As the bank angle approaches 90 degrees, slowly apply top rudder, then as you roll past knife edge, start adding increasingly more forward stick pressure and top rudder. Finally, neutralize aileron and rudder — adjust the inverted pitch attitude to achieve 70 to 80 kts.



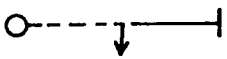
½ ROLL to INVERTED

CAUTION!

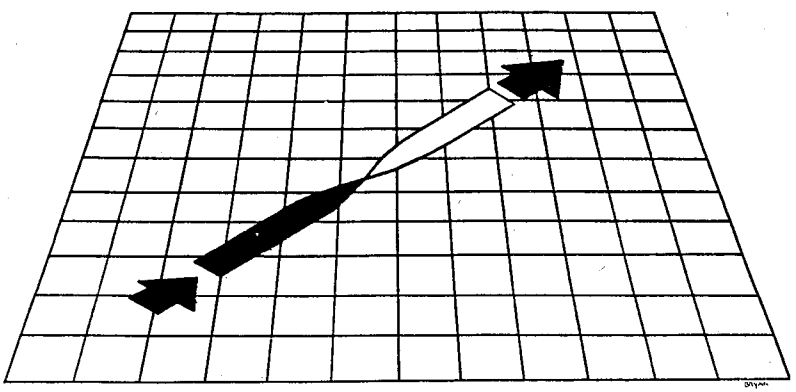
1) Because of the unusual, dangerous attitude and the inherently false visual references, attempting to learn this maneuver without the onboard supervision of an acro instructor, WILL RESULT in an uncontrolled dive, screaming past Vne!

2) Modern racing sailplanes CAN'T fly in an inverted attitude and therefore they should not be rolled inverted!

½ ROLL from INVERTED (advanced)



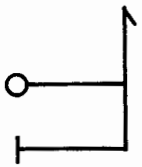
In inverted flight, adjust pitch attitude for about 90 to 95 kts. Add forward stick pressure and at the same time full aileron with opposing rudder for coordination. As the sailplane rolls through a 90 degree bank angle, switch slowly from bottom rudder to top rudder and slowly reduce the forward stick pressure as well. (The combination of top rudder and increasing back pressure will prevent the sailplane's nose from dropping.) Neutralize the aileron as the bank angle approaches zero. Resume normal flight.



½ ROLL from INVERTED

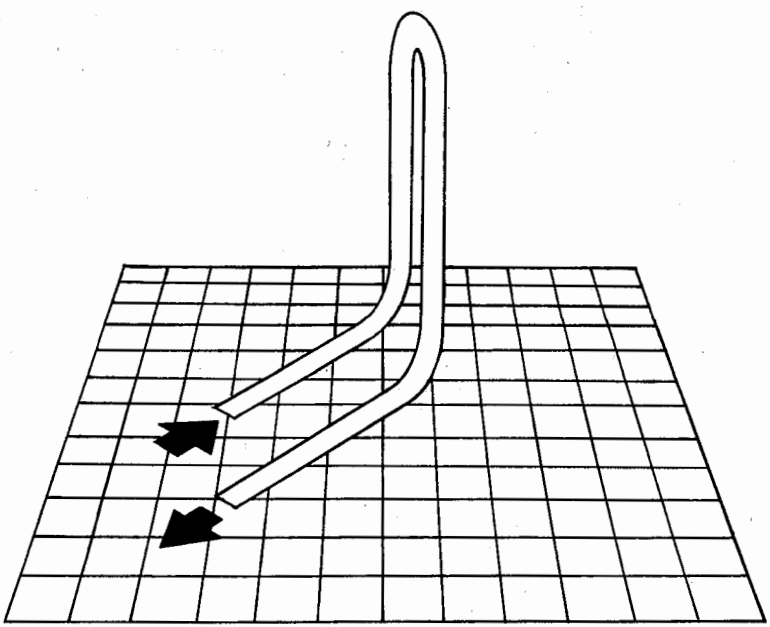
THE FOLLOWING FIGURES MAY ONLY BE DONE IN SAILPLANES APPROVED FOR UNLIMITED AEROBATICS

STALL TURN



Enter from normal flight as follows:

First, put the sailplane into a 45 degree dive and hold this attitude until the sailplane accelerates to 100 kts. Now assume a horizontal pitch attitude and hold this momentarily. Add back stick pressure firmly, but not abruptly to a +4 G pull up. Maintain constant back pressure until the sailplane's longitudinal axis approaches vertical. (The "CG" of the sailplane is on the vertical 90 degree line.) Hold the vertical flight path constant. When the sailplane slows to 60 to 57 kts, add full rudder in the desired direction. A second later, add full OPPOSITE aileron momentarily and then neutralize aileron pressure. Maintain full rudder as the



STALL TURN

sailplane starts to "fall" on its side toward the earth. Stabilize the sailplane in a vertical down line. As the speed builds recover to a normal flight atttiude.

CAUTION!

1) If the "CG" of the sailplane is not on the vertical 90 degree line: a combination tailslide and stall turn will occur.

2) The longitudinal axis of the sailplane may or may not be parallel with the vertical line, depending on whether the "CG" of the sailplane falls on or off the axis.

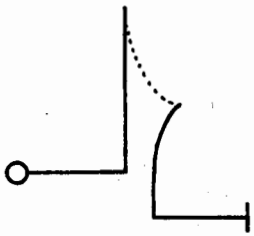
3) Speeds given above for the rudder application will vary from sailplane to sailplane, however, this is a good starting point.

4) The Stall Turn, done improperly, can result in an inadvertent Tailslide!

NOTES:

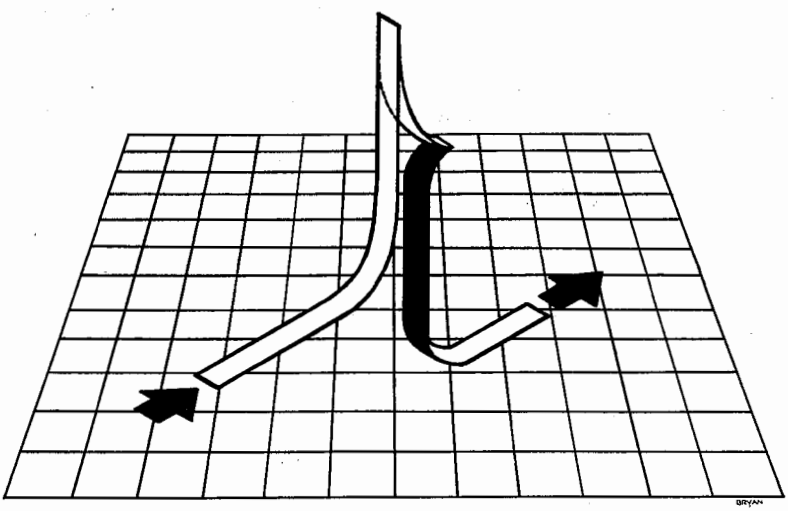
1) Some sailplanes do not like the application of hard rudder. In this case, soon after you reached the vertical line try giving rudder slowly at first.

TAILSLIDE (negative or stick forward)



Enter from normal flight as follows:

First, put the sailplane into a 45 degree dive and hold this attitude until the sailplane accelerates to 100 kts. Add back stick pressure firmly, but not abruptly to a +4 G pull up. Maintain constant back pressure until the sailplane's longitudinal axis is vertical. Hold the vertical flight path constant. As the sailplane stops, there will be no sound, and the yaw string will start going backwards; only then give full forward stick pressure and at the same time stiffen your legs to prevent possible rudder movement during the tailslide. (The sailplane will be falling through



TAILSLIDE (negative or stick forward)

an inverted attitude backwards, toward the canopy.) After the nose drops toward the earth, recover with back stick pressure to normal flight attitude.

CAUTION!

1) The Tailslide is one of the most critical aerobatic maneuvers!

2) If the elevator is moved full forward early (before the sailplane comes to a stop), a pitch attitude change to the absolute vertical attitude can occur. The result may be a high speed fall causing severe damage!

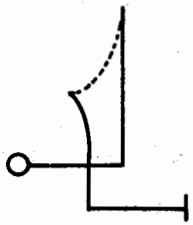
3) Practicing this maneuver, plan on establishing an upward flight path of 10 degrees or more PAST the 90 degree vertical attitude. As proficiency improves, work progressively closer to the vertical plane.

4) The "CG" of the sailplane must never stay on the 90 degree line; the resultant high speed tailslide will seriously damage the sailplane!

5) The Tailslide must always be done at high altitude (3 to 5 thousand feet). If the maneuver is done improperly, the pilot may need the extra altitude in order to jump safely.

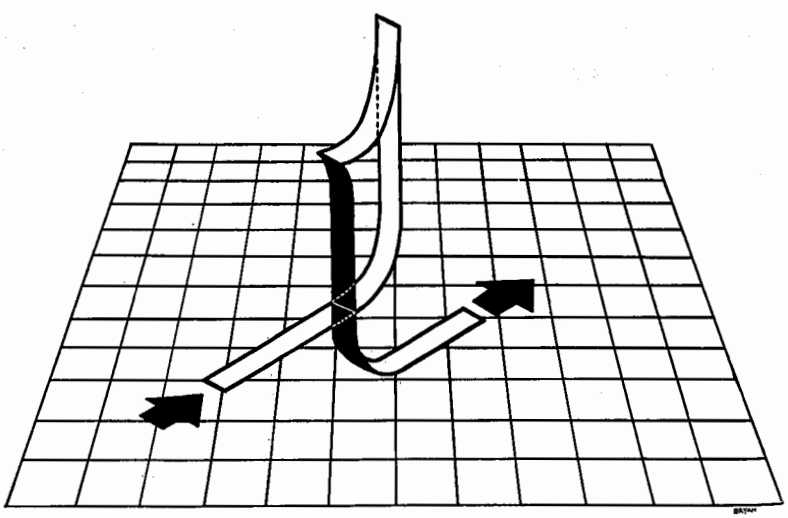
6) The unintentional TAILSLIDE MUST BE AVOIDED since it can seriously damage the sailplane!

TAILSLIDE (positive or stick back)



Enter from normal flight as follows:

First, put the sailplane into a 45 degree dive and hold this attitude until the sailplane accelerates to 100 kts. Add back stick pressure firmly, but not abruptly to a +4 G pull up. Maintain constant back pressure until the sailplane's longitudinal axis is 15 degrees short of vertical (75 degrees up from the horizon). Hold this flight path constant. As the sailplane stops, there will be no sound, and the yaw string starts going backwards; only then give full back stick pressure and at the same time stiffen your legs to prevent possible rudder movement during the tailslide. (The sailplane will be falling through a normal, up-right attitude or towards your feet.) After the nose drops toward the earth, recover with back stick pressure to normal flight attitude.



TAILSLIDE (positive or stick back)

CAUTION!

1) The Tailslide is one of the most critical aerobatic maneuvers!

2) If the elevator is moved full back early (before the sailplane comes to a stop), a pitch attitude change to the absolute vertical attitude can occur. The result may be a high speed fall causing severe damage!

3) Practicing this maneuver, plan on establishing an upward flight path of 20 degrees SHORT of the 90 degree vertical attitude. As proficiency improves, work progressively closer to the vertical plane.

4) The "CG" of the sailplane must never reach the 90 degree line; the resultant high speed tailslide will seriously damage the sailplane!

5) The Tailslide must always be done at high altitude (3 to 5 thousand feet). If the maneuver is done improperly, the pilot may need the extra altitude in order to jump safely.

6) The unintentional TAILSLIDE MUST BE AVOIDED since it can seriously damage the sailplane!

½ SNAPROLL (negative or from inverted flight)

In inverted flight adjust pitch attitude for 85 kts, add full forward stick then followed by full rudder the desired direction. After the rotation starts, relax the forward stick pressure somewhat (this will help when you need to stop the rotation). As the sailplane approaches an inverted attitude, reduce the forward stick pressure and align the direction of the sailplane with the rudder. Some experimentation is necessary to select the exact moment of recovery needed to achieve the inverted wings level attitude. Extreme control positions may be maintained for the continuation of the snaproll. Relaxing the forward stick pressure and the rudder will stop the roll.

CAUTION!

1) This maneuver must be done only in sailplanes approved for unlimited aerobatics!

2) Snaproll should not be attempted in long wingspan sailplanes, because the wingroots can suffer serious damage!

3) Full control deflection must not be used above maneuvering speed!

½ SNAPROLL (positive or to inverted)

Enter from normal flight as follows:

Put the sailplane into a 45 degree dive and hold this attitude until the sailplane reaches 90 kts, then adjust pitch attitude to a point slightly above the horizon. As speed decays to 85 kts, firmly add full back stick pressure and a moment later add full rudder in the direction you want to roll. After the rotation starts, relax the back pressure somewhat (this will help when you need to stop the rotation). Experimentation is necessary to determine at what point in the roll you should remove back pressure and rudder to stop the sailplane in the desired inverted attitude.

CAUTION!

1) This maneuver will need about +6 Gs. Must be done in sailplanes approved for unlimited aerobatics!

2) Snaproll should not be attempted in long wingspan sailplanes, because the wingroots can suffer serious damage!

3) Full control deflection must not be done above maneuvering speed!

APPENDICES

APPENDIX A

Building an Aerobatic Program

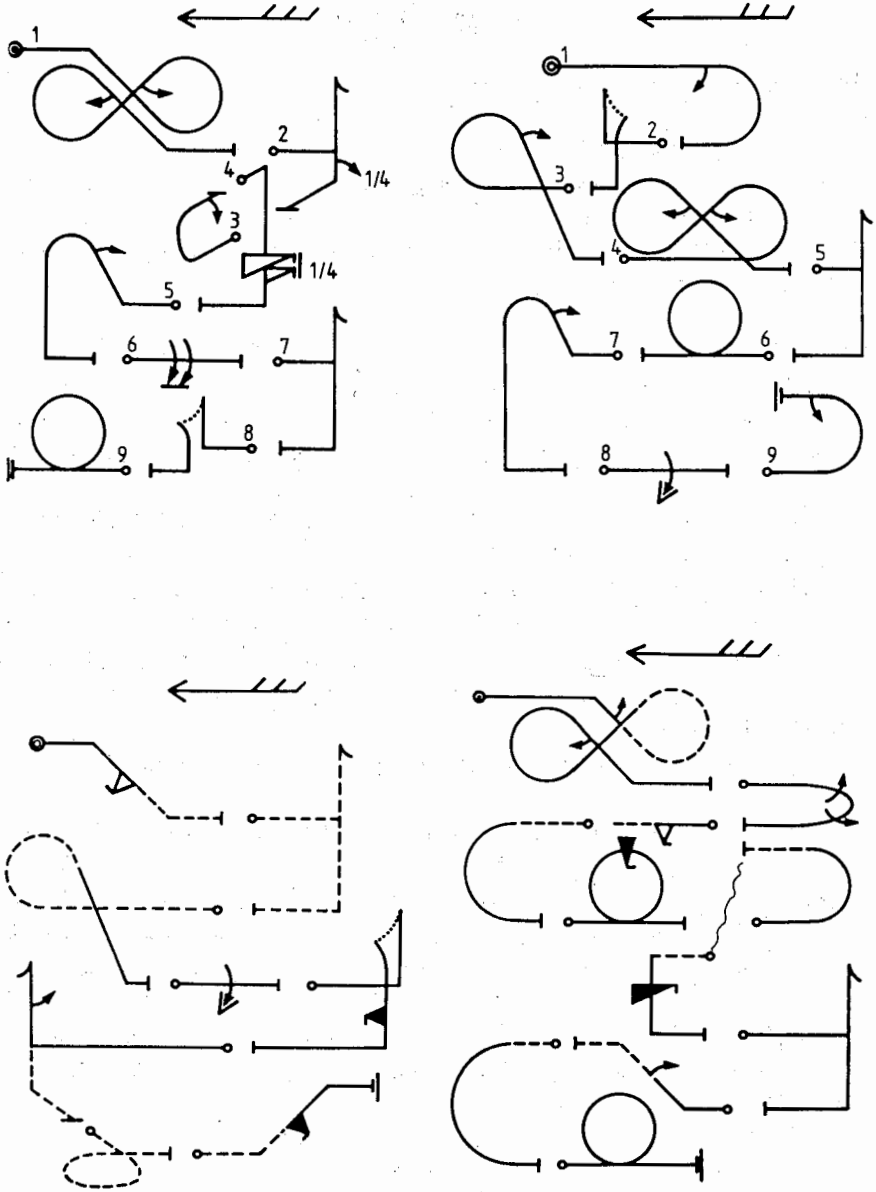
For the experienced acro pilot participating in airshows or competition, designing an aerobatic program or "Sequence" can be a lot of fun! Be creative ... imagine how your sequence will look to the spectators or judges on the ground. At the same time, bear these facts in mind:

Each aerobatic figure has its own entry and exit speed. Considering the speed requirements for each figure to be flown, put them together in such a fashion that the exit speed of the previous maneuver matches the entry speed of the next figure.

POSITIONING is important, particularly in competition, where the sailplane must remain in "The Box" (1km x 1km x 1km). In contrast to the competition "Box," airshow audiences usually expect that performers will spread their routines around a bit more so everyone gets a good look. Plan 180 degree turn-around figures according to the purpose of your flight: competition may require more of these to stay in The Box, while planning every 3rd or 4th maneuver to include a turn around may work at an airshow.

HARMONY for an airshow is probably the most important factor in designing an airshow sequence. Nothing is more dull than (yawn) waiting for that sailplane to (finally) get set up for the next figure. Ideally at an airshow, try to create contrast with the smaller, faster aerobatic planes. Try for a smooth, flowing, graceful feel. Set to music over a PA system, your routine can be a real show-stopper! Pairing the right sequence with the right music may be a real challenge, but you can create a beautiful experience for the audience.

To the judges at a sailplane aerobatic competition, "Harmony" means that the timespan between figures is uniform, with no interruptions. (To learn more about sailplane aerobatic contests see Appendix D & E.)



MUHLDORF, W. Germany, 1983. 1st International Glider Aerobatic Championship. The top two sequences are the Intermediate Category's "Known I & II" and the bottom two are the "Known I & II" for the Unlimited Category. Arrow indicates wind direction.

APPENDIX B

EXCERPTS FROM:

FEDERAL AVIATION REGULATIONS CONCERNING ACROBATIC FLIGHT

ACROBATIC FLIGHT is defined as an intentional maneuver involving an abrupt change in an aircraft's attitude, an abnormal attitude, or abnormal acceleration, not necessary for normal flight. (91.71)

PARACHUTES AND PARACHUTING

(91.15c) Unless each occupant of the aircraft is wearing an approved parachute, no pilot of a civil aircraft ... may execute any intentional maneuver that exceeds:

1. A bank of 60 degrees relative to the horizon.

2. A nose-up or nose-down attitude of 30 degrees relative to the horizon.

(91.15e) Approved parachute means:

1. A parachute manufactured under a type certificate or a technical standard order (C-23 series).

2. A personnel-carrying military parachute identified by an NAF, AAF, or AN drawing number, an AAF order number, or any other military designation or specification number.

(91.15a) No pilot of a civil aircraft may allow a parachute that is available for emergency use to be carried in that aircraft unless it is an approved type (91.15e) and:

1. If a chair type (canopy in back), it has been packed by a certificated and appropriately rated parachute rigger within the preceeding 120 days.

2. If any other type, it has been packed by a certificated and appropriately rated parachute rigger within the preceeding 60 days.

AEROBATIC FLIGHT

No person may operate an aircraft in aerobatic flight:

1. When flight visibility is less than three miles (91.81e).

2. Within a control zone or Federal airway (91.71c).

3. Over any congested area of a city, town or settlement; over an open air assembly of persons (91.71a,b).

4. Below an altitude of 1500 feet above the surface (91.71d).

In addition, minimum safe altitudes apply to all flying: (91.79b and c)

> except ... for takeoff or landing, no person may operate an aircraft below ... 1000 feet above the highest obstacle within a horizontal radius of 2000 feet of the aircraft in a congested area; in sparsely populated areas not closer than 500 feet to any person, vessel, vehicle or structure (91.79b,c).

WAIVERS OF FAR Subpart 91B

1. The administrator may issue a certificate of waiver authorizing the operation of aircraft in deviation of any rule of this subpart if he finds that the proposed operation can be safely conducted under the terms of this certificate of waiver (91.63a).

2. An application for a certificate of waiver under this section is made on a form and in a manner prescribed by the Administrator and may be submitted to any F.A.A. office (91.63b).

3. A certificate of waiver is effective as specified in this certificate (91.63c).

Special waivers may be granted for acrobatic flight within controlled airspace, for instance, airshows. The airshow director requests a waiver listing day, time, location, and participants.

When acrobatic flight takes place outside controlled airspace but within an area with considerable traffic, F.A.A. should be notified so a NOTAM can be issued.

Individuals may request a waiver of FAR 91.71d. A copy of the acrobatic program must be attached to the request for waiver. An F.A.A. inspector watches the program performed above 1500 feet to determine pilot proficiency. If proficient, the program is done again below 1500 feet but above 1000 feet. If a waiver is granted, F.A.A. issues a waiver card good for one year. The card specifies minimum altitude and specific maneuvers that may be performed at that altitutde. A pilot may request additional waivers for lower altitudes (500 feet, no limit) and more maneuvers. The F.A.A. again requires the approved form, a program, and sufficient records to attest to the pilot's acrobatic experience. Again, an inspector will view the program and decide on the pilot's proficiency.

Ref: Soaring Flight Manual, 1979, Chapter 6

F.A.A.-G.A.D.O., Scottsdale Municipal Airport, 1/84.

APPENDIX C

CONSIDERATIONS IN AVOIDING G INCAPACITATION

Any type of flying involves some degree of risk. The prudent pilot, the skilled pilot, is familiar with the risks involved in all aspects of his/her particular flying interest(s) and acquires the knowledge and skills necessary for reducing these risks to a minimum. In addition, he/she is aware of his/her own limitations and can make accurate judgements of his/her ability to withstand the stresses of flight. As noted, susceptibility to G's is an especially important limitation of the aerobatic pilot, and to recognize and understand this limitation is important to safe aerobatic flying. Briefly, the response of the heart, the amount of mobilizable blood, and the tone of the vessels determine the tolerance to G's. Because of this, the following factors do, or may, play a role in a pilot's tolerance.

BODY SIZE: Tall persons appear to be more susceptible than shorter persons. This is probably related to the length of the column of blood between the heart and the head, it being longer in taller persons and thus more difficult to maintain a head of pressure at the base of the brain to permit adequate perfusion.

PHYSICAL FITNESS: Common sense suggests that a certain degree of physical fitness would keep the anti-G compensating mechanisms in a desireable state of tone. Studies have indicated that weight lifting can increase tolerance to G's but intense aerobatic training (marathon running) probably decreases tolerance. Endurance trained individuals have enhanced cardiovascular vagal tone evidenced by slower heart rates both during exercise and at rest. It is probably because of poor cardiac response to the +G accelerations that such individuals have lowered toelrance.

PREEXISTING CARDIAC ARRHYTHMIAS: An arrhythmia reflects cardiac dysfunction of one degree or another. Since the major anti-G physiological response is a speeding or slowing of the heart, before aerobatic flying, a pilot with arrhythmia would be

advised to have a careful cardiac evaluation by a flight surgeon familiar with the effects of G's.

G-INDUCED DYSRHYTHMIAS OR LOC (Loss Of Consciousness): Any pilot who has had a symptomatic G-induced dysrhythmia or LOC should avoid aerobatic flying until he/she has had a thorough evaluation by a flight surgeon familiar with the hazards of G's in aerobatic flying. In civil aviation this is a decision to be made by the pilot. In military aviation such an incident may call for a thorough cardiovascular evaluation with additional studies conducted on the human centrifuge.

HYPOGLYCEMIA STATE: Tolerance is lowered with lower blood sugar levels.

DEHYDRATION/EXCESSIVE SWEATING: Loss of salt and water cause decrease in blood volume and make it more difficult for the body to maintain the blood pressure needed to perfuse the brain under G loading. Dietary restriction of salt, sunburn, and weight reduction dieting have been found to decrease G tolerance.

PROLONGED INACTIVITY: Inactivity causes increased pooling of fluids in the lower parts of the body and probably reduces G tolerance because of apparent decrease in readily mobilizable blood volume. Prolonged bed rest reduces G tolerance.

POSTPRANDIAL STATE: Following a large meal there is pooling of blood in the abdominal organs and this would tend to counteract the mobilization of blood to maintain brain perfusion pressure.

FATIGUE: The physiological tone necessary to mount a counter G response is probably progressively lowered with increasing degrees of fatigue so that aerobatic pilots would be advised to avoid flying strenuous maneuvers during states of appreciable fatigue.

ILLNESS AND DISEASE: Just as fatigue probably lowers physiological tone and impairs the desired anti-G response, so probably do acute and chronic illnesses. Pilots who are ill or do not feel "well" should avoid exposure to significant levels of G's.

MEDICATION AND DRUGS: Many prescription and over the counter medications have an effect on the cardiovascular system and could impair the desired response to G loading. Pilots taking edications for colds, sleeplessness, diarrhea, ulcers, high blood pressure, pain, etc., should not perform aerobatics unless the issue is thoroughly checked out with a flight surgeon familiar with the rigors of aerobatic flying.

ALCOHOL AND RECREATIONAL DRUGS: Alcohol has been shown to impair a pilot's ability to perform tasks during G loading. Hangover does not decrease performance although the subjects often feel fatigued. Recreational drugs have effects on brain function. Their effects on G tolerance are not described; however, alcohol and drugs should be avoided by the serious aerobatic pilot. In addition to changes in G tolerance as noted above, Voge has reviewed indicators of other physiological changes that may occur in individuals subjected to high levels of G acceleration. All of these have been shown in animals and humans accelerated under laboratory conditions.

CONCLUSIONS: Historical evidence suggests that humans have a variable but limited tolerance to G's and that if tolerance is exceeded the individual may lose consciousness.

APPENDIX D

Sailplane Aerobatic Association

The Sailplane Aerobatic Association was formed in May of 1985 to promote the sport of glider aerobatics. The Association is an organization of individuals that "relate" to sailplane aerobatic flying and is made up of pilots, families, crews and others who are interested. Membership is open to anyone; owning an aerobatic sailplane or being a pilot is not required. Purposes of the Association include:

- Setting safety standards for sailplane aerobatics
- establishing categories for sailplane aerobatics
- supervising sailplane aerobatic competitions
- giving recognition to members for their accomplishments related to sailplane aerobatics.
- publishing the *Sailplane Aerobatic News*

The *Sailplane Aerobatic News* contains flight stories, contest results, member achievements; announcements, want ads, information on aerobatic sailplane developments and other items of interest.

Join us today! Write to:

Sailplane Aerobatic Association
3108 Fairway Dr.
Tempe, AZ 85282

APPENDIX E

The *National & International Rules of Glider Aerobatics* contains sailplane aerobatic contest rules developed by C.I.V.A. All sanctioned championships must adhere to these rules.

The "ALFA catalogue" by Heinz Clasen is the official dictionary of sailplane aerobatic maneuvers. Its content has been adopted from the Aresti dictionary of powerplane aerobatic maneuvers. It is a must for anyone desiring to compete.

"G Effects on the pilot during aerobatics"

FAA-AM-72-2B

"G Incapacitation in aerobatic Pilots: A flight Hazard"

FAA-AM-82-13

Above publications available from:

Sailplane Aerobatic Association
3108 Fairway Dr.
Tempe, AZ 85282

APPENDIX F

Some of the sailplanes used for aerobatics in the U.S.

LIMITED aerobatics:

1-26D
1-34
1-36
GROB 103 Acro
AS-K 21
ASW 15
2-32
Lark (two seater)
Blanik L-13
Some Pilatus B-4s
Std Jantar

UNLIMITED aerobatics:

Salto
Some Pilatus B-4s
Saggita