SAILPLANE THERMALING PROCEDURES

by Richard H. Johnson, Published in *Soaring* Magazine, February 1997

Introduction

The first step toward successful thermal soaring is the knowledge needed to locate thermals. The second step is the efficient utilization of the thermals during subsequent climb to altitude. From there the beauty of soaring flight can be enjoyed by flying locally, or an adventuresome cross country flight can begin. This paper describes the author's recommendations for these most important initial phases of soaring.

1. Locating Thermals

A. While On Tow

It is always desirable to start the search for the sometimes elusive thermals while climbing on tow. This is particularly important when aero towing or self launching in a motor glider because those launches usually include the first 3 to 4 miles of the flight. During that portion of flight the convection activity should be evaluated, the location of any usable thermals encountered should be noted. Even during relatively short auto or winch tows thermals are often encountered, and those areas can be returned to and searched after tow release. Remember that it is necessary to subtract both the sailplane's still air circling sink rate and the tow still air climb rate from that indicated during a thermal encounter on tow to arrive at a net climb rate that the sailplane could be expected to achieve when not under tow. For that reason it is usually best to set a variable range variometer to its high range when towing.

In addition to evaluating thermal strengths during the tow, the size of the thermals need to be evaluated. Since most modern sailplanes today are towed at about 100 ft/sec (59 kts), and they fly at about 80% of that speed (47 kts) while thermaling in a 35 degree bank, the minimum usable thermal diameter must be almost 600 ft. That means that one must be in the thermal for at least 5 to 6 seconds while on tow if a successful transition from tow to thermaling is to be assured. Thermals are often not that large below 1000 ft of altitude, so it is usually not wise to release from tow until achieving at least 1500 ft. However, knowing the locations of the too-small-to-circle thermals encountered during the earlier portions of the tow is important because one can return to those locations after release and expect the thermal to have expanded in diameter at higher altitudes. One needs to estimate where the wind might have drifted the thermal to when attempting to return to a previously encountered thermal, because thermals drift fully with the horizontal winds.

B. Effect Of Wing Loadings

Sailplanes with lighter wing loadings such as the popular Schweizer 1-26 and Schleicher K-6 / K-8 series do have the advantage of thermaling at lower airspeeds, and therefore they can successfully thermal in smaller diameter thermals than can the current modern sailplanes. For a given bank angle, a sailplane's circling diameter is proportional to the square of its flight speed.

Because a 1-26 can safely circle down to about 35 kts (59 ft/sec) when banked at 35 degrees, its turn diameter is only about 310 feet. For that reason it and the other lighter sailplanes have the capability of successfully thermaling at lower altitudes than can the higher wing loaded modern sailplanes.

C. After Release

Ideally the sailplane pilot should release from tow in a large and strong thermal, but that does not happen as often as we wish it would! Tell the tow pilot where you think the best lift is (or ask him or her), and request to be towed there, if that is agreeable. If no lift is found in the release area, then either return to the areas where lift was encountered during tow (allowing for wind drift), or head for the likely lift areas. The best choices are usually nearby thermaling birds or sailplanes, or small growing cumulus clouds. Remember that your first thermal does not have to be a boomer, but it needs to reliably carry you to at least 2500 ft AGL where one can more comfortably search for the stronger thermals.

When no cumulus clouds are present, or within easy gliding range of the gliderport, then it is usually best to go to the "house thermal" areas where the local lift is often found. Those are usually the nearby higher terrain dry areas that the sun heats the most. Stay away from the cool and damp creek, river and lake areas.

When thermal marking cumulus clouds are present, ask the tow pilot to take you directly to one of the closest growing clouds. Avoid going to an overly mature large cloud, especially for your first thermal, because it is too likely that at its lower altitudes the rising currents will have departed by the time you arrive. By choosing a smaller but growing cumulus it is more likely that the thermal will still be active when you arrive beneath it. Also, should the pilot fail to find lift when arriving beneath the first cumulus cloud, there often are additional small growing clouds in the same vicinity that can be searched with a good probability of success.

Remember that rising thermals drift downwind at the speed of the wind; therefore search the areas slightly upwind of the clouds. How far upwind depends upon your flight altitude, the wind speed, and the strength of the thermal. That usually means that the best lift under cumulus clouds will be found along their upwind edges, but not always. When the wind decreases in velocity or changes direction near the cloud base, best lift is often shifted to other sides of the cloud.

D. Under Cumulus Clouds And Cloud Streets

When flying under cumulus clouds and cloud streets, look for tendrils of cloud vapors that hang down below the otherwise level cloud bases, because those are usually the areas where the updrafts are the strongest. Contrary to popular beliefs, the air in a typical thermal is only warmer than the surrounding air when it is near the surface of the ground. By the time that it reaches an altitude of roughly 1500 ft or so, sufficient additional surrounding air has been entrained into the initially warmer-than-the-surrounding-air thermal, and that cools it to about the same temperature as the surrounding air, and even less (see Reference A).

E. Virtual Temperature

Why then does a thermal continue to rise? According to Reference B, there are two basic reasons. One is that the vertical momentum of the thermal resists its slowing down, and the other is that the thermal usually contains more moisture than the surrounding air. The sun heats the surface features and causes extra surface moisture to be released as a vapor into the thermal when it forms. The addition of water vapor to a thermal not only increases its buoyancy, but it also increases its dew point. That often can lead to the formation of vapor condensation tendrils slightly before the thermal reaches the usual cloud base. When they do form, the tendrils appear to hang down from the bases of cumliform clouds, and that is usually a sign of strong lift. The water vapor molecules are less dense than dry air molecules because they are made up from low density hydrogen-oxygen molecules. These displace some of dry air's higher density nitrogen and oxygen molecules, thus adding buoyancy to the thermal. A neat scientific term used in describing this water vapor effect of adding buoyancy to a thermal is called Virtual Temperature. That is the temperature to which a completely dry air sample would have to be increased to for it to have the same buoyancy as the moist air sample. That can amount to as much as 4 or 5 degrees Fahrenheit, if the moisture is relatively high.

F. Looking For Thermals When Low

We try to not let it happen, but sometimes we find ourselves getting too low for comfort when on a cross country flight, or when too far away from the gliderport to safely return. Unless a thermal can be found within the next few minutes, an off-field landing will have to be made. The options for finding lift are now quite limited and little time is left to implement a search. At such times we are likely flying alone and without the help of other sailplanes, so it is only ourselves that can keep the sailplane airborne. What to do?

First of all and most importantly, keep a suitable landing field within safe range at all times. Secondly, look for soaring birds that might be circling nearby, and for any rising smoke, dust, or dust devils. Any indication of a surface wind convergence give clues as to where a thermal might be forming because they must feed warmed air into any rising current. Tractors plowing dry ground in adjacent fields are often excellent thermal sources, and any convergence of their dust trails often provide reliable thermal location indicators. If all visible clues are lacking, then search slightly downwind of sunny dry ground areas. If an area of smooth zero sink is found, try a few circles in it because it may be a new emerging thermal that will soon get stronger. Attempting to contact thermals under cumulus clouds when low is usually hopeless because the thermal bubble that formed the cloud will likely no longer exist at the lower altitudes by then. If a dust devil is found, circle it in the opposite direction to that which it is rotating because that will minimize the sailplane's turn radius. If too low to safely circle in a dust devil, try to gain altitude by flying straight through it repeatedly.

G. Thermal Search Pattern

When uncomfortably low and needing more lift to sustain flight, it is sometimes helpful to perform some kind of a search pattern; but only if in an area where some thermal activity is evident. If in a likely thermal producing area, and some sign of lift is indicated by the variometer, then it is often beneficial to search that immediate area, instead of continuing along in a straight path. The 270 degree turn thermal search pattern is a good one, and a planform view of that pattern is shown in Figure 1. There, after the pilot encounters some indication of thermal activity, he performs a gentle 20 to 30 degree banked turn at near best L/D airspeed; either to the left or the right. If after performing about 3/4ths of a circle (270 degrees), and not finding the thermal, then the pilot should level his wings and fly straight ahead for about 6 to 8 seconds before initiating

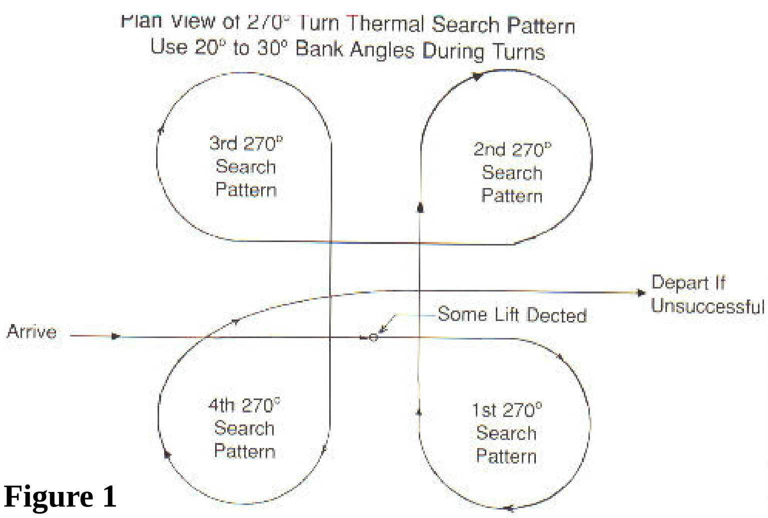

Figure 1

a second 270 degree turn, in the same direction as the first. If still unsuccessful, then a 3rd, and even a 4th search pattern can be performed, if need be. Often that clover leaf search pattern will locate an elusive thermal, or at least an area of zero sink, if any exist in the vicinity. If not, then one has no alternative but to continue on to a hopefully better area.

2. Deciding Which Way To Circle

A. Off Tow

When releasing into a thermal from an airplane tow, we must by safety convention turn to the right. Therefore, unless that thermal is already occupied by other sailplanes circling in the opposite direction, or we are within an active contest site (which require left turns when within a 5 mile radius), then it is usually best to continue circling to the right rather than waste some time and altitude reversing direction.

B. When Alone

When alone and searching for lift, try to keep a light hand on the control stick and attempt to detect if one wing rises more than the other. If it does, then it is likely that the strongest part of the lift is in that direction, and the turn into the rising wing will most likely be the best way to turn. If no wing rise is detected when approaching lift, then you might just as well turn in your favorite direction and hope that you can find the core quickly.

3. Thermaling Etiquette And Safety

A. Difficulty In Seeing Air Traffic

When not in sunlight sailplanes are often difficult to see, especially if slightly below the horizon from the observer. Head on or tail on profiles are particularly difficult to see because the modern sailplanes present very small viewing profiles. Painting the sailplane nose, wing and tail tips with a bright contrasting color is good insurance, and it adds to flight safety. U.S. flight accident statistics indicate that about 85% of the midair collisions occur when one aircraft is overtaking another (Ref. C & D). That indicates that the occupants of only one aircraft have an opportunity to see the other before the collision, and that increases the likelihood of collision enormously. Thus it is very important, especially for a sailplane, to be readily visible to overtaking aircraft. The best thing that we can do, short of adding strobe lights, is to brightly paint sailplanes, where possible, and that will decrease the likelihood of a midair collision to some extent. Because of high temperature effect on structural strength, most composite sailplanes can only be brightly painted at their nose, wing, and tail extremities; but even that helps considerably. The worst case collision scenario is an all white aircraft flying beneath dark clouds, or over snow covered terrain!

When flying in congested airspace, a sailplane pilot can also enhance his visibility by performing turning maneuvers, or at least rocking his wings periodically. Also, when crossing a busy airway, do so at 90 degrees so that you can see any converging air traffic, and stay at least 500 ft below any clouds.

B. Approaching An Occupied Thermal

When approaching a gaggle of sailplanes in a thermal, or even an apparently unoccupied area, continue to keep a sharp lookout because air traffic is often difficult to see, especially those flying below your horizon. Therefore, extra care must be taken to visually search those below-the-horizon areas well. Try to judge your entry into an occupied thermal such that your entry point will be opposite that of any sailplanes within about 200 feet of your altitude. That can usually be accomplished by either slowing one’s airspeed if arriving too soon, or speeding up if arriving too late for the desired opposite-to-the-traffic entry. If arriving at a high airspeed, allow extra altitude for safe clearance from the traffic circling above because of the significant altitude gain achieved when slowing to thermaling airspeed.

When established in a shared thermal, try to avoid following the sailplane ahead of you in his blind spot, which is principally his 4:30 to 7:30 clock relative positions. That is sometimes not possible in a crowded thermal, but the added danger of not doing so must be recognized, and avoided when possible. When it is not possible to avoid following a sailplane in his blind spot, assuring him by radio that you are watching him constantly and will maintain safe clearance is good etiquette, and that is always appreciated. When departing an occupied thermal, care must be taken that one does not speed up too soon or too abruptly; such as to be a hazard to the sailplanes flying below; and in your blind spot!

4. Thermaling Techniques

A. General Considerations

When rising air has been contacted, the next step is to find where the lift is strongest, then somehow center the sailplane as best you can within the strongest part of the rising air current. Most thermals are essentially circular in cross-section, although sometimes twin core and other odd shapes are encountered. It is best to assume that the thermal that you want to center within is circular in cross-section and strongest at its center. Also, assume that its entire diameter is limited to about 600 feet; less than that when low (1000 ft) and somewhat more than that if high (3000 ft+). That means that one must not just fly straight ahead after encountering lift because after about 7 seconds it is likely that one will have exited its far side, even if lucky enough to be on a course through its center. Therefore it will be necessary for the sailplane to circle to stay within the thermal.

If the thermal is already occupied by a circling sailplane, then it is necessary for safety's sake to circle in the same direction. If the thermal is occupied by a circling soaring bird, turn toward his direction because he almost always knows where the best lift is. Birds do not seem to mind if we circle in an opposite direction to them! If otherwise clueless, try to detect if one wing of your sailplane rises more than the other, and that will usually indicate on which side of the sailplane's course the best lift is located. Whichever way the turn, one needs to start circling within about 3 or 4 seconds after first encountering a thermal.

B. 270 Degree Method For Centering Thermals

There are several methods for centering a thermal, but I think that the 270 degree method is one of the best and simplest. After first encountering lift, the pilot performs a moderate 30 to 40 degree banked turn while maintaining near constant airspeed, and notes approximately on which heading the strongest lift was encountered during the initial 270 degree turn (see Fig. 2). When determining the approximate heading at which the strongest lift was encountered, care needs to be taken to allow for the 1 to 2 seconds of variometer instrument lag, which is characteristic of most modern variometers. If it is clear as to where the best lift is located, then stop turning for about 2 to 4 seconds when on a heading that is about 270 degrees past the heading where the best lift was encountered. That should take the sailplane about 100 to 200 feet farther in the direction of the strongest portion of the thermal. Now resume the 30 to 40 degree banked turn in the same direction as before, and repeat the 270 degree centering procedure. By using gradually smaller turn stop periods, or by just reducing the bank angle, one can quickly center into the strongest part of the thermal. After the first exploratory centering move, one usually needs only to decrease and increase bank angle to move the center of the turn gradually toward the strongest part of the thermal; still using the 270 degree centering principal.

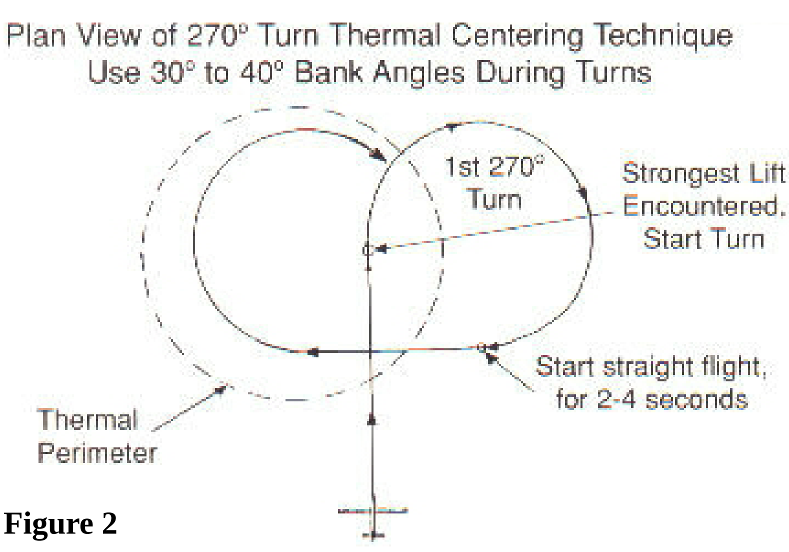

Figure 2

A similar technique is to tighten one's turn when in the best lift, and to reduce the bank when on a heading to bring the sailplane deeper into the strongest part of the thermal. With either technique do not try to observe your sailplane's compass indications, but keep your views outside the cockpit and use the ground or a cloud for directional reference.

C. Optimum Bank Angles

When searching for a thermal it is usually best to either fly straight ahead, or to use gentle turns, banking less than 30 degrees, to extend the search area and at the same time minimizing the sailplane's sink rate. After the thermal has been located and centered, then the optimum sailplane bank angle is that which will maximize its climb rate. Usually the optimum thermaling bank angle will be between 30 and 40 degrees, but that depends upon both the sailplane's wing loading and the thermal diameter. Obviously it is necessary to keep the circle within the thermal perimeter. However, the thermals are almost always strongest at their centers, and it is not obvious as to which bank angle will produce the highest rate of climb because the sailplane's sink rate increases rapidly when circling at high bank angles. Technical papers have been written on that subject, but in the real world where each thermal is different, the bank angle evaluation usually need to be based upon trials. If alone, then the variometer indications need to be maximized by trying various bank angles. If flying with other sailplanes, then it quickly becomes obvious as to which sailplane is achieving the best climb rate, and his bank angle and turn diameter will provide a reliable guide for others. Remember that a higher wing loading will usually require a higher bank angle to optimize climb performance than will a lightly loaded sailplane; because the lighter wing loading will provide lower thermaling airspeeds and a smaller turn radius at a given bank angle.

D. Using Audio Variometers - A Must!

For safety reasons, every sailplane should be equipped with an audio variometer! That allows a pilot to not have to watch his instrument panel while thermaling, and to spend 100% of his time looking outside the cockpit, as he should. As a minimum the audio should make a cheerful sound in proportion to the sailplane's climb rate. In addition, it should be capable of presenting a complete audio picture to the pilot by making a distinctly different unhappy sound in proportion to the sailplane's sink rate.

Also for safety reasons, every sailplane should be equipped with a canopy mounted yaw string! It should not be necessary for a pilot to look at any of his instruments while thermaling, and except for an occasional glance at the yaw string, his eyes should be focused outside the sailplane cockpit. Generally, airspeed can be controlled more effectively while thermaling by noting flight attitude, airflow sounds, and control system feel than it can by watching an airspeed indicator . One of the most effective ways to learn this "eyes out of the cockpit" thermaling technique is to tape a paper or cloth cover over the instrument panel and practice. Do this "no instruments" practicing only when flying at a safe altitude. If with an instructor aboard, this technique can be practiced at any altitude, but uncover before entering a landing pattern in any case because accurate airspeed knowledge is extremely important there. One should also be able to judge altitude by the appearance of known surface object sizes, and through their movements relative to the sailplane.

Before and during turns, always check the horizon frequently, especially in the direction of the turn to make sure that no collision hazards are threatening your safety. It does little good to watch the ground below because unless someone down there is shooting at you, your most severe threats will be in the form of other aircraft flying at close to your altitude.

E. Before Landing

When finished soaring and before entering a landing pattern, remember to turn off your audio variometer. Its sounds are no longer needed and that eliminates a significant distraction at the time that needs all your concentration. Happy and safe soaring!

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