Chapter 10

Soaring Techniques

Introduction

Soaring flight, maintaining or gaining altitude rather than slowly gliding downward, is the reason most glider pilots take to the sky. After learning to stay aloft for two or more hours at a time, the urge to set off cross-country often overcomes the soaring pilot. The goal is the same whether on a cross-country or a local flight—to use available updrafts as efficiently as possible. This involves finding and staying within the strongest part of the updraft. This chapter covers the basic soaring techniques.

In the early 1920s, soaring pilots discovered the ability to remain aloft using updrafts caused by wind deflected by the very hillside from which they had launched. This allowed time aloft to explore the air. Soon afterward, they discovered thermals in the valleys adjacent to the hills. In the 1930s, mountain waves, which were not yet well understood by meteorologists, were discovered, leading pilots to make the first high altitude flights. Thermals are the most commonly used type of lift for soaring flight, since they can occur over flat terrain and in hilly country.

There are two favored theories of thermal characteristics. One is that thermals are continuous updrafts like a plume of smoke from a campfire rising up and sometimes twisting depending on the wind currents. This theory requires the glider pilot to locate the rising thermal current and estimate the amount of slant caused by the winds shifting the rising updraft downwind from the heat source. Just like a campfire, the winds may tend to twist and oscillate around the hotter origin.

The other theory is that thermals can be more like a hot water bubble rising in a pan on a stove. If you can stay in the bubble, you can climb. If you spill out of the bubble, there is no lift even just under where you were climbing because the lift is not a continuous vertical stream. The glider pilot must search for the next rising bubble to obtain lift.

In the practical world, the nature of thermals is probably a blend of these theories. The sun produces heat, and often that heating is unequal on the surface of the earth, so winds occur as natural forces that work to equalize the atmosphere. Some of these winds are vertical currents. We call them updrafts and downdrafts. Updrafts provide lift and downdrafts provide sink. Since the atmosphere always seeks equality, if there is an updraft, there must be a downdraft or drafts close to replace the upward flowing air. The goal of soaring pilots is to maximize time in lifting currents and minimize their time in sinking currents.

The contemporary models and experience seem to support the theory of a central updraft surrounded by compensating downdrafts. The skill involves staying in the lift as long as possible and exiting or passing through the sink as quickly as possible.

As a note, glider pilots refer to rising air as lift. This is not the lift generated by the wings as discussed in Chapter 3, Aerodynamics of Flight. The use of this term may confuse new pilots, but when used in the context of updrafts, the energy in a rising column of air is translated as lift. This chapter refers to lift as the rising air within an updraft and sink as the descending air in downdrafts.

Thermal Soaring

Locating Thermals

When locating and utilizing thermals for soaring flight, called thermaling, glider pilots must constantly be aware of any nearby lift indicators. Successful thermaling requires several steps: locating the thermal, entering the thermal, centering the thermal, and, finally, leaving the thermal. Keep in mind that every thermal is unique in terms of size, shape, and strength.

Cumulus Clouds

According to the last chapter, if the air is moist enough and thermals rise high enough, cumulus clouds, or Cu (pronounced like the word "cue") form. Glider pilots seek Cu in the developing stage, while the cloud is still being built by a thermal underneath it. The base of the Cu should be sharp and well defined. Clouds that have a fuzzy appearance are likely to be well past their prime and probably have little lift left or even sink as the cloud dissipates. *[Figure 10-1]*

Judging which clouds have the best chance for a good thermal takes practice. On any given day, the lifetime of an individual Cu can differ from previous days, so it becomes important to observe Cu lifecycle on a particular day. A good looking Cu may already be dissipating by the time it is reached. Soaring pilots refer to such Cu as rapid or quick cycling, which means the Cu forms, matures, and dissipates in a short time. The lifetime of Cu often varies during a given day as well; quick cycling Cu early in the day often become well formed and longer lived as the day develops.

Sometimes Cu cover enough of the sky that seeing the cloud tops becomes difficult. Hence, glider pilots should learn to read the bases of Cu. Generally, a dark area under the

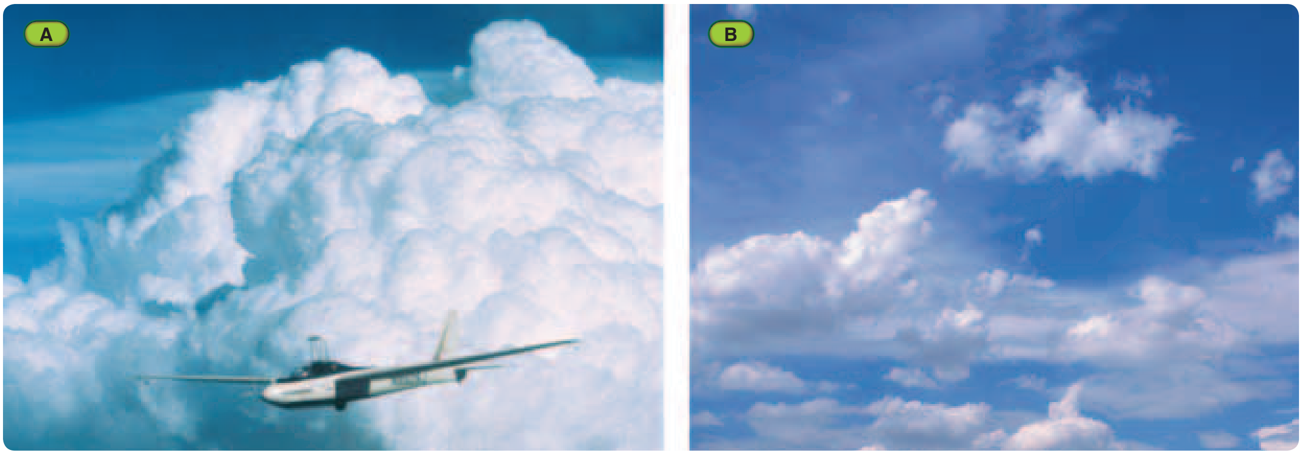

Figure 10-1. *Photographs of (A) mature cumulus probably producing good lift, and (B) dissipating cumulus.*

cloud base indicates a deeper cloud and, therefore, a higher likelihood of a thermal underneath. Also, several thermals can feed one cloud, and it is often well worth the deviation to those darker areas under the cloud. At times, an otherwise flat cloud base under an individual Cu has wisps or tendrils of cloud hanging down from it, producing a particularly active area. Cloud hanging below the general base of a Cu indicates that the air is more moist, and hence more buoyant. Note the importance of distinguishing features under Cu that indicate potential lift from virga. Virga is precipitation in the form of rain, snow, or ice crystals, descending from the cloud base that is evaporating before it strikes the ground. Virga often signals that the friendly Cu has grown to cumulus congestus or thunderstorms. *[Figure 10-2]*

Another indicator that one area of Cu may provide better lift is a concave region under an otherwise flat cloud base. This indicates air that is especially warm, and hence more buoyant, which means stronger lift. This can cause problems for the unwary pilot, since the lift near cloud base often dramatically increases, for instance from 400 to 1,000 feet per minute (fpm). When trying to leave the strong lift in the concave area under the cloud, pilots can find themselves climbing rapidly with cloud all around—another good reason to abide by required cloud clearances. See Title 14 of the Code of Federal Regulations (14 CFR) part 91, section 91.155, Basic VFR Weather Minimums.

After a thermal rises from the surface and reaches the convective condensation level (CCL), a cloud begins to form. At first, only a few wisps form. Then, the cloud grows to a cauliflower shape. The initial wisps of Cu in an otherwise blue (cloudless) sky indicate where an active thermal is beginning to build a cloud. When crossing a blue hole (a region anywhere from a few miles to several dozen miles of cloud-free sky in an otherwise Cu-filled sky), diverting to an initial wisp of Cu is often worthwhile. On some days, when only a few thermals are reaching the CCL, the initial wisps may be the only cloud markers around. The trick is to get to the wisp when it first forms, to catch the thermal underneath.

Lack of Cu does not necessarily mean lack of thermals. If the air aloft is cool enough and the surface temperature warms sufficiently, thermals form whether or not enough moisture exists for cumulus formation. These dry, or blue thermals as they are called, can be just as strong as their Cu-topped counterparts. Glider pilots can find blue thermals, without Cu markers, by gliding along until stumbling upon a thermal. With any luck, other blue thermal indicators exist, making the search less random.

Other Indicators of Thermals

One indicator of a thermal is another circling glider. Often the glint of the sun on wings is all that can be seen, so finding other gliders thermaling requires keeping a good lookout, which glider pilots should be doing anyway. Circling birds are also good indicators of thermal activity. Thermals tend to transport various aerosols, such as dust, upward with them. When a thermal rises to an inversion, it disturbs the stable air above it and spreads out horizontally, thus depositing some of the aerosols at that level. Depending on the sun angle and the pilot's sunglasses, haze domes can indicate dry thermals. If the air contains enough moisture, haze domes often form just before the first wisp of Cu.

On blue, cloudless days, gliders and other airborne indicators are not around to mark thermals. In such cases, pay attention to clues on the ground. First, think about previous flight experiences. It is worth noting where thermals have been found previously since certain areas tend to be consistent thermal sources. Remember that weather is fickle, so there is never a guarantee that a thermal currently exists where one existed before. In addition, if a thermal has recently formed, it takes time for the sun to reheat the area before the next thermal is triggered. Glider pilots new to a soaring location should ask the local pilots about favored spots—doing so might save the cost of a tow. Glider pilots talk about house thermals, which are simply thermals that seem to form over and over in the same spot or in the same area.

Stay alert for other indicators, as well. In drier climates, dust devils mark thermals triggering from the ground. In hilly or

Figure 10-2. *Photographs of (A) cumulus congestus, (B) cumulonimbus (Cb), and (C) virga.*

mountainous terrain, look for sun-facing slopes. Unless the sun is directly overhead, the heating of a sun-facing slope is more intense than that over adjacent flat terrain because the sun's radiation strikes the slope at more nearly right angles. *[Figure 10-3]* Also, cooler air usually pools in low-lying areas overnight; taking longer to warm during the morning. Darker ground or surface features heat quicker than grass covered fields. Huge black asphalt parking lots can produce strong thermals. A large tilled black soil field can be a good source of lift if the pilot can find the sometimes very narrow plume of rising air. Finally, slopes often tend to be drier than surrounding lowlands, and tend to heat better. Given the choice, it usually pays to look first to the hills for thermals.

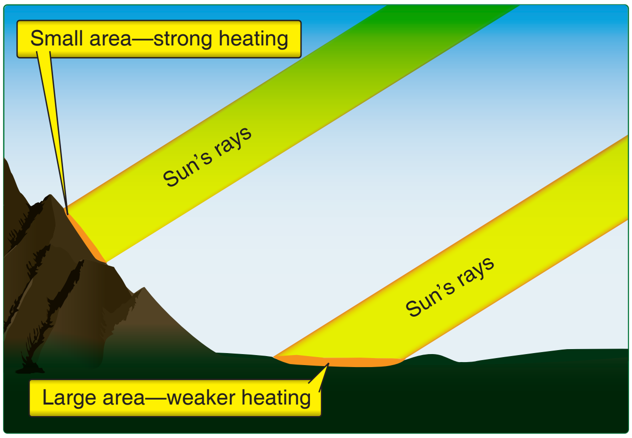

Figure 10-3. *Sun's rays are concentrated in a smaller area on a hillside than on adjacent flat ground.*

Whether soaring over flat or hilly terrain, some experts suggest taking a mental stroll through the landscape to look for thermals. Imagine strolling along the ground where warmer areas would be found. For instance, walk from shade into an open field where the air suddenly warms. A town surrounded by green fields is likely to heat more than the surrounding farmland. Likewise, a yellowish harvested field feels warmer than an adjacent wet field with lush green vegetation. Wet areas tend to use the sun's radiation to evaporate the moisture rather than heat the ground. Thus, a field with a rocky outcrop might produce better thermals. Rocky outcrops along a snowy slope heat much more efficiently than surrounding snowfields. Although this technique works better when at lower altitudes, it can also be of use at higher altitudes in the sense of avoiding cool-looking areas, such as a valley with many lakes.

Wind

Wind has important influences not only on thermal structure, but on thermal location as well. Strong winds at the surface and aloft often break up thermals, making them turbulent and difficult or impossible to work at all. Strong shear can break thermals apart and effectively cap their height even though the local sounding indicates that thermals should extend to higher levels. On the other hand, as discussed in Chapter 9, Soaring Weather, moderately strong winds without too much wind shear sometimes organize thermals into long streets, a joyous sight when they lie along a cross-country course line. *[Figure 10-4]*

Figure 10-4. *Photograph of cloud streets.*

In lighter wind conditions, consideration of thermal drift is still important, and search patterns should become "slanted." For instance, in Cu-filled skies, glider pilots need to search upwind of the cloud to find a thermal. How far upwind depends on the strength of the wind, typical thermal strength on that day, and distance below cloud base (the lower the glider, the further upwind the gliders needs to be). The task can be challenging when you add to this the fact that windspeed does not always increase at a constant rate with height, and/or the possibility that wind direction also can change dramatically with height.

Wind direction and speed at cloud base can be estimated by watching the cloud shadows on the ground. The numerous variables sometimes make it difficult to estimate exactly where a thermal should be. Pay attention to where thermals appear to be located in relation to clouds on a given day, and use this as the search criterion for other clouds on that day. If approaching Cu from the downwind side, expect heavy sink near the cloud. Head for the darkest, best defined part of the cloud base, then continue directly into the wind. Depending on the distance below cloud base, just about the time of passing upwind of the cloud, fly directly into the lift forming the cloud. If approaching the cloud from a crosswind direction (for instance, heading north with westerly winds), try to estimate the thermal location from others encountered that day. If only reduced sink is found, there may be lift nearby, a short leg upwind or downwind may locate the thermal.

Thermals drift with the wind on blue days as well, and similar techniques are required to locate thermals using airborne or ground-based markers. For instance, if heading toward a circling glider but at a thousand feet lower, estimate how much the thermal is tilted in the wind and head for the most likely spot upwind of the circling glider. *[Figure 10-5]* When in need of a thermal, pilots might consider searching on a line upwind or downwind once abeam the circling glider. This may or may not work; if the thermal is a bubble rather than a column, the pilot may be below the bubble. It is easy to waste height while searching in sink near one spot, rather than leaving and searching for a new thermal. Remember that a house thermal will probably be downwind of its typical spot on a windy day. Only practice and experience enable glider pilots to consistently find good thermals.

Cool, stable air can also drift with the wind. Avoid areas downwind of known stable air, such as large lakes or large irrigated regions. On a day with Cu, stable areas can be indicated by a big blue hole in an otherwise Cu-filled sky. If the area is broad enough, a detour upwind of the stabilizing feature might be in order. *[Figure 10-6]*

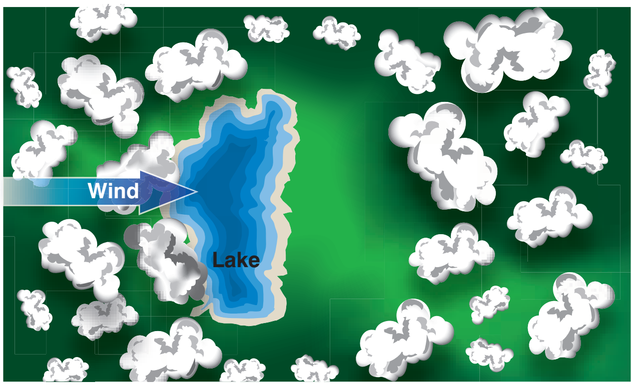

Figure 10-6. *Blue hole in a field of cumulus downwind of a lake.*

The Big Picture

When the sky is full of Cu, occasional gliders are marking thermals, and dust devils move across the landscape, the sky becomes glider pilot heaven. If gliding in the upper part of the height band, it is best to focus on the Cu, and make choices based on the best clouds. Sometimes lower altitudes cause glider pilots to go out of synch with the cloud. In that circumstance, use the Cu to find areas that appear generally active, but then start focusing more on ground-based indicators, like dust devils, a hillside with sunshine on it, or a circling bird. When down low, accept weaker climbs. Often the thermal cycles again, and hard work is rewarded.

When searching for lift, use the best speed to fly, that is, best L/D speed plus corrections for sink and any wind. This technique allows glider pilots to cover the most ground with the available altitude. See Chapter 3, Aerodynamics of Flight, to review shifting of the polar for winds and sink.

Entering a Thermal

Once a thermal has been located, enter it so you do not lose it right away. The first indicator of a nearby thermal is often, oddly enough, increased sink. Next, a positive G-force is felt, which may be subtle or obvious, depending on the thermal strength. The "seat-of-the-pants" indication of lift is the quickest, and is far faster than any variometer, which has a small lag. Speed should have been increased in the sink adjacent to the thermal; as the positive G-force increases, reduce speed to between L/D and minimum sink. Note the trend of the variometer needle (should be an upswing) or the

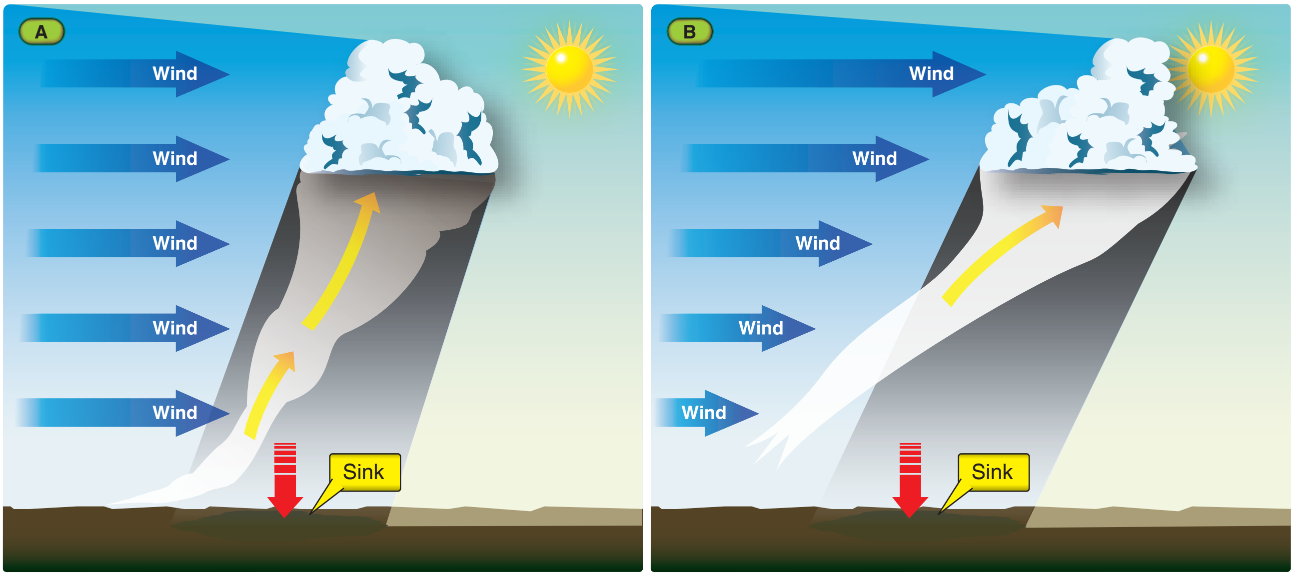

Figure 10-5. *Thermal tilt in shear that (A) does not change with height, and that (B) increases with height.*

audio variometer going from the drone to excited beeping. At the right time in the anticipated lift, begin the turn. If everything has gone perfectly, the glider will roll into a coordinated turn, at just the right bank angle, at just the right speed, and be centered perfectly. In reality, it rarely works that well.

Before going further, what vital step was left out of the above scenario? CLEAR BEFORE TURNING! The variometer is hypnotic upon entering lift, especially at somewhat low altitudes. This is exactly where pilots forget that basic primary step before any turn—looking around first. An audio variometer helps avoid this.

To help decide which way to turn, determine which wing tends to be lifted. For instance, when entering the thermal and the glider is gently banking to the right, CLEAR LEFT, then turn left. A glider on its own tends to fly away from thermals. *[Figure 10-7]* As the glider flies into the first thermal, but slightly off center, the stronger lift in the center of the thermal banks the glider right, away from the thermal. It then encounters the next thermal with the right wing toward the center and is banked away from lift to the left, and so on. Avoid letting thermals bank the glider even slightly. Sometimes the thermal-induced bank is subtle, so be light on the controls and sensitive to the air activity. At other times, there is no indication on one wing or another. In this case, take a guess, CLEAR, then turn. As a note, new soaring pilots often get in the habit of turning in a favorite direction, to the extreme of not being able to fly reasonable circles in the other direction. If this happens, make an effort to thermal in the other direction half the time—being proficient in either direction is important, especially when thermaling with traffic.

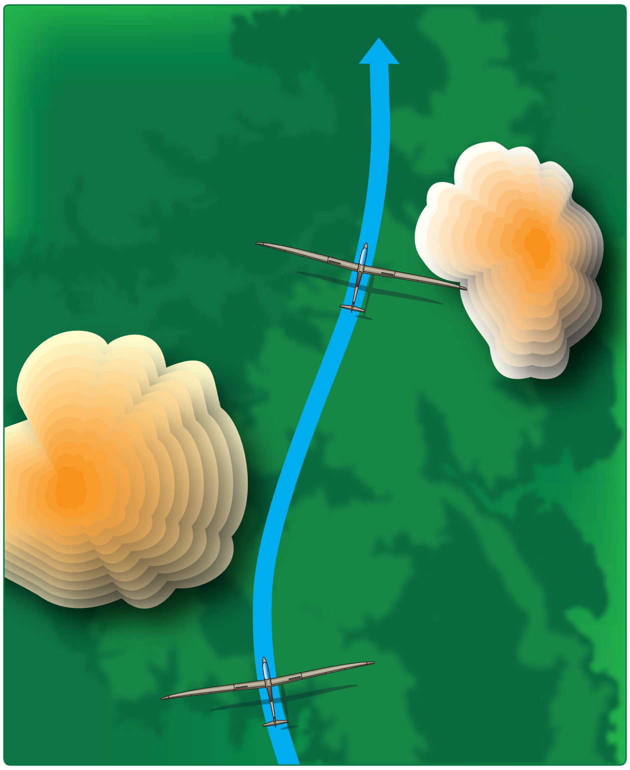

Figure 10-7. *Effect of glider being allowed to bank on its own when encountering thermals.*

As a glider encounters lift on one side, some gliders tend to slip laterally as indicated by the yaw string. The glider pilot must bring the climbing wing down, not just to level the wings but further to begin the turn into the lifting columns of air. In these instances, the soaring pilot should turn towards the tip of the yaw string to seek the lift.

Inside a Thermal

Bank Angle

Optimum climb is achieved when proper bank angle and speed are used after entering a thermal. The shallowest possible bank angle at minimum sink speed is ideal. Thermal size and associated turbulence usually do not allow this. Large-size, smooth, and well-behaved thermals can be the exception in some parts of the country. Consider first the bank angle. The glider's sink rate increases as the bank angle increases. However, the sink rate begins to increase more rapidly beyond about a 45° bank angle. Thus, a 40° compared to a 30° bank angle may increase the sink rate less than the gain achieved from circling in the stronger lift near the center of the thermal. As with everything else, this takes practice, and the exact bank angle used depends on the typical thermal, or even a specific thermal, on a given day. Normally, bank angles in excess of 50° are not needed, but exceptions always exist. It may be necessary, for instance, to use banks of 60° or so to stay in the best lift. Thermals tend to be smaller at lower levels and expand in size as they rise higher. Therefore, a steeper bank angle is required at lower altitudes, and shallower bank angles can often be used while climbing higher. Remain flexible with techniques throughout the flight.

Speed

If turbulence is light and the thermal is well formed, use the minimum sink speed for the given bank angle. This should optimize the climb because the glider's sink rate is at its lowest, and the turn radius is smaller. As an example, for a 30° bank angle, letting the speed increase from 45 to 50 knots increases the diameter of the circle by about 100 feet. In some instances, this can make the difference between climbing or not. Some gliders can be safely flown several knots below minimum sink speed. Even though the turn radius is smaller, the increased sink rate may offset any gain achieved by being closer to strong lift near the thermal center.

There are two other reasons to avoid thermaling speeds that are too slow: the risk of a stall and lack of controllability.

Distractions while thermaling can increase the risk of an inadvertent stall and include, but are not limited to: studying the cloud above or the ground below (for wind drift), quickly changing bank angles without remaining coordinated while centering, thermal turbulence, or other gliders in the thermal. Stall recovery should be second nature, so that if the signs of an imminent stall appear while thermaling, recovery is instinctive. Depending on the stall characteristics of the particular glider or in turbulent thermals, a spin entry is always possible. Glider pilots should carefully monitor speed and nose attitude at lower altitudes. Regardless of altitude, when in a thermal with other gliders below, maintain increased awareness of speed control and avoid any stall/spin scenario. Controllability is a second, though related, reason for using a thermaling speed greater than minimum sink. The bank angle may justify a low speed, but turbulence in the thermal may make it difficult or impossible to maintain the desired quick responsiveness, especially in aileron control, in order to properly remain in the best lift. Using sufficient speed ensures that the pilot, and not the thermal turbulence, is controlling the glider.

Soaring pilots' opinions differ regarding how long to wait after encountering lift and before rolling into the thermal. Some pilots advocate flying straight until the lift has peaked. Then, they start turning, hopefully back into stronger lift. It is imperative not to wait too long after the first indication that the thermal is decreasing for this maneuver. Other pilots favor rolling into the thermal before lift peaks, thus avoiding the possibility of losing the thermal by waiting too long. Turning into the lift too quickly causes the glider to fly back out into sink. There is no one right way; the choice depends on personal preference and the conditions on a given day. Timing is everything, and practice is key to developing good timing.

Centering

Usually upon entering a thermal, the glider is in lift for part of the circle and sink for the other part. It is rare to roll into a thermal and immediately be perfectly centered. The goal of centering the thermal is to determine where the best lift is and move the glider into it for the most consistent climb. One centering technique is known as the 270° correction. *[Figure 10-8]* In this case, the pilot rolls into a thermal and almost immediately encounters sink, an indication of turning the wrong way. Complete a 270° turn, straighten out for a few seconds, and if lift is encountered again, turn back into it in the same direction. Avoid reversing the direction of turn. The distance flown while reversing turns is more than seems possible and can lead away from the lift completely. *[Figure 10-9]*

Often, stronger lift exists on one side of the thermal than on the other, or perhaps the thermal is small enough that lift exists on one side and sink on the other, thereby preventing

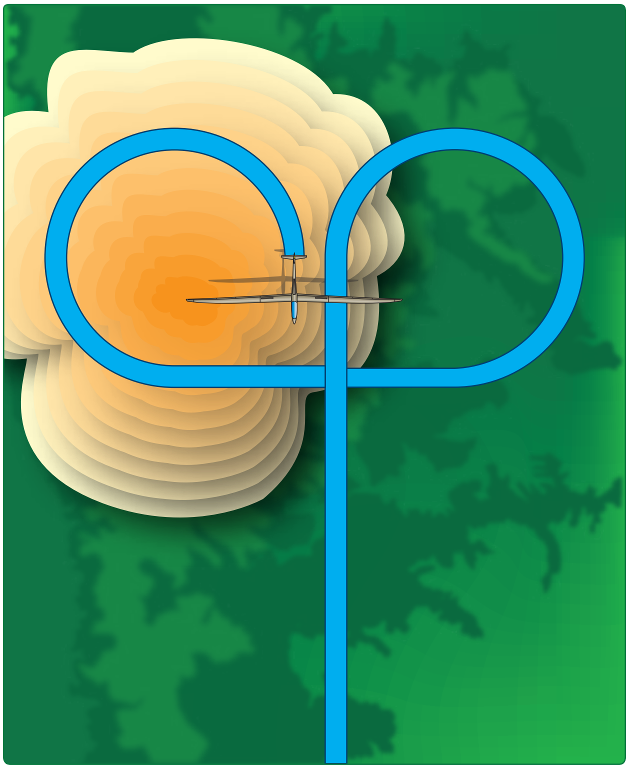

Figure 10-8. *The 270° centering correction.*

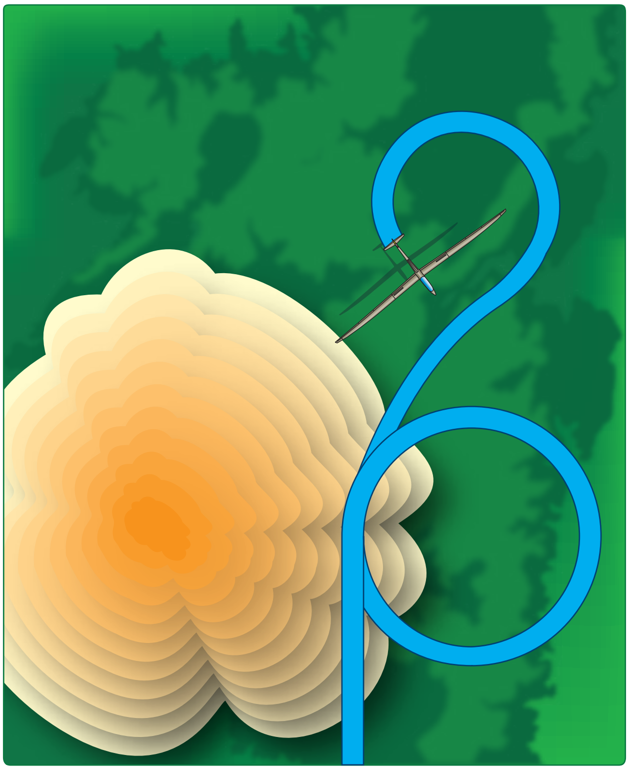

Figure 10-9. *Possible loss of thermal while trying to reverse directions of circle.*

a climb. There are several techniques and variations to centering. One method involves paying close attention to where the thermal is strongest; for instance, toward the northeast or toward some feature on the ground. To help judge this, note what is under the high wing when in the best lift. On the next turn, adjust the circle by either straightening or shallowing the turn toward the stronger lift. Anticipate things and begin rolling out about 30° before actually heading toward the strongest part. This allows rolling back toward the strongest part of the thermal rather than flying through the strongest lift and again turning away from the thermal center. Gusts within the thermal can cause airspeed indicator variations; therefore, avoid "chasing the airspeed indicator." Paying attention to the nose attitude helps pilots keep their focus outside the cockpit. How long a glider remains shallow or straight depends on the size of the thermal. *[Figure 10-10]* Other variations include the following: *[Figure 10-11]*

1. Shallow the turn slightly (consider 5° or 10°) when encountering the weaker lift, then as stronger lift is encountered again (feel the positive G, variometer swings up, audio variometer starts to beep) resume the original bank angle. If shallowing the turn too much, it is possible to fly completely away from the lift.
2. Straighten or shallow the turn for a few seconds 60° after encountering the weakest lifts or worst sink indicated by the variometer. This allows for the lag in the variometer since the actual worst sink occurred a couple of seconds earlier than indicated. Resume the original bank angle.

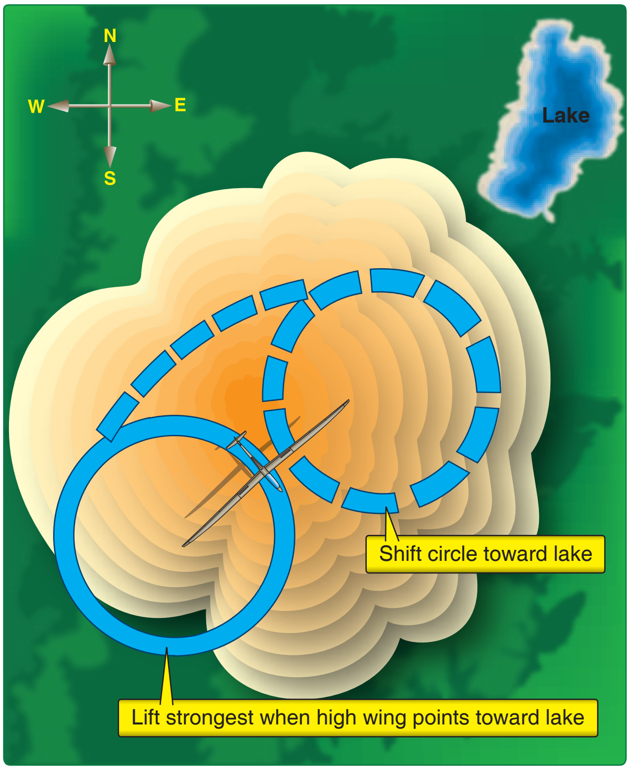

Figure 10-10. *Centering by shifting the circle turn toward stronger lift.*

3. Straighten or shallow the turn for a few seconds when the stronger seat-of-the-pants surge is felt. Then, resume the original bank. Verify with the variometer trend (needle or audio).

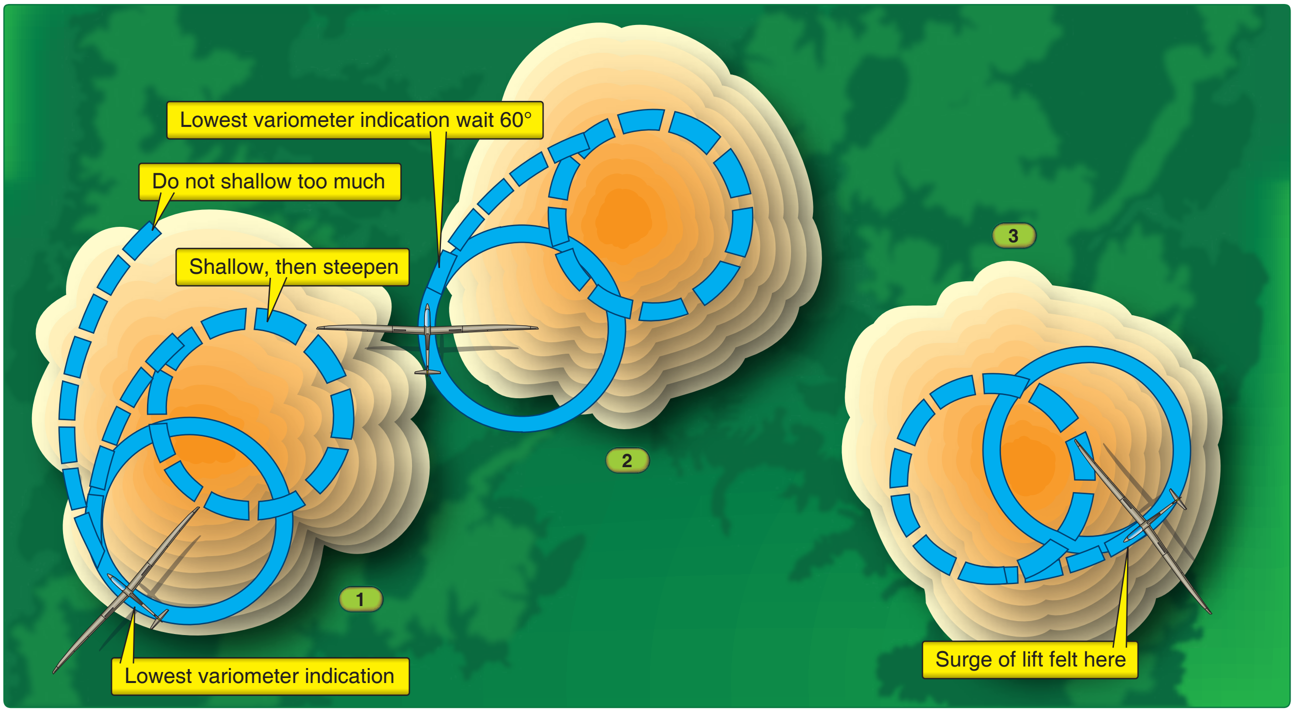

Figure 10-11. *Other centering corrections.*

For the new glider pilots, it is best to become proficient using one of the above methods first, and then experiment with other methods. As an additional note, thermals often deviate markedly from the conceptual model of concentric gradients of lift increasing evenly toward the center. For instance, it sometimes feels as if two (or more) nearby thermal centers exist, making centering difficult. Glider pilots must be willing to constantly adjust, and recenter the thermal to maintain the best climb.

In addition to helping pilots locate lift, other gliders can help pilots center a thermal as well. If a nearby glider seems to be climbing better, adjust the turn to fly within the same circle. Similarly, if a bird is soaring close by, it is usually worth turning toward the soaring bird. Along with the thrill of soaring with a hawk or eagle, it usually leads to a better climb.

Collision Avoidance

Collision avoidance is of primary importance when thermaling with other gliders. The first rule calls for all gliders in a particular thermal to circle in the same direction. The first glider in a thermal establishes the direction of turn and all other gliders joining the thermal should turn in the same direction. Ideally, two gliders in a thermal at the same height or nearly so should position themselves across from each other so they can maintain best visual contact. *[Figure 10-12]* When entering a thermal, strive to do so in a way that does not interfere with gliders already in the thermal, and above all, in a manner that does not cause a hazard to other gliders. An example of a dangerous entry is pulling up to bleed off excess speed in the middle of a crowded thermal. A far safer technique is to bleed off speed before reaching the thermal and joining the thermal at a "normal" thermaling speed. Collision avoidance, not optimum aerodynamic efficiency, is the priority when thermaling with other gliders. Announcing to the other glider(s) on the radio that you are entering the thermal enhances collision avoidance. *[Figure 10-12]*

Different types of gliders in the same thermal may have different minimum sink speeds, and it may be difficult to remain directly across from another glider in a thermal. Avoid a situation where the other glider cannot be seen or the other glider cannot see you. Radio communication is helpful. Too much talking clogs the frequency, and may make it impossible for a pilot to broadcast an important message. Do not fly directly above or below another glider in a thermal since differences in performance, or even minor changes in speed can lead to larger than expected altitude changes. If sight of another glider is lost in a thermal and position cannot be established via a radio call, leave the thermal. After 10 or 20 seconds, come back around to rejoin the thermal, hopefully with better traffic positioning. It cannot be stressed enough that collision avoidance when thermaling is a priority! Mid-air collisions can sometimes be survived, but only with a great deal of luck. Unsafe thermaling practices endanger everyone. *[Figure 10-13]*

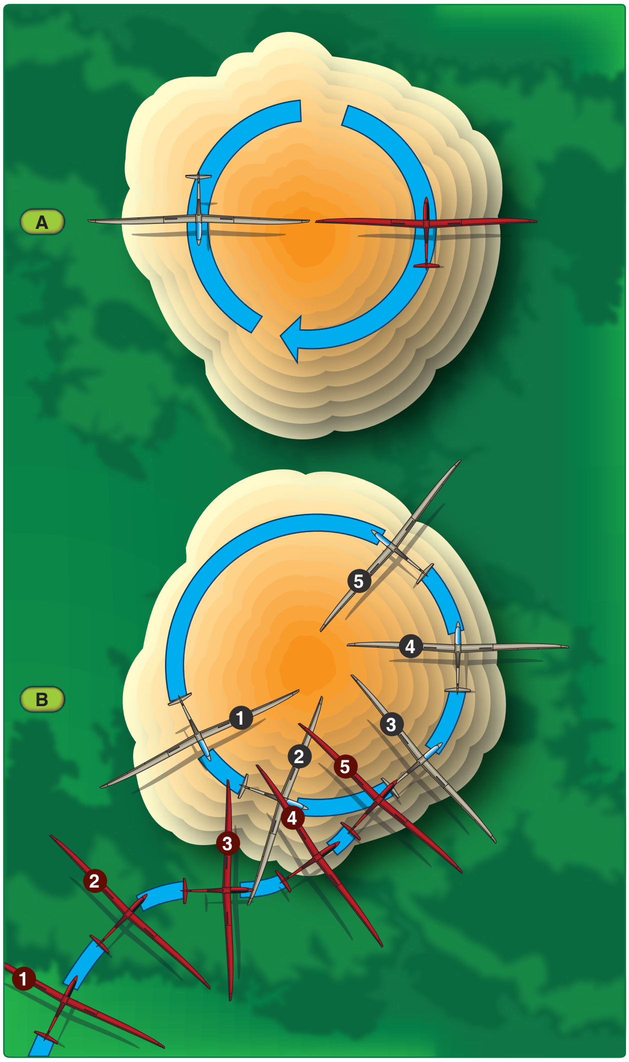

Figure 10-12. *Proper positioning with two gliders at the same altitude. Numbers represent each glider's position at that time.*

Exiting a Thermal

Leaving a thermal properly can also save some altitude. While circling, scan the full 360° of sky with each thermaling turn. This first allows the pilot to continually check for other traffic in the vicinity. Second, it helps the pilot analyze the sky in all directions to decide where to go for the next climb. It is better to decide where to go next while still in lift rather than losing altitude in sink after leaving a thermal. Exactly when to leave depends on the goals for the climb—whether the desire is to maximize altitude for a long glide or leave when lift weakens in order to maximize time on a cross-country flight. In either case, be ready to increase speed to penetrate the sink often found on the edge of the thermal, and leave the thermal in a manner that does not hinder or endanger other gliders.

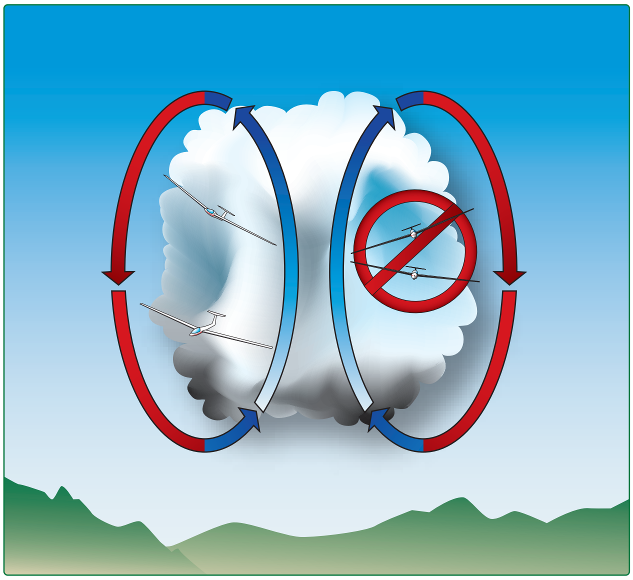

Figure 10-13. *When thermaling, avoid flying in another glider's blind spot, or directly above or below another glider.*

Atypical Thermals

Exceptions to normal or typical thermals are numerous. For instance, instead of stronger sink at the edge of a thermal, weak lift sometimes continues for a distance after leaving a thermal. Glider pilots should be quick to adapt to whatever the air has to offer at the time. The mechanics of simply flying the glider become second nature with practice, as do thermaling techniques. Expect to land early because anticipated lift was not there on occasion—it is part of the learning curve.

If thermal waves are suspected, climb in the thermal near cloud base, then head toward the upwind side of the Cu. Often, only very weak lift, barely enough to climb at all, is found in smooth air upwind of the cloud. Once above cloud base and upwind of the Cu, climb rates of a few hundred fpm can be found. Climbs can be made by flying back and forth upwind of an individual Cu, or by flying along cloud streets if they exist. If no clouds are present, but waves are suspected, climb to the top of the thermal and penetrate upwind in search of smooth, weak lift. Without visual clues, thermal waves are more difficult to work. Thermal waves are most often stumbled upon as a pleasant surprise.

Ridge/Slope Soaring

Efficient slope soaring (also called ridge soaring or ridge running) is fairly easy; simply fly in the updraft along the upwind side of the ridge. Although the appearance may seem simple, it is very complicated and can be very hazardous for the untrained glider pilot. Ridge soaring can also be very demanding on the glider and the pilot. Even though it is easy to fly, there are many situations in which a glider pilot can be exposed to hazards if proper training has not been received. A thorough preflight and route planning needs to be accomplished. This planning also includes ridge selection based on the current winds. The horizontal distance from the ridge varies with height above the ridge, since the best lift zone, or optimum lift zones (OLZ) tilts upwind with height above the ridge. These zones, or OLZ, vary but usually are slightly off the top of the ridge, with a slight angle into the prevailing wind. The bottom of the OLZ may be slightly down from the top line under normal conditions. These OLZ vary with the size and terrain makeup of the ridge. *[Figure 10-14]*

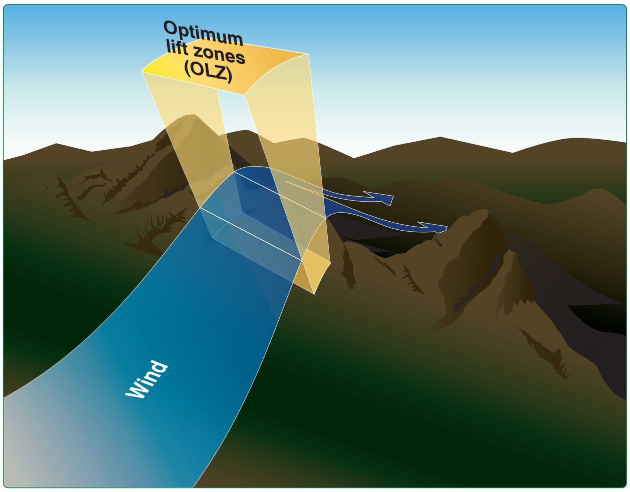

Figure 10-14. *Optimum lift zone of a ridge.*

Surface winds of 15–20 knots that are perpendicular to the ridge are ideal. Wind flow within 45° of the perpendicular line also provides adequate lift. Winds less than 10 knots have also produced adequate ridge soaring dependent on the terrain, but with 10 knots of wind or less, pilots should avoid flying low over any ridge due to the possibility of encountering sink. Local ridge pilots know about of these conditions and the need for good preflight planning and training is required. *[Figure 10-15]*

- Airflow mirrors a hill or ridge shape. Imagine a flow of water around the ridge instead of air. However, air is thinner and can be compressed as in a "venturi effect" and can be "squeezed" and accelerated, especially along the ridge. *[Figure 10-16]*
- Ridges that have an irregular profile are hazardous. The more complicated the ridge is, the more erratic the airflow may become. *[Figure 10-17]*

Traps

Even though the idea is simple, traps exist for both new and expert glider pilots. Obtain instruction when first learning to ridge soar/slope soar. Avoid approaching from the upwind side perpendicularly to the ridge. Instead, approach the ridge

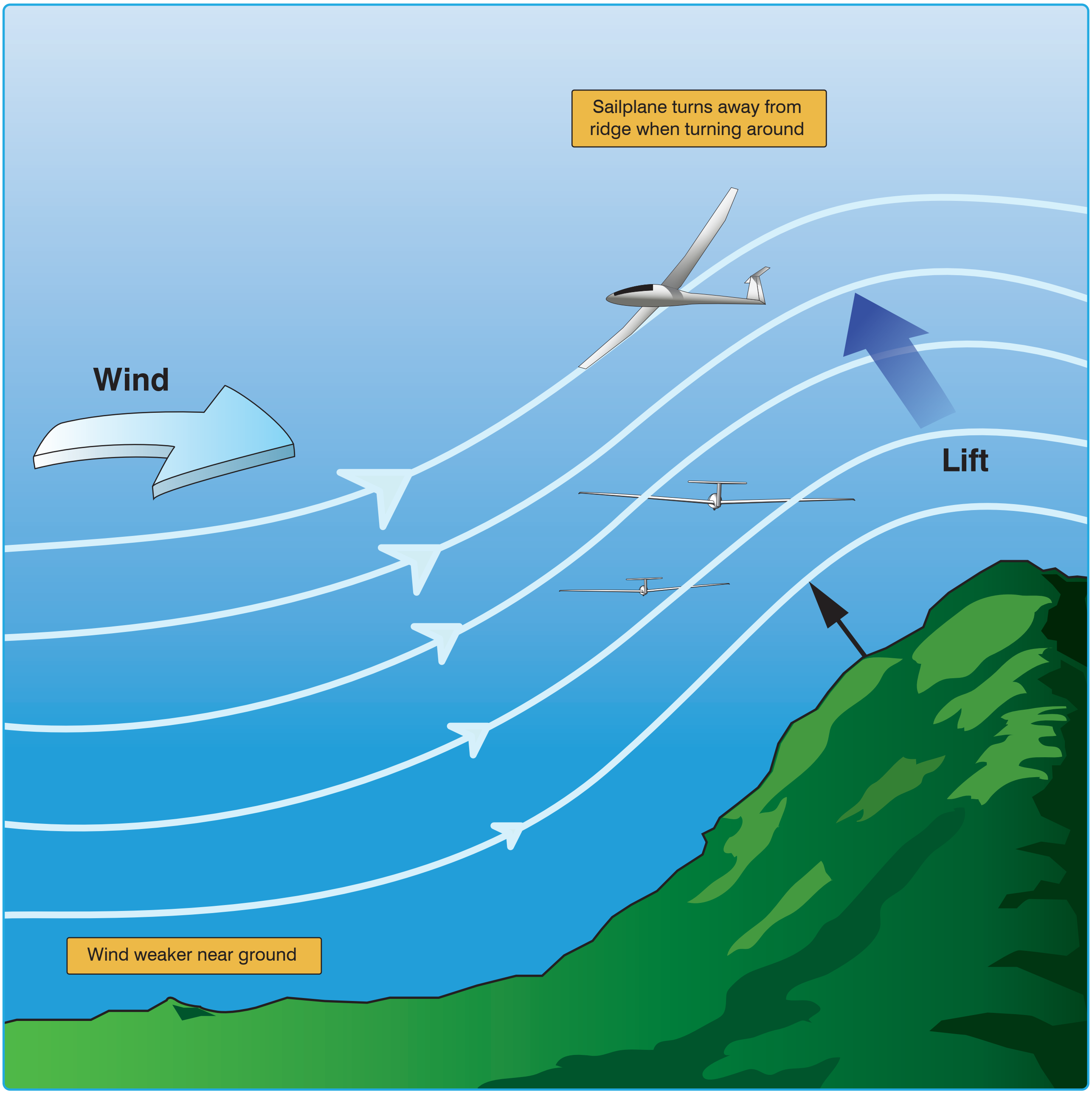

Figure 10-15. *Ridge wind flow.*

at a 45° angle, so that a quick egress away from the ridge is possible should lift not be contacted.

NOTE: When approaching the ridge from downwind, approach the ridge at a diagonal. If excess sink is encountered, this method allows a quick turn away from the ridge. *[Figure 10-18]*

While flying along the ridge, a crab angle is necessary to avoid drifting too close to the ridge or, if gliding above the ridge, to avoid drifting over the top into the leeside downdraft. Thermal sink can turn the glider upside down, a phenomenon known as upset. A thermal may appear anywhere. When it appears from the opposite side of the ridge, it has strong energy. When flying in strong conditions (winds and thermals), fly with extra speed for positive control of the glider. DO NOT fly on the ridge crest or below the ridge on the downwind side. *[Figure 10-19]*

For the new glider pilot, crabbing along the ridge may be a strange sensation, and it is easy to become uncoordinated while trying to point the nose along the ridge. This is both

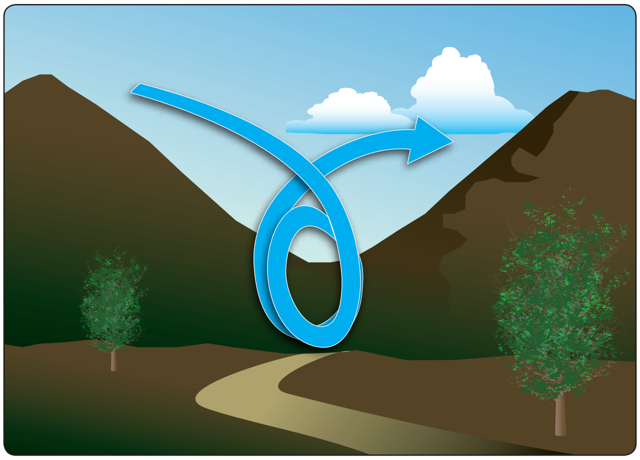

Figure 10-16. *Airflow reflects a hill's shape.*

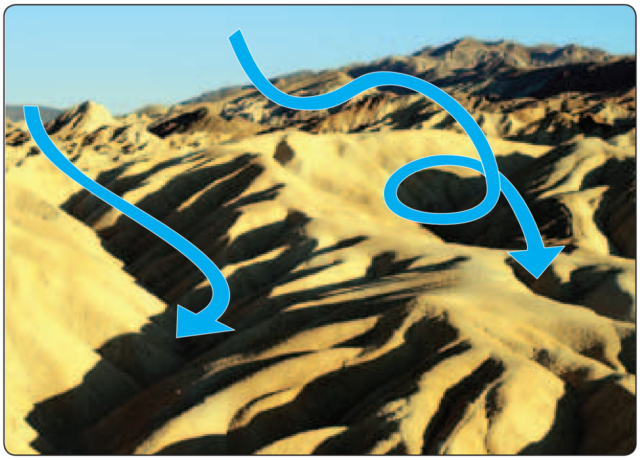

Figure 10-17. *Irregular profiles are hazardous.*

Figure 10-18. *From downwind, approach ridges diagonally.*

inefficient and dangerous, since it leads to a skid toward the ridge. *[Figure 10-20]*

In theory, to obtain the best climb, it is best to slope soar at minimum sink speed. However, flying that slowly may be unwise for two reasons. First, minimum sink speed is relatively close to stall speed, and flying close to stall speed near terrain has obvious dangers. Second, maneuverability at minimum sink speed may be inadequate for proper control near terrain, especially if the wind is gusty and/or thermals are present. When gliding at or below ridge top height, fly faster than minimum sink speed—how much faster depends on the glider, terrain, and turbulence. When the glider is at least several hundred feet above the ridge and shifting upwind away from it in the best lift zone, reduce speed. If in doubt, fly faster.

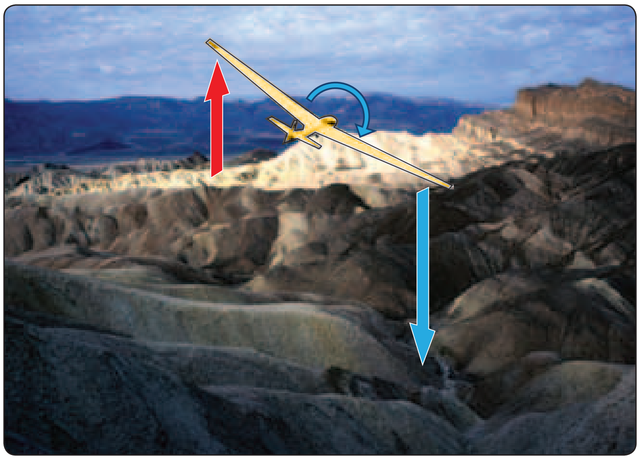

Figure 10-19. *Thermal sink can roll the craft toward the mountain.*

NOTE: When flying close to the ridge, use extra speed for safety—extra speed gives the glider more positive flight control input and also enables the glider to fly through areas of sink quickly. Ensure that seat and lap belts are tightened. *[Figure 10-21]*

Procedures for Safe Flying

Slope soaring comes with several procedures to enable safe flying and to allow many gliders on the same ridge. The rules are explained in the following paragraphs and illustrated in *Figure 10-22*.

Make all turns away from the ridge. *[Figure 10-22A]* A turn toward the ridge is dangerous, even if gliding seemingly well away from the ridge. The groundspeed on the downwind portion of the turn is difficult to judge properly, and striking the ridge is a serious threat. Even if above the ridge, it is easy to finish the turn downwind which may take the glider over the ridge crest; this puts the glider into heavy sink.

Do not fly directly above or below another glider. *[Figure 10-22B]* Gliders spaced closely together in the vertical are in each other's blind spots. A slight change in climb rate between the gliders can lead to a collision.

Pass another glider on the ridge side, anticipating that the other pilot will make a turn away from the ridge. *[Figure 10-22C]* Sometimes the glider to be passed is so close to the ridge that there is inadequate space to pass between

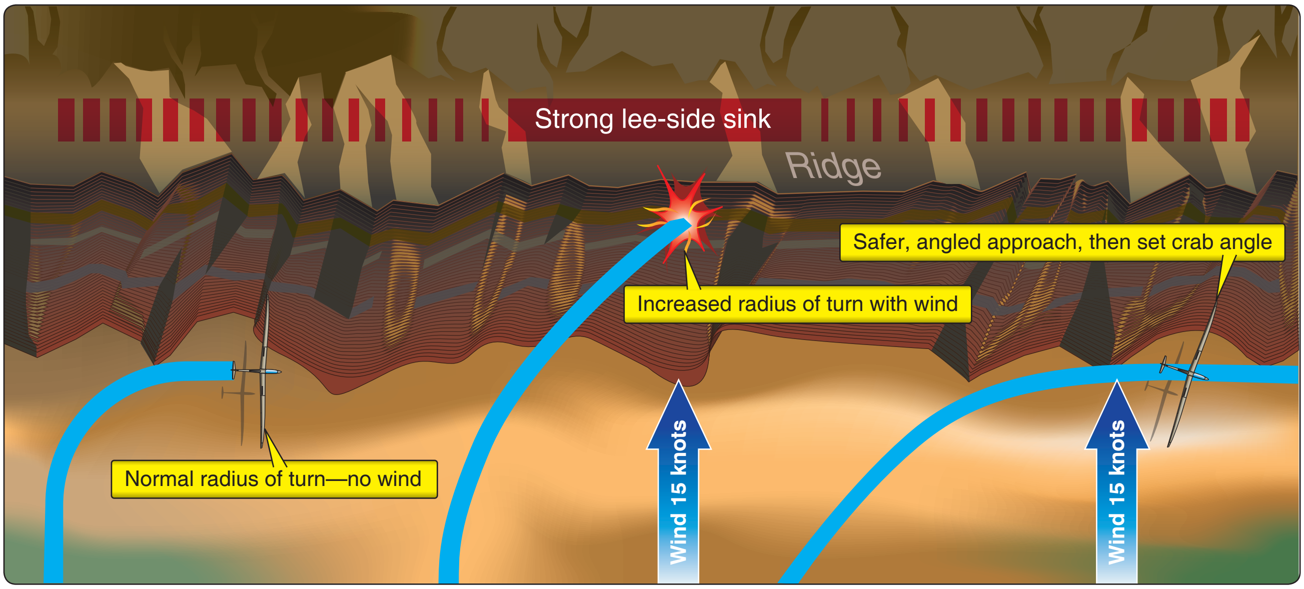

Figure 10-20. *Flying with a wind increases the turn radius over the ground, so approach the ridge at a shallow angle.*

Figure 10-21. *When flying close to a ridge, use extra speed for more control and to pass quickly through sink.*

the glider and the ridge. In that case, either turn back in the other direction (away from the ridge) if traffic permits or fly upwind away from the ridge and rejoin the slope lift as traffic allows. If using a radio, try to contact the glider by the completion number and then coordinate the passing. When soaring outside of the United States, be aware that this rule may differ.

The glider with its right side to the ridge has the right of way. *[Figure 10-22D]* Title 14 of the Code of Federal Regulations (14 CFR) requires both aircraft approaching head-on to give way to the right. A glider with the ridge to the right may not have room to move in that direction. The glider with its left side to the ridge should give way. Additionally, when overtaking a slower glider along the ridge, always pass on the ridge side. If the overtaking glider encounters sink, turbulence, etc., it must maneuver away from the ridge. This is acceptable. When piloting the glider with its right side to the ridge, ensure the approaching glider sees you and is yielding in plenty of time. In general, gliders approaching head-on are difficult to see; therefore, extra vigilance is needed to avoid collisions while slope soaring. The use of a radio during ridge soaring is recommended. Pilots must be familiar with 14 CFR part 91, section 91.113, Right-of-way rules: Except water operations, and section 91.111, Operating near other aircraft.

Bowls and Spurs

If the wind is at an angle to the ridge, bowls or spurs (i.e., recessed or protruding rock formations) extending from the main ridge can create better lift on the upwind side and sink on the downwind side. If at or near the height of the ridge, it may be necessary to detour around the spur to avoid the sink, then drift back into the bowl to take advantage of the better lift. After passing such a spur, do not make abrupt turns toward the ridge. Always consider what the general flow of traffic is doing. If soaring hundreds of feet above a spur, it may be possible to fly over it and increase speed in any sink. This requires caution since a thermal in the upwind bowl, or even an imperceptible increase in the wind, can cause greater than anticipated sink on the downwind side. Always have an escape route or, if in any doubt, detour around. *[Figure 10-23]*

Slope Lift

It is not uncommon for thermals to exist with slope lift. Indeed, slope soaring can often be used as a “save” when thermals have temporarily shut down. Working thermals from slope lift requires special techniques. When a thermal is encountered along the ridge, a series of S-turns can be made into the wind. Drift back to the thermal after each turn if needed and, of course, never continue the turn to the point that

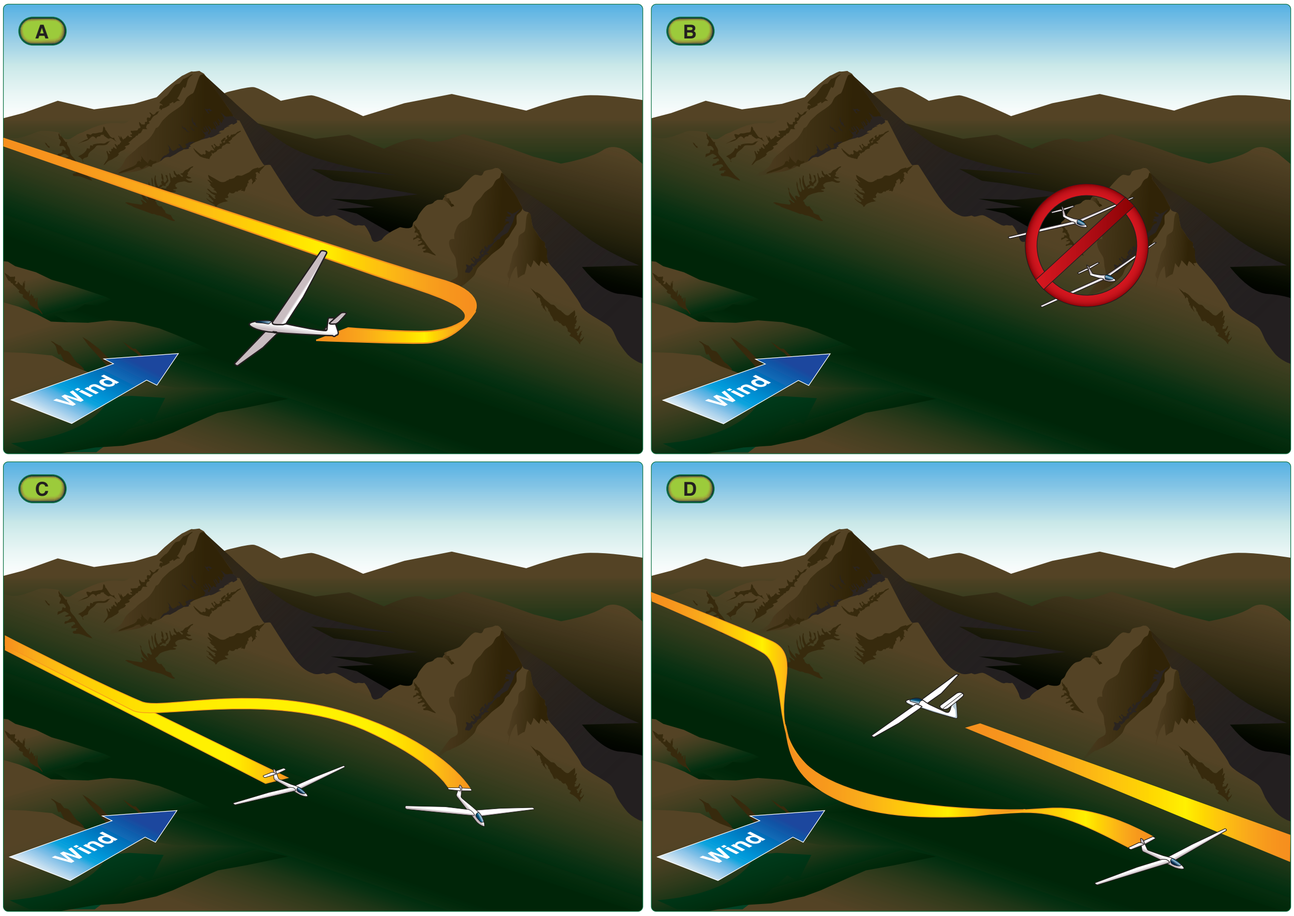

Figure 10-22. *Ridge rules.*

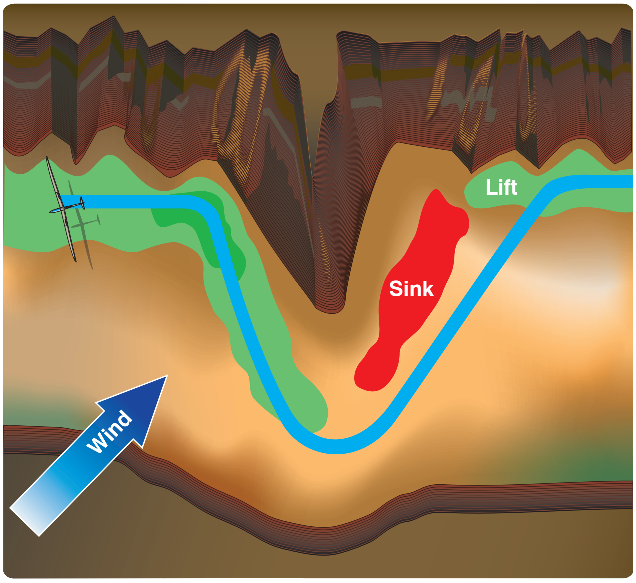

Figure 10-23. *Avoid sink on the downwind side of spurs by detouring around them.*

the glider is turning toward the ridge. Speed is also important, since it is easy to encounter strong sink on the sides of the thermal. It is very likely that staying in thermal lift through the entire S-turn is not possible. The maneuver takes practice, but when done properly, a rapid climb in the thermal can be made well above the ridge crest, where thermaling turns can begin. Even when well above the ridge, caution is needed to ensure the climb is not too slow as to drift into the lee-side sink. Before trying an S-turn, make sure it would not interfere with other traffic along the ridge. *[Figure 10-24]*

A second technique for catching thermals when slope soaring is to head upwind away from the ridge. This works best when Cu mark potential thermals, and aids timing. If no thermal is found, the pilot should cut the search short while still high enough to dash back downwind to the safety of the slope lift. *[Figure 10-25]*

Obstructions

As a final note, caution is also needed to avoid obstructions when slope soaring. Obstructions include wires, cables, and power lines, all of which are very difficult to see. When flying at extremely low altitudes along the ridge (tree top level), the glider and pilot may be placed at a high risk of collision with wires. Ensure an adequate reconnaissance has been completed when flying at these altitudes. Aeronautical charts show high-tension towers that have many wires between them. Soaring pilots familiar with the area should

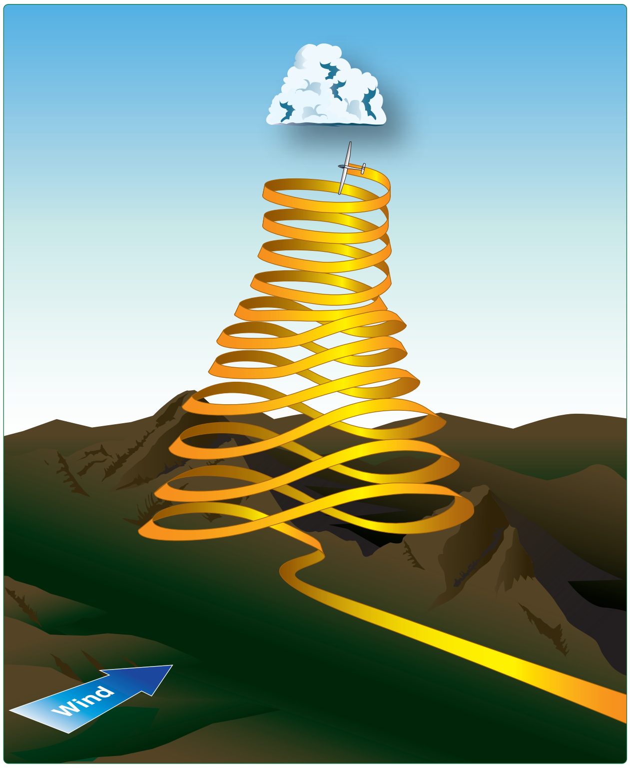

Figure 10-24. *One technique for catching a thermal from ridge lift.*

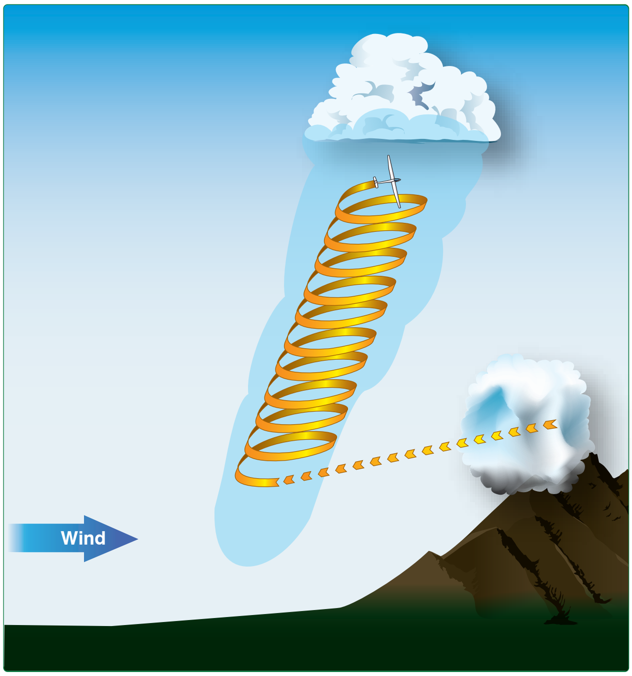

Figure 10-25. *Catching a thermal by flying upwind away from the slope lift.*

be able to provide useful information on any problems with the local ridge.

Tips and Techniques

Observe the ridges slope for collectors or dividers of the wind flow. Plan to determine which of the slopes is gathering wind flow. *[Figure 10-26]* Due to the changes in wind directions and or sun angles, any portion on the ridge can change in only a few minutes.

- Collectors are mountain/ridge bowls and canyon ends that can offer extreme areas of lift when the wind is blowing into them. Remember to have a way out.
- Dividers are ridges parallel with the wind and tend to have airflow separation. A collector that may be downwind from a divider may receive more airflow, making better lift possible.

Figure 10-26. *Analyze sloping ground for collectors and dividers of wind.*

The downwind side of any ridge or hill produces turbulence and sink. The larger or higher the ridge and the greater the wind velocity, the wider the turbulence may be. During these conditions, remember to ensure that seat and shoulder harnesses are tight. Sink calls for speed. Turbulence and speed are very hard on the glider airframe and pilot comfort. Pilots must obey glider limitations set forth in the GFM/POH. Also, do not exceed the design speed for maximum gust intensity (V_b). *[Figure 10-27]*

The ridge crest is where all airflow starts down. Steep ridges with narrow ridge tops can collect thermal action from both sides of the crest. The best lift could be directly above the crest. However, this terrain can be very hazardous as a pilot cannot see it or may not have visual cues. If wind is the only source of lift, the crest can be very dangerous. Always stay upwind of the crest. *[Figure 10-28]*

Areas along the ridge that are in deep shade is where the air goes down and sink can be found. If there is strong lift on the sunny side of the ridge, then chances are that strong sink

Figure 10-27. *Expect turbulence and sink in the downwind of any hill.*

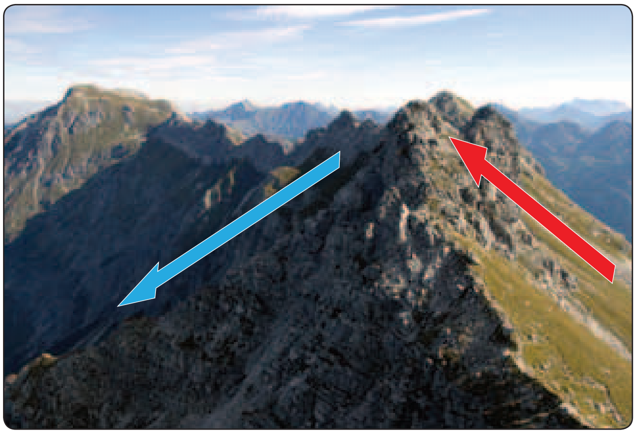

Figure 10-28. *The crest is where rising air starts back down.*

can be found on the shady or dark side of the ridge. This is true when the sun angle is low or late in the afternoon. *[Figure 10-29]*

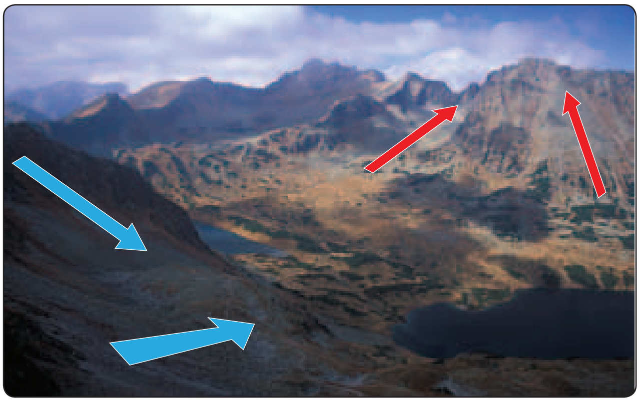

Figure 10-29. *Deep shade is where colder air goes down.*

Thermal source can be found where drainages area along the ridge meet. Where the ridge or peaks are numerous and slope down into a valley, thermal sources may be found. Canyons or large bowls hold areas of warm air.

Ridges may form cloud streets above the ridge. A glider pilot should try to climb in a thermal to reach these streets. Fast cruising speeds can be found under these streets. The glider pilot must stay upwind to stay in this type of lift near the ridge.

Since gliders tend to seek the same conditions for lift, thermals and areas of ridge lift are areas for special diligence for avoiding other aircraft. To some extent, for the same reasons that gliders seek rising air, other low flying airplanes and helicopters will plan to use that area for flights, so be aware for all aircraft. A portable VHF radio and sharing a common channel for traffic calls is an enhancement for safety, but nothing replaces a good visual scan at all times looking for other aircraft.

Density altitude is increasing as the glider climbs. At 10,000 feet mean sea level (MSL), a pilot is required to have approximately 40 to 45 percent more room to maneuver a glider. The air is less dense by 2 percent per one thousand feet of altitude gained. *[Figure 10-30]*

Wave Soaring

Almost all high-altitude flights are made using mountain lee waves. As covered in Chapter 9, Soaring Weather, lee wave systems can contain tremendous turbulence in the rotor, while the wave flow itself is usually unbelievably smooth. In more recent years, the use of lee waves for cross-country soaring has led to flights exceeding 1,500 miles, with average speeds of over 100 mph. *[Figure 10-31]*

Figure 10-30. *At 10,000' MSL, 44 percent more room is needed to complete a turn due to density altitude.*

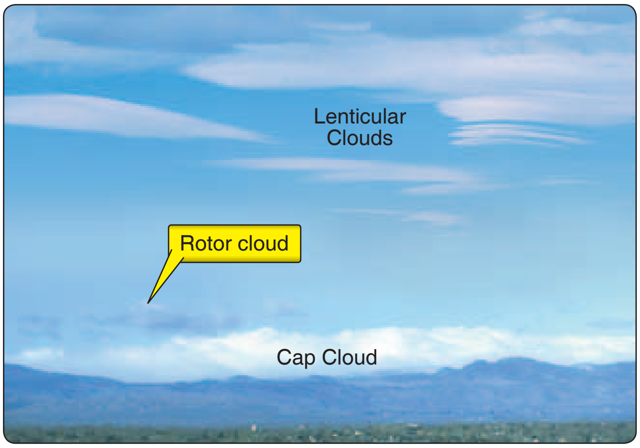

Figure 10-31. *Rotor and cap clouds with lenticulars above.*

Preflight Preparation

The amount of preflight preparation depends on the height potential of the wave itself. Assume that the pilot is planning a flight above 18,000 feet MSL during the winter. (Pilots planning wave flights to much lower altitudes can reduce the list of preparation items accordingly.)

At all times during flights above 14,000 feet MSL, and for flights of more than 30 minutes above 12,500 feet MSL up to and including 14,000 feet MSL, 14 CFR states that required crewmembers must use supplemental oxygen. Pilots must be aware of their own physiology; however, it may be wise to use oxygen at altitudes well below 14,000 feet MSL. In addition, pilots should recognize signs of hypoxia.

When flying at higher altitudes, the inside of the glider can get cold. The portions of your body exposed to the sun through the canopy might feel comfortable but your feet will probably feel the temperature drop and could get cold. It is important to prepare for this and pack thermal underwear, wear warm socks and shoes and have gloves easily accessible during the flight.

Within the continental United States, Class A airspace lies between 18,000 and 60,000 feet MSL (flight level (FL) 180 to FL 600). Generally, flights in Class A airspace must be conducted under instrument flight rules (IFR). However, several clubs and glider operations have established so-called wave windows. These are special areas, arranged in agreement with air traffic control (ATC), in which gliders are allowed to operate above 18,000 feet MSL under visual flight rules (VFR) operations. Wave windows have very specific boundaries. Thus, to maintain this privilege, it is imperative to stay within the designated window. On any given day, the wave window may be opened to a specific altitude during times specified by ATC. Each wave window has its own set of procedures agreed upon with ATC. All glider pilots should become familiar with the procedures and required radio frequencies.

True airspeed (TAS) becomes a consideration at higher altitudes. To avoid the possibility of flutter, some gliders require a reduced indicated never-exceed speed (V_{NE}) as a function of altitude. For instance, the Pilot's Operating Handbok (POH) for one common two-seat glider, list a V_{NE} at sea level of 135 knots. However, at 19,000 feet MSL, it is only 109 knots. Study the glider's POH carefully for any limitations on indicated airspeeds.

There is always the possibility of not contacting the wave. Sink on the downside of a lee wave can be high—2,000 fpm or more. In addition, missing the wave often means a trip back through the turbulent rotor. The workload and stress level in either case can be high. To reduce the workload, it is a good idea to have minimum return altitudes from several locations calculated ahead of time. In addition, plan for some worse case scenarios. For instance, consider what off-field landing options are available if the planned minimum return altitude proves inadequate.

A normal preflight of the glider should be performed. In addition, check the lubricant that has been used on control fittings. Some lubricants can become very stiff when cold. Also, check for water from melting snow or a recent rain in the spoilers or dive brakes. Freezing water in the spoilers or drive brakes at altitude can make them difficult to open. Checking the spoilers or dive brakes occasionally during a high climb helps avoid this problem. A freshly charged battery is recommended, since cold temperatures can reduce battery effectiveness.

Check the radio and accessory equipment, such as a microphone in the oxygen mask even if it is not generally used. As mentioned, the oxygen system is vital. Other specific items to check depend on the system being used.

A briefing with the tow pilot is even more important before a wave tow. Routes, minimum altitudes, rotor avoidance (if possible), anticipated tow altitude, and eventualities should be discussed on the ground prior to flight.

After all preparations are complete, it is time to get in the glider. Some pilots may be using a parachute for the first time on wave flights, so become familiar with its proper fitting and use. The parachute fits on top of clothing that is much bulkier than for normal soaring, so the cockpit can suddenly seem quite cramped. It takes several minutes to get settled and organized. Make sure radio and oxygen are easily accessible. If possible, the oxygen mask should be in place, since the climb in the wave can be very rapid. At the very least, the mask should be set up so that it is ready for use in a few seconds. All other gear (mittens, microphone, maps, barograph, etc.) should be securely stowed in anticipation of the rotor. Check for full, free rudder movement since footwear is probably larger than normal. In addition, given the bulky cold-weather clothing, check to make sure the canopy clearance is adequate. The pilot's head can break a canopy in rotor turbulence, so seat and shoulder belts should be tightly secured. This may be difficult to achieve with the extra clothing and accessories, but take the time to ensure everything is secure. There will not be time to attend to such matters once the rotor is encountered.

Getting Into the Wave

There are two ways to get into the wave: soaring into it or being towed directly into it. Three main wave entries while soaring are thermaling into the wave, climbing the rotor, and transitioning into the wave from slope soaring.

At times, an unstable layer lower than the mountaintop is capped by a strong, stable layer. If other conditions are favorable, the overlying stable layer may support lee waves. On these days, it is sometimes possible to avoid the rotor and thermal into the wave. Whether lee waves are suspected or not, the air near the thermal top may become turbulent. At this point, attempt a penetration upwind into smooth wave lift. A line of cumulus downwind of and aligned parallel to the ridge or mountain range is a clue that waves may be present. *[Figure 10-32]*

Another possibility is to tow into the upside of the rotor, then climb the rotor into the wave. This can be rough, difficult, and prone to failure. The technique is to find a part of the rotor that is going up and try to stay in it. The rotor lift is usually stationary over the ground. Either perform a figure 8 in the rotor lift to avoid drifting downwind, fly several circles with an occasional straight leg, or fly straight into the wind for several seconds until lift diminishes. Then, circle to reposition in the lift. The choice that works depends on the size of the lift and the wind strength. Since rotors have rapidly changing regions of very turbulent lift and sink, simple airspeed and bank angle control can become difficult. This wave-entry technique is not for new pilots.

Depending on the topography near the soaring site, it may be possible to transition from slope lift into a lee wave that is created by upwind topography as shown in *Figure 9-27*. In this case, climb as high as possible in slope lift, then penetrate upwind into the lee wave. When the lee waves are in phase with the topography, it is often possible to climb from slope to wave lift without the rotor. At times, the glider pilot may not realize wave has been encountered until finding lift steadily increasing as the glider climbs from the ridge. Climbing in slope lift and then turning downwind to encounter possible lee waves produced downwind of the ridge is generally not recommended. Even with a tailwind, the lee-side sink can put the glider on the ground before the wave is contacted.

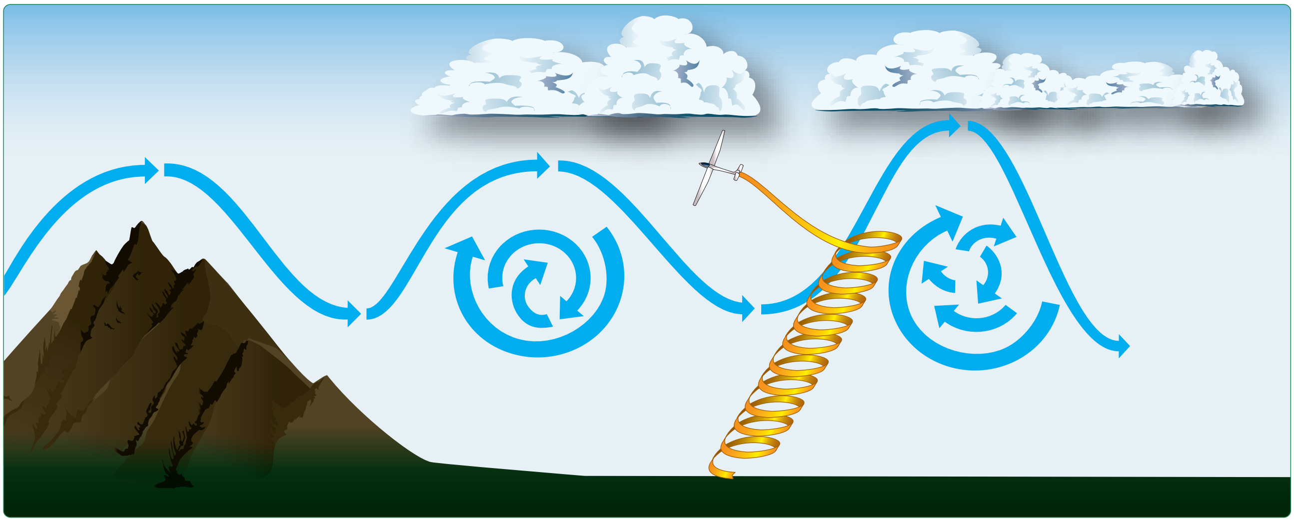

Figure 10-32. *Thermaling into wave.*

Towing into the wave can be accomplished by either towing ahead of the rotor or through the rotor. Complete avoidance of the rotor generally increases the tow pilot's willingness to perform future wave tows. If possible, tow around the rotor and then directly into the wave lift. This may be feasible if the soaring site is located near one end of the wave-producing ridge or mountain range. A detour around the rotor may require more time on tow, but it is well worth the diversion. *[Figure 10-33]*

Often, a detour around the rotor is not possible and a tow directly through the rotor is the only route to the wave. The rotor turbulence is, on rare occasion, only light. However, moderate to severe turbulence is usually encountered. The nature of rotor turbulence differs from turbulent thermal days, with sharp, chaotic horizontal and vertical gusts along with rapid accelerations and decelerations. At times, the rotor can become so rough that even experienced pilots may elect to remain on the ground. Any pilot inexperienced in flying through rotors should obtain instruction before attempting a tow through rotor.

When towing through a rotor, being out of position is normal. Glider pilots must maintain position horizontally and vertically as best they can. Pilots should also be aware that an immediate release may be necessary at any time if turbulence becomes too violent. Slack-producing situations are common, due to a rapid deceleration of the towplane. The glider pilot must react quickly to slack if it occurs and recognize that slack is about to occur and correct accordingly. The vertical position should be the normal high tow. Any tow position that is lower than normal runs the risk of the slack line coming back over the glider. On the other hand, care should be taken to tow absolutely no higher than normal to avoid a forced release should the towplane suddenly drop. Gusts may also cause an excessive bank of the glider, and it may take a moment to roll back to level. Full aileron and rudder deflection, held for a few seconds, is sometimes needed.

Progress through the rotor is often indicated by noting the trend of the variometer. General downswings are replaced by general upswings, usually along with increasing turbulence. The penetration into the smooth wave lift can be quick—in a matter of few seconds—while at other times it can be more gradual. Note any lenticulars above; a position upwind of the clouds helps confirm contact with the wave. If in doubt, tow a few moments longer to be sure. Once confident about having contacted the wave lift, make the release. If heading into more or less crosswind, the glider should release and fly straight or with a crab angle. If flying directly into the wind, the glider should turn a few degrees to establish a crosswind crab angle. The goal is to avoid drifting downwind and immediately losing the wave. After release, the towplane should descend and/or turn away to separate from the glider. Possible nonstandard procedures need to be briefed with the tow pilot before takeoff. *[Figures 10-34* and *10-35]*

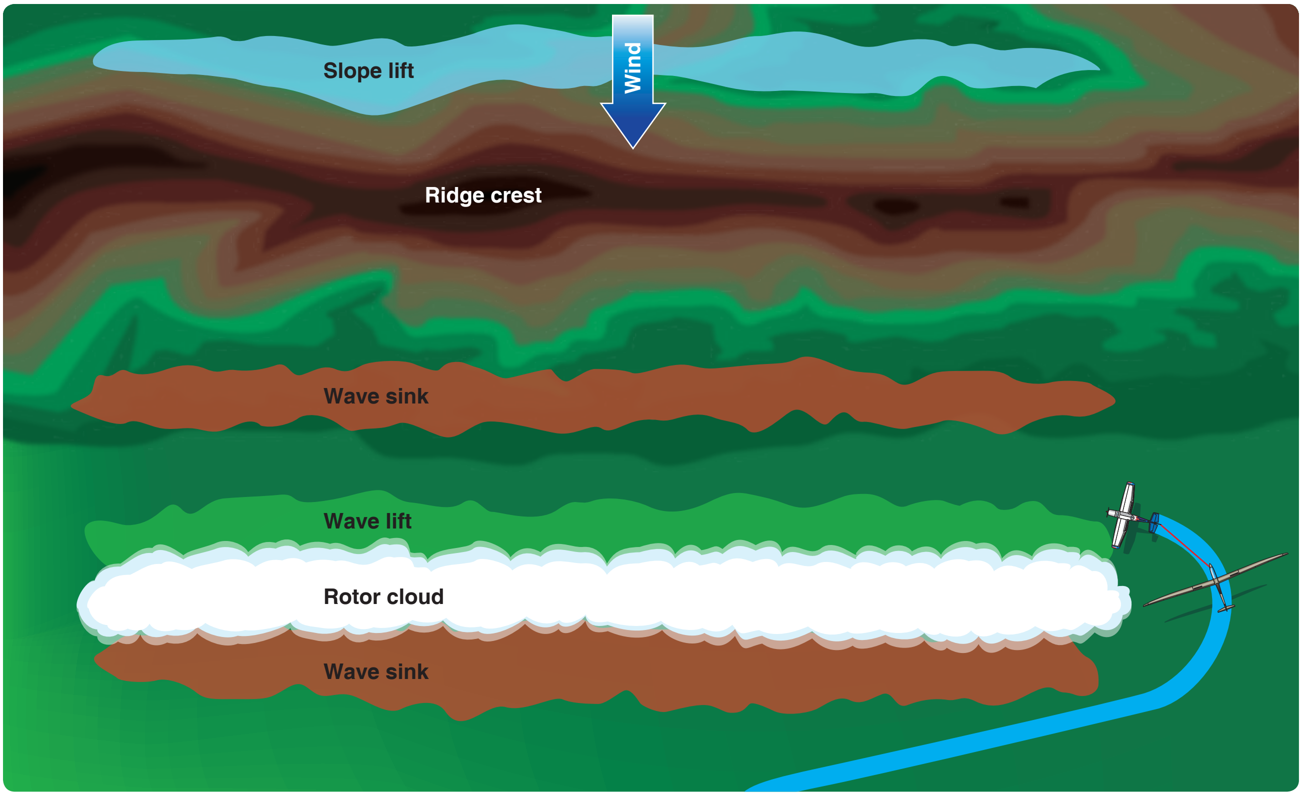

Figure 10-33. *If possible, tow around the rotor directly into the wave.*

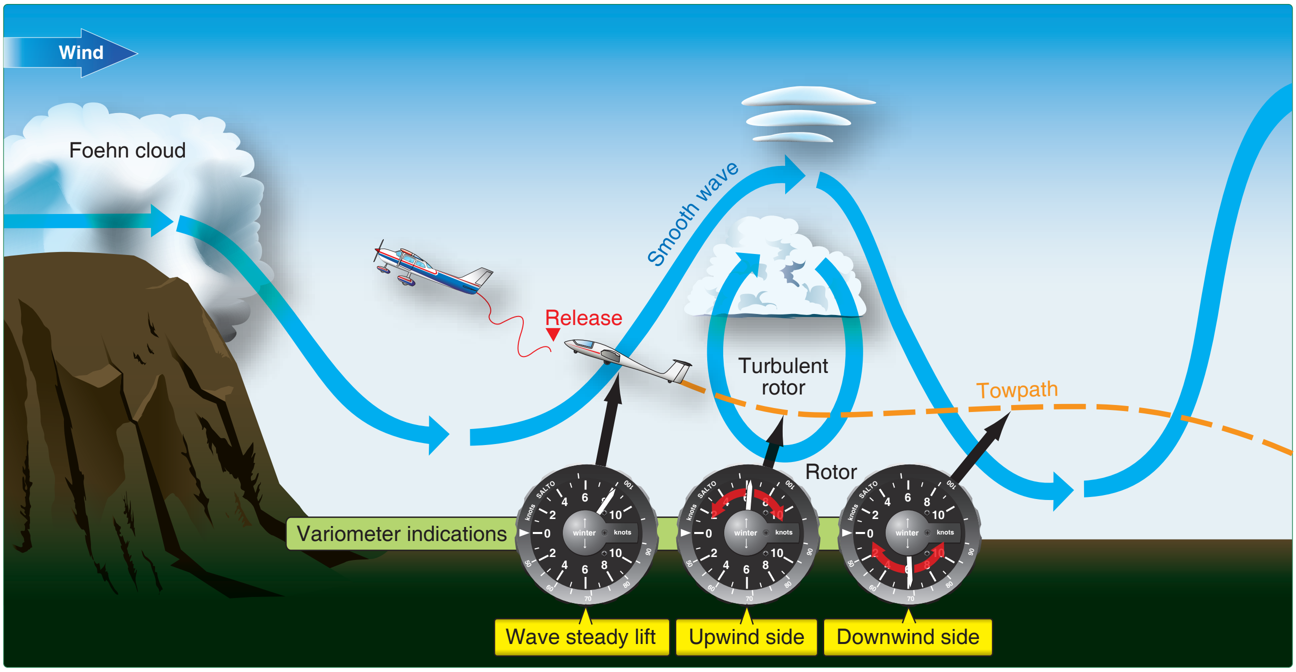

Figure 10-34. *Variometer indications during the penetration into the wave.*

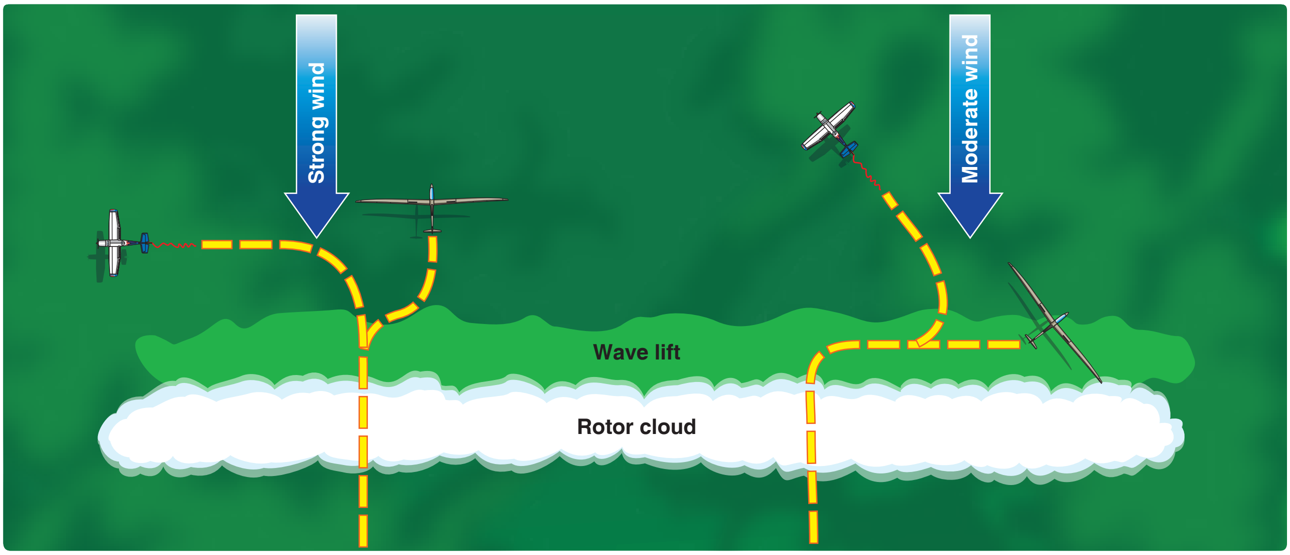

Figure 10-35. *Possible release and separation on a wave tow.*

Flying in the Wave

Once the wave has been contacted, the best techniques for utilizing the lift depend on the extent of the lift (especially in the direction along the ridge or mountain range producing the wave) and the strength of the wind. The lift may initially be weak. In such circumstances, be patient and stay with the initial slow climb. Patience is usually rewarded with better lift as the climb continues. At other times, the variometer may be pegged at 1,000 fpm directly after release from tow.

If the wind is strong enough (40 knots or more), find the strongest portion of the wave and point into the wind, and adjust speed so that the glider remains in the strong lift. The best lift is found along the upwind side of the rotor cloud or just upwind of any lenticulars. In the best-case scenario, the required speed is close to the glider's minimum sink speed. In quite strong winds, it may be necessary to fly faster than minimum sink to maintain position in the best lift. Under those conditions, flying slower allows the glider to drift downwind (fly backward over the ground) and into the down side of the wave. This can be a costly mistake since it is difficult to penetrate back into the strong headwind. When the lift is strong, it is easy to drift downwind while climbing into stronger winds aloft, so it pays to be attentive to the position relative to rotor clouds or lenticulars. If no clouds exist, special attention is needed to judge wind drift by finding nearby ground references. It may be necessary to increase speed with altitude to maintain position in the best lift. Often the wind is strong, but not quite strong enough for the glider to remain stationary over the ground so that the glider slowly moves upwind out of the best lift. If this occurs, turn slightly from a direct upwind heading, drift slowly downwind into better lift, and turn back into the wind before drifting too far. *[Figure 10-36]*

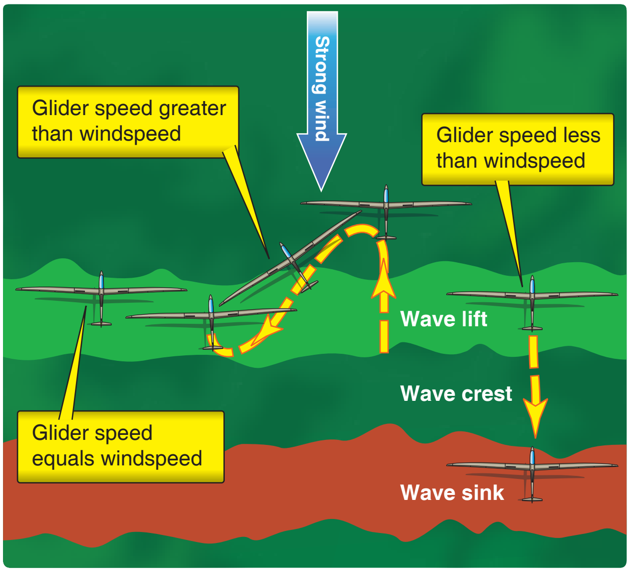

Figure 10-36. *Catching a thermal by flying upwind away from the slope lift.*

Often, the wave lift is not perfectly stationary over the ground since small changes in windspeed and/or stability can alter the wavelength of the lee wave within minutes. If lift begins to decrease while climbing in the wave, one of these things has occurred: the glider is nearing the top of the wave, the glider has moved out of the best lift, or the wavelength of the lee wave has changed. In any case, it is time to explore the area for better lift, and it is best to search upwind first. Searching upwind first allows the pilot to drift downwind back into the up part of the wave if he or she is wrong. Searching downwind first can make it difficult or impossible to contact the lift again if sink on the downside of the wave is encountered. In addition, caution is needed to avoid exceeding the glider's maneuvering speed or rough-air redline, since a penetration from the down side of the wave may put the glider back in the rotor. *[Figure 10-37]*

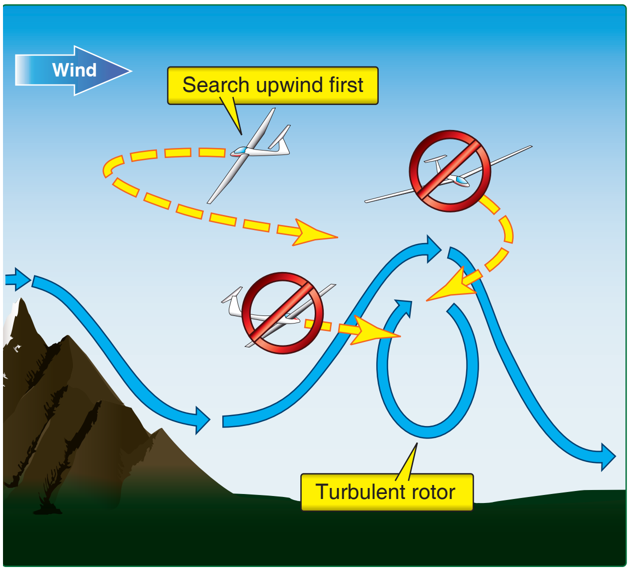

Figure 10-37. *Search upwind first to avoid sink behind the wave crest or the rotor.*

If the winds are moderate (20 to 40 knots), and the wave extends along the ridge or mountain range for a few miles, it is best to fly back and forth along the wave lift while crabbing into the wind. This technique is similar to slope soaring, using the rotor cloud or lenticular as a reference. All turns should be into the wind to avoid being on the down side of the wave or back into the rotor. Once again, it is easy to drift downwind into sink while climbing higher, and searching for better lift should be done upwind first. When making an upwind turn to change course 180°, remember that the heading change will be less, depending on the strength of the wind. Note the crab angle needed to stay in lift on the first leg, and assume that same crab angle after completing the upwind turn. This prevents the glider from drifting too far downwind upon completing the upwind turn. With no cloud, ground references are used to maintain the proper crab angle, and avoid drifting downwind out of the lift. While climbing higher into stronger winds, it may become possible to transition from crabbing back and forth to a stationary upwind heading. *[Figure 10-38]*

Weaker winds (15 to 20 knots) sometimes require different techniques. Lee waves from smaller ridges can form in relatively weak winds of approximately 15 knots. Wave lift from larger mountains rapidly decreases when climbing to a height where winds aloft diminish. As long as the lift area is big enough, use a technique similar to that used in moderate winds. Near the wave top, there sometimes remains only a small area that still provides lift. In order to attain the maximum height, fly shorter figure 8 patterns within the remaining lift. If the area of lift is so small that consistent climb is not possible, fly a series of circles with an occasional leg into the wind to avoid drifting too far downwind. Another possibility is an oval-shaped pattern—fly straight into the wind in lift and, as it diminishes, fly a quick 360° turn to reposition. These last two techniques do not work as well in moderate winds, and not at all in strong winds since it is too easy to be downwind of the lift and into heavy sink. *[Figure 10-39]*

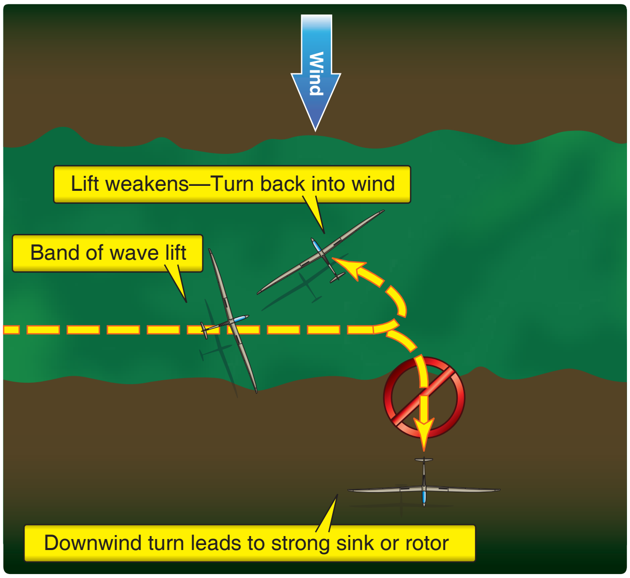

Figure 10-38. *Proper crabbing to stay in lift and effects of upwind turn (correct) or downwind turn (incorrect).*

In the discussion thus far, a climb in the primary wave has been assumed. It is also possible to climb in the secondary or tertiary lee wave (if existing on a given day) and then penetrate into the next wave upwind. The success of this depends on wind strength, clouds, the intensity of sink downwind of wave crests, and the performance of the glider. Depending on the height attained in the secondary or tertiary lee wave, a trip through the rotor of the next wave upwind is a distinct possibility. Caution is needed if penetrating upwind at high speed. The transition into the downwind side of the rotor can be as abrupt as on the upwind side, so speed should be reduced at the first hint of turbulence. In any case, expect to lose a surprising amount of altitude while penetrating upwind through the sinking side of the next upwind wave. *[Figure 10-40]*

If a quick descent is needed or desired, the sink downwind of the wave crest can be used. Sink can easily be twice as strong as lift encountered upwind of the crest. Eventual descent into downwind rotor is also likely. Sometimes the space between a rotor cloud and overlying lenticulars is inadequate and a transition downwind cannot be accomplished safely. In this case, a crosswind detour may be possible if the wave is produced by a relatively short ridge or mountain range. If clouds negate a downwind or crosswind departure from the wave, a descent on the upwind side of the wave crest is needed. Spoilers or dive brakes may be used to descend through the updraft, followed by a transition under the rotor cloud and through the rotor. A descent can be achieved by moving upwind of a very strong wave lift if spoilers or dive brakes alone do not allow an adequately fast descent. A trip back through the rotor is at best unpleasant. At worst, it can be dangerous if the transition back into the rotor is done with too much speed. In addition, strong wave lift and lift on the upwind side of the rotor may make it difficult to stay out of the rotor cloud. This wave descent requires a good deal of caution and emphasizes the importance of an exit strategy before climbing too high in the wave, keeping in mind that conditions and clouds can rapidly evolve during the climb.

Some of the dangers and precautions associated with wave soaring have already been mentioned. Those and others are summarized below.

- If any signs of hypoxia appear, check the oxygen system and immediately begin a descent to lower altitudes below which oxygen is not needed. Do not delay!
- Eventually, a pilot becomes cold at altitude regardless of how warmly the pilot is dressed. Descend well before it becomes uncomfortably cold.

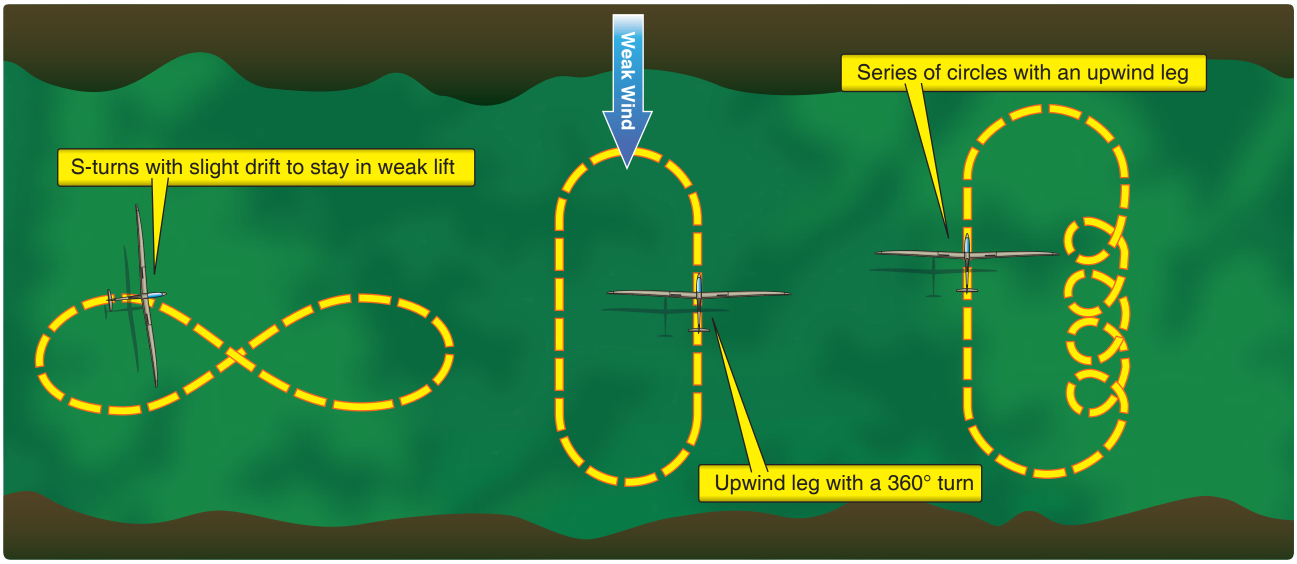

Figure 10-39. *Techniques for working lift near the top of the wave in weak winds.*

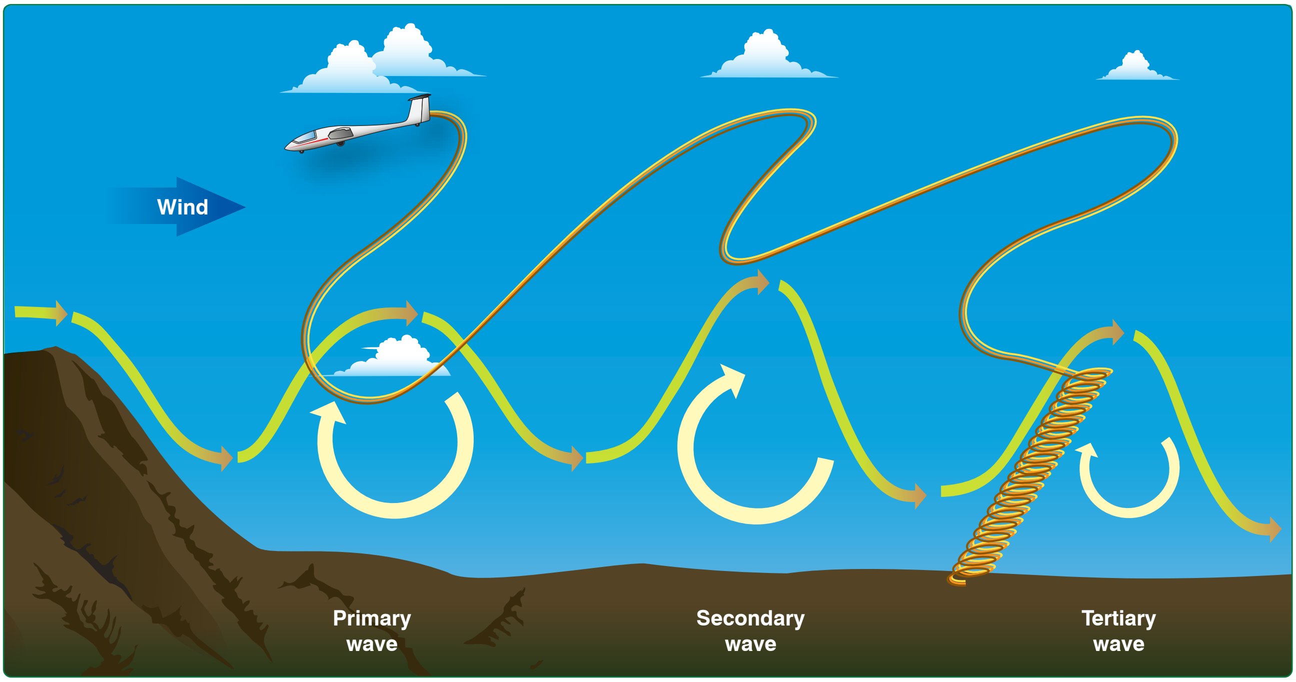

Figure 10-40. *Possible flightpath while transitioning from the tertiary into the secondary and then into the primary.*

- Rotor turbulence can be severe or extreme. Caution is needed on tow and when transitioning from smooth wave flow (lift or sink) to rotor. Rotors near the landing area can cause strong shifting surface winds of 20 or 30 knots. Wind shifts up to 180° sometimes occur in less than a minute at the surface under rotors.
- Warm, moist exhaled air can cause frost on the canopy, restricting vision. Opening air vents may alleviate the problem or delay frost formation. Clear vision panels may also be installed. If frost cannot be controlled, descend before frost becomes a hazard.
- In wet waves, those associated with a great deal of cloud, beware of the gaps closing beneath the glider. If trapped above cloud, a benign spiral mode is an option, but only if this mode has been previously explored and found stable for the glider.
- Know the time of actual sunset. At legal sunset, bright sunshine is still found at 25,000 feet while the ground below is already quite dark. Even at an average 1,000 fpm descent, it takes 20 minutes to lose 20,000 feet.

Caution: Flights under a rotor cloud can encounter high sink rates and should be approached with extreme caution.

Soaring Convergence Zones

Convergence zones are most easily spotted when cumulus clouds are present. They appear as a single, straight, or curved cloud street, sometimes well defined and sometimes not. The edge of a field of cumulus can mark convergence between a mesoscale air mass that is relatively moist and/or unstable from one that is much drier and/or more stable. Often, the cumulus along convergence lines have a base lower on one side than the other, similar to that in *Figure 9-31*.

With no cloud present, a convergence zone is sometimes marked by a difference in visibility across it, which may be subtle or distinct. When there are no clues in the sky itself, there may be some clues on the ground. If lakes are nearby, look for wind differences on lakes a few miles apart. A lake showing a wind direction different from the ambient flow for the day may be a clue. Wind direction shown by smoke can also be an important indicator. A few dust devils, or—even better—a short line of them, may indicate the presence of ordinary thermals versus those triggered by convergence. Spotting subtle clues takes practice and good observational skills, and is often the reason a few pilots are still soaring while others are already on the ground.

The best soaring technique for this type of lift depends on the nature of the convergence zone itself. For instance, a sea-breeze front may be well defined and marked by curtain clouds; the pilot can fly straight along the line in fairly steady lift. A weaker convergence line often produces more lift than sink; the pilot must fly slower in lift and faster in sink. An even weaker convergence line may simply serve as focus for more frequent thermals; normal thermal techniques are used along the convergence line. Some combination of straight legs along the line with an occasional stop to thermal is often used.

Convergence zone lift can at times be somewhat turbulent, especially if air from different sources is mixing, such as along a sea-breeze front. The general roughness may be the only clue of being along some sort of convergence line. There can also be narrow and rough (but strong) thermals within the convergence line. Work these areas like any other difficult thermals, using steeper bank angles and more speed for maneuverability.

Combined Sources of Updrafts

Finally, lift sources have been categorized into four types: thermal, slope, wave, and convergence. Often, more than one type of lift exists at the same time, such as thermals with slope lift, thermaling into a wave, convergence zones enhancing thermals, thermal waves, and wave and slope lift. In mountainous terrain, it is possible for all four lift types to exist on a single day. The glider pilot needs to remain mentally nimble to take advantage of various types and locations of rising air during the flight.

Nature does not know that it must only produce rising air based on these four lift categories. Sources of lift that do not fit one of the four lift types discussed probably exist. For instance, there have been a few reports of pilots soaring in travelling waves, the source of which was not known. At some soaring sites, it is sometimes difficult to classify the type of lift. This should not be a problem. Simply work the mystery lift as needed, then ponder its nature after the flight.