The AOPA MOUNTAIN FLYING COURSE

A uniform system of study for the nonprofessional pilot who wishes to become more proficient and to fly more safely. It is a course in basic mountain flying techniques and procedures under the direction of a qualified flight instructor.

The AOPA Mountain Flying Course consists of four hours of ground school and four hours of flight instruction.

A Project Of The AOPA AIR SAFETY FOUNDATION

General Aviation Education—Research—Accident Prevention

• This course is intended to help pilots develop the necessary skills and aeronautical knowledge to fly safely in mountainous areas.

The AOPA Mountain Flying Course manual is a textbook for students to use under the guidance of an instructor who is teaching the course in accordance with an instructor's syllabus which is furnished by the AOPA Safety Foundation.

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Development of The AOPA Mountain Flying Course, its associated training aids, and this manual was made possible by voluntary contributions to the AOPA Air Safety Foundation by AOPA members. The course represents another addition to the many projects the AOPA Air Safety Foundation has sponsored in the interest of furthering aviation education and flying safety.

The AOPA MOUNTAIN FLYING COURSE

The airplane today allows people to travel point to point with a minimum expenditure of effort and time. The time savings realized are particularly significant in mountainous areas. Within the mountainous regions of this country are located many resort and recreational facilities. There are many airports throughout the mountains providing access to these areas for the pilot with the necessary basic airmanship and knowledge of the techniques of mountain flying.

The confidence and knowledge that will be acquired during this course will enable you to fly into and out of these areas safely and increase the utilization of your airplane. Additionally, the mountains offer some of the most beautiful vistas seen anywhere. Flying an airplane in the mountains is an enjoyable experience, making mountain flying a sport in itself.

The inexperienced mountain flyer will encounter, perhaps for the first time, many environmentally engendered operational constraints that require the development of new piloting techniques and skills.

The primary differences between the previously experienced low-altitude environment and the new high-altitude/high-terrain to be encountered will be developed and amplified by this course.

MOUNTAIN FLIGHT PREPLANNING

The planning for a flight in the mountains is probably as important as the planning required for any other type of flight. To adequately plan the flight, the pilot should consider the performance of his aircraft at altitude; the weather, including anticipated airflow patterns; the route to be flown; and the airport or airports from which the pilot will be operating.

Mountain flying techniques that have been passed from pilot to pilot over the years do not contain any magic. These techniques have been generated by mountain flying experience, strict adherence to technical data contained in aircraft manuals, and the application of good basic airmanship.

MOUNTAIN METEOROLOGY

Planning any flight involves a consideration of the weather conditions. This is especially true for mountain flying, because the weather presents many variables to the inexperienced pilot in a foreign area of the country.

The principal weather hazards that a pilot experiences in flatland flying also apply to mountain flying. These include the usual fronts, fogs, thunderstorms, and squall lines. The basic situation that makes mountain flying different is the manner in which airflow behaves as it passes over the terrain. This phenomenon sometimes is responsible for the development of localized mini-weather systems within the mountains.

Every pilot has witnessed how air that is lifted through heating rises and forms clouds. As air flows over mountains, it is raised by being pushed up the terrain. As it rises, the air cools and may form clouds. This action, under certain conditions, can form fog known as "upslope" fog. As air descends, it is heated and dried. Consequently, areas on the upwind side of a mountain range will have more precipitation than areas on the downwind side, as seen in Figure 1.

Most mountain ranges are oriented approximately perpendicular to the prevailing winds. As an air mass moves upslope, it is usually stable. When air passes over a ridge and begins moving downslope, it can become unstable and turbulent. On the upslope side the ride is smooth and the updrafts help climb performance, while on the downslope side we have a rough ride and usually encounter downdrafts.

As wind crosses a ridge, the velocity may be greatly accelerated. In Figure 2, the steady-state wind flow is 30 knots. The wind above the ridge may double to 60 knots. In a mountain pass, the wind velocity may be triple the steady-state wind.

A determination as to the stability of the air existing at the point of takeoff and along the planned path of flight should be made. The local weather bureau or flight service station can make an assessment as to the stability and existing weather for the planned flight. One does not have to be a professional meteorologist to obtain this information. Be sure that the forecaster knows what you want and what you are planning to do. The pilot can ascertain from sequence reports and other sources the wind velocity, direction, and how gusty it is. Subjectively, the stability of the air can be determined by noting the type of clouds and whether they demonstrate a lot of vertical development, as illustrated in Figure 3.

MOUNTAIN WAVE

When the airflow over mountainous terrain meets certain criteria, a phenomenon known as the mountain or standing wave may exist (see Figure 4). The three requirements for a mountain wave are:

1. Wind flow that is perpendicular to the range, with velocities of 25 knots or more at mountaintop level. It usually will have a core of turbulence and can extend downwind as far as 20 miles from the ridge.

2. A wind profile which shows an increase in wind velocity with altitude near the mountaintop level, and a strong steady flow at higher levels to the tropopause.

3. An inversion or stable layer somewhere below 14,000 feet. Intensity of any given wave is determined in part by:
   a. mountain height;
   b. degree of slope;
   c. strength of wind flow.

The degree of turbulence is a function of:
   a. wind velocity;

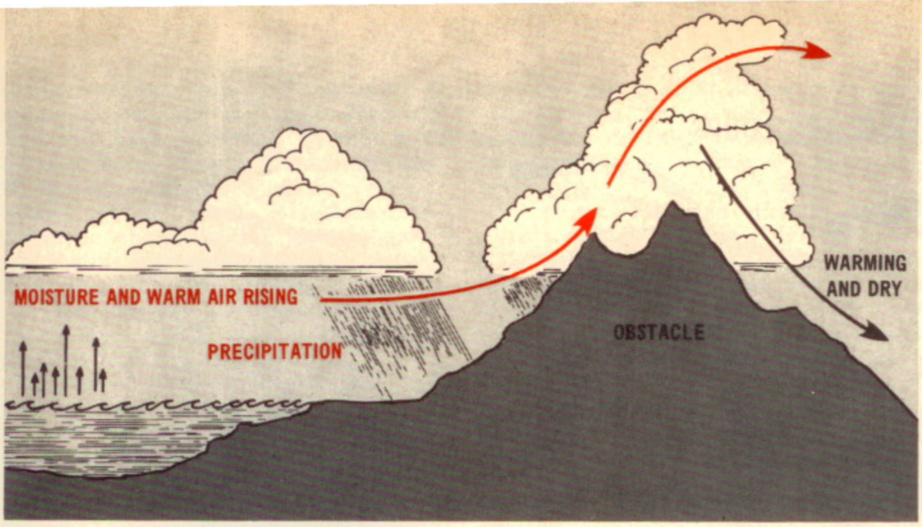


Figure 1. As air flows over a ridge, the air is lifted. Moisture in the air mass may form clouds and create precipitation.

contiguous with the base of the lenticular clouds above 20,000 feet. Sometimes they are small in size and may form and dissipate while being observed.

The cap cloud, or foehnwall, looks like a fur hat sitting on top of the mountain ridge. The major part of the cloud extends upwind, with fingerlike extensions running down the slope on the downwind side of the ridge. Under certain dry air conditions, a mountain wave may be present with no visible cap cloud.

The existence of the mountain wave indicates a probability of turbulence. The type of turbulence will vary from light and hardly noticeable to extreme, where occupants of the airplane may be thrown about and the airplane becomes uncontrollable. A mountain wave usually will have a core of turbulence, and can extend downwind many miles.

b. stability of the air mass;

c. rate of advection of cold air aloft (horizontal flow).

The lenticular cloud is the lens-shaped cloud that is found at high altitudes, normally 25,000 to 40,000 feet. Lenticulars may form in bands or as a single cloud, located above and slightly downwind from the ridge of the mountain. Sometimes a mountain wave may exist without the formation of lenticular clouds. Although the airflow through the cloud is laminar and not turbulent, many times turbulence will be encountered flying under the cloud.

The rotor cloud is well named because of its horizontal rotary motion. The rotary motion is at first difficult for a pilot to see. Once seen, perhaps through the help of a stop-action movie, a pilot can easily identify the rotor cloud. Sometimes referred to as a "horizontal tornado," this cloud can produce updrafts and downdrafts in excess of 5,000 feet per minute. The rotor cloud will be located downwind from the ridge, sometimes in several rows lying parallel to the ridge. The bases may be at or below ridge level, with the tops sometimes

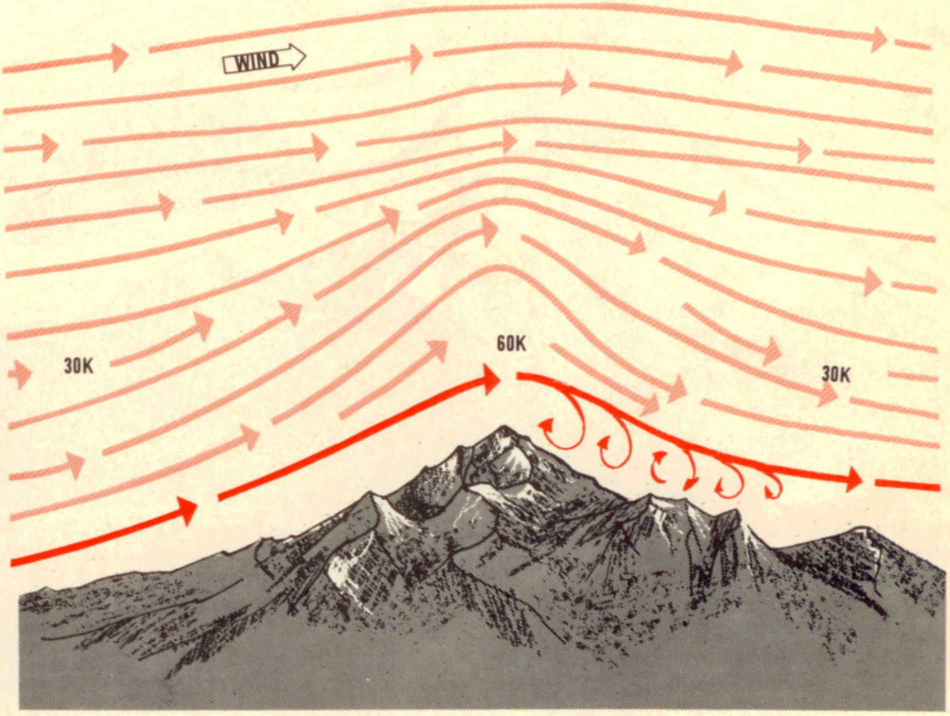


Figure 2. A ridge may cause the "steady-state" wind to double over the ridge.

Figure 3. The shape of the clouds can reflect the stability of the air.

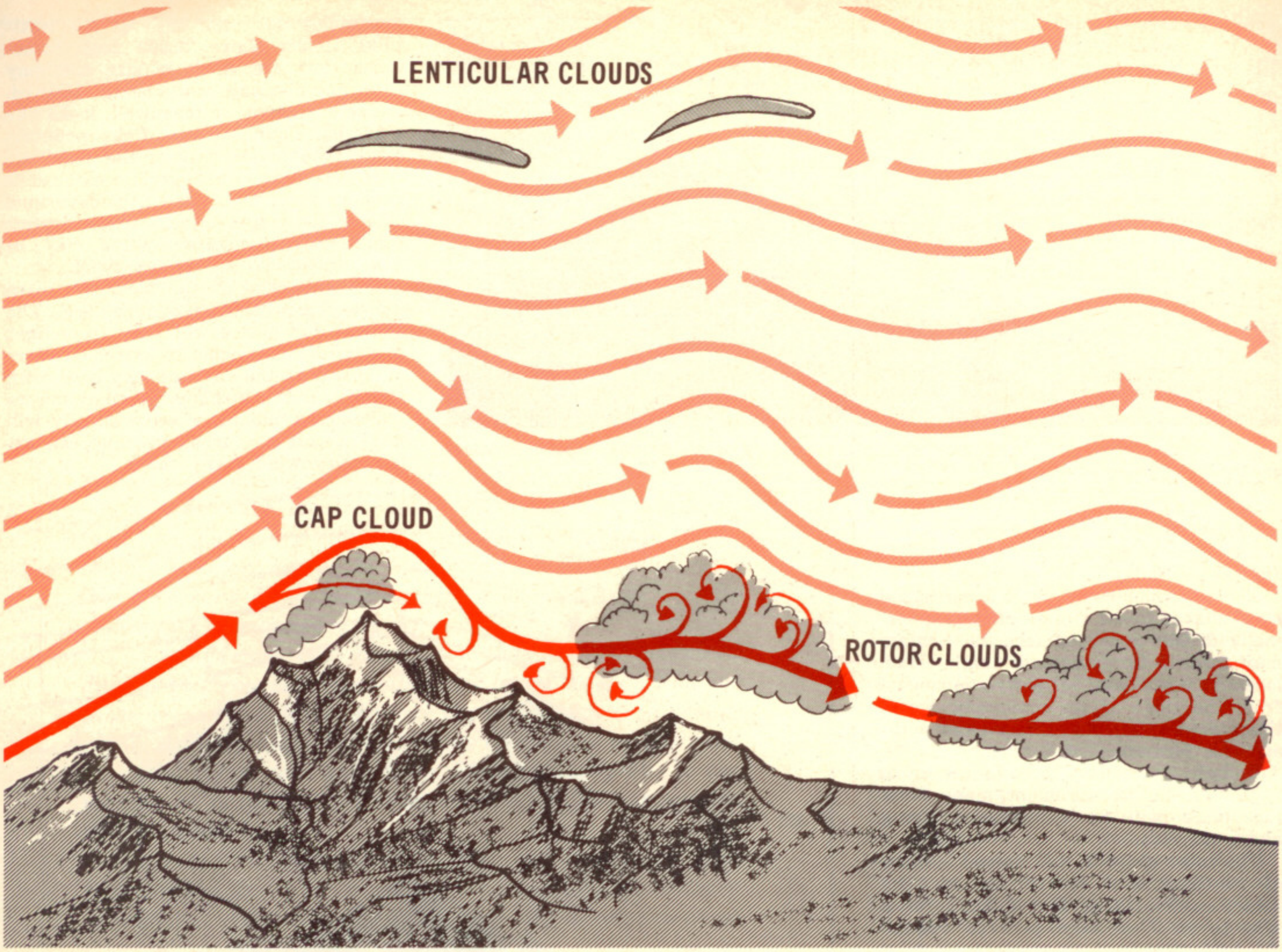


Figure 4. The three visible indications that a pilot may observe in determining the existence of the mountain wave. They are: (1) lenticular cloud (lens-shaped cloud); (2) rotor cloud; (3) cap cloud (foehnwall).

Meteorologists are able to forecast a mountain wave with a high degree of accuracy. In planning a mountain flight, a pilot who is informed by the weather briefer that a "mountain wave" is forecast should know what to expect and plan accordingly.

If a mountain wave condition is forecast or observed, the next question is: What are the pilots reporting? If there are no Pireps available, extra caution should be exercised, and an extra margin of altitude should be maintained. When a mountain wave condition exists, pilots unfamiliar with the area should consult local pilots who are familiar with the passes and the conditions that could conceivably be encountered during the flight. These local pilots can many times make recommendations as to the best routes to be flown and give a realistic assessment of the current conditions. If the aircraft to be flown does not have an extra margin of performance, the flight should not be attempted.

ROUTE PLANNING

The first prerequisite is a thorough study of the terrain along your proposed route. This is necessary for several reasons. The route should be checked to determine the highest and lowest elevations to be encountered, so you can choose an appropriate altitude which will provide adequate terrain clearance (Figure 5). Check the route for particularly rugged terrain so you can avoid it, if possible. Areas where a takeoff or landing will be made should be carefully checked for tall obstructions. Television transmitting towers may extend to altitudes over 1,500 feet above the surrounding terrain. It is essential for you to be aware of their presence and location. Determine whether you will be able to use the radio and navigational aids along the route at the altitudes that you are planning to fly. If good radio navigation signal coverage will not be available, particular attention should be paid to the pilotage aspects of the planned flight. The new sectional charts now being issued will show VFR routes through most of the major mountain passes in the United States. When you are estimating the time en route, consideration should be given to time spent in climbing to the appropriate altitude and to the prolonged operation of the aircraft at high power settings and its relationship to fuel consumption.

Another very important item is the filing of a flight plan. If a flight plan is not filed and an unscheduled landing is made, the initiation of search procedures can be delayed many hours. If circumstances do not permit the filing of a flight plan, be sure to inform someone at your destination or point of departure of your planned operation, so that search procedures can be instituted if necessary. The flight should be planned to place the route adjacent to populated areas and through well-known mountain passes. If accurate, up-to-date weather information is difficult to obtain, a phone call should be made to the destination to get the current weather. Please refer to the appendix at the back of this course manual for a compendium of recommended preflight and land-survival procedures for mountainous areas.

AIRCRAFT HIGH-ALTITUDE PERFORMANCE

When a pilot considers the performance characteristics of his aircraft, he should keep in mind that these figures are dependent on the density altitude that will exist at the time and in the area where he will be flying.

Density altitude is a measure of air density. Under nonstandard conditions, density altitude will differ from the elevation. As air density decreases (air becomes thinner), density altitude increases, and vice versa. Low atmospheric pressure, combined with high temperature and high humidity, results in a decrease in air density and an increase in density altitude. This increase in density altitude affects aircraft performance in the following manner:

1. Engine horsepower decreases (unless it is a turbocharged engine).
2. The propeller loses some of its efficiency, since it will not take as much of a bite out of the thinner air.
3. Takeoff distance is increased, and rate of climb is decreased, because of the loss of engine and propeller efficiency. A higher true airspeed is necessary to obtain the required lift in the thinner air. (As an example: If the density altitude is 8,000 feet at an elevation of 5,000 feet, the aircraft flies and performs as though it were at 8,000 feet.)

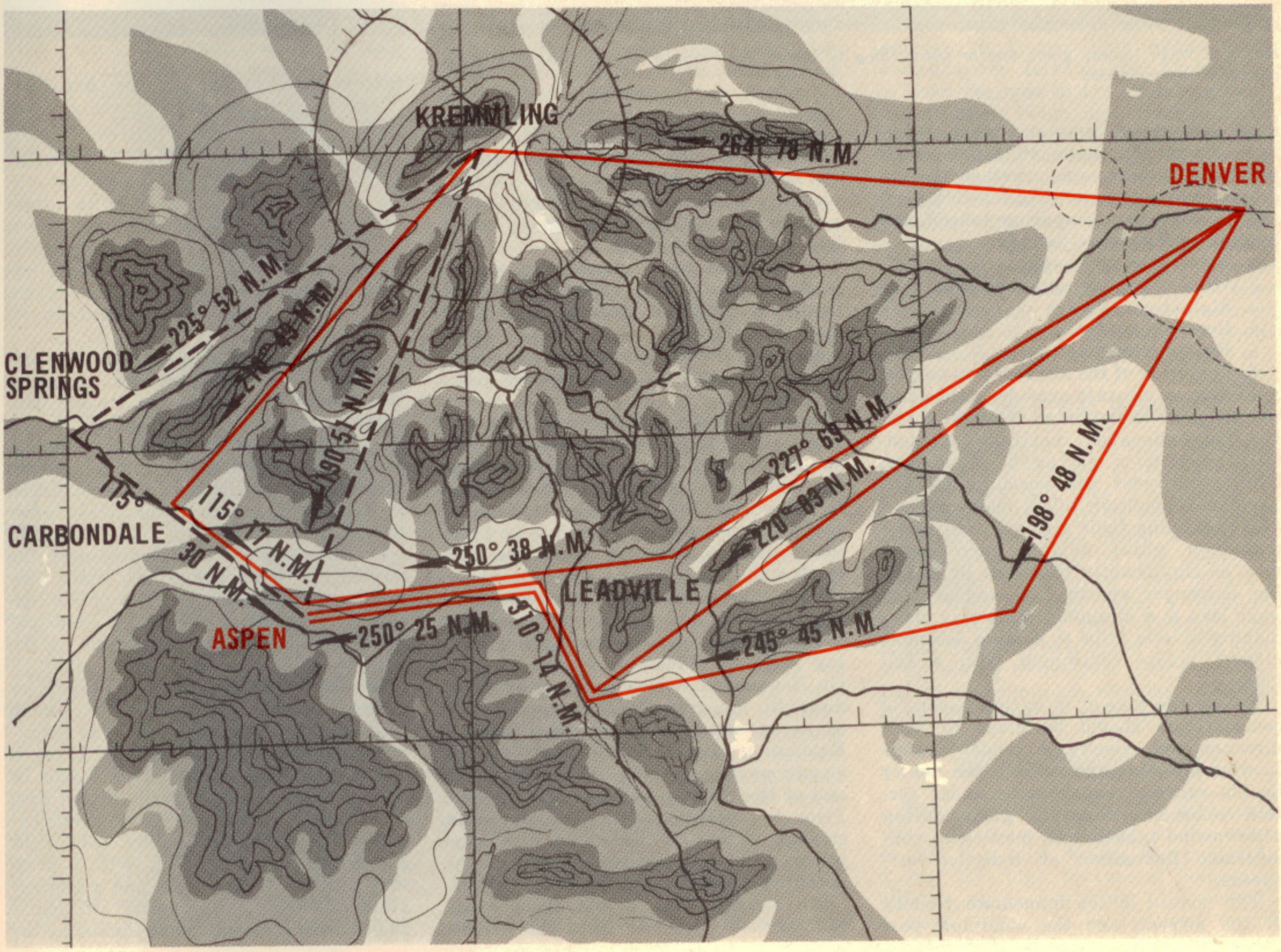
Most pilots do not have occasion to be concerned about the density altitude except when considering takeoff performance. Remember, the density altitude also affects rate of climb, service ceiling, absolute ceiling, cruise speeds, best-rate-of-climb speed, best-angle-of-climb speed, and all aircraft landing parameters.

Density altitude for a given time and place can be determined by first setting the altimeter to 29.92 inches of mercury and reading the pressure altitude directly. The ambient temperature and the pressure altitude are then set into a computer in the true airspeed window. Density altitude is read directly in the density altitude window of the computer. This method of finding the density altitude is a simple computer problem with which all pilots are familiar. There are several commercial sources for density altitude computers, called "Denalt Computers." If a computer is not readily available, the pilot may request tower ground control to supply him with the density altitude, if he is operating from a controlled airport. Most airports throughout the mountainous areas of the country post a sign which gives the existing density altitude and is updated quite often.

The relative humidity is another factor to be considered when computing aircraft performance. Contrary to prevailing opinion, moist air is less dense than dry air. Water vapor actually weighs less than dry air—approximately five-eighths as much. Pilots have no convenient way of determining the effect of relative humidity on aircraft performance directly. However, the pilot should know and understand that the difference between the actual reported air temperature and the dewpoint temperature is an indication of how close the air is to saturation. This temperature/dewpoint difference is commonly called the "spread." Relative humidity increases as the differential decreases, and is 100% when the spread is 0 degrees. The pilot should realize that high humidity will cause a decrement of performance and that relatively dry air will give better performance.

Pilots flying light twin-engine aircraft under 6,000 pounds gross weight should always keep in mind that single-engine performance does not have to be guaranteed to meet Federal aviation standards. For example, the average light twin-engine aircraft at gross weight at sea level usually has no better than somewhere in the area of a 100- to 300-foot-per-minute single-engine climb performance. When the aircraft is flown at higher density altitudes, the single-engine climb capability does not exist. If loss of an engine should occur on takeoff in a light twin-engine aircraft at high density altitudes, the only acceptable procedure is a straight-out emergency landing. It is mandatory that in any takeoff situation in a single- or light twin-engine aircraft where any doubt arises as to the aircraft's performance

Figure 5. The recommended routes between Denver and Aspen involve many considerations. Note that none show a direct route.



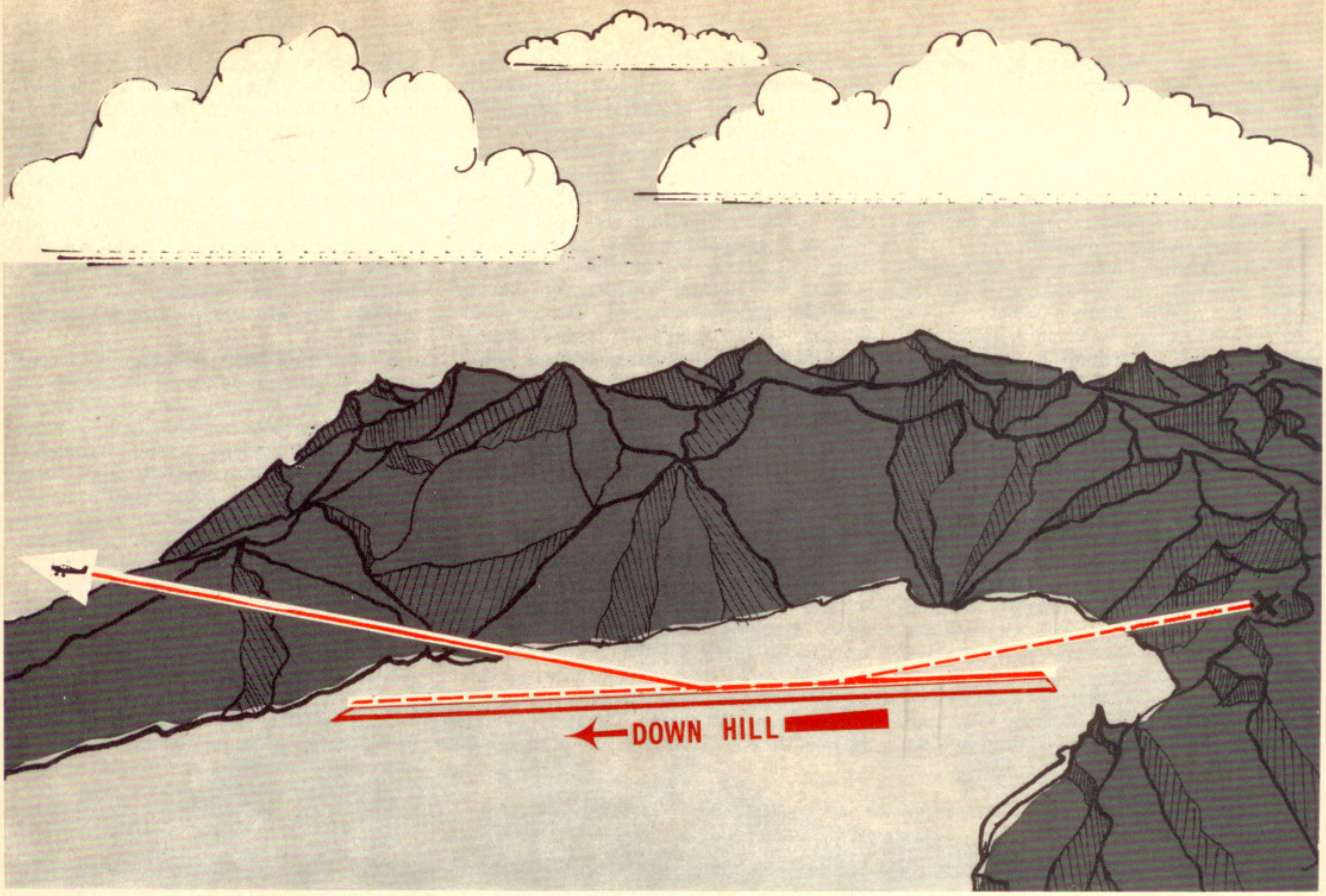


Figure 6. When runway grade and/or surrounding terrain is significant, a downhill takeoff and departure is recommended.

capability at the time and place, reference should be made to the aircraft handbook to determine whether the operation being considered is feasible. Considerations when computing takeoff and landing performance include:

1. Aircraft gross weight.
2. Wind direction and velocity.
3. Stability of the air.
4. Runway surface.
5. Runway gradient.
6. Condition of the aircraft and engine.

Flying an aircraft over designed gross weight is in violation of Federal Aviation Regulations and constitutes a potentially hazardous operation when high density altitudes are encountered. Experienced mountain pilots make a practice of keeping their airplane well under maximum gross weight. Performance may be significantly improved by reducing passenger and/or fuel and/or baggage load to a minimum. This may mean making several trips to a more desirable airport before continuing with a full load.

Before the takeoff is initiated, careful consideration should be given to wind direction and velocity. A sudden change in wind direction and velocity can nearly double runway requirements under certain conditions. Following gusts, during a downwind takeoff roll, may cause considerable fluctuation of indicated airspeeds.

The terrain in the immediate vicinity of the airport, and the wind-flow patterns over that terrain, should be considered. A thunderstorm near the airport or along the departure path is good enough reason to stay on the ground for a while to avoid turbulence, gusty winds, and sudden wind shifts.

A variable when considering takeoff performance is the runway condition. Optimum condition consists of a hard, flat, dry runway. Grass, mud, snow, water, and uneven runway surface all increase the total distance required for a safe takeoff.

Runway grade is a factor at most airports in mountainous country. The grade, or difference in elevation between one end of the runway and the other, can be more than 200 feet. For this reason many airports are considered to be "one-way" airports. In other words, the pilot lands uphill so that the grade helps decelerate the aircraft, as opposed to landing downhill and flaring while gliding downhill, then, once on the ground, braking against downhill rolling inertia. On the takeoff, which is normally made downhill, the grade helps in accelerating to flying speed, as shown in Figure 6. Examining the sectional chart and the elevations will give a clue as to which end of the runway would be the low end. Prior to operations into and out of a strange airport, a discussion with local pilots, as to the best techniques and the potential problems, can be most helpful.

An aircraft that is just about ready for overhaul will not meet the performance specifications in the handbook. Frost, ice, mud, or snow on the airplane will seriously reduce performance. Low tires will add to rolling resistance and takeoff roll.

MOUNTAIN FLIGHT TECHNIQUES

After thoroughly planning and preparing for the flight, careful consideration should be given to the takeoff, with particular regard to the runway conditions, departure and initial climbout path. This consideration should include which route will be best for obstruction or terrain clearance immediately after takeoff, and the best en route course to take advantage of the airflow over the terrain, to gain additional climb performance. For example, you might decide to take off downhill and climb out down a valley on the right side, if the wind were blowing from left to right.

At some airports, the local pilots, or notices in the Airman's Information Manual, will recommend one-way operations, even though the runway grade is not a significant factor. This would be caused by the terrain grade in the area immediately around the airport. For example, the airport at Granby, Colo., is at an elevation of 8,203 feet. With a pressure altitude of 8,500 feet and a temperature of +20°C, the density altitude is 11,000 feet. If the airplane climbs at the rate of 700 feet per minute at sea level, at this density altitude, the climb performance is reduced to 140 feet per minute. Assume that a takeoff from Granby Airport is made to the east, ignoring the sign on the hangar wall recommending that all takeoffs be made to the west. If our ground speed upon departure is 80 miles per hour, by the time the airplane is three miles from the airport, the airplane will be 315 feet above the airport elevation. However, the terrain rises 800 feet within that three miles. Also, an easterly wind would be a downslope wind which would cause a downdraft.

If a takeoff is made to the west, the runway grade will help you accelerate for a shorter takeoff roll. Once airborne, it won't be necessary to climb at all, because of the descending terrain.

RUNUP PREPARATION

It is very important to lean the mixture for maximum power before takeoff. The best way to lean the mixture is to use an EGT gauge (exhaust gas temperature gauge). When using the EGT, the mixture must be leaned at max power. Lean the mixture, using the gauge, until peak temperature is reached. Then enrich the mixture until the EGT has cooled 75°F. If an EGT gauge is not installed on a noninjected engine without a pressure carburetor, the mixture may be adjusted at full throttle by leaning until the r.p.m. peaks and begins to drop. Then enrich the mixture as far as possible and still maintain peak r.p.m.

Many fuel-injected engines have a fuel flowmeter that is calibrated to show proper mixture settings for various altitudes. If the fuel-flow gauge is properly calibrated, lean the mixture to the proper altitude setting. Another method is to establish takeoff power at the specific airport elevation while in flight, and lean, then determine the mixture position at that point and mark or note the mixture-control setting.

TAKEOFF TECHNIQUE

A margin over the computed takeoff distance should be allowed. If the pilot computes the landing distance, then that distance can be subtracted from the other end of the runway. Then the pilot will know how far the takeoff roll can go and still leave room to stop, in the event the decision is made to abort the takeoff. As a general rule, if the aircraft has not achieved 70% of liftoff speed at the decision point, the takeoff should be aborted.

Remember that the takeoff run at high density altitudes will be longer because of the reduced engine power available, loss of propeller efficiency, and the need for the aircraft to accelerate to much higher true airspeeds prior to liftoff. Pilots should resist the temptation to attempt to lift off prematurely or to over-rotate and raise the nose to a high angle of attack. If the takeoff is being made downwind, remember that in gusty downwind conditions, overtaking wind gusts can cause wide variations in indicated airspeeds and add to the takeoff run.

If a premature rotation is made at a high angle of attack, the aircraft may climb successfully out of the ground effect and then quickly get on the back side of a power-curve situation and not accelerate or climb. Generally speaking, flaps are not recommended for high-altitude takeoffs, going on the assumption that the runway condition is fairly good. If a modified short-field takeoff is made, utilizing flaps at the recommended takeoff setting, immediately after breaking ground the angle of attack should be reduced in ground effect, and the aircraft allowed to accelerate, while the flaps are cautiously retracted. The best-rate-of-climb/best-angle airspeed should then be obtained for the climbout.

Experienced pilots who have flown to any extent from high-altitude airports with concurrent high density altitude conditions will gather in hangars, airport coffee shops, and other appropriate gathering places and discuss that "close one" they experienced on a takeoff at some nameless airport where the lack of performance they encountered was not really justified by the existing meteorological conditions. Inevitably, the term "bad air" arises. Is "bad air" myth or fact? Engineers and meteorologists are unanimous in denying the existence of a phenomenon known as "bad air." Pilots are equally adamant in their insistence that it does exist. Nearly any grizzled mountain pilot will recall without hesitation instances when he has fallen victim to its treachery. Without taking sides in the controversy, let us discuss its observable effects and perhaps a solution.

When your airplane lifts off with a nice healthy feel, in about the advertised distance, and you suddenly realize it's taking you way past the end of the runway to gather some semblance of normal climb speed, and enough altitude to get you off a first-name basis with the pine trees or sagebrush, then, brother, you're in the stuff, no matter what is it called. Butte, Mont., Cody, Wyo., and Prescott, Ariz., are a few of the many places where you can expect it any time the wind is over 20 knots. It doesn't always wait for a windy day to show up. It has made its presence felt on a lovely summer day when the windsock showed only an occasional swing in one direction or another from a vagrant heat swirl.

The only real weapon against this enemy is speed. If you have to stay in ground effect to get it, do so. You are far better off clearing the trees by five feet, with an extra 20 or 30 miles per hour, than by 100 feet and slow airspeed. If sink is encountered and contact with the ground appears imminent, you can begin decelerating to your best-rate- or best-angle-of-climb speed, and the extra speed will help to minimize the rate of descent or, hopefully, help to establish a climb. Do not allow the airspeed to fall below the best-angle-of-climb speed.

CLIMBOUT TECHNIQUE

The first consideration in the climbout is maintaining terrain clearance and the best-angle- or best-rate-of-climb speed. If this is assured, then it may be possible to get help from the updrafts to improve climb performance, or at least to avoid turbulent or downdraft areas. Often, at mountain airports, the usual traffic pattern is ignored and a pattern is flown that is favorable to the terrain. Conditions may require that considerable time be devoted to obtaining adequate altitude before heading in the direction of the intended flight. While climbing out, the pilot should attempt to assess the apparent stability of the air. If the air is very unstable, with considerable turbulence and downdrafts, the decision might be made to return to the airport and wait for improving conditions, or at least to provide some extra margin of altitude when clearing the terrain. When experiencing turbulence, sharp updrafts or downdrafts, the pilot should maintain attitude control and accept the momentary fluctuations of airspeed and altitude.

The owner's manual should be consulted for turbulent-air penetration speeds. If that information is not available, the design maneuvering speed may be used. For a given degree of turbulence, a heavily loaded airplane will give a smoother ride than a lightly loaded one.

It should be realized when flying in mountainous terrain that visual cues as to the true horizon are not as definitive as when flying in flat country. When flying toward higher terrain, there is a tendency to fly nose-high. When flying toward lower terrain, the tendency is to lower the nose and, as a consequence, lose altitude. When making approaches in mountainous terrain, particularly during turbulent conditions, monitor the airspeed quite frequently to ensure maintenance of safe approach airspeeds. Remember the basic reference for safe airspeeds is the indicated airspeed.

The most important rule to remember is to always maintain a position from which a turn can be made to fly downhill, in the event of inadequate terrain clearance, downdrafts, or power loss.

EN ROUTE FLIGHT TECHNIQUES

By being aware of the basic principles of airflow over terrain, a pilot can select a route that will give a minimum of turbulence or downdrafts and the maximum assistance from updrafts. The airplane service ceiling, or the occupant's requirement for oxygen, may dictate a route that deviates from a straight-line, point-to-point flight. Consideration should also be given again at this point to the ability to navigate with radio aids, and to the minimum reception altitudes along the route of the flight.

RIDGE AND CANYON FLYING

When crossing a ridge, the flight path should be at a 45° angle to the ridge, so that if a pilot decides he can't make it over the ridge, because of inadequate altitude or encountering a downdraft, a lesser turn will be required to get

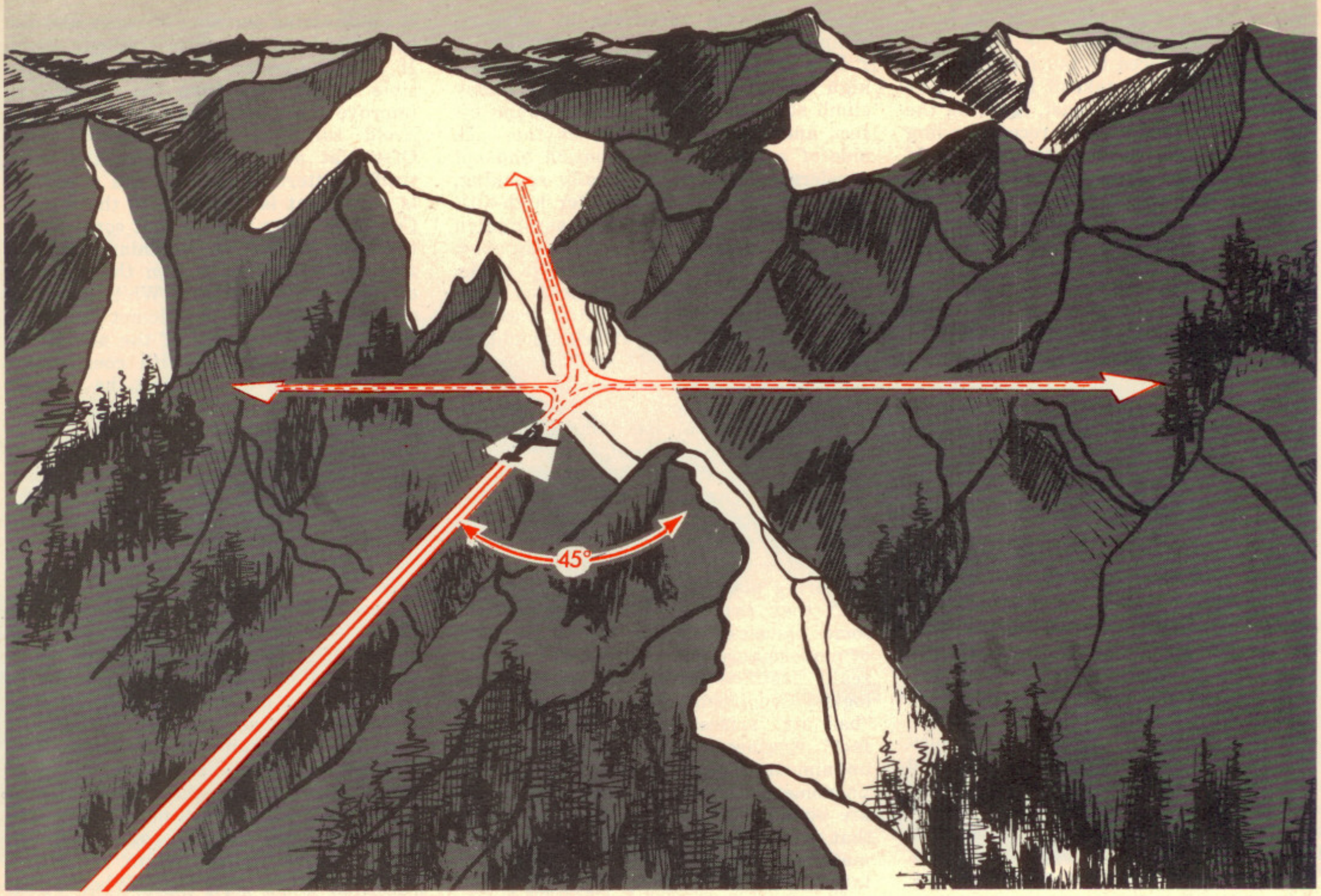


Figure 7. A ridge should be crossed at a 45° angle.

headed downhill again, as seen in Figure 7. As a ridge is approached, if more and more of the terrain beyond the ridge can be seen, the airplane will clear the ridge. Conversely, if less and less of the terrain behind the ridge can be seen, the airplane will not clear the ridge.

The determination of a safe altitude margin over a ridge varies with the existing conditions. If the winds aloft are light and the air is stable, sometimes as little as 500 feet is an adequate margin. However, if the winds are over 20 knots and the air is unstable, or a mountain wave condition exists, an adequate margin might be more than 3,000 feet. When the aircraft is flying parallel to a ridge, the upwind side of the ridge will provide smooth air and updrafts that will add to the rate of climb or airspeed.

At all times, the pilot should be in a position to turn and fly downhill, in the event terrain clearance becomes questionable. When flying through a valley or canyon, the pilot should fly to one side, preferably the side that has the air flowing upslope (see Figure 8). If it becomes necessary to make a 180° turn, the pilot will have more area in which to turn, and he will be turning toward lower terrain. If the pilot were to fly up the middle and then find it necessary to make a 180° turn, he would only have half the canyon to turn in, and the turn would be toward higher terrain. The experienced mountain pilot is always familiar with the turning radius of the specific airplane he is flying and is aware that the turning radius is increased by higher true airspeeds at altitude. Remember to maintain airspeed in downdrafts, and remember that by putting the aircraft nose down and speeding up, the time spent in the downdraft is decreased. Some canyons and valleys are so narrow that they are not safe to fly in. Box canyons can trap the unwary pilot. If the weather is marginal, never fly through a canyon. Powerlines and cables strung across valleys or canyons are extremely difficult to see. Again, this is a good facet to dis-

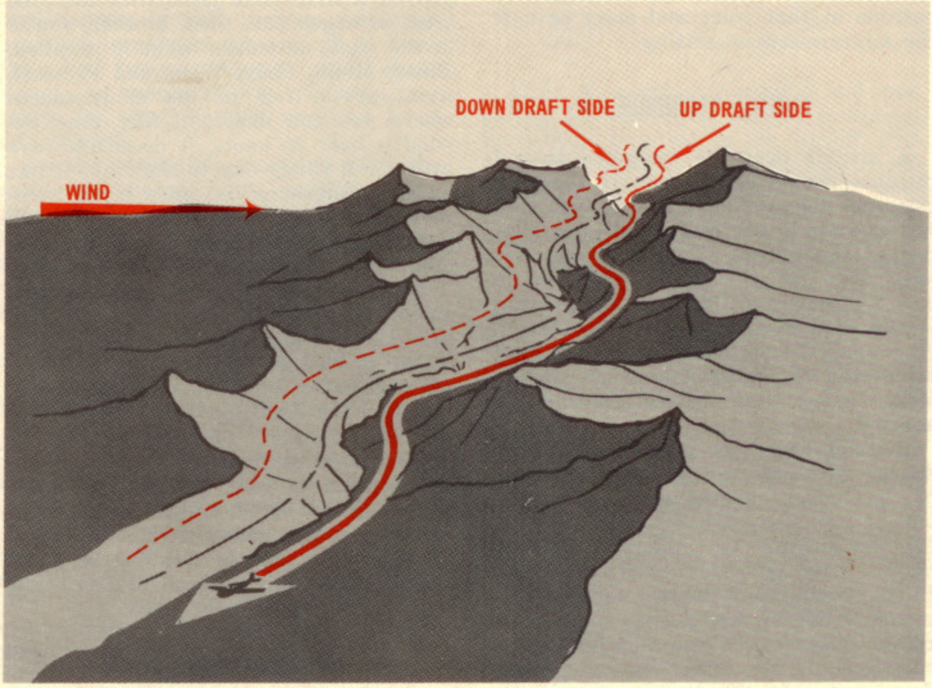


Figure 8. When one flies through a valley or canyon, the best path is on the updraft side. If low-level flight is necessary, fly through the valley or canyon from high end to low end.

cuss with local area pilots prior to attempting the operation. Flying at low level and over rugged terrain can be done safely in some cases if one is familiar with the area, and if optimum conditions exist.

EMERGENCY LANDING

If an engine failure or other emergency occurs, requiring an emergency landing or ditching, the first step is to turn downhill immediately. Begin looking for valleys and meadows or other favorable landing areas. When the choice is made, the approach pattern should be set up to land uphill. Contact with the ground should be made with flying speed. Do not try to stall out at altitude or "pancake" in. Minimizing vertical speed is important. Attempting to minimize forward speed will result in both a high vertical and a high forward impact.

THE DESCENT

The primary concern when descending in rugged terrain is to avoid speed in excess of maneuvering speed, in the event turbulence is encountered.

HIGH-ALTITUDE LANDING APPROACHES

An unfamiliar mountain airport should always be flown over at altitude to check for runway layout, wind direction and velocity, and traffic and terrain considerations in the approach path. If a low pass over the runway is necessary, and the grade or surrounding terrain is significant, the pass should be made from high toward low terrain. A low pass will allow an assessment, under controlled conditions, of the severity of the turbulence and downdrafts that might be encountered during the approach for landing. Be sure that the aircraft engine is leaned to the best setting for the altitude at which the aircraft will be landed. If runway grade or surrounding terrain is significant, a full-stop landing should be made uphill (see Figure 9). If a touch-and-go landing is to be made, the landing would normally be made downhill. The approach path may offer no resemblance to a standard traffic pattern (see Figure 10). After checking the airport, the pilot may fly down the canyon or a valley, let down, and fly back, prepared to land. There are a few airports in rugged terrain that, because of the upslope in the landing direction, commit a pilot to land on the first approach, and a successful aborted approach is improbable.

A common mistake make by the inexperienced pilot when landing at high-altitude fields is the adding on of excessive airspeed because of factors ranging from gusts to five knots, to the wife and kiddies. Airplane wings recognize indicated airspeeds, and they stall at the same indicated airspeed, regardless of altitude. Approaches at altitude should be flown at 1.3 VSO, in the same manner that they are flown at the lower altitudes. If the air is gusty, a very small increment of airspeed may be added. Again, remember that the approach is flown at the normal approach speeds for the aircraft, but keep in mind that the true airspeed and ground speed is much higher, and this leads, at the normal descent rate of 500 feet per minute, to a much flatter glideslope. In other words, you cover more ground for a given time. The use of full flaps is recommended, keeping in mind that if a go-around is attempted, you should retract the flaps in order to achieve the best-rate-of-climb or best-angle-of-climb speed in the shortest period of time. When one lands uphill, with significant uphill slopes, the normal landing flare has to be exaggerated because the aircraft is not only leveled to a level flight attitude, but beyond, to make contact with the upslope at the proper angle.

Be aware, during the landing approach, that the uneven terrain surrounding the airport gives a very poor visual cue to the pilot as to actual aircraft attitude. The airspeed will have to

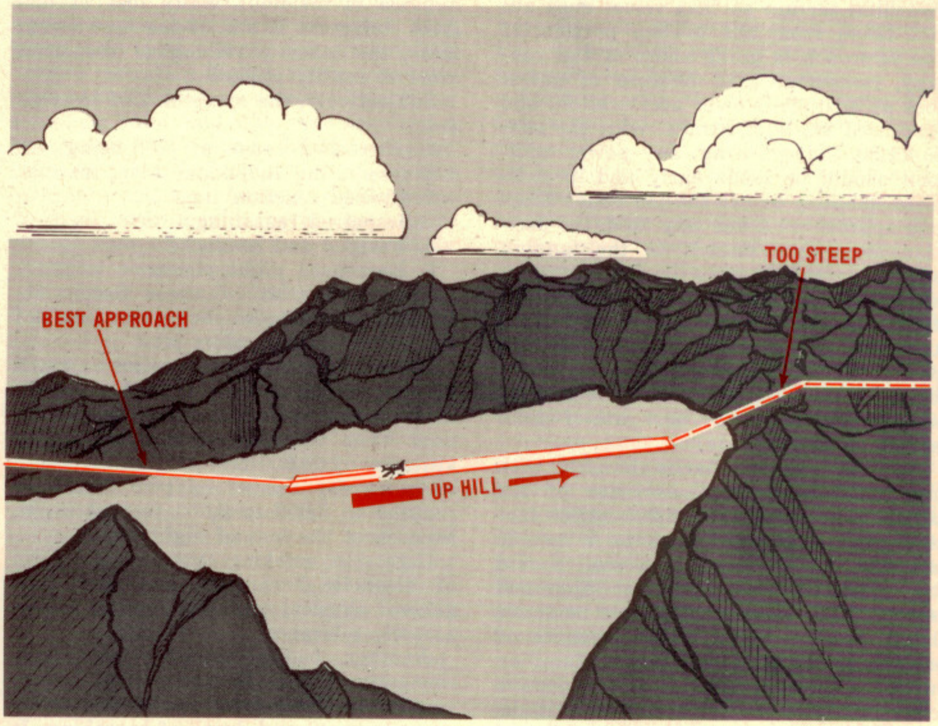


Figure 9. If a landing is to be made where runway grade and/or surrounding terrain is significant, the approach and landing should be uphill.

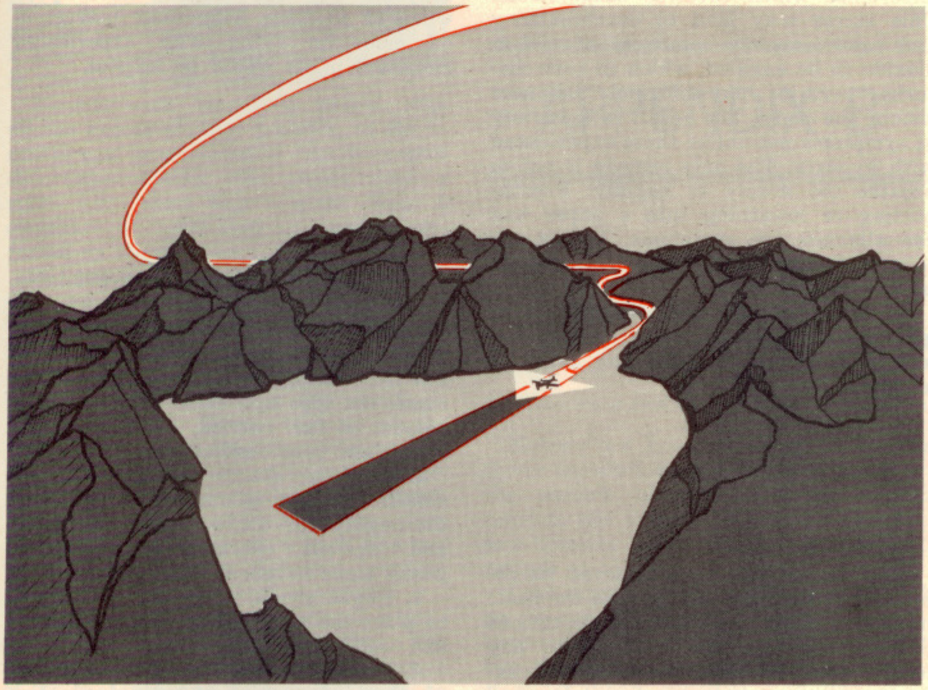


Figure 10. The landing approach path may be determined by the terrain and may bear little or no resemblance to the standard pattern.

be monitored during the complete approach. When one approaches an up-slope strip, a visual illusion occurs during the final approach: the pilot feels that he is higher than he really is, relative to the intended touchdown point. He also thinks he is more nose-down than he really is. To compensate, most pilots fly lower and slower than necessary. The visual illusion is caused by the fact that the runway slants up, but the pilot's eye interprets it as being level. Again, during the approach, particular attention should be paid to indicated airspeed, and a wide scan should be made of the whole surrounding terrain so that visual cues are not taken from one uneven portion. If the approach is going short of the runway, remember that, because of power loss at altitude, slower acceleration, and increased angle of attack, with the concomitant induced drag, any power addition should be made early and in sufficient quantity to get the job done. When one approaches a one-way field, the decision to commit oneself to the landing should be made early in the approach sequence. Any go-arounds should be initiated as soon as the need is apparent; then one should go immediately to full power, retract the wheels, and cautiously bring up the flaps as the aircraft accelerates to best-angle- or best-rate-of-climb speed, as appropriate.

A pilot can familiarize himself with the acceleration characteristics of his airplane by climbing to 8,000–10,000 feet and practicing approaches to a specific altitude. An approach to a stall should be practiced, using normal approach speeds. Then go-arounds should be simulated, practicing the whole sequence of events, so the pilot will become familiar with the slow acceleration and subjective characteristics of the aircraft at altitude.

If the runway lies on a plateau, or if the terrain on the approach to the runway is lower than the runway, downdrafts may be experienced while the aircraft is on short final. Pilots should be alert and anticipate this problem. Sometimes a steeper-than-normal approach slope is indicated.

PHYSIOLOGICAL CONSIDERATIONS

EFFECTS OF ALTITUDE ON THE BODY

It is a generally accepted precept that taking the body to altitudes greater than 10,000 feet causes a deterioration of psychological/physiological performance. Since mountain flying, by necessity, requires flight operations at altitudes considerably above sea level, a basic review of the effects of exposure to altitude is in order.

Man can acclimatize to altitudes as high as 18,000–20,000 feet. An example of this is the Andean natives living and usefully working at these altitudes. Simply described, the body can adjust to reduced barometric pressures (increased altitude) by certain physiological changes. The ability of the heart to pump larger volumes of blood is increased, the oxygen-carrying capacity of the blood is slightly increased, and the individual breathes at a faster rate. This attempt by the body to adjust to altitude normally requires about six to eight weeks. The acclimatization, when achieved, is soon lost upon the individual's return to sea level.

Individual altitude tolerance varies from day to day. The person who makes the statement, "Altitude never bothers me," is sadly misinformed. The onset of hypoxia is insidious. Since loss of discreet judgment is one of the first symptoms, the other physiological responses are not readily apparent.

Subjectively, the symptoms of hypoxia are:

1. Increased sense of well-being, or, conversely, the individual feels terrible.
2. Slowed reaction time.
3. Impaired reasoning.
4. Fatigue and headache.
5. Decreased night vision.

The end result of these bodily responses to altitude obviously does not add up to a sharp, alert pilot.

Since mountain flying requires an extra margin of alertness, it is highly recommended that supplementary oxygen be used when the aircraft is operating at altitudes of 10,000 feet or greater. These altitudes for use of oxygen should be reduced to 5,000 to 8,000 feet at night, because of the loss of night vision.

Cigarette smoking, the recent intake of alcoholic beverages, age, and poor general physical condition further reduce altitude tolerance.

Another bodily response sometimes encountered when flying is called hyperventilation. This condition is caused by excessive rate and depth of breathing. It is caused 99.9% of the time by psychological stress. Mountain flying is a new experience which involves some stress. This stress may lead to overbreathing and cause excessive amounts of carbon dioxide to be exhaled, which in turn disturbs certain physiological balances within the body. The result is a variety of symptoms not unlike those experienced with hypoxia. The only remedy is not to breathe too deeply or rapidly. Breath-holding or breathing into a paper bag can alleviate the symptoms. Do not try to compensate for the effect of altitude by overbreathing.

In summary, use supplementary oxygen above 10,000 feet during the day and in the 5,000- to 8,000-foot altitudes at night.

SKILLS AND LIMITATIONS

This course will have achieved its objectives if the pilot has learned the basic mountain flying skills and his limitations in applying these skills. As with any newly acquired skill, practice and experience are vital to maintain and broaden that capability.

A truism about mountain flying exists which bears repeating: Meteorological conditions—wind, weather, and turbulence—are constantly changing. The old hand, wise to the ways of nature's whims, expects the worst, allows plenty of extra margin, and is pleased if conditions are not as bad as he anticipated.

The basic tenet of mountain flying should always be borne in mind: **"ALWAYS REMAIN IN A POSITION THAT WILL ALLOW YOU TO TURN AND FLY DOWNHILL."**

APPENDIX A

DO'S AND DON'TS ON MOUNTAIN FLYING

These Do's and Don'ts were suggested by the oldest and most experienced mountain pilots in the Rocky Mountain area. It is possible to fly our mountain terrain of 12,000 feet or higher with light airplanes by using a soaring technique, provided the weather is good and the wind is not higher than 35 miles per hour. However, high-performance aircraft, preferably multi-engine, will experience little difficulty under reasonably favorable weather conditions.

It is also recommended that flights be planned for early morning or late afternoon, as heavy turbulence is often encountered in early afternoon, especially in the summer. Attempt flight with as little weight as possible. It is suggested that you ship heavy luggage, or make the flight solo the first time. Stay out of canyons. Fly the ridges; know your winds at all times. Some dual instruction on mountain flying with experienced mountain pilots would be helpful.

GENERAL PREFLIGHT ADVICE

1. Where FAA facilities are available, file a flight plan. Where they are not available, fill in the "Cross-Country Log" which mountain-state operators maintain. The information filed should include your name, the type and color of your plane, amount of fuel carried, route to be followed, and your destination.
2. Sectional charts are excellent for details of air pilotage. Study them thoroughly for altitude over the route and obvious checkpoints. Prominent peaks make excellent checkpoints.
3. Flight should generally be planned to place the route along populated areas and well-known mountain passes.
4. Don't hesitate to telephone for weather information at your destination in case of doubt.

5. Don't forget to check your weather. It is very important in mountain flying—especially "winds aloft," assuming weather is good.

6. Expect winds above 10,000 feet to be prevailing westerlies in mountain states.

7. Don't fly when the winds aloft at your proposed altitude are above 35 miles per hour. Expect winds to be of much greater velocity over mountain passes than reported a few miles' distance away from them. This is very important to remember.

8. Don't fly in doubtful or bad weather, thunderstorms in summer, and snow storms with high winds in colder weather.

9. FROST, ICE OR SNOW adhering to aircraft surfaces interferes with lift and should be removed before you attempt takeoff.

10. Sufficient altitude should be maintained en route to permit gliding to a reasonably safe landing area.

FLIGHT TECHNIQUE ADVICE

11. Know your wind direction at all times and compare it to water as it flows up, over, and down the mountain ranges. Watch for abrupt changes of wind direction and velocity in mountain areas.

12. Realize that the actual horizon is near the base of the mountain. The mistake of using summits of the peaks as a horizon will result in the aircraft's being placed in an attitude of constant climb.

13. If your aircraft is radio equipped, be sure to tune in the nearest FSS station for current weather reports along your proposed route.

14. Don't be worried if your plane takes a much longer time to take off and the climb angle is much less than at a lower altitude. Remember, the engine is developing less horsepower.

15. Approach mountain passes with all the excess altitude possible, as downdrafts can be expected on the downwind side. Approaching the passes over a ridge will lessen this a great deal. A clearance of 2,000 feet or more is preferred on windy days.

16. Approach passes and ridges at a 45° angle so that you will be able to turn approximately 90° into a valley or lower terrain if you encounter severe downdrafts.

17. If you encounter a downdraft, do not be alarmed. Keep the nose of the plane down so as to maintain a normal airspeed. If you have sufficient altitude, continue through it, as each downdraft is normally followed by a compensating updraft. If in doubt, turn back and try crossing again at a different location, and if possible at a higher altitude.

18. Don't fly up the middle of a canyon at any time. It is better to fly on the downwind side in order to take advantage of up-currents and to provide room to execute a turn-around. Don't be suckered into a blind canyon while climbing out of a valley.

19. Don't fly any closer than necessary to abrupt changes of terrain, such as cliffs or rugged areas. Very dangerous turbulence can be expected, especially with high winds.

LET SOMEONE KNOW, AT YOUR POINT OF TAKEOFF, THE ROUTE YOU INTEND TO FLY, WHEN YOU WILL TAKE OFF, AND YOUR ETA AT DESTINATION.

It should be pointed out that private pilots east of the Rocky Mountains have had a healthy respect for mountain flying. Their regard for mountain-pilot qualifications has been so great that many of them have not undertaken rugged mountain flights. Pilots who have learned to fly from mountain airports, on the other hand, and who have acquired a knowledge of mountain flying technique, have no hesitation about flying over the mountain country. Among the pleasures of flying over mountains are an unsurpassed view of ranges and a constantly changing scenic appeal.

Mountain resorts, which offer hunting, fishing, skiing, scenic attractions, and relaxation, are generally accessible by air. Mountain pilots point out that turbulence over the ranges rarely gets as violent as the thunderstorms over western Kansas in midsummer.

Successful mountain flying requires an aircraft (high climb performance advisable) in first-class condition, coupled with common sense and good judgment on the part of the pilot. Plenty of power and altitude are excellent safety factors. Don't let "false pride" push you beyond your limitations. Know your aircraft. If trouble is encountered, turn around and/or proceed to the nearest airport. Mountain pilots stand ready to offer their counsel and the benefit of their knowledge and experience to those who will ask for it.

APPENDIX B

DOWN IS NOT OUT

Two-Pound Packet Is Home Away From Home

Reprinted From FAA Aviation News, February 1966

Nobody we know is going to have a flying accident, especially not you, but on the outside chance something should happen, the difference between survival and disaster might weigh less than two pounds.

Look around your airplane and what do you see in the way of survival equipment: that can of fruit juice you bought two years ago that was going to be the start of your survival kit? Throw it away, it's probably worthless now. What else? The fishing line and hook stashed away in the envelope near the wing root? You gave that to the kid who washed the plane two years ago.

Nothing else? No pocket knife? No matches—oh, you don't smoke?

With the rapidly growing acceptance of air travel, especially in general aviation aircraft, pilots have paid diminishing attention to personal survival in the event of a forced landing where rescue might be delayed for days.

Yet, individual survival kits can be assembled at very little cost from readily available off-the-shelf items you can pick up in any supermarket. The principal ingredient in any survival kit is action: **Put it together now!** Planned kits, to be assembled later, are useless.

Starting with the first aid items, the two-pound kit will include bandaids, a roll of half-inch adhesive tape, a pack of X-acto knife blades, a tube of antiseptic ointment for burns and lacerations, aspirin, water purification tablets, ammonia inhalers and triangle bandages.

This is a minimum of first aid supplies. Other items may be added, but keep the emphasis on lightness and storability.

Now for food. Supermarket shelves are crammed with a wide variety of concentrated soup mixes, bouillon cubes (chicken and beef), dehydrated coffee and milk, sugar, salt, hard candy and vitamin capsules. Pack an assortment of each of these in a compact cube wrapped in several layers of heavy-duty aluminum foil. If needed, the foil later can be formed into cooking utensils. Don't forget the necessary water, carried in a plastic container.

PEMMICAN SUPREME

Pemmican, an old Indian favorite in concentrated food, and still a staple where weight and space are important considerations, might make a valuable addition to your personal survival kit. Here is the way Capt. Daniel H. Seal and S/Sgt. Dorman K. Roberts, of the School of Aerospace Medicine, Brooks AFB, Tex., make their new, improved, tastier version, as reported in Airman Magazine.

Take equal portions of hickory-smoked, crisp, dried beef and pecans, plus one-half portion of crisp, dried pitted dates. Put these through an ordinary food chopper separately and then mix together and grind the whole batch again.

Pack in bars of approximately three ounces; cover first with two layers of thin plastic sandwich wrap, then a double thickness of heavyweight aluminum foil. If the bar develops mold spots after storage, scrape them away. The mold is harmless, though unappetizing in appearance.

Into the cockpit kit should go equipment for living off the land. Some 50 feet of high-strength fishing line and a half-dozen fish hooks are basic. A gill net is a good addition, and so is a length of light wire from the aircraft for use as a snare for small game.

A scout knife, along with a pocket whetstone, is the single most important tool. You can literally carve a path to survival with it—provided you treat it as a knife and not a pinch bar.

Other desirable items in the kit include a waterproof match container (there are commercial ones available which include compass and striking edge built into the case); waterproof matches; heat tablets; needles; safety pins; a file; a plastic roll-up canteen (gallon size); mirror for signaling; a button compass; and a pen-light flashlight (keep batteries separate, out of flashlight).

Kits can be custom made to suit the terrain where you do most of your flying. Important considerations are storability, weight and compactness. Resist the temptation to turn what should be a very sparse kit into a portable version of a supermarket and sporting goods store.

IF FORCED DOWN, remain in the vicinity of the aircraft—it's bigger than you, more colorful and more likely to be seen from the air. In snowy weather try to keep the wings and horizontal stabilizer clear of snow—the reflective surfaces act as a signal mirror.

The ability to spot downed flyers is the single most difficult problem facing rescuers. And it needn't be. The countryside, in its natural state, tends to be placid and unchanged. The quickest way to attract attention is to change the appearance of the terrain around you. This is relatively easy to do; an "SOS" trampled into the snow, an "X" made with boughs, a smudge fire—all serve to disturb the face of the terrain. The variations are endless.

Frame of mind is a major factor of survival, and this can be preconditioned by planning. If you filed a flight plan, as recommended by the FAA, you can feel confident that you will be missed, and the searchers will have some idea where to look for you.

The will to survive, backed up by a little knowledge and the understanding that survival is hard work, can make the difference between life and death.

The will to live was demonstrated by a man and a woman who survived for 78 days on nothing but water. Their eventual rescue came when searchers spotted a flag they had fashioned from aircraft fabric and tied to a tree. Survival experts rate boredom as one of the most corrosive factors in the will to survive. This can be defeated by leadership—of self and others.

A basic ingredient is "doing things"—making your "camp" even better, even if it means doing tedious things repeatedly, and sticking to a routine where tasks have to be done on a regular, scheduled basis.

Recommended reading is Air Force Manual 64-5, "Survival," available from the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402, for $1.

How To Obtain An AOPA Mountain Flying Course Certificate

When the pilot finishes the AOPA Mountain Flying Course, his instructor should fill out the blank form supplied with course materials and send it to the AOPA Air Safety Foundation, 4650 East-West Highway, Bethesda, Md. 20014. A certificate of completion will then be sent directly to the pilot by the AOPA Air Safety Foundation. For the pilot who desires to continue training, a minimum of four hours of practice should be performed after each course, reviewing and practicing each test and procedure included in the course completed.

References for Further Study

1. **DOT/FAA Advisory Circular 91-15, "Terrain Flying,"** revised 1967. Available from U.S. Government Printing Office, Washington, D.C. 20402. Price, 55 cents.
2. **FAA Advisory Circular 61-23, "Private Pilot's Handbook of Aeronautical Knowledge,"** 1965.
3. **"The Joy of Soaring,"** Soaring Society of America, Box 66071, Los Angeles, Calif. 90066. Newly published training manual. Price $5.75 prepaid.