When your black boxes conk out, or you are in area where navaids are inadequate, landmarks may be indispensable in navigating. Pilotage is fun to many flyers who can correctly interpret terrain signs. Even a road map comes in handy sometimes

Terrain Flying Is Still In Style

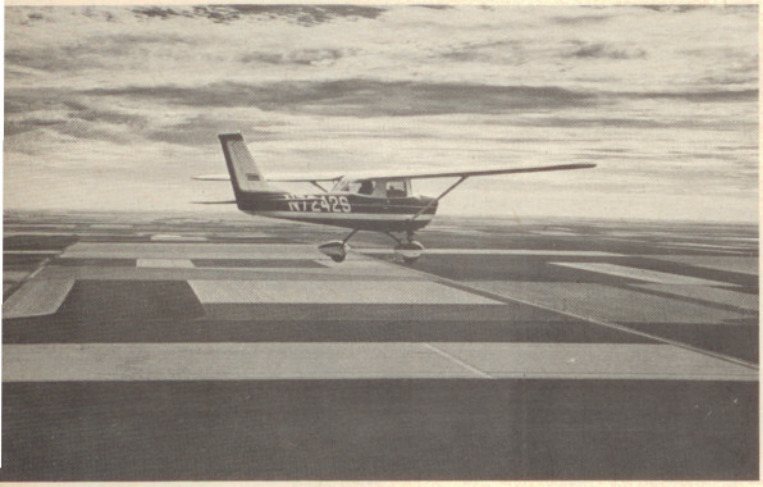
by DON DOWNIE / AOPA 188441

Lakes make some of the best map-reading landmarks. The picture shows a Cherokee flying over Lake Mead, formed by the Hoover Dam on the Colorado river.

EDITOR'S NOTE: *Back in June 1960,* The PILOT *published an article entitled "Terrain Flying," written by regular contributor Don Downie. Since that issue of* The PILOT *was published, AOPA has grown from 84,000 members to its present total of about 150,000. During that same period of time, thousands of copies of this basic article on pilotage have been distributed to AOPA members. Because of the continued requests for this article, we've asked the original reporter, now a little grayer, a few pounds heavier, and perhaps another 1,600 flying hours more knowledgeable, to update "Terrain Flying."*

■■ In these days of rapid change, particularly in the field of aviation, it's really surprising how few modifications have been made in the basic art of terrain flying. Sure, you change the CAA to the FAA and update the Federal Aviation Agency to Federal Aviation Administration, with its new role as part of the Department of Transportation, if you feel so inclined. You change the FAA's old Fourth Region to the Western Region, replace the Airman's Guide with the Airman's Information Manual, and substitute the Denalt computer for the Koch density-altitude chart. Unfortunately, you eliminate reference to WAC (World Aeronautical Charts, with their convenient scale of 1:1,000,000) charts and reserve your comments regarding the new doublesided sectional charts until there are no ladies present.

East-west, north-south section lines of the Great Plains make navigation relatively easy in this area where mountains are few and far between.



A Cessna 150 approaching Banning Pass, in southern California, over a cloud deck. Mt. San Gorgonio (11,502 feet), on the north side of the pass, is a landmark that can be seen for a hundred miles on a clear day.

You don't talk about radio range stations unless you're headed for the back country of Alaska.

But the hard-core basics of terrain flying (Webster calls terrain "a tract of ground immediately under observation") really haven't changed, because the terrain's the same, and the basics of aircraft and meteorology are no different from what they were nine—or 49—years ago.

For the past several months, we've kept a dog-eared copy of the original "Terrain Flying" article in our map case. Whenever we were out in the back country at those small, uncontrolled, isolated, "for fun" airports and there was time for a bit of hangar flying, we've pulled out this report and asked some of the oldtimers to go over it and comment. What have we left out? What's new? What material isn't here that should be passed along to the newcomer?

We picked up a number of specific mistakes made in recent years that have been added to this report. However, there really isn't much new technique in terrain flying. So, if you're an oldtime AOPA member, much of what follows may sound as though you've read it before. You have.

Cross-country flying with a thumb on the map is almost out of style in these days of modern omni stations. The amount of accurate navigational information to be had at the flip of a switch has done much to increase the utility of today's aircraft, and it's getting better all the time. However, pilots are still getting lost, not because of the omni stations, but in spite of them. There are still many areas within the continental limits of these United States that are not covered by omni when a nonpressurized aircraft without oxygen is flying down at that "comfortable level."

So how can any pilot, newcomer or veteran, consider himself fully proficient if he must put complete dependence on electronic navigation? These black boxes have been known to quit, but this is an increasingly rare occurrence. However, when you're forced to fly at low altitudes by bad weather, the results are exactly the same as a complete radio failure (communications and navigation) the first time a hill gets between you and the omni station.

Despite the increasing state-of-the-art in airborne black boxes, ground-based navigation stations for VFR flight are still called *radio aids* and should always be considered as such.

Nature's own signposts are the key to terrain flying. Back in the days before Barry Goldwater (AOPA 19898) entered politics, we were cruising with him in the *Navion* he owned at that time, over the northern part of his home state. "If you can see Mount Humphreys (12,655 feet high), you're never lost in this part of the world," explained Goldwater. "It's usually very clear in this area, and this peak is sometimes visible for 100 miles. As long as the weather is good, how can you get lost here?"

Rivers, lakes, lakebeds, and shoreline indentations make key signposts for the map-reading navigator.

Man-made checkpoints also have their advantages. In the flat country of the Midwest, all the section lines are east-west or north-south. Railroads and superhighways have a certain permanance. Highways are particularly good for nighttime pilotage. The shape of cities stands out at night perhaps even better than in daylight because of the contrast of streetlights and signs. There's a "poor man's omni" at Bakersfield, Calif., for example, where a huge flashing sign of the Rancho Motel is two miles out on the final approach to Meadows Field.

Unless you're doublechecking your navigation by reading the signs on the water towers, the higher you are, the easier it is to navigate, because there are more landmarks to see. This is particularly true at night, when roads and towns stand out brightly, even under a blanket of snow, where they might not be as easy to see in daylight.

If you restrict your flying to on-airways, omni-to-omni hopping, you're going to miss some of the most interesting terrain in this country. You may fly near these hideaway areas, but if you're driving that omni needle, you'll see little detail because of your altitude.

Terrain flying is visual, ground-contact navigation, dependent on highways, railroads, rivers, and mountains. Unless you have a flawless memory and have been over a route many times before, you can't do terrain flying—sometimes called "pilotage"—without current maps. Sectional and local aeronautical charts are fine. Plain, old-fashioned roadmaps from the corner gas station are also excellent, and they'll furnish a wealth of background information about the local area that isn't included in the U.S. Coast and Geodetic Survey charts. Several years ago, four of us took a *Navion* from San Diego to Reading, Pa., with nothing but a Rand McNally book of state highway maps. We did have airways and radio charts aboard, but we never used them.

It always helps to carry current charts. With the present mortality of airports, there's nothing more embarrassing than flying all the way from A to B, only to find out that the airport of your choice is now a booming subdivision.

Part of your preflight planning should include putting all your maps in the proper order and making sure that they're all there. This preplanning saves the wrestling contest of unfolding large maps in small cockpits. When you're forced to use the new doublesided sectional charts, spread them out on the kitchen floor the night before your flight and draw a prominent courseline with a brush pen or a grease pencil that goes from one checkpoint near the edge of the map to the same checkpoint on the other side. More pilots have become "temporarily disoriented," since these new two-faced sectionals came out, than would care to admit it. The predetermined courseline gives a continuity of direction from one side of

Snow sometimes makes landmarks difficult to see. However, Meteor Crater in Arizona stands out even after a snowstorm.

Ski lift up a peak of the San Francisco Mountains north of Flagstaff, Ariz., makes an additional checkpoint for pilotage.

the chart to the other that makes pilotage somewhat more simplified.

Normal map-reading procedure puts the destination toward the nose of the aircraft. Then the pilot can merely fly down a previously marked courseline. A simple "how goes it" list of checkpoints every 10 or 15 minutes will quickly show any unexpected changes in wind direction or velocity.

Naturally, the best way to navigate under any conditions is not to get lost in the first place. This may sound a bit obvious, but a high percentage of lost aircraft are "disoriented" within 10 minutes after takeoff. Once you have wheels in the wells after takeoff, make sure that the railroad or highway you're eyeballing leads toward your destination. If it angles 10° or 20° off course in "almost the right direction," double-check your heading with the magnetic compass, take a look at the deviation card mounted next to the compass, and find out if you have a high crosswind that's drifting you off course. If there's any appreciable difference and things don't check out right, circle back over your airport of departure and take another good look.

Probably each pilot has his favorite area for getting "just a little lost." Unfortunately, the two spots in the country that give me the most trouble are Wichita, Kan., and Lock Haven, Pa. And it just happens that many of the new aircraft I ferry to the West Coast come from these two factory towns. From Wichita, it's a cinch to follow the wrong railroad out of town. From Lock Haven, you're following one of three parallel rivers, and each has a railroad and a highway. Compound these varied situations with an airplane that is brand-new to you, and it's understandable why ferry pilots get lost now and then.

There are two things that make terrain flying relatively simple. One is plenty of fuel. The other is "having been there before." Just as pilots fly around their own "home" airport in Special VFR weather that makes the hair stand right straight up on a visitor, the knowledge of freeway locations, tiny lakes, a county fairground, or a well-lit motel sign makes it a relatively routine matter for the pilot who is near home. Here, of course, should be added the for-real caution to make sure that your weather remains at least Special VFR unless you're fully instrument-qualified and well familiar with the aircraft you're flying.

There are two basic types of terrain flying: (1) over the "flats," and (2) in the mountains. Each takes its own type of technique and know-how. "Flatland" navigation is the less spectacular of the two, but can lull a pilot into false security. Many pilots write down the number of minutes after the hour when they pass over a checkpoint that they're absolutely sure about. Then, if there's a doubt later, they can recheck from the last known spot and draw an arc on the map equal to the number of minutes in the air past that point. You should be somewhere inside that arc.

Most pilots who become lost on a flat-country trip do so because they're "wishful thinking" that they're making better progress than they are. Almost always, a pilot who is lost and nearly on course is some distance short of his estimated position. Headwinds; lower-than-normal cruising speeds, because of weight or optimistic "optimum" performance; clear nights where faraway lights look close; even forgetting to pull up the wheels on a retractable-gear aircraft can put a pilot far behind his optimistic ETA. When in doubt, assume that you're not there yet, unless you're a member of the jet set—or the rare "jetstream set."

Flying in the mountains by pilotage should be as easy as flying over the plains, but it seldom works out that way. Hills frequently cut out both omni information and air-to-ground communications. Turbulence, lack of suitable landing spots near any civilization, and/or anoxia can combine to produce a fine case of jitters that plays hob with pilot proficiency.

An increasing number of states produce their own aeronautical charts. Many of these state charts that come from mountainous terrain have gems of information not included on regular sectional charts. One such time-tested list of "Do's and Don'ts on Mountain Flying" has been carried on the back of the Idaho State Department of Aeronautics charts for years. The following advice "is based on considerably more than a thousand flights into our primitive area, and may be of some help to the amateur mountain pilot, regardless of the amount of hours he may have tucked away beneath his flying belt."

In part, the Idaho list includes:

"1. First and foremost, do not consider flying the back country unless you have at least 150 hours and are proficient in slow flight.

"2. Know your airplane. Do not take a ship into this territory that will not take off and land in a minimum distance.

"3. Remember that for each thousand feet above sea level, your takeoff run will increase approximately 25% and your landing speed 2%.

"4. Know the field you are going into. Check with experienced mountain pilots if possible. Know the altitude, the length, and whether it is a one-way field.

"5. Check your weather . . . Stay out of doubtful or bad weather.

"6. Make your trips early in the morning hours. The air, as a rule, begins to get bad around 10 a.m., grows steadily worse until about 4 p.m., then gradually improves until dark.

"7. Stay out of the mountains if the wind is over 25 m.p.h.

"8. Keep your airplane as light as possible. Do not carry one pound of needless weight.

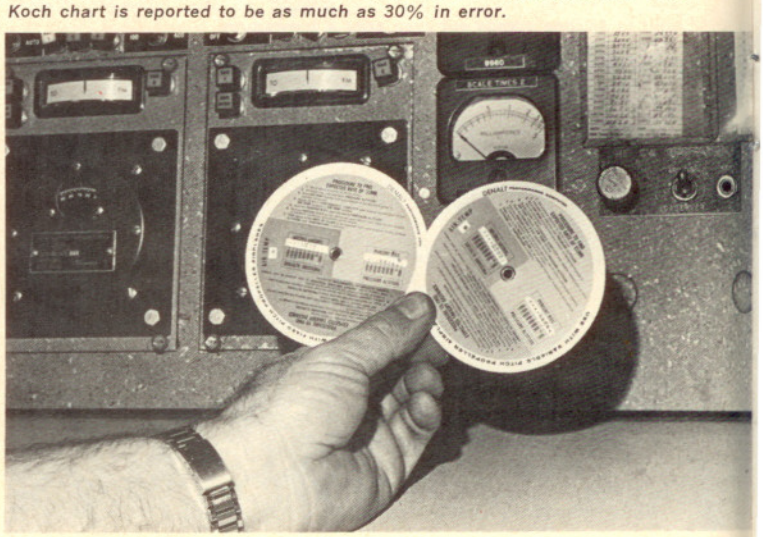
"9. Route your trip over valleys whenever possible. Study your charts thoroughly. Watch your compass and don't get lost.

"10. Maintain as much altitude as possible at all times.

"11. Approach all ridges at an angle

Navigation over broad expanses of desert differs from any other form of pilotage. Here a Cessna Cardinal is prepared for a flight from a sandy strip near Twentynine Palms, Calif. *Photos by the Author*

Denalt density-altitude computers for fixed-pitch and controllable-prop aircraft are available from the FAA. Under certain conditions, the older Koch chart is reported to be as much as 30% in error.



so you can turn away if you hit a downdraft. After you cross a ridge, head directly away from it.

"12. Expect the wind to be changing constantly in the mountains. Don't rely on cloud shadows for wind direction. If you can't gain altitude on one side of a canyon, try the other . . . If there is no improvement there, ride the center but under no circumstances head up any canyon or valley without sufficient altitude and room to turn around. . .

"13. Keep that flying speed in downdrafts. . . [by lowering the nose—Ed.]

"14. Remember that you will not have a [level] horizon to check . . . once you begin to let down in the mountains.

"15. Use common sense on takeoffs. If the air is bad or you have a tailwind, wait it out. Remember, none of these fields is long enough to land again once you have left the ground.

"16. You can gain extra takeoff speed by making your turn at the end of the field at a good fast taxi speed and opening the throttle as the plane swings around to line up with the runway. Practice this maneuver with an instructor on a good standard airport."

The AOPA PILOT, October 1966 (and, later, Volume 2 of AOPA's hardcover "Places To Fly"), carried the account of one of our visits to Leadville, Colo., the nation's highest paved airport, at 9,927 feet. This airport is 4,800 feet long, and since we were flying a turbocharged *Aztec C*, there was no problem. However, in conjunction with this flight and further research on high-altitude operation, we came up with a "sidebar" article that has a direct bearing on modern terrain flying.

Neither people nor airplanes operate with peak efficiency at high altitudes. When veteran lightplane designer John Thorp (AOPA 22461) was asked about Leadville, he replied, "If you write about flying into Leadville, Colo., you're going to be the indirect cause of some serious airplane crashes, no matter how strongly you explain the problems of high-altitude flying . . . On a warm day of just 76°F [at Leadville], you can expect a density altitude of 13,000 feet and you'll be able to draw about 55% of sea-level power on takeoff with an unsupercharged engine.

"You can't afford to fly well at 13,000 feet," continued designer Thorp, "since this type of performance would penalize other flight characteristics of the design. I'd recommend that no pilot fly a two-placer into a field this high unless he does it solo, with partial fuel and little or no baggage. A four-place plane at this altitude should be considered as a good two-placer with the same limitations."

In talking about Leadville and other high altitude strips, we found that a rate of climb of 300 f.p.m. is the slenderest margin you should have after takeoff. The 300 f.p.m. minimum was set by the FAA a number of years ago and later changed to the best angle of climb that approximates this rate—300 f.p.m. is only five feet per second, and the pilot of any low-powered aircraft or sailplane knows that five f.p.s. of "soft air" (downdrafts) is extremely common. Have just a little wind passing across these high ridges and the vertical currents far exceed this 300 f.p.m. figure.

High-altitude takeoffs and landings should carry the same fuel-air leaning as cruising at altitude. Always lean your engine for maximum r.p.m. at full throttle before starting your takeoff roll, unless you are on a rocky strip where there would be propeller damage. If it is a rocky strip, you'd better be sharp enough to be able to lean during your takeoff roll, or follow the procedures used by many mountain pilots of establishing their maximum high-altitude power mixture just before landing, and then shut off the engine with the fuel valve. A disadvantage in this pre-landing adjustment is that the landing may be made during the cool of the evening, when the density altitude is comparable with the actual altitude. If the takeoff were to be made at midday with a warmer-than-normal temperature, the mixture would be too rich for maximum performance, because the density altitude of the airport would have risen.

If you're flying a turbocharged aircraft, most mixtures should be kept lean during runup, in order to avoid stalling. Once the throttle(s) is advanced on takeoff, the mixture should go rich, since the exhaust-driven turbine will be up to speed, and you'll be developing sea-level horsepower.

While the airplane itself doesn't know the difference, and the indicated airspeed remains the same as at sea level, things happen faster during high-altitude landings, and slower during high-altitude takeoffs. At Leadville, for example, your airspeed correction is almost 20%. So, if you normally cross the fence at 80 m.p.h., you'll correctly use the same 80 m.p.h. indicated, plus perhaps an extra 5% for a strange airport. Your indicated 80 m.p.h. becomes 96, and this extra ground speed becomes a definite factor during rollout. If your bird has a nose gear, apply firm braking and retract your flaps immediately after touchdown, since brakes develop their highest energy at their highest speeds.

High-altitude takeoffs are going to be longer, much longer, than those at sea level. When you have only 50% of your sea-level power available (unsupercharged), you double your takeoff distance. In addition, at 10,000 feet, the lift-off speed is 20% faster in ground speed.

"The takeoff distance might easily be infinity at 10,000 feet," computed designer Thorp. "You might never get going fast enough to take off. If you can climb 300 f.p.m., you probably have enough excess power to hack it."

Since effective wing loading increases with angle of bank, all high-altitude turns should be made more shallow than those at sea level. Planes loaded out of center-of-gravity (C.G.) limits, particularly those loaded aft C.G., can develop unexpected stability and control characteristics.

Each aircraft model has performance specifications in the operations manual

that will tell the pilot what he can expect under ideal conditions. An ex-student of mine who was a meticulous engineer calibrated the takeoff roll of his old 90 h.p. Cessna 140 at 700 feet for an elevation of 300 feet. Maximum sea-level r.p.m. with his fixed-pitch cruise prop was 2,000 r.p.m. The same airplane with the same load took 4,000 feet to break ground at an elevation of 7,010 feet at Flagstaff, Ariz., and the r.p.m. was only 1,500. Light aircraft with fixed-pitch props suffer even more than those with controllable blades at altitude.

Anoxia, the result of insufficient oxygen, is frequently an insidious factor in mountain flying. A typical, although uneventful, example of anoxia happened a few years ago when two of us were bringing a new *Skylane* to the West Coast. To miss the worst headwinds, we cruised at 10,500 feet as far as Pueblo, Colo. After fueling, we climbed to 12,500 feet and somewhat higher for another two hours across the beautiful, snowcapped Continental Divide. When we landed at Grand Junction with nary a bounce, both of us were so unsharp that we didn't specify a small, economy-model rental car, and it cost us exactly double for a set of wheels that night. Anoxia, pure and simple!

Since a majority of terrain navigation is done over fairly wild, lonesome country, the advisability of a flight plan should be obvious. It's the cheapest insurance you can buy. When flying into isolated fields without communication to "the outside world," tell the airport operator at your last landing in "civilization" where you're going and when you plan to be back. Then stick with your "flight plan," even though it may just be verbal.

Terrain flying has a number of advantages over what is now standard omni cross-country navigation. It keeps the pilot's head out of the cockpit, which gives him an opportunity to look at the picturesque scenery below—and makes it easier to see other aircraft. It keeps him from zeroing in on each and every omni station, where the traffic can be terrific. There's less chance to doze off—fat, dumb, and short of oxygen—if the pilot is busy with maps and terrain identification at an altitude low enough where he can identify these objects on the ground. Wind shifts and significant changes in ground speed show up more rapidly close to the ground, because checkpoints are usually much closer together.

Old-fashioned, true. But terrain flying is the fun way to go. See the country for a change. Visit the smaller off-airways airports, where service is fast if you're in a hurry, and as leisurely as "you-all come back," if you have the time and inclination to talk.

Why not turn off the "nav" portion of your nav/com system on your next cross-country flight? Find out if you can really read a map and find your destination without a D/F steer. Who knows, you might have to do it that way someday, and if you're a good terrain pilot, it could save your life. □