

Mountain Flying

Why?

- The mountains are a beautiful place to visit
- There are many out-of-the-way vacation spots that are hard to reach by car but easy to reach by plane (e.g. Big Bear, Mammoth)
- Learning to fly in the mountains increases overall flying skill
- It's always nice to do something new
- Note: Backcountry flying requires additional training beyond just plain mountain flying! Soft field techniques, one-way runways, etc.

Flying Club Rules

- Flying clubs differ, but almost all require some kind of mountain checkout
 - WVFC: When going to an airport > 2,000' MSL or flying over mountainous terrain > 8,000' MSL
 - Sundance: When going to an airport > 2,500' MSL

Example Airports

- Low airports (< 3,500' MSL): Trinity Center, Placerville, Columbia, Pine Mountain Lake, Grass Valley
- High airports (< 6,500' MSL): Reno, Truckee, South Lake Tahoe, Alpine County, Bridgeport, Minden, Jackson Hole, Sedona, Grand Junction
- Really high airports (≥ 6,500' MSL): Mammoth Yosemite, Lee Vining, Bryce Canyon, Grand Canyon, Telluride, Leadville

What's Different About Flying in the Mountains?

- The air is thin – this affects both airplane and pilot
- There are few weather reporting stations and limited weather forecasting
- Wind causes turbulence, updrafts, downdrafts, and altimeter errors
- The airplane is usually fairly close to the terrain – including narrow canyons
- Airports have relatively short runways and unfriendly terrain preventing a normal traffic pattern
- Navigation relies more on pilotage and dead reckoning

Oxygen Requirements

Hypoxia – Below 25,000'

- The percentage of oxygen stays the same, but the *partial pressure* decreases with altitude
- Blood becomes less saturated with oxygen as altitude increases
- Symptoms are many and varied depending on the person
 - Indifferent stage
 - Reduced vision at night
 - Compensatory stage
 - Respiration increases in depth or rate
 - Pulse rate increases

- Systolic blood pressure increases
- o Disturbance stage
 - Fatigue
 - Lassitude
 - Thinking is slow, memory is faulty
 - *Judgment is poor*
 - Sleepiness or drowsiness
 - Dizziness
 - Headache
 - Breathlessness
 - Euphoria
 - Vision impaired
 - Touch and pain diminished or lost
- o Critical stage
 - Loss of consciousness
 - Eventual death
- Smoking makes everything much worse
 - o Hemoglobin has an affinity for carbon monoxide 20X greater than for oxygen
 - o A smoker as a physiological altitude of 3,000' to 8,000' while at sea level

When to Use Oxygen

- FARs
 - o Cabin pressure altitude $\leq 12,500'$: Not required
 - o Cabin pressure altitude $> 12,500'$ and $\leq 14,000'$: Crew needs oxygen after 30 minutes
 - o Cabin pressure altitude $> 14,000'$: Crew needs oxygen at all times
 - o Cabin pressure altitude $> 15,000'$: Passengers provided with oxygen (they don't have to use it)
- Realistically
 - o Above 10,000' during the day
 - o About 5,000' at night
- A portable pulse oximeter can be used to read blood oxygen saturation in real time (about \$400)

High Altitude Chamber

- Available at various military installations around the country
 - o Contact the FAA at 405/954-6212
 - o Write: FAA Airmen Education Branch
AAM-420
CAMI
Post Office Box 25082
Oklahoma City, Oklahoma 73125
 - o Contact the UND Aerospace Foundation for the aviation physiology corporate aviator course by calling George LaMora at 701/777-3286 or e-mailing him (lamora@aero.und.edu).
- Private training is also offered by:
L.B. Barometric Training Center
1698B West Hibiscus Boulevard
Melbourne, Florida 32901
(321) 676-3200
www.lbhyperbarics.com

Effects of Altitude

Density Altitude

- *Density altitude* is the altitude “at which the plane thinks it’s flying”
- Density altitude increases, air density decreases, and airplane performance decreases with:
 - Increasing altitude
 - Increasing temperature
 - Increasing humidity
- The worst combination is high, hot, and humid
- Rule of thumb: density altitude increases 600 feet for each 10 degrees F above standard temperature
- Plan the trip based on the highest forecast temperature to be conservative

Effect on Airframe

- There is less parasitic drag on the airframe due to the reduced air density

Effect on Propeller

- The propeller has less air to “push” against and thus produces less thrust

Effect on Engine

- A normally aspirated (non-turbocharged) engine produces less power when the air is less dense because there is less air to combine with fuel
- For each 1,000 feet of density altitude, a normally aspirated engine will lose approximately 3 percent of its rated power

Effect on Airspeed Indicator: True vs. Indicated Airspeed

- *True airspeed* is the actual speed of the airplane through the air
- *Indicated airspeed* is the airspeed shown on the airspeed indicator
- At sea level on a standard day indicated airspeed and true airspeed are the same
- At higher density altitudes the indicated airspeed is *less* than the true airspeed
- Rule of thumb: True airspeed increases about 2% per 1,000 feet over indicated airspeed
 - Indicated airspeed: 120 KTS
 - Altitude: 8,000 feet
 - True airspeed: $120 + 120 \times (8 \times 2\%) = 120 + (120 \times 16\%) = 120 + 19 = 139$ KTS

Flying Performance vs. Airspeed

- Almost all performance airspeeds are *indicated* airspeed!
 - Takeoff speed
 - Approach speed
 - Stall speed
 - Flap extension speed
 - Never-exceed speed
- At a high altitude, the true airspeed will be higher than indicated airspeed

- Thus the *ground speed* while taking off or landing will be higher than you're used to – fly the airspeed indicator, not visual cues!

Weather, Wind, and Mountains

Weather Reporting and Forecasting

- There are usually very few, if any, weather reporting stations in the mountains
- Some places (certain mountain passes in Colorado and Alaska) have special ASOS stations or web cams to help pilots
- Weather forecasts are iffy at best in mountainous areas
- Weather can vary greatly from location to location, and can change rapidly
 - There is no such thing as “marginal VFR” in the mountains – it's either VFR, or it's not!
 - Plan for alternates in case the weather turns sour
- Checking winds aloft at airports and at mountain height is very important
 - A large difference can mean severe windshear

The Venturi Effect

- Wind flowing over a ridge, over a mountain, or through a pass or canyon will *increase in speed* due to the Venturi effect
 - The wind over the top of a ridge or through a pass may be 2-3 times stronger than the same wind away from the ridge
- The increase in wind speed will cause a *decrease* in air pressure that will affect the altimeter (the Bernoulli Effect)
 - The altimeter can read up to 1,000 feet *higher* than you're actually flying
 - Always use visual cues to decide if you're going to pass over a ridge at a safe altitude

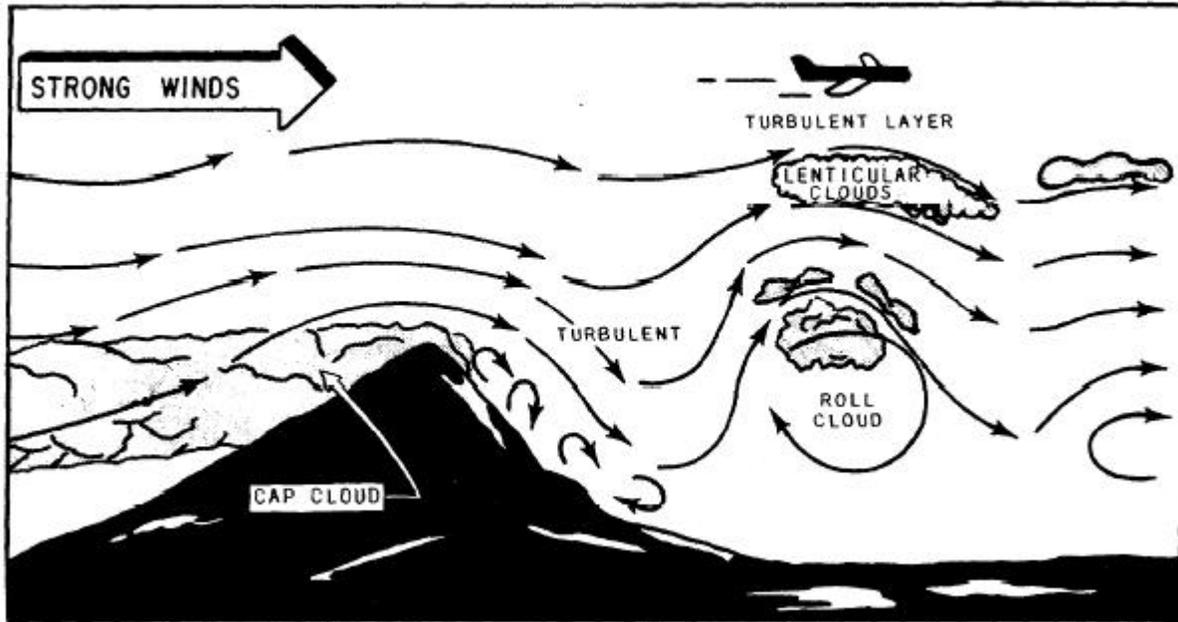
Ridges

- Wind flowing over a ridge or mountain will cause an updraft on the windward side, and a downdraft on the lee side
- Approach at 45 degrees within ½ mile or farther
- Turning around is much easier because you only need to turn 90 degrees instead of 135 or 180
- If you enter a downdraft, keep the nose down and increase airspeed to get out of the descending air. You'll get out of it sooner and with less altitude loss.

Timing Your Trip

- Try to fly early in the morning
 - Density altitude is lower
 - Turbulence is less
 - You can get closer to ridge lines
- Flying in the evening may be OK too, but beware that it gets dark quickly in the mountains, and sunset is earlier than expected

Mountain Waves



- Mountain waves are caused by wind moving over a ridge or mountain peak and causing a series of waves on the lee side
- As the air is raised and cooled, water may condense, and as the air descends, water may no longer condense. This can cause a cloud to appear at the crest of the wave.
- This almond or lens-shaped cloud, called a *lenticular* cloud, may contain winds of 50 KTS or greater even though it appears to be standing still
- Severe mountain wave turbulence should be expected when winds of 40 KTS or greater are blowing across a mountain ridge and the air is stable
- Rotor or roll clouds on the lee side of a mountain may contain extreme turbulence and should be avoided



Handling Turbulence

- For light turbulence, fly below the yellow arc
- For moderate or heavier turbulence, fly below V_a for your current weight

Rules of Thumb

- If surface winds are greater than 20 KTS, use caution
- If winds at ridge height are greater than 30 KTS, delay the flight
- If possible, fly in the morning (before 10am) or evening (after 4pm)

Navigation

- Local knowledge is important
 - If possible, talk to local pilots

- o Study roads in the area – they often follow the lowest terrain
- VOR reception is unreliable because it requires line of sight, which is blocked by terrain
- GPS usually works
 - o Flying GPS direct is probably a bad idea because it doesn't take into account weather and terrain
 - o GPS can be used to find mountain passes and to make sure you're flying in the correct canyon
- Dead reckoning and pilotage are usually the best way to navigate
 - o Study the topography, valleys, and passes on the sectional chart before flying
 - o Compass errors may be large in the mountains, although areas of magnetic disturbance are usually marked on the charts
 - o Things look different in the snow and it may be impossible to see roads

Flying in Canyons

- Fly on the side, not the middle
 - o Use the updraft side
 - Best climb performance
 - Full width to turn around
 - Less turbulence than in the middle
 - o In a narrow canyon (less than 2 turning diameters), fly on the *downdraft* side
 - Turning toward the updraft side will give increased performance when it's most needed
- When to turn around
 - o Airspeed getting slower and slower (terrain is climbing too fast and you're subconsciously raising the nose)
 - o Opposite side of canyon getting closer (narrowing)
 - o Visibility getting marginal
 - o Clouds getting lower
 - o Turbulence getting unbearable
- How to turn around – canyon turn
 - o Start on windward side
 - o Slow down as much as possible – trade airspeed for altitude
 - o Lower flaps
 - o Steep bank (at least 45 degrees)
 - Don't stall!
- Don't fly into a canyon below the rim unless you know where the canyon goes and what the terrain does

Takeoff

- Takeoff performance is drastically affected by high density altitude
 - o Engine performance decreased (if not turbocharged)
 - o Propeller efficiency decreased
 - o Wing efficiency decreased
- Weight
 - o 10% increase in weight =>
 - 5% increase in takeoff speed
 - 9% decrease in acceleration
 - 21% increase in distance
 - o Take less fuel and fly to a lower airport to refuel if there's any doubt
- Runway slope effect on ground roll
 - o 1% of down -5%
 - o 1% of up +7%
 - o Takeoff up hill if headwind component is 10% or higher of takeoff speed
- Surface effect on ground roll
 - o Firm turf +7%
 - o Short grass +10%

- o Tall grass +25%
- o Mud or snow +25% to infinity
- Use POH charts and above rules of thumb to determine takeoff roll, then add a margin of safety (like 50%)
- Pay attention to surrounding terrain
 - o Can we climb?
 - Airplane climb performance
 - Presence of downdrafts
 - o Turbulence
 - o Rising terrain may be too steep
 - Is there a place to circle?
 - Use the windward side of a mountain to get lift if possible
- Optimal takeoff technique
 - o Some flap as mentioned in POH
 - o Rolling takeoff if possible (may want to do a full-brake runup if turbocharged)
 - o Full power may be OK in runup and taxi because performance is so bad
 - o Set mixture for best power on the takeoff roll or during runup
 - o Airspeed and groundspeed will be very different
 - o Fly indicated airspeed!!!
- Takeoff decision
 - o ½ way point of runway – need 70% of takeoff speed
 - o Only valid if runway is uniform slope and surface

Landing

- Non-standard traffic pattern may be required due to terrain – plan ahead
- Normal stabilized approach
- Widen downwind because higher true airspeed results in wider turns
- Be exactly on airspeed (+10% airspeed => +21% distance)
- Avoid power off landings
- Pick a spot and aim for it, keeping airspeed perfect
- Mixture should be set for the density altitude
 - o On downwind, full power, set best power mixture + a little rich, then reduce throttle
- Because landing distance increases with the square of the ground speed, landing distances at high density altitude airports are much longer than at sea level
- Go arounds may be difficult or impossible – check go-around performance in POH and pay attention to terrain before starting the approach
- Remember: Just because you can land doesn't mean you can take off!

Flying Skills

- Slow flight!
 - o Straight and level
 - o Turns
 - o Clean and dirty
 - o Climbing and descending

Personal Minimums

- Minimums need to be more conservative than for non-mountain flying
- Suggested minimums:
 - o 2,000' ceiling above highest terrain
 - o 7 SM visibility

Safety and Survival

- First goal: don't crash!
 - Make sure airplane is well-maintained
 - Have enough fuel, including fuel to divert to a realistic alternate
 - Don't fly in marginal or worsening weather
- Second goal: make the forced landing as good as possible
 - Fly as high as practical for more glide distance
 - Always have lower ground available
 - Keep visual contact with airports or fields as much as possible
 - Try to stall right at tree-top height, or fly between two trees to shear off the wings
- File a flight plan
 - Average time to find a plane with a flight plan – 38 hours
 - Average time to find a plane without a flight plan – 3 days!
 - Update location enroute with FSS
- File a “personal” flight plan with friends or family
- ELT functional and battery fresh
- Tie loose objects down with straps or cargo net
- Survival kit
 - Water
 - Warm clothing & rain gear
 - Fire-starting materials
 - Tarp, tent, or large "Space Blanket"
 - Food
 - Sleeping bag
 - Signaling equipment: ELT or handheld transceiver, flares, strobe, red carpenter's chalk, heavy-duty flashlight
 - Tools: knife, pliers, flex saw, vise grips, axe/hatchet
 - Complete first aid kit

Mountain/Backcountry Flying Courses

- McCall Mountain Canyon Flying
 - POB 1175
 - McCall, ID 83638
 - 208-634-1344
 - www.mountaincanyonflying.com

Bibliography

- “Mountain Flying Bible and Flight Operations Handbook Expanded” by Sparky Imeson
- “Practical Wave Flying” by Mark Palmer (out of print)

A Few NTSB Reports

NTSB Identification: **LAX02FA211**

Accident occurred Sunday, June 30, 2002 in OJAI, CA

Aircraft: Beech V-35A, registration: N156U

Injuries: 3 Fatal.

[...]

On June 30, 2002, about 1059 Pacific daylight time, a Beech V-35A, N156U, collided with terrain while maneuvering near Ojai, California. The pilot/owner was operating the airplane under the provisions of 14 CFR Part 91. The commercial pilot and two pilot rated passengers sustained fatal injuries; the airplane was destroyed. The personal local flight departed Van Nuys (VNY), California, about 1030 en route to Oceano (L52), California. Day visual meteorological conditions prevailed, and no flight plan had been filed. The primary wreckage was at 34 degrees 33.503 minutes north latitude and 119 degrees 28.139 minutes west longitude.

[...]

The witness reported that the two lead airplanes separated from the rest of the group, descended to an estimated 500 to 1,000 feet above ground level (agl), and proceeded up a canyon. A few moments later, the witness observed smoke and a fire. Several of the airplanes orbited the site and notified authorities.

The two airplanes came to rest within 75 feet of each other at the bottom of the head of the canyon at an estimated elevation of 4,925 feet. The slope of the terrain at the accident site was approximately 45 degrees. A saddle on top at the head of the canyon was at an estimated elevation of 5,400 feet, and less than 1/2 mile from the accident site.

[...]

NTSB Identification: **LAX98LA156**

Accident occurred Wednesday, May 13, 1998 in GORMAN, CA

Aircraft: Bellanca 7GCBC, registration: N11867

Injuries: 1 Fatal.

Ground witnesses observed the aircraft flying uphill in mountainous terrain below the clouds at an estimated 100 to 200 feet above the ground in a northerly direction. The aircraft impacted an upsloping hill heading in a westerly direction. The wreckage was confined in one area with little or no forward movement. The examination of the engine found the right magneto to be inoperative.

NTSB Identification: **LAX98FA152**

Accident occurred Thursday, May 07, 1998 in AVALON, CA

Aircraft: Cessna 172N, registration: N6514E

Injuries: 4 Fatal.

The private pilot and his three passengers were on a personal trip to an island off of the California coastline. After departure the pilot proceeded to explore the distant side of the scenic island. The aircraft wreckage was located at the confluence of two narrowing box canyons in a near inverted attitude on the 40-degree mountainside of the island. No preimpact mechanical malfunctions were found with the aircraft during the investigation.

NTSB Identification: LAX98FA031

Accident occurred Sunday, October 26, 1997 in MARKLEEVILLE, CA

Aircraft: Cessna U206B, registration: N4982F

Injuries: 4 Fatal.

The aircraft was destroyed when it impacted trees in mountainous terrain at about 7,850 feet msl. The density altitude was calculated to be about 8,400 feet. Examination of the trees and the aircraft wreckage disclosed that the aircraft was in near level flight at the time of initial tree contact. The aircraft gross weight at the time of impact was calculated to be about 3900 pounds; the maximum certificated takeoff weight was 3500 pounds. No mechanical malfunction was found in the airframe or the engine. The owner had personally installed a set of amphibious floats and a three-blade propeller. The installation was not inspected or signed off for return to service, and there was no evidence that the weight and balance had been recomputed.

NTSB Identification: LAX97LA127

Accident occurred Wednesday, March 19, 1997 in GILROY, CA

Aircraft: Passadori Norman BREEZY, registration: N16KB

Injuries: 1 Fatal, 1 Serious.

The passenger, also an airline transport pilot, reported that the pilot had fueled the aircraft to capacity before takeoff. The passenger was in the rear seat of the 125-horsepower aircraft as they climbed from takeoff toward a ridge line separating them from their sightseeing destination. They were climbing slowly up a canyon at low altitude when the pilot acknowledged that the aircraft was not climbing fast enough to clear the ridge. The pilot attempted to reverse course, but during the turn the aircraft mushed and the right wing struck a tree. The aircraft then cartwheeled onto the ground. The passenger stated that there were no mechanical problems with the aircraft.

NTSB Identification: LAX96FA340

Accident occurred Saturday, September 21, 1996 in CALIENTE, CA

Aircraft: Piper PA-28-181, registration: N2393W

Injuries: 3 Fatal, 1 Serious.

The noncertificated dual student made a business trip with friends to a destination with a dirt airstrip. He retained a flight instructor (CFI) to provide instruction in the airplane along the route. During arrival, the CFI took control of the airplane and maneuvered to land on the east/west runway. The wind was reportedly from 290 degrees at 5 gusting 10 knots. A ground witness observed the airplane make a downwind low approach. A passenger said that the instructor circled the area to alert the student pilot's friends. The airplane was then observed to reenter the traffic pattern and land downwind. The airplane's speed was excessive and a go-around was initiated. The airplane disappeared from the ground witness' view. After the aborted landing, the airplane entered a box canyon area. Reportedly, the instructor initiated a turn between 90 and 110 degrees, and the stall warning buzzer sounded. The airplane then struck trees and crashed in a nose-down attitude. Postaccident examination of the airplane disclosed no evidence of a preimpact malfunction or failure.