Mountain Flying in Flatland Airplanes

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Mountain Flying in Flatland Airplanes: Outline

- High Altitude Airplane Performance

- Mountain Flying techniques

- Mountain Weather

Pre/post quiz

Under otherwise identical conditions at sea-level you would approach at 70 knots. Landing at South Lake Tahoe, you would:

A) Approach at a higher speed to accommodate the thinner air
B) Approach at the same indicated airspeed.
C) Anticipate a longer landing roll
D) All of the above

Flying in a narrow valley, it is best to:

A) Fly down the middle
B) Keep to the right side
C) Fly on the downwind side

The temperature rose 15C from AM to early PM. The density altitude:

A) increased about 1800’
B) increased about 2900’
C) decreased

Compared to sea-level, at a high altitude airport

A) Landing distances are the same but takeoff distances increase
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Rising air can be found on which side of standing lenticular clouds -

A) upwind
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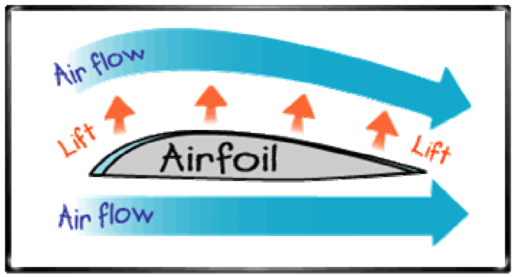
Runway 3-21 at Sedona is 5129’ long and slopes up 1.8% to the NE. It is located on top of a mesa elevation 4821’. The temperature is 22°C. The wind is from 030 at 5 knots. On which runway you would expect a shorter takeoff roll in the 182: 03 or 21? In the Archer?

In thinner air we must fly faster to generate the same lift.

LVK $\rho \xrightarrow{v}$

Aspen $\rho \xrightarrow{V}$



Same ρv^2 :
Same lift/drag
Same IAS

Lift (and drag) are proportional to air_density * TAS^2 i.e ρv^2
As the air density drops with altitude, we must increase our TAS (by 1.6%/1000 ft) to maintain the same lift, all else equal (i.e. identical configuration, AOA etc.).

However, the airspeed indicator actually measures the ram pressure ρv^2 but is calibrated taking the density to be that at sea-level. Thus, with the same *indicated* airspeed, we have the same ρv^2 and therefore the same lift and drag, independent of altitude.

Indicated aerodynamic and structural speeds are independent of altitude:
The airplane stalls at the same *indicated* airspeed, regardless of altitude.
The airplane's best glide speed is the same *indicated* airspeed, regardless of altitude.
Va, Vne and Vno are unaffected (though flutter margin reduced)
The actual "true" airspeeds increase with altitude.

Flying into Aspen airport (elevation 7820’).

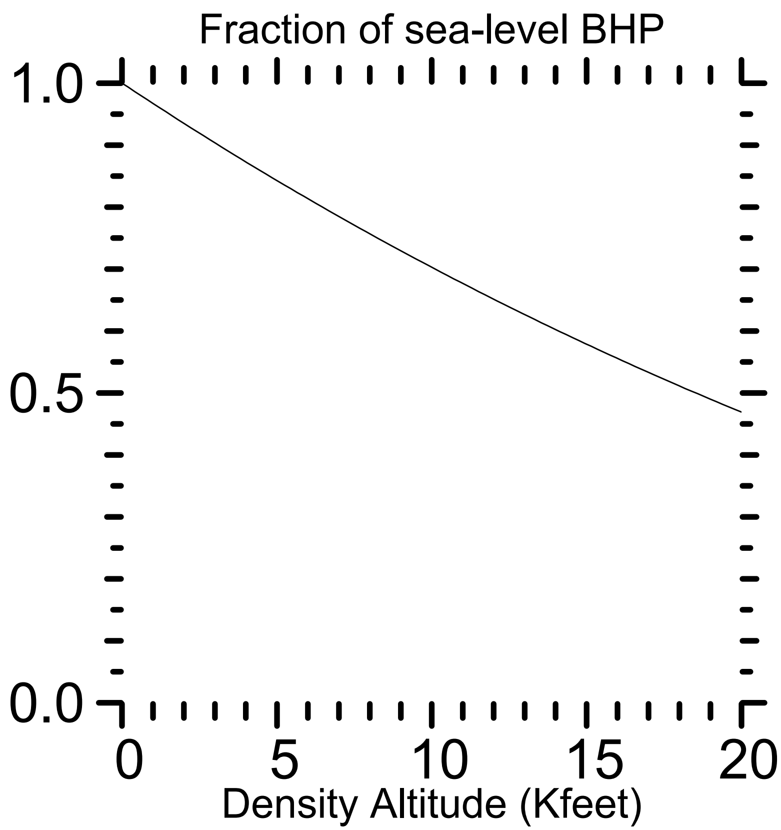
We’ll use the same *indicated* airspeeds for our approach – but our *true* airspeeds will be higher than at a sea-level airport.

What really matters is the *density altitude*. It exceeds the pressure altitude(*) by 120’ per degree °C above standard for the altitude. If it were 20°C (= 68°F) in ASE, (ISA = 15-2*8=-1°C) the density altitude would be ~10280 feet!

TAS is 16% higher than IAS. Landing roll will be ~32% longer because of the higher touchdown speed.

(*) Read altimeter set to 29.92” or increase altitude by 1000’ for every 1” below standard.

Our (non-turbo) airplanes lose available power as the density altitude increases

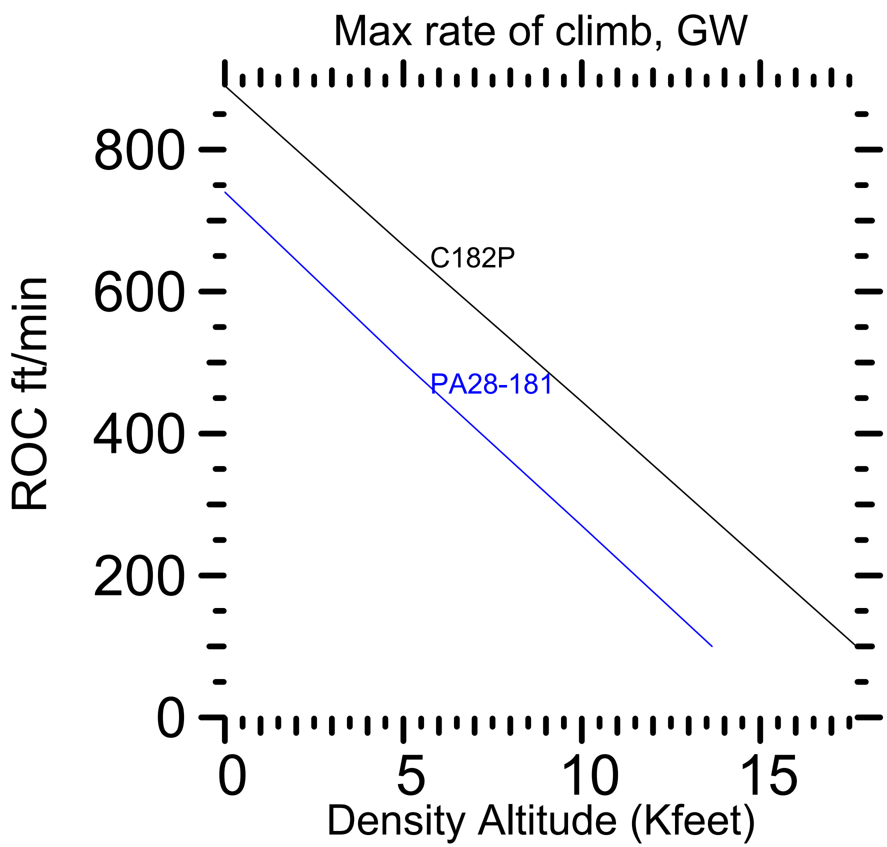


The minimum power required for level flight increases with altitude. (The minimum drag doesn't change – but you have to fly faster.)

More power required for level flight and less available with altitude means the excess power available for climb falls rapidly with altitude.

(At sea-level the C182 will fly level on 35% power, the Archer needs 38%.)

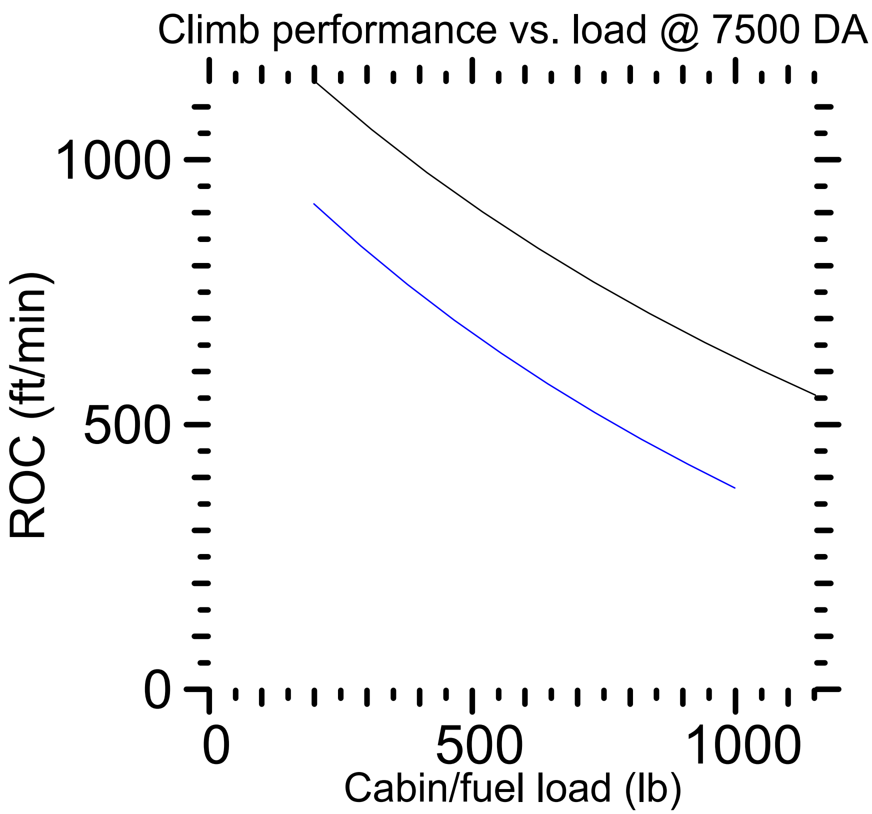
At their respective gross weights, the C182 has a 3-4000 foot higher altitude capability than the Archer



0fpm ROC - absolute ceiling
100fpm ROC – service ceiling

~<400fpm ROC – adequate climb gradient for departure?

In the mountains you want to fly as light as possible!



Don't tanker unnecessary fuel.

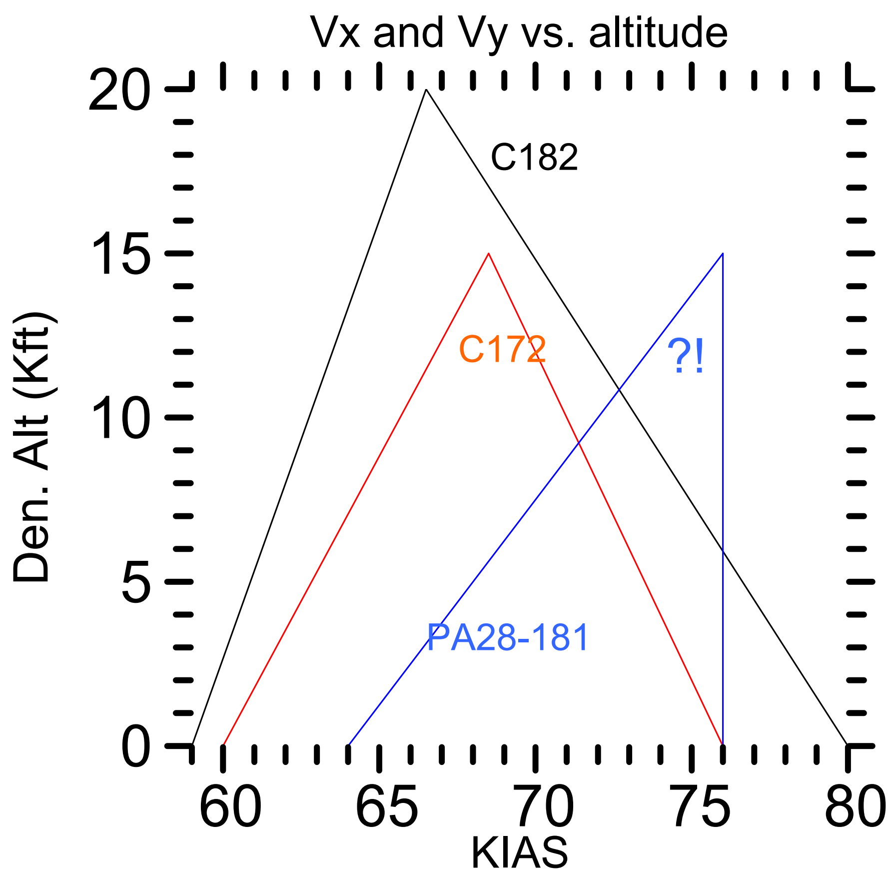
Ferry your load in/out of high altitude strips if necessary.

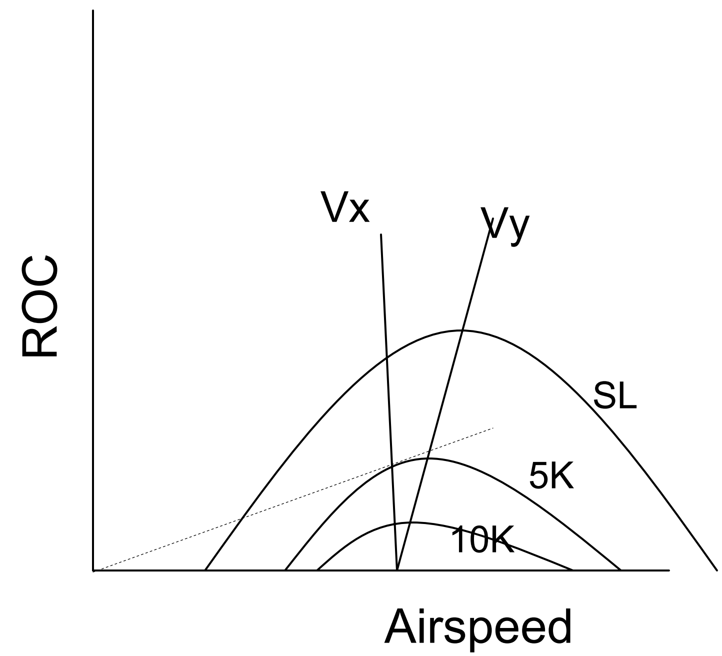
Fuel up a distance from mountains you need to cross to give you time to climb and to burn some off.

The 182 will carry more…

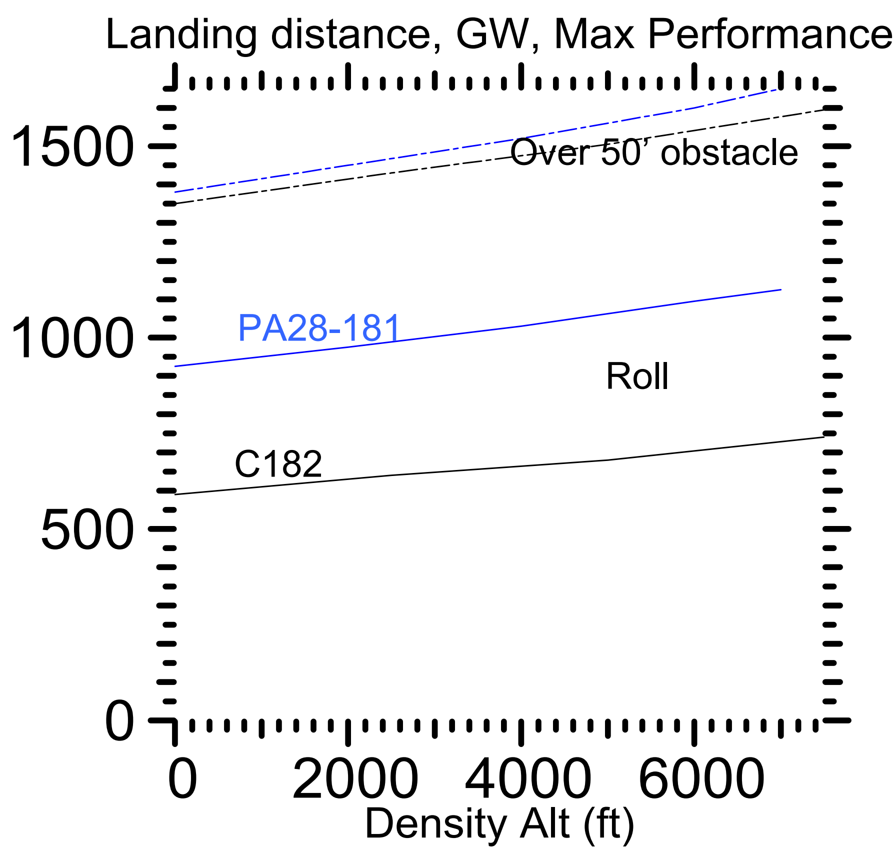
Vx and Vy converge as you climb to the absolute ceiling.

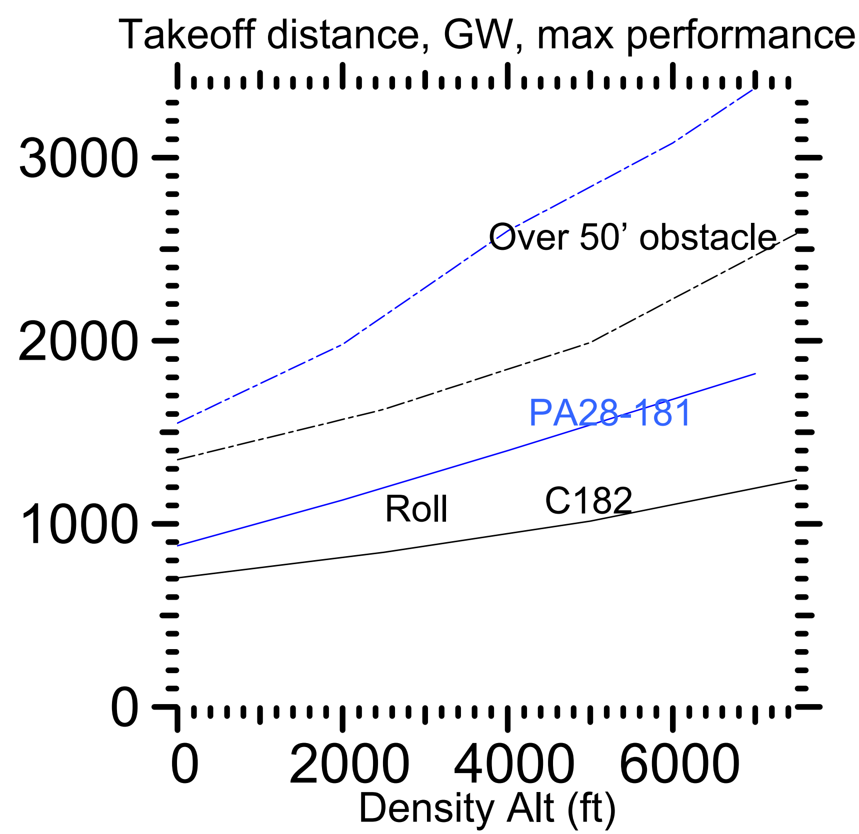
Vx: Best Angle of Climb Speed
Vy: Best Rate of Climb speed.





In the mountains, you can fly into shorter strips than you can depart!





Landing distance increases ~20%, takeoff ~100%!

A POH C182 approaches at 4 degrees and brakes at 0.27g;
A POH Archer at 6 degrees with 0.21g braking!
Landing more dependent on technique than takeoff…

Many mountain airport runways have significant slope.

Land uphill
Depart downhill

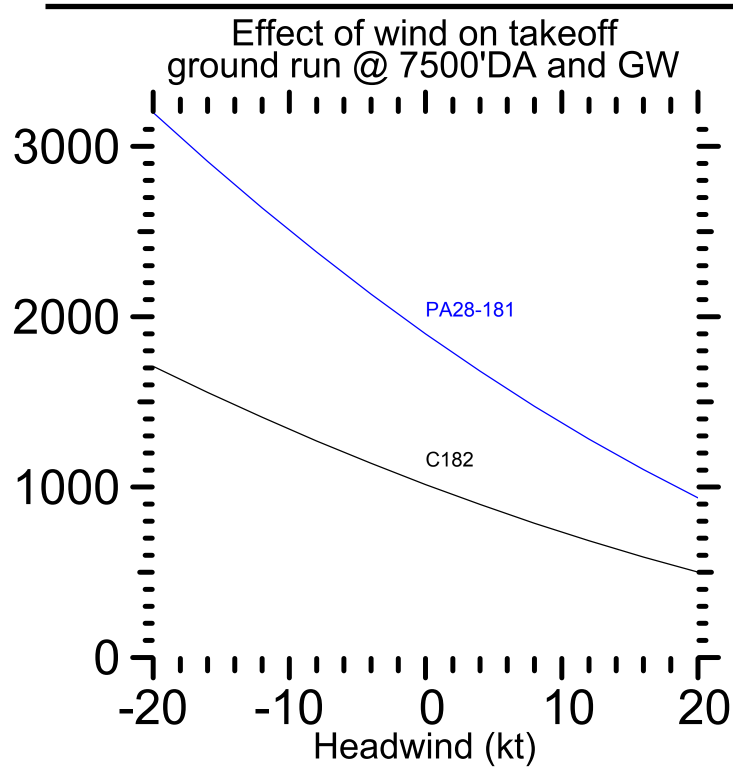
In less extreme cases there may be a tradeoff with wind.

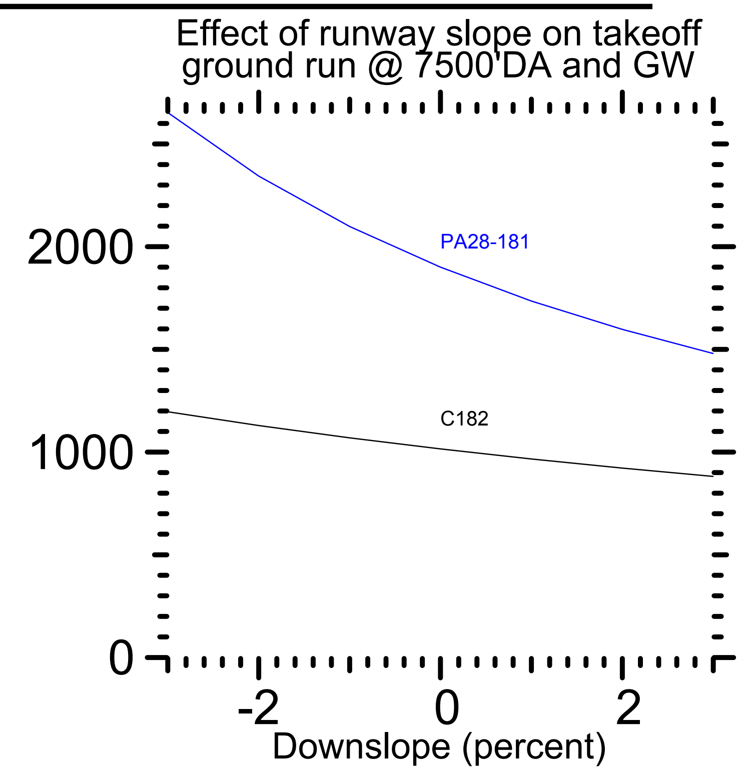
Takeoff into the wind or downhill?

Land into the wind or uphill?

Mile Hi Airport - Idaho Back country.

Runway slope has the greatest effect on takeoff when performance is marginal.





Ground roll decreases about 6% per thousand feet of ground roll for each percent of downslope. *(Same* ***increase*** *for landing ground roll.)*
Ground roll varies as the square of your liftoff ground speed.

For the C182 at 7500' 1% downslope ⇔ 2 knots headwind, for the Archer ⇔ 4 knots
Runway slope is published in AF/D or measure it with your altimeter.
The slope of the terrain off the runway end may be more significant consideration than the length of the ground roll. Climb angle vs. terrain slope…

Sloping runways

ASPEN.PITKIN CO/SARDY FLD (ASE) 3 NW UTC7(6DT) N39°13.39 W106°52.13 **DENVER**
7820 B S2 **FUEL** 100LL, JET A1 + OX 3 TPA.See Remarks ARFF Index B **H.3E, L.5D, 6E**
RWY 15.33: H7006X100 (ASPH.PFC) S.80, D.100, DT.160 MIRL 2.0% up SE **IAP, AD**

- Many mountain airports have sloping runways. The "FAA" maximum is 2%. More than 5% is severe…
- Surrounding terrain may make airport "one-way", e.g. ASE – always departing downhill and landing uphill. For an uphill landing add about 5 knots to allow for the extra flare. If you must land downhill, use the *minimum* possible approach speed or you will float, float, float…
- Perspective illusions make you tend to approach too steep on downhill runways and vice-versa. Check your VSI.
- On downhill takeoffs, accelerate in ground effect. Don't over-rotate.
- In general be cautious about mixing wind and runway gradient. However, if the surrounding terrain allows takeoff in either direction, the better direction will be no worse than a no-wind/no-slope takeoff roll.
- Taking off uphill, chances are that the terrain beyond the departure end rises and may exceed the climb capability of the airplane.
- If you haven't got 70% of your liftoff speed(*) half-way to your liftoff point, abort!

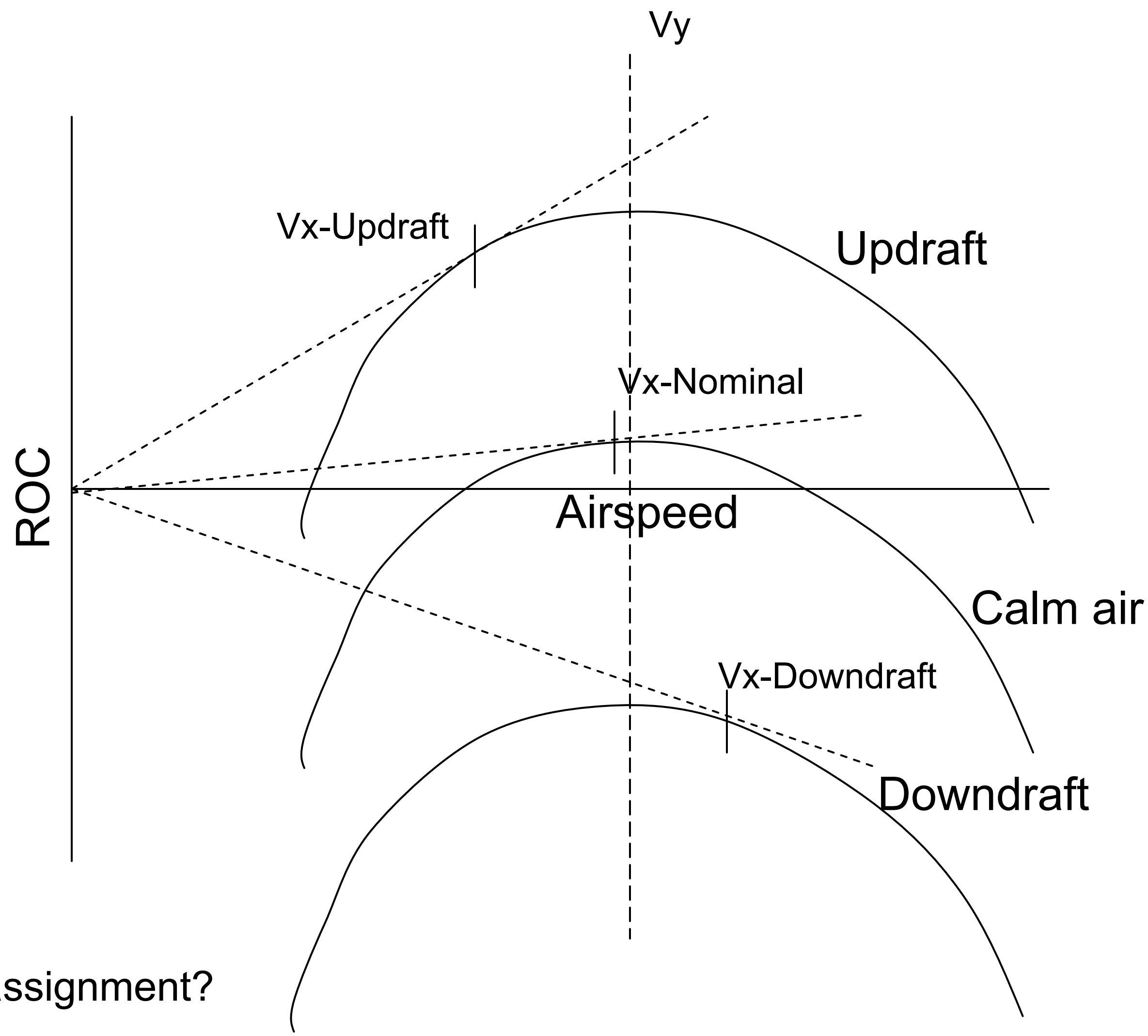
(*) 70% of the liftoff speed plus/minus 30% of the head/tailwind component includes the effect of the wind. (Lowry)

Near your ceiling think "high performance sailplane" not "doggy airplane".

- Up and down-drafts are the sailplane pilot's friend. Make them yours. Don't dilly-dally in downdrafts.
- In strong up- and down-drafts: (1) Try to maintain altitude (BAD) (2) Maintain airspeed (BETTER) (3) Slow in updrafts and dive through downdrafts. (BEST)
- Where up? Upwind of ridges, above sunlit slopes, in mountain waves, under Cu. clouds.
- In a canyon or narrow valley, hug the updraft (downwind) side. This give more room for a 180. Never fly beyond a point where you can no longer make a gliding 180.
- Crossing a ridgeline, make your final approach (last ½ - 1 mile) at a 45 degree angle to facilitate a turn back to lower terrain. Beware of the "false horizon" stall and the "short left arm". 2000 feet of terrain clearance is usually adequate, with experience, often less.

In a downdraft causing altitude loss, you should fly faster than Vy.

By diving in downdrafts and zooming in updrafts, you spend more time going up than down…



IFR: block altitude assignment?

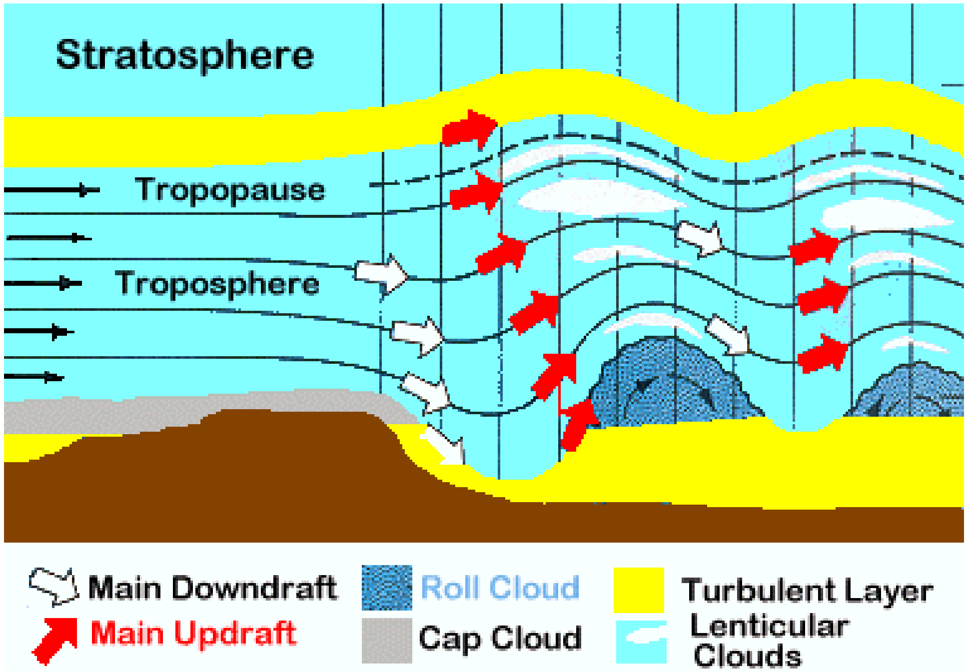
At ~5000 ft+ density altitudes you need to lean for takeoff.

- Lean for max power in a full-power run-up. If it isn’t paved, lean on the takeoff roll.
- On the landing checklist, don’t go to full rich but something close to max power.
- Don’t lean turbo- airplanes!
- Allow the airplane accelerate to Vx/Vy after takeoff. Don’t fly with a short left arm! Center the ball.
- Go-arounds at high elevation airports can be very critical, even impossible if left too late. Establish a commit point.

Mountain weather

- Mountains amplify weather. Orographic lifting adds to synoptic effects.
- Observations are more sparse and the weather is more changeable. Remember ceiling heights are above airport (valley) elevations.
- Terrain reduces your options to fly around the weather.

Mountain Waves - stable air plus wind



Leading edge of the lenticulars (if present) marks the updrafts. Loiter there to gain altitude that can be spent later.
Beware of roll/rotor clouds below the wave.

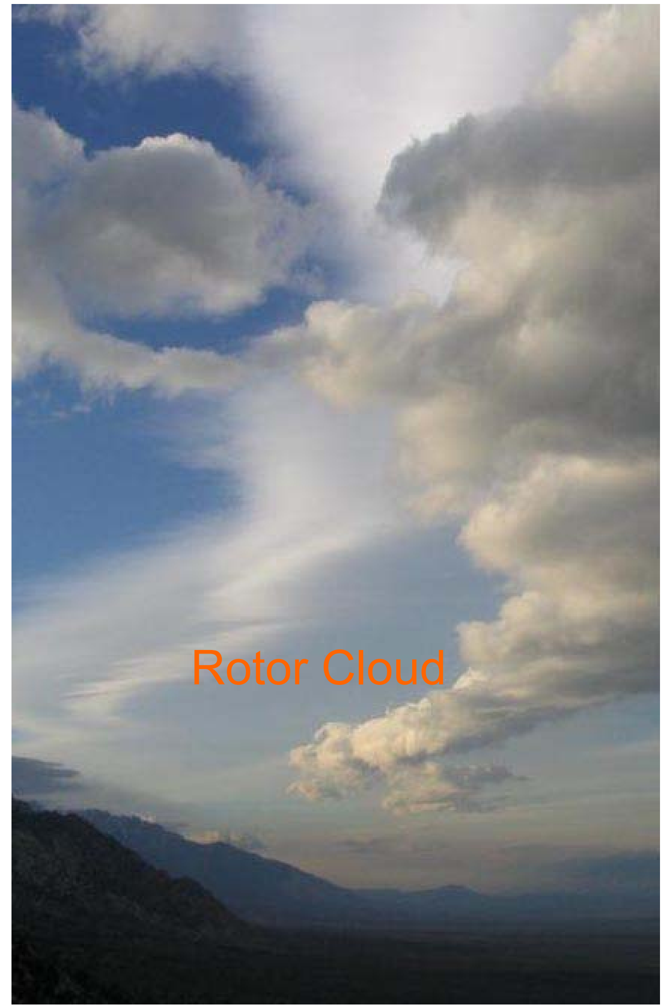
A strong mountain wave requires:

- Marked stability in the air stream disturbed by the mountain. Rapidly building cumulus over the mountains visually marks the air unstable; convection, evidenced by the cumulus, tends to deter wave formation.
- Wind speed at the level of the summit should exceed a minimum which varies from 15 to 25 knots depending on the height of the range. Upper winds should increase or at least remain constant with height up to the tropopause.
- Wind direction should be within 30 degrees normal to the range. Lift diminishes as winds more nearly parallel the range.

Stacked lenticulars over Boulder, Colorado

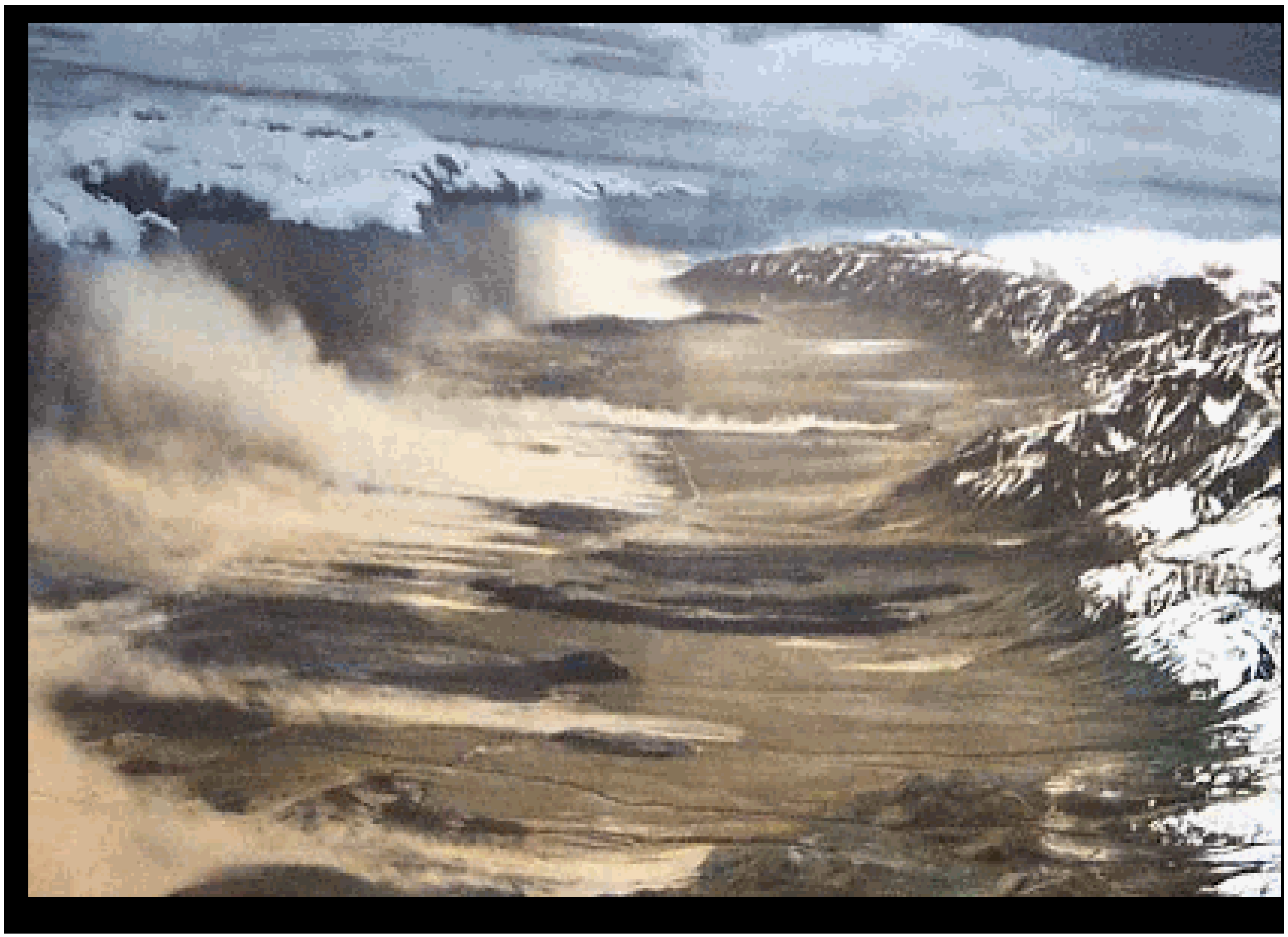
Rotor clouds - possible extreme turbulence!

Owens Valley April 1 1955. Tom Henderson.



Owens Valley April 20 2004
Sierra Rotor Project Alex Reneicke

Bob Symons' famous picture of the Sierra Wave taken from a P-38 soaring with both engines feathered.



Mountain TRWs – unstable + moisture

Cumulus building over the Sierras

Typically form PM.
Mountain flying is normally best in the AM!
- cooler temperatures
- clearer skies

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Bedtime reading

- Mountain Flying
  - Mountain Flying, Sparky Imeson, Airguide Pub. (Long Beach 1982)
  - Mountain Flying, Doug Geeting and Steve Woerner, Tab (1991)
  - A Guide to Bush Flying, Fred Potts, ACS Pubs (Tucson 1993)
- Aircraft Performance
  - Aerodynamics for Naval Aviators
  - The Advanced Pilot's Flight Manual, Kershner
  - Flying High Performance Singles and Twins, Eckalbar
- Mountain Weather
  - Turbulence: A New Perspective for Pilots, Lester (Jeppesen 1993)
  - Exploring the monster, Whelan, (Wind Canyon Books, 2000)

T-REX http://www.eol.ucar.edu/projects/trex/