Density Altitude

What you don’t see can affect your flight

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Density Altitude Defined

- Density altitude (DA) is the pressure altitude corrected for non-standard temperature variations
- DA significantly impacts aircraft performance
- Altimeter settings lower than standard increase pressure and density altitude
- Example:
  - Airfield Elevation: 3,000 ft MSL (ISA = 8°C)
  - Airfield Temperature: 35°C (ISA+27°C)
  - DA of 6000 ft MSL,
  - Aircraft will perform as if it were a 6000 ft elevation airport on a “standard day” (+3°C)
  - Equivalent aircraft performance -> 3000’ at 35°C and 6000 at 3°C

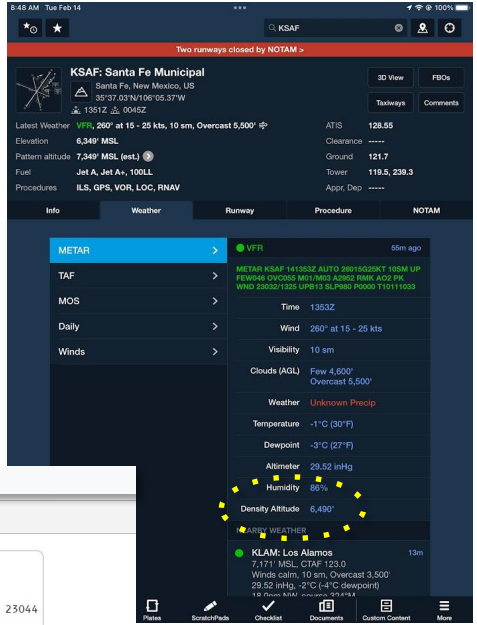
ISA Temperature ~= 15° -(Pressure Altitude/1000*2)

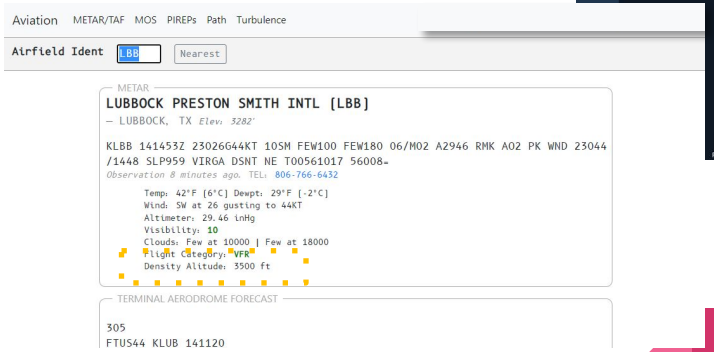
Components contributing to DA

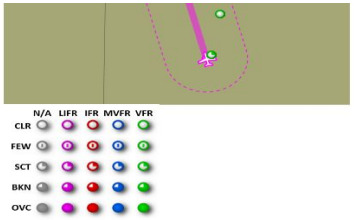
- **Altitude**: Starting off higher increases density altitude
  Examples:
    KLBB – 3,282’ AMSL Temp 104°F, Standard altimeter = DA **7024’**
    KGLS – 6’ AMSL, Temp 20 °F, Standard altimeter = DA **-2500’**
- **Temperature**: The hotter the air, the less dense it is.
  Increasing temperature => increasing DA.
- **Humidity**: The more humid the air, the less dense it is.
  Increasing humidity => increasing DA. Small influence ~few hundred feet
- **Other factors:** Altimeter setting (pressure altitude)

Where to find/calculate DA

- ASOS/AWOS Broadcasts
- aviation.caprockweather.com
- 1800wxbrief.com
- Many GPS navigators
- Many flight planners







Departure:
Current conditions at Lubbock Preston Smith International, Lubbock, TX (KLBB), VFR, Wind from 250° at 8 knots, 10 statute miles visibility, Scattered Clouds at 21,000 feet, Scattered Clouds at 28,000 feet, Temperature -1°C, Dewpoint -9°C, Altimeter is 30.08. Density Altitude at KLBB is 2005 feet.

How does DA affect Aircraft Performance

Density altitude impacts:

- Available horsepower
- Engine cooling
- Takeoff and landing distances
- Rate of climb
- Climb and descent distances / gradients
- True (and ground speed)

Density altitude does not affect IAS which remains locked to aircraft performance

SHORT FIELD TAKEOFF DISTANCE AT 2550 POUNDS

CONDITIONS:
Flaps 10°
Full Throttle prior to brake release.
Paved, Level, Dry Runway
Zero Wind

Lift Off: 51 KIAS
Speed at 50 Feet: 56 KIAS

Pressure Altitude Feet	0°C		10°C		20°C		30°C		40°C	
	Gnd Roll Feet	Total Feet To Clear 50 Foot Obst	Gnd Roll Feet	Total Feet To Clear 50 Foot Obst	Gnd Roll Feet	Total Feet To Clear 50 Foot Obst	Gnd Roll Feet	Total Feet To Clear 50 Foot Obst	Gnd Roll Feet	Total Feet To Clear 50 Foot Obst
Sea Level	860	1465	925	1575	995	1690	1070	1810	1150	1945
1000	940	1600	1010	1720	1090	1850	1170	1990	1260	2135
2000	1025	1755	1110	1890	1195	2035	1285	2190	1380	2355
3000	1125	1925	1215	2080	1310	2240	1410	2420	1515	2605
4000	1235	2120	1335	2295	1440	2480	1550	2685	1660	2880
5000	1355	2345	1465	2545	1585	2755	1705	2975	1825	3205
6000	1495	2605	1615	2830	1745	3075	1875	3320	2010	3585
7000	1645	2910	1785	3170	1920	3440	2065	3730	2215	4045
8000	1820	3265	1970	3575	2120	3880	2280	4225	2450	4615

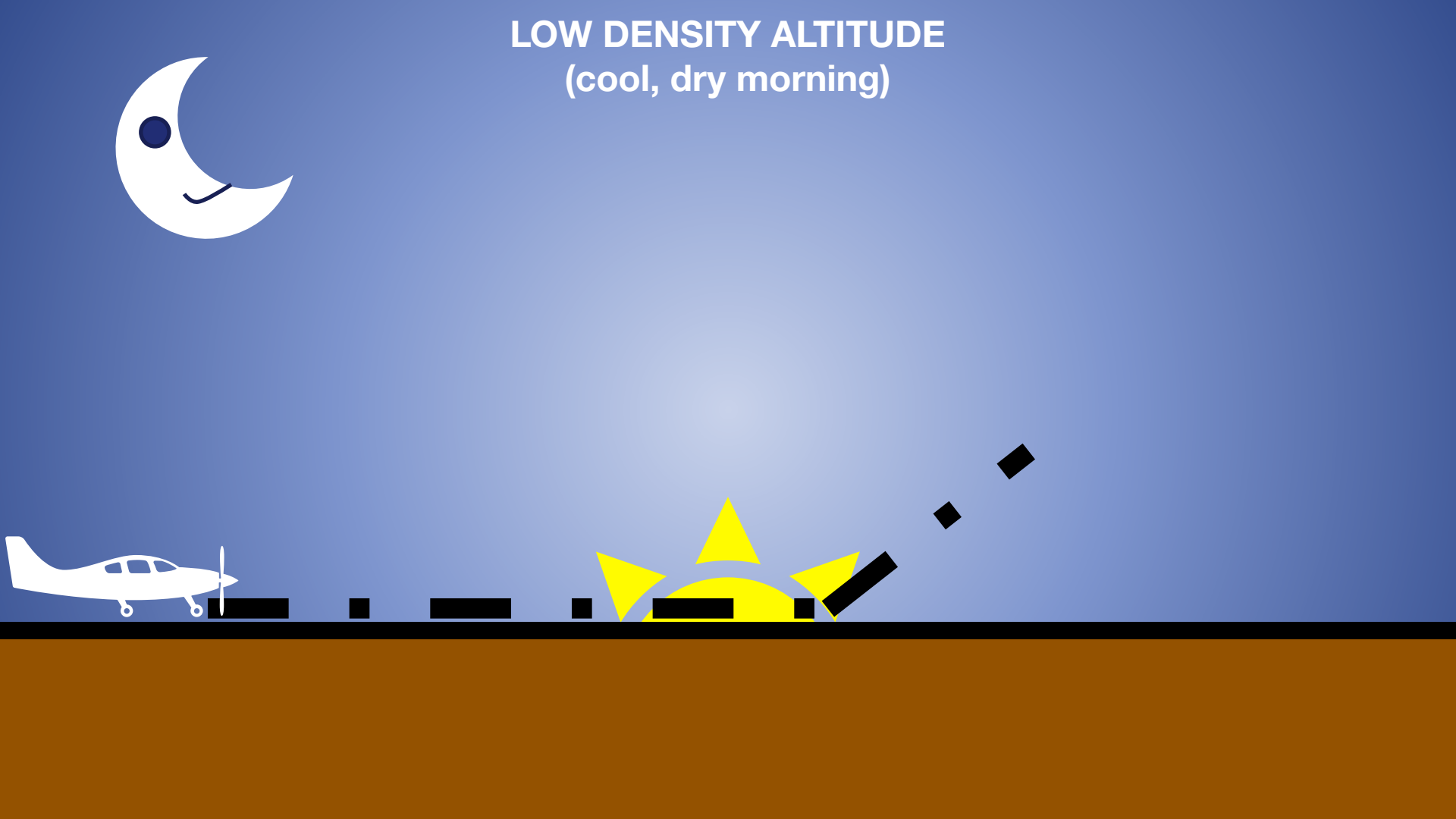
MAXIMUM RATE OF CLIMB AT 2550 POUNDS

CONDITIONS:

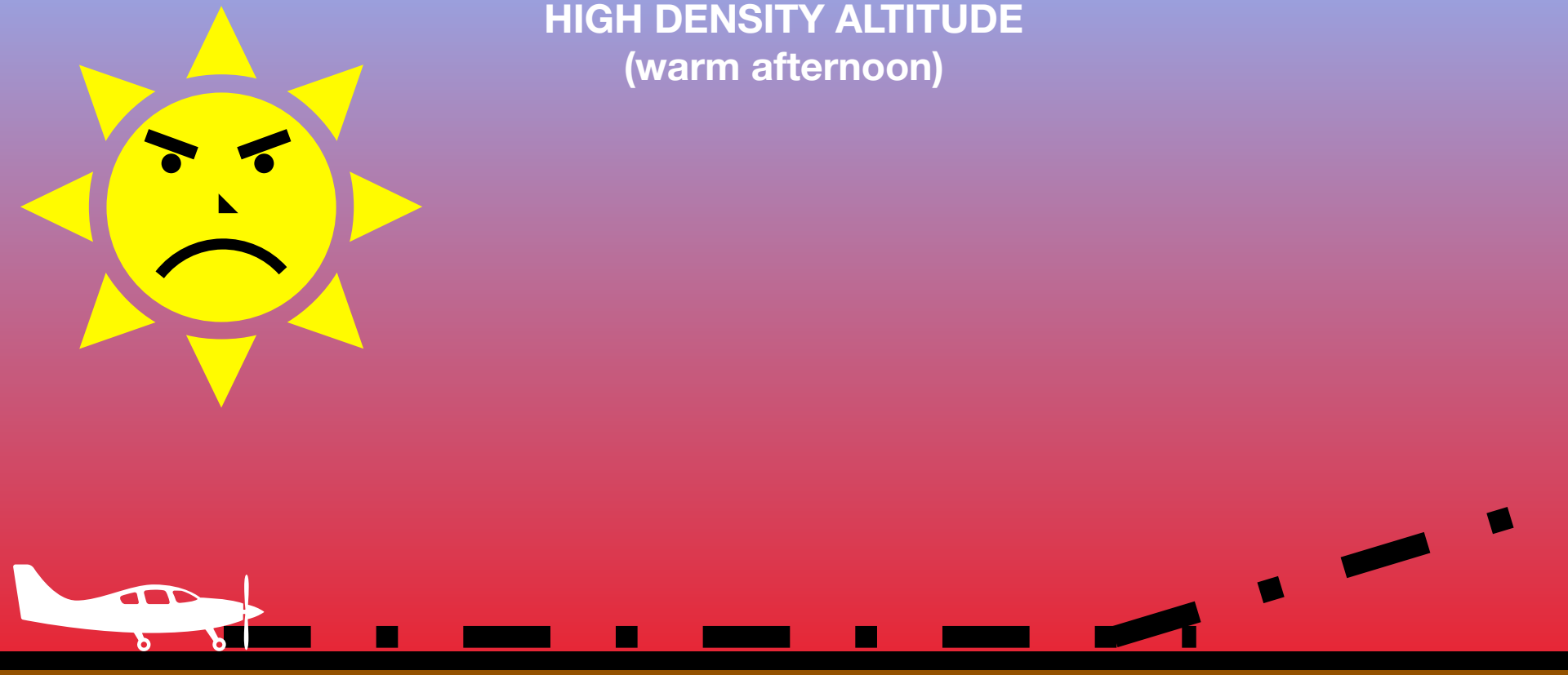
Flaps UP
Full Throttle

Pressure Altitude Feet	Climb Speed - KIAS	Rate of Climb - FPM			
		-20°C	0°C	20°C	40°C
Sea Level	74	855	785	710	645
2000	73	760	695	625	560
4000	73	685	620	555	495
6000	73	575	515	450	390
8000	72	465	405	345	285
10,000	72	360	300	240	180
12,000	72	255	195	135	---

LOW DENSITY ALTITUDE
(cool, dry morning)



HIGH DENSITY ALTITUDE
(warm afternoon)



Density Altitude in Action

https://www.youtube.com/watch?v=FD1T97UqMMU

Example case - Telluride Elev: 9070

Pleasant July day - 64°F (18°C)

Density Altitude: 11500’

50’ obstacle clearance distance ???

Brand new 172 might see 300 fpm climb

That’s ~240’ per NM at Vy

What about 9000’? →

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A closer look is warranted…

Consider: 8000’ pressure altitude

Can we extrapolate? NO! *Equations are not linear*

Is some guidance available? **Yes.** If we use Density Alt!

9070’ at 18C is **equivalent DA (~11500’)** to 8000’ at 30C
Make use of your E6B

If we carefully compute an equivalent density altitude, we can obtain performance insight.

Understand FULLY and cross check with an experienced mountain flyer!

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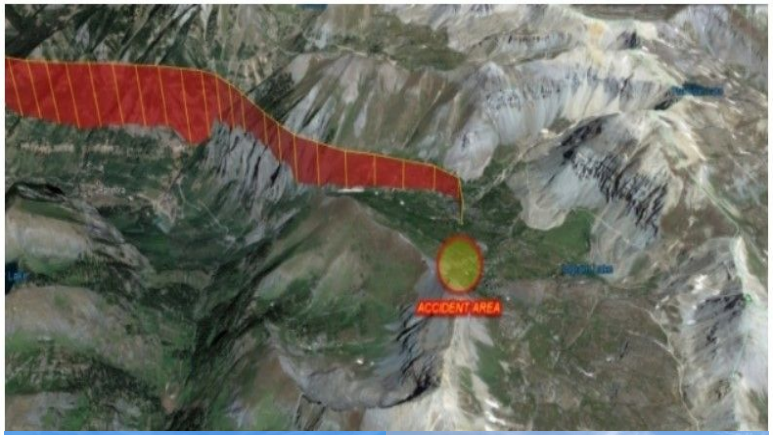
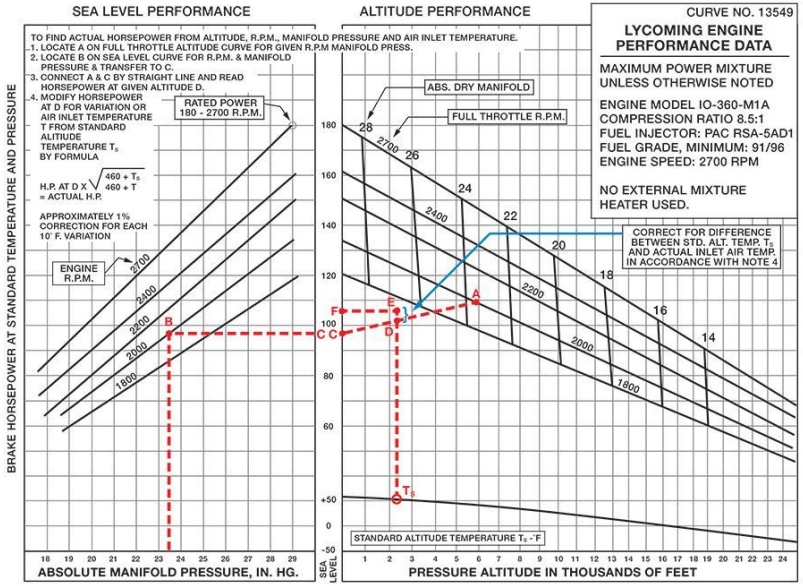
Telluride DA accident

- Bonanza with newlywed couple.
- Pilot a 757/767 First officer who flew extensively in Florida
- Crash at 11,823’ AMSL - DA est 13,600’
- At best, 160’/NM climb
- Nearly vertical path terrain impact Stall/spin?



http://www.kathrynsreport.com/2020/10/beechcraft-s35-bonanza-n4444k-fatal_10.html

Engine performance considerations



Have you seen a graph like this?
It's in your engine operating handbook?
Ever read it?
Know how to use such a diagram?

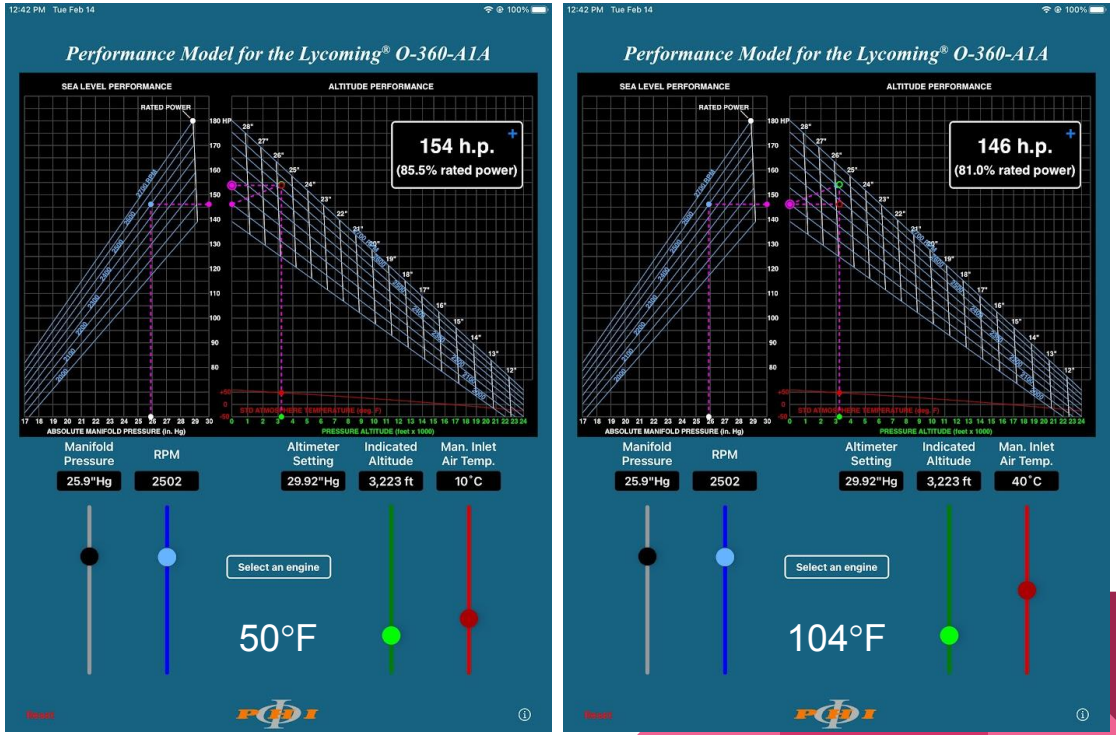
Turbochargers reduce, but don't eliminate density altitude effects!
The wing isn't immune!

iOS Aircraft Power App

Neat tool to easily view effects on density altitude, HP, and RPM on power

View how much less power you may have on a hot day

This example yields 8HP loss but a fixed pitch prop would probably be -10 HP or higher at 3000’



Manifold pressure loss due to higher DA not factored in this example

Density Altitude Mitigation

- Of prime importance : CHECK DA!!!
- Review performance data (+safety margin)
- Conduct high DA ops in cool of morning
- Plan for times of favorable winds
- Consider runway slope
- Is leaning appropriate via the POH?
- Know thy aircraft.
    - Keep a log of aircraft performance.
    - Analyze Track Logs (Cloud Ahoy, Google Earth KML)

Compare book to actual performance considering field elevation, winds, temperature, and runway gradient.

Closing comments / questions?

Increased DA can result in:

- Increased takeoff distance
- Reduced rate of climb
- Increased landing distance
- Faster cruise TAS in many situations (hey, a positive!)
- Increased true airspeed on approach and landing (well, not all positive!)

Thank you!

Calculations

```
/**
 * density Altitude Calculation
 * presMb = Station Pressure in MB
 * dwptC = Dewpoint C
 * tempC = Temperature C
 */
function densityAltitude($tempC, $dwptC, $presMb) {
    //console.log("T "+tempC+" Td "+dwptC+" P "+presMb);
    $Tv = virtualTemp($tempC, $dwptC, $presMb);
    $Tr = (($Tv * 1.8) + 32) + 459.67;
    $presInhg = $presMb * 0.02953;
    $densityAltitude_ft = 145366 * (1 - pow((17.326 * $presInhg /
($Tr)), 0.235));
    return $densityAltitude_ft;
}
/**
 *
 * @param type $tempC
 * @param type $dwptC
 * @param type $presMb
 * @return type
 */
function virtualTemp($tempC, $dwptC, $presMb) {
    $ewv = calcVaporPressure($dwptC);
    $tv = $tempC / (1 - ($ewv / $presMb) * (1 - 0.622));
return $tv;
}
```

```
/**
 * Use the BUCK equation to calculate vapor pressure
 * @param type Temp in deg C
 * @return type vapor pressure in hPA
 */
function calcVaporPressure($tempC) {
    return 6.1121 * exp(((18.678 - ($tempC / 234.5)) *
          ($tempC / (257.14 + $tempC))));
}
```