Pilot's Ground School Handout

Search Pilot Qualification Course

Civil Air Patrol

Auxiliary of the United States Air Force

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Dedication:

Mountain Fury is dedicated to all the men and women of the Civil Air Patrol who gave their lives so that others may live. Strength through training!

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Mountain Fury

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INTRODUCTION

Mountain Fury is a total training program that was developed to help ensure that Civil Air Patrol pilots are able to fly safely in mountainous terrain while conducting search missions.

The course is geared to those current and qualified mission pilots. "Current" means current Form 5s and Form 91s and ES Cards in the personal possession of the pilot.

The course curriculum is broken down into a full-day ground school program; and four separate sections of training in aircraft at high altitude with a qualified CAP check pilot and/or mission check pilot who has completed the course or has specific exemption authorization from Wing Headquarters.

The trainee pilot is responsible for having each segment of his graduation certificate signed off before being allowed to graduate from the program.

The first two segments are to be flown with a CAP check pilot and require specific actions to be taken by the pilot at high altitude. The third segment calls for flying in mountainous terrain and into and out of airports in mountainous terrain. It is highly recommended that airports with a high density altitude be used on the day of training (to be no less than 6,000 feet).

Enclosed is the paperwork and the outline for each sortie. Follow and complete the formats as part of this handbook. Each sortie form must be completed in its entirety before being allowed to progress to the next segment of the program.

Sortie three, four and the Form 91 check ride need to be conducted at a *Mountain Fury Sarex* in mountainous terrain. A pilot will not be allowed to participate at a Mountain Fury Sarex unless he/she has successfully completed the "Ground Portion," "Sortie One" and "Sortie Two" as evidenced by a sign-off by an authorized Check Pilot or Mission Check Pilot. The sign-off required must be signed off on the proper phase of the Graduation Certificate, Grade Sheet enclosed and the paperwork for Sortie One and Sortie Two.

After the pilot has successfully completed all facets of the program, he or she may apply for an ES Card Renewal with the proper paperwork.

Mountain Fury
Search Pilot
Qualification Course Outline

Civil Air Patrol

Auxiliary of the United States Air Force

Mountain Fury is dedicated to all the men and women of the Civil Air Patrol who have given their lives so that others may live

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Course Objectives

- Instruct Civil Air Patrol pilots to fly safely in mountainous terrain.
- Instruct Civil Air Patrol Mission Pilots to safely and effectively search in mountainous terrain.

Course Background

- Specific skills are required to safely and effectively conduct mountain flight operations .
- The Civil Air Patrol frequently conducts flight operations in mountainous terrain.
- CAP pilots require academic and flight training in mountain flight operations.
- The Mountain Fury Process Action Team was convened from nationwide experts to develop the CAP mountain search course, the training requirements, and the associated regulations.
- CAP HQ adopted the course and the associated regulatory changes.

Course Content

- Academic Blocks of Instruction
    - ➢ High Altitude Flying
    - ➢ Mountain Weather
    - ➢ Mountain Flying
    - ➢ Mountain Searching
- Written Examination
- Flight Training
- Support Materials
- Recurrency Training
- High Altitude Flying
    - Pressure altitude
    - Density altitude
    - Predicting density altitude
    - Aircraft performance
    - Maximum safe operating altitude
    - Aircraft maneuvering
    - Physiological effects of altitude
    - Personal equipment
- Mountain Weather
    - Slopes
    - Wind
    - Turbulence
    - Standing Wave

  - Clouds
  - Ceilings
  - Visibility
  - Thunderstorms
  - Weather forecasts
- Mountain Flying
  - Flying with Mountain Winds
  - Exiting Downdrafts
  - Crossing ridges
  - Canyon Flying
  - Sensory Illusions
  - Mountain Airport Operations
  - Night flying
  - Mountain Flying Safety
- Mountain Searching
  - Route and ELT searching
  - Grid navigation
  - Search strategies
  - Contour searching
  - Steep valley searching
  - Effects of lighting
  - Actions upon target location
  - Crew consideration
- Written Examination
  - 40 multiple-choice questions
  - Closed book
  - Covers all material presented in ground school
  - Charts needed for reference will be provided
  - Seventy percent passing score
  - Successful completion required prior to flying phase
- Flight Training
  - Discover how aircraft performance changes with altitude
  - Learn techniques of mountain flying
  - Learn techniques of mountain search flying
  - Designed to be accomplished in four sorties
  - Specific but flexible training syllabus
  - Flown under the supervision of a Mentor Pilot
  - Grade sheets annotated following each flight
  - Concluded with Form 91 checkride
- Support Materials
  - Ground school training presentation
  - Written test
  - Videotapes
  - Sparky Imeson's "Mountain Flying Bible" book
  - Course guide
  - Briefing guide
  - Flight training syllabus
  - Applicable regulations
- Recurrency Training
  - Required every two years not involving refresher training

- Review instructional material
- Satisfactorily complete written examination
- Satisfactorily complete Form 91 check flight evaluation

- Refresher/Reinstatement Training
  - Required every four years
  - Attend academic training
  - Satisfactorily complete written examination
  - Satisfactorily complete Form 91 flight evaluation
- Definition of Mountain Flying

  For the purpose of this course, mountain flying constitutes flying and searching in close proximity to precipitous terrain
- Pre-Flight Preparation

  Pre-flight preparation is one of the keys to any successful flight. It involves many facets and needs to be taken seriously. Considerable time and effort should be placed in this area. The course curriculum for the ground and flight portion recognizes this issue and deals with the issues of conducting a safe flight.

- Accurate weight and balance
- Weather
  - ➢ Current and forecast weather at departure and destination airports
  - ➢ Current and forecast weather, winds and temperature aloft
  - ➢ Density altitude at departure airport and operating altitudes
- Aircraft performance data
  - ➢ Takeoff and landing distance
  - ➢ Best rate and angle of climb speeds at takeoff and operating altitudes
  - ➢ Maximum safe search altitude, stall speed, turn radius, etc.
- Thorough preparation is crucial for safe and effective mountain flying
  - Safety of flight operations in high altitude and mountain operations is paramount
  - To achieve this goal, a CAP Mission Pilot must know where and when to fly (and not to fly)
  - Consider density altitude, weather, terrain, aircraft performance, and the physiological limits of the crew before and during each flight
  - And always WATCH YOUR AIRSPEED!

Each sortie for the air work will take approximately 3.5 hours. The Form 91 flight should take a little less time if it is conducted effectively.

It is highly recommended each Wing have CAP Check Pilots who are also well qualified as mission check pilots and instructors for this course. Each wing needs to utilize only those CAP Check Pilots and Mission Check Pilots who have exhibited recent proficiency in flight and in and around Mountainous Terrain.

It is also highly recommended that as a minimum, the Mountain Flying, Mountain Searching and the Form 91 be conducted at a supervised SAREX. CAP Check Pilots and Mission Check Pilots, other than the one or one(s) the individual normally flies with should be conducting the training.

The Form 91 Check Ride needs to be conducted with a current and qualified Mission Check Pilot other than the individual or individuals who helped train the pilot.

BLOCK ONE

High Altitude Flying

- Lower air temperature
- Lower air pressure
- Stronger winds
- Different weather phenomenon
- Pressure Altitude

Pressure altitude is the absolute altitude above mean sea level corrected for non-standard atmospheric pressure.

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Calculating Pressure Altitude

PA = H - 925 x (S - 29.92), where
PA = Pressure Attitude
H = Absolute Altitude
S = Barometric pressure corrected for altitude

Example:
9,000 absolute altitude, altimeter setting 28.50
PA = 9,000 - 925 x (28.50 - 29.92)
PA = 9,000 - 925 x (-1.42) [Watch your sign]
PA = 9,000 + 1,313
PA = 10,313

Calculating Density Altitude DA = PA + 66 x (T - TS), where T = Actual temperature TS = Standard temperature

Example:
9,000 absolute altitude, 60ºF, altimeter setting 28.50
DA = PA + 66 x (60 OF - 22.20F)
DA = PA + 66 x 37.8
DA = 10,313 (from previous example) + 2,495
DA = 12,808

Predicting Density Altitude

- Methods of determining altimeter setting
    - ➢ ATIS or AWOS for closest airport
    - ➢ Surface observation from FSS or DUATS

Methods of determining temperature aloft

- ➢ Consult Winds and Temperatures Aloft forecast
- ➢ Obtain local surface temperature, then subtract 3.5ºF for each 1,000 feet of altitude above reporting point

Remember: As the density altitude increases,

- ➢ available horsepower decreases
- ➢ aircraft performance decreases
- ➢ maximum safe operating altitude decreases

For flight operations in close proximity to precipitous terrain, the maximum safe operating altitude is that altitude at which the aircraft can achieve **at least 300 fpm rate of climb**.

- Aircraft Maneuvering
  - Increased true airspeed
  - Increased turn radius
  - Vertically and horizontally confining terrain
  - Downdrafts, turbulence
  - Reduced engine power
- Physiological Effects of Altitude
  - Oxygen deprivation (hypoxia)
  - Sinus pressure
  - Ultraviolet radiation
  - **Definition of Hypoxia**:
    Hypoxia is a lack of oxygen at the tissue level of the body due to a decrease of oxygen pressure in inspired air or because of conditions that interfere with the diffusion or absorption of oxygen within the body

1

  - **Types of Hypoxia**
    - **Histotoxic Hypoxia**
      - ➢ Interference of the tissue's ability to absorb or metabolize delivered oxygen
      - ➢ 0ften caused by alcohol, narcotics, or poisons
    - **Hypemic Hypoxia**
      - ➢ Reduction of the blood's ability to carry oxygen
      - ➢ Carbon monoxide is most common cause
      - ➢ Other causes: anemia, blood loss, and smoking
    - **Hypoxic Hypoxia**
      - ➢ Lack of oxygen in the tissues due to decrease in the partial pressure of oxygen at altitude
    - **Causes of Hypoxia**
      - ➢ Flight at an altitude where there is insufficient partial pressure of oxygen to cause oxygen transfer
      - ➢ Ingestion or inspiration of drugs that interfere with the blood's ability to absorb or transport oxygen from the lungs to the cells
      - ➢ Malfunction of the circulatory system
      - ➢ Positive "g" forces preventing oxygenated blood from reaching the brain
      - ➢ Mechanical malfunction of supplemental oxygen equipment
  - **Symptoms of Hypoxia**
    - ➢ Decreased visual acuity
    - ➢ Mental confusion
    - ➢ Shallow, rapid breathing
    - ➢ Cyanosis of the fingernails
    - ➢ Headache
    - ➢ Eventual incapacitation, followed by death
  - **Prevention of Hypoxia**
    - ➢ Use lowest practical flight level
    - ➢ Minimize duration of high-altitude operations
    - ➢ Allow acclimatization to higher altitudes,
    - ➢ Refrain from alcohol and tobacco products
    - ➢ Maintain good physical condition

  - ➢ Use supplemental oxygen
- Supplemental Oxygen
  - ➢ Required for crewmembers when flying between 12,500 and 14,000 MSL for over 30 minutes
  - ➢ Required for crewmembers at all times when flying above 14,000 MSL
  - ➢ Must be provided to passengers above 15,000 MSL
  - ➢ Will have beneficial effects at altitudes well below those required by regulation

Note:

While the regulations require use of supplemental oxygen in terms of absolute altitude, the physiological effects of hypoxia result from DENSITY ALTITUDE. Base your decisions regarding exposure to hypoxia on your calculations of the density altitude at which you are operating.

- **Sinus Pressure**
  - ➢ Close your mouth and keep it closed
  - ➢ Pinch your nostrils closed tightly
  - ➢ Force your tongue against the roof of your mouth
  - ➢ Exhale forcibly through the upper throat into your nasal cavity until pressure is equalized
- **Ultraviolet Radiation**
  - ➢ Thin air at higher altitudes allows more damaging UV radiation from the sun to reach your cockpit.
  - ➢ Protect exposed skin with sunscreen
  - ➢ Wear sunglasses which block both UV-A and UV-13 radiation
- **Personal Equipment**
  - ➢ Wear layers of warm clothing
    - Aircraft heater may be ineffective or inoperative
    - Heater may not distribute air evenly throughout the aircraft
    - May be all you retain following rapid egress from aircraft
  - ➢ Drink water to prevent dehydration
  - ➢ Augment normal aircraft survival gear
    - Mountains become very cold at night, even in the summer
    - Sleeping bag can be a lifesaver, especially if injured
    - High-calorie food necessary in low temperature environment
    - Traveling for water or shelter can be difficult in steep terrain

BLOCK TWO

Mountain Weather

- **Slopes**

  Most U.S. mountain ranges are oriented north-south, while the prevailing winds are from the west. This orientation causes wind to rise over the ranges then descend on the other side. On these ranges, the west side is the "upslope" or "windward" side, while the east side is the "downslope" or "leeward" side.

- **Wind**
  - ➢ Upwind slopes and updrafts tend to be relatively stable and smooth
  - ➢ Downwind slopes and downdrafts tend to be more random and turbulent
  - ➢ Wind channels and accelerates through valleys and mountain passes, also causing turbulence

- **Wind Acceleration**
  - ➢ Wind will often accelerate when passing over or through mountains. Especially in the presence of an inversion layer, rising air will be "squeezed" between the mountain ridges and the overlying air mass, causing a venturi effect which can double the wind velocity. For this reason, steady-state winds aloft in excess of thirty knots can preclude mountain flying.

- **Diurnal Wind Flow**
  - ➢ Convection causes winds to flow up valleys in the morning (Valley Breeze), then flow down valleys in the afternoon and evenings (Mountain Breeze).

- **Turbulence**
  - ➢ Turbulence in the mountains is usually the result of airflow over, around, or between obstructions
  - ➢ Severity is often proportional to wind velocity
  - ➢ Location is usually predictable
    - But there are many exceptions to this rule
  - ➢ Usually strongest on leeward side
    - Depends on the steepness of the downslope

- **Standing Wave Clouds**
  - ➢ Formed from moisture present in the airmass
  - ➢ Useful in visualizing wind and weather patterns
  - ➢ Lenticular clouds unique to the mountain environment
    - Smooth, lens-shaped clouds above peaks and ridges indicate strong winds flowing up and through that area
  - ➢ Cap clouds form at the top of peaks and ridgelines
    - Appear as stationary, but actually reflect strong winds
  - ➢ Rotor clouds form downwind of a ridgeline
    - Indicate strong, violent winds moving In a rotary motion

- **Cloud Ceilings**
  - ➢ Ceilings are reported above ground level; in the mountains, this usually means above the valley floor
    - Surrounding terrain often extends into the ceiling
    - Valley floors sometimes rise into the ceiling
  - ➢ All aircraft forced to fly in valleys and through passes
    - VOR signals may be lost or become unreliable
    - Radio communication will be degraded
    - Increased potential for mid-air collision

- ➢ **<u>CAP minimum ceiling for VFR flight is 1,000 feet</u>**
  - A higher ceiling may be appropriate for mountain flying
- **Visibility**
  - ➢ Reduced visibility is dangerous in the mountains
    - Obstructions can appear quite quickly
  - ➢ Power lines, towers, rock outcroppings, other aircraft
    - Situational awareness can be lost
    - Inadvertent IMC can be encountered
  - ➢ Use caution when flying near rain
    - Rain tends to move and appear in previously clear areas
    - Creates visual illusion of excess altitude
  - ➢ **<u>CAP minimum for VFR flight is three miles</u>**
    - Greater visibility appropriate in unfamiliar terrain

Airmass Stability

Stable air tends to rise over obstructions then return to its original level in a fairly orderly manner. Stable air is less likely to result in convective activity and the associated turbulence. Unstable air has a higher adiabatic lapse (temperature drop) rate when displaced, and therefore tends to continue rising. Expect greater convective activity and turbulence from a moving unstable air mass, especially if it is relatively moist.

- **Frontal Thunderstorms**
  - ➢ Adequately forecast
  - ➢ Lines break up when encountering mountains
    - Rarely encounter imbedded thunderstorms
    - Diminish due to interruption of moist air inflow
  - ➢ Squall lines do not normally occur near mountains
    - Necessary down flow of cool air is interrupted
  - ➢ Still dangerous when present
    - Consider canceling flight in these conditions
- **Orographic Thunderstorms**
  - ➢ Formed when air is forced up by terrain
  - ➢ Requires moist, unstable air to form
  - ➢ Usually isolated or scattered
  - ➢ Can build rapidly
  - ➢ Can occur at any time when conditions are present
- **Convective Thunderstorms**
  - ➢ Result from rising unstable air
    - Usually forced upward by solar ground heating
  - ➢ Formative stage in mid-morning
    - Billowing cumulous clouds
    - Light to moderate turbulence beneath bases
  - ➢ Rapid development by early afternoon
    - Towering and thickening cumulous clouds
    - Increasing turbulence
  - ➢ Mature thunderstorms are dangerous
    - Severe turbulence, hail, lightning, downdrafts
    - Remain well clear ... at least 10 miles

- Weather Forecasts
    - ➢ Not as accurate as in the flatlands
        - Fewer reporting stations
        - More localized weather phenomena
    - ➢ Pilot reports often best source of valid information
    - ➢ As a general rule, weather best during the morning
    - ➢ Weather can change quickly in the mountains
    - ➢ Always have a good escape plan

BLOCK THREE

Mountain Flying

- **Flying with Mountain Winds**
  - ➢ Determine direction and velocity of steady winds
    - Observe dust, smoke, tree leaves, or aircraft drift
    - At 100-knots ground speed, 6° crab = 10-knot crosswind
  - ➢ Smoother and easier flying along windward slopes
  - ➢ Use caution along leeward slopes until tested
    - Downdrafts, turbulence, especially below passes
  - ➢ Always be in a position to turn toward lower terrain
  - ➢ Constantly monitor airspeed and vertical velocity
- **Exiting downdrafts**
  - ➢ In a strong or sustained downdraft:
    - Turn towards lower terrain
    - Apply maximum power (throttle + propeller pitch)
    - Attain and maintain best rate-of-climb airspeed
    - Attempt to fly out of the downdraft area (downwind is usually best)
  - ➢ If descending faster than your calculated rate of climb:
    - Increase airspeed to rapidly fly out of downdraft area
    - Use cruise speed or, if in turbulence, use maneuvering speed
    - Accept temporary increase in rate of descent
- **Canyon Flying**
  - ➢ Never fly up a canyon if there is insufficient lateral width to comfortably turn around
- **Crossing Ridges**
  - ➢ Approaching ridge from windward side:
    - Fly directly toward ridge
    - If caught In downdrafts while crossing a ridge, this course is the most direct path away from the ridgeline
  - ➢ Approaching ridge from leeward side
    - Achieve desired altitude well before reaching ridge
    - Approach at 45° angle to allow shortest turn away if caught in downdraft
  - ➢ Determining relative height
    - If you see more terrain on other side of ridge as you approach, your altitude is greater than that of ridgeline
  - ➢ Never fly beyond the "point of no return"
  - ➢ Always remain in a position to allow a turn toward lowering terrain
  - ➢ Fly along one side of the canyon (usually the upwind side) to provide the full canyon width to turn around
  - ➢ Always know your location; side canyons can look like your desired route but can lead to disaster
- **Course Reversal Maneuver**
  - ➢ May be required in rapidly-rising terrain or rapidly-narrowing canyon
  - ➢ Pull up to gain altitude and achieve best cornering velocity
  - ➢ Deploy 10°-20° flaps to increase lift
  - ➢ Rapidly achieve 60° bank and pull to achieve tightest turn radius while maintaining adequate stall margin
  - ➢ If vertical terrain clearance permits, accept altitude loss during turn to maintain one-g loading and safe airspeed

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- **Sensory Illusions**
  - ➢ False horizon
    - Perhaps the greatest cause of mountain mishaps
    - Experienced when flying toward gradually rising terrain
    - Actual horizon is well below perceived horizon
    - Airspeed decays during unperceived slow climb
  - ➢ High terrain hidden in shadow
    - Lighting from behind distant high terrain hides closer hill
  - ➢ Indicated versus true airspeed
    - Perceived airspeed margin due to high ground speed
- **Night Flying**
  - ➢ High terrain can "sneak up" on you at night
  - ➢ Maintain positional awareness at all times
  - ➢ Terrain clearance must be constantly monitored
    - Optical information is often insufficient
    - Utilize charts, radar services, local knowledge
  - ➢ Decreasing lights ahead indicates higher ridgeline
  - ➢ Isolated lights can produce vertigo
  - ➢ Follow lighted roads
    - Usually runs through lowest terrain (beware of tunnels)
    - Useful in the event of power loss
- **Mountain Airport Operations**
  - ➢ Often confined spaces and sloped runways
  - ➢ Plan your pattern to accommodate local conditions
  - ➢ Traffic patterns usually on side away from terrain
  - ➢ Thoroughly research local procedures
  - ➢ Runway surface may be questionable
  - ➢ Expect unpredictable air currents at low altitudes
  - ➢ Beware of downdrafts immediately after liftoff
  - ➢ Conduct circling climb above airport before heading directly toward high terrain
- **Uphill vs. Downhill Takeoff**

Use this formula when deciding whether to take off downhill with a tailwind or uphill with a headwind. Elect an uphill takeoff if the actual headwind component is greater than the calculated “Break-even headwind.”

$$\text{Break-even headwind} = \frac{\text{Runway slope x no-wind TO distance}}{\text{5 x Liftoff speed in KTAS}}$$

- **Mountain Flying Safety**
  - ➢ Always exercise good judgment and caution
  - ➢ Always maintain positional awareness
  - ➢ Know your aircraft performance capabilities
  - ➢ Do not exceed your aircraft performance capabilities
  - ➢ Watch for power lines and their support structures
  - ➢ Determine the best emergency notification frequency
    - May not be 121.5
    - Consider remote antenna locations, ARTCC frequencies
  - ➢ Always have a downward path toward lower terrain
  - ➢ And always WATCH YOUR AIRSPEED

BLOCK FOUR

Mountain Searching

- **Flying with Mountain Winds**
- **ELT Searches**
  - ➢ Conduct search at highest practical altitude
    - Increase chance of detecting ELT located in valley
  - ➢ Fly straight line along suspected route
    - If no detection, fly 7-mile offsets
  - ➢ Fly expanding circle over high-probability area
  - ➢ If deep canyons in area, fly over each one
    - Preclude missing signal confined to vertical propagation
  - ➢ Signals may only be detectable at certain times
    - Weak batteries may only transmit when warmed by sun
- **Grid Navigation**
  - ➢ Use every means available to identify grid area
    - GPS, VOR, visual confirmation of terrain features
  - ➢ If equipped, set up GPS to remain within grid
    - Monitor bearing and distance from selected corner
  - ➢ Assess weather and winds in the search area
  - ➢ Assess grid to determine best search method
    - Will be dictated by terrain features
    - Take the time to plan method for searching each feature
  - ➢ Record searched areas on chart or hand drawing
- **Search Strategies**
  - ➢ Ascertain areas of high probability, such as:
    - Natural pathways through the terrain
    - Aircraft often follow valleys and fly through passes
    - Particularly when low ceilings were present
    - False canyons and gradually rising terrain
    - Especially if the pilot was unfamiliar with the terrain
    - Areas of cloud cover or thunderstorm activity
    - First ridge on a direct route between origin and destination
  - ➢ Consider focusing on these areas before conducting an exhaustive contour search of the grid
- **Pilot Responsibilities**
  - ➢ Plan and clear the flight path
  - ➢ Assure proper terrain clearance
  - ➢ Maintain constant altitude
  - ➢ Maintain optimal airspeed (about 80 knots)
  - ➢ Put observers in best position to scan terrain
  - ➢ Keep track of areas searched
  - ➢ Identify areas remaining to be searched
  - ➢ Monitor aircraft systems and performance
- **Contour Searching**
  - ➢ Use contour search techniques In mountainous terrain other than canyons and steep valleys
  - ➢ Begin at the highest elevation
  - ➢ Maintain a constant altitude while flying adjacent to steep terrain

- Once all terrain at that altitude has been searched, descend 500 feet and continue contour searching
- Put your observers in the optimal position to detect the target
- If you encounter a sub-ridge, either:
  - Include it in your current contour search
  - Return later to search it separately
- Two options in searching ridge or mountain:
  - Contour all the way around the terrain before descending
  - Contour one face at a time
- Resist temptation to scan when the terrain is on your side of the aircraft
  - Your job is to safely fly the airplane

- **Search Spacing**
  - 500-feet vertically and laterally is ideal
    - Closer and terrain appears as a blur
    - Farther and objects cannot be detected
  - Factors which might prevent this spacing
    - Turbulence, downdrafts, terrain features
  - Generally maintain this spacing, following terrain
    - But do not turn into small gullies and ravines
    - Return later to fly a drainage search pattern
- **Scanning a Plateau**
  - Scanning in foliage
  - Difficult to spot target in or below trees
  - May have to fly above, then adjacent to each area
    - In pass above, direct observers to look vertically
    - In pass adjacent, direct observers to look horizontally
  - Look for indications of a crash
    - Broken trees or limbs
    - Dried leaves
- **Searching a Cove**
  - Be certain your aircraft turn radius will allow flying comfortably into and out of the cove
  - If too tight, use the drainage search method
  - A low-wing aircraft will block the observer's view
  - Explain your plan to your crew before entering
- **Searching a Promitory**
  - If the terrain cuts sharply away from your flight path, do not turn sharply to follow it in a high-wing aircraft
    - Temporarily exceed optimal spacing
    - High wing will block observer's view
    - Instead, extend outward, then reverse course to re-approach
  - If the terrain cuts sharply into your flight path, do not turn sharply to follow it in a low-wing aircraft
    - Low wing will block observer's view
    - Forced to conduct a drainage search pattern
- **Searching a Drainage**
  - Required in narrow or steep drainages
  - Involves flying straight down the drainage
    - Both observers scan each side simultaneously
  - Approach from the top at low airspeed

- ➢ Reduce power when beginning descent
- ➢ Use partial or full flaps to increase drag
- ➢ S-turns allow scanning bottom of drainage

- **Searching a Canyon**
  - ➢ Reconnoiter the canyon from above
    - Confirm correct routing
    - Note presence and location of side canyons
    - Look for power lines and their support structures
  - ➢ Always fly down canyons
    - Reduce the chance of turning up a dead end side canyon
  - ➢ Maintain positional awareness at all times
  - ➢ Continue to look for power lines across the canyon
- **Effects of Lighting**
  - ➢ Shadows can prevent sighting targets
    - Loss of sufficient lighting
    - Loss of contrast
  - ➢ Direct light may reflect from shiny targets
  - ➢ Most mountainous terrain is best searched mid-day
  - ➢ Steep slopes may be best early or late in the day
  - ➢ Flying in deepening shadows can be dangerous
    - Difficult to judge distance from terrain
    - Difficult to detect layered back lighted obstructions
- **Action Upon Target Detection**
  - ➢ Immediately note a prominent visual landmark
  - ➢ Capture location on GPS (if installed)
  - ➢ Note exact altitude at time of acquisition
  - ➢ Return to the location at the same altitude
    - Allow time to approach the target wings-level
  - ➢ Use 360° racetrack pattern or 180° teardrop pattern
    - Racetrack pattern has advantage of re-creating same direction
  - ➢ Be cautious when turning back toward vertical terrain
    - Ensure adequate turning radius
    - Use shallow approach angle
- **Crew Consideration**
  - ➢ Insure entire crew is fit for duty prior to takeoff
  - ➢ Consult with crew regarding mission accomplishment
    - Correct spacing, flight track, lighting, etc.
  - ➢ Take periodic breaks from searching
    - Relax, drink, snack, stretch
    - Perform ops check switch fuel tanks, etc.
  - ➢ Terminate mission when appropriate
    - Two hours "in-grid" is a practical maximum
    - Upon crewmember airsickness, exhaustion, etc.
- **Closing Thoughts**

Mountain flying is demanding, yet at the same time very rewarding. Maintaining awareness of, and proficiency in, the principals and techniques described in this course will allow you to safely and effectively fly and search in the mountains *"So That Others May Live."*

Notes:

Mountain Fury
Search Pilot
Qualification Course Outline

Civil Air Patrol

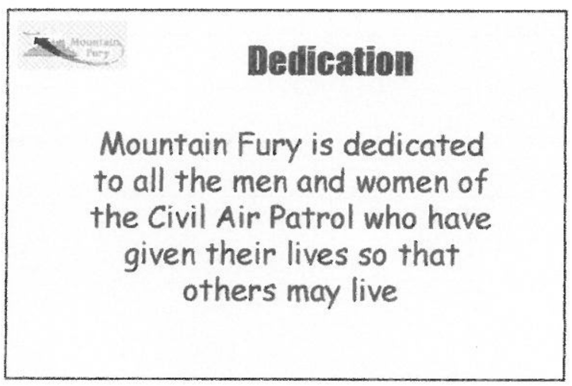
Auxiliary of the United States Air Force

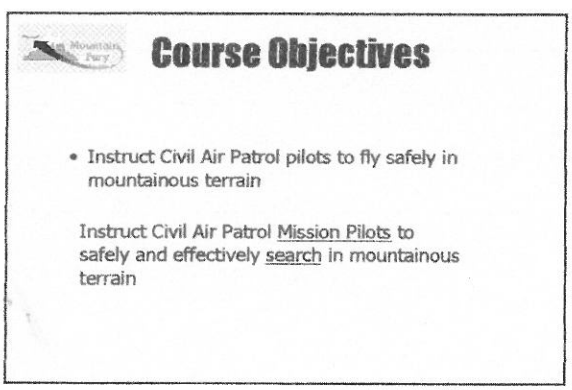
Mountain Fury is dedicated to all the men and women of the Civil Air Patrol who have given their lives so that others may live

Welcome and Introduction	8:00 AM
Course Outline and Objective	8:20 AM
Sparky Imeson Video - *Mountain Flight*	8:40 AM
Break	10:00 AM
High Altitude Flying	10:10 AM
Break	11:10 AM
Mountain Weather	11:20 AM
Lunch	12:10 PM
Mountain Flying	1:00 PM
Break	2:45 PM
Mountain Search	3:00 PM
Break	4:40 PM
Test	4:50 PM
Grading of Test	5:20 PM
Critique of Program and Awarding of Certificates	5:30 PM

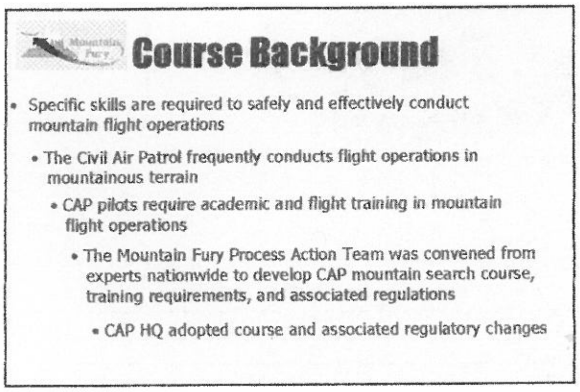
NOTES:


Mountain
Fury
Search Pilot
Qualification Course
Civil Air Patrol
Auxiliary of the United States Air Force

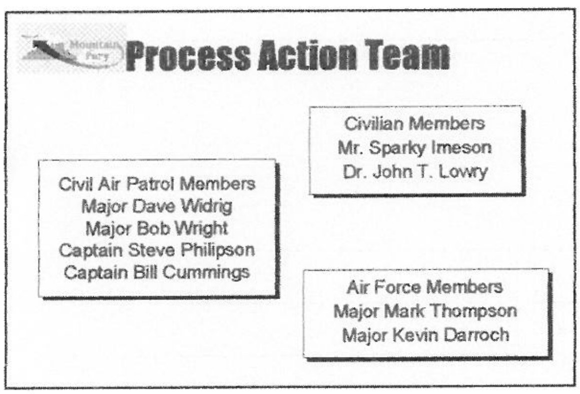

Dedication
Mountain Fury is dedicated to all the men and women of the Civil Air Patrol who have given their lives so that others may live

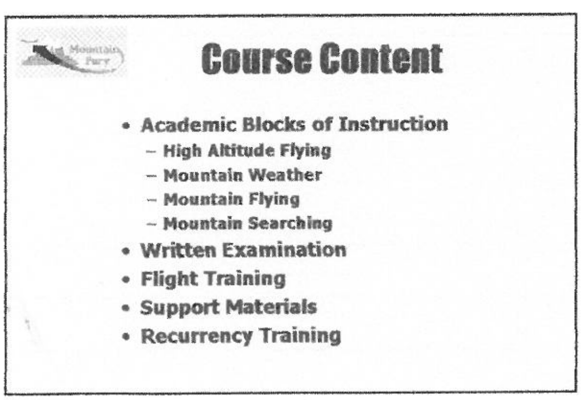

Course Objectives
• Instruct Civil Air Patrol pilots to fly safely in mountainous terrain
Instruct Civil Air Patrol Mission Pilots to safely and effectively search in mountainous terrain

3


Course Background
Specific skills are required to safely and effectively conduct mountain flight operations
The Civil Air Patrol frequently conducts flight operations in mountainous terrain
CAP pilots require academic and flight training in mountain flight operations
The Mountain Fury Process Action Team was convened from experts nationwide to develop CAP mountain search course, training requirements, and associated regulations
CAP HQ adopted course and associated regulatory changes

3


Process Action Team
Civilian Members
Mr. Sparky Imeson
Dr. John T. Lowry
Civil Air Patrol Members
Major Dave Widrig
Major Bob Wright
Captain Steve Philipson
Captain Bill Cummings
Air Force Members
Major Mark Thompson
Major Kevin Darroch


Course Content
Academic Blocks of Instruction
– High Altitude Flying
– Mountain Weather
– Mountain Flying
– Mountain Searching
Written Examination
Flight Training
Support Materials
Recurrency Training

High Altitude Flying

- Pressure altitude
- Density altitude
- Predicting density altitude
- Aircraft performance
- Maximum safe operating altitude
- Aircraft maneuvering
- Physiological effects of altitude
- Personal equipment

Mountain Weather

- Slopes
- Wind
- Turbulence
- Standing Wave
- Clouds
- Ceilings
- Visibility
- Thunderstorms
- Weather forecasts

Mountain Flying

- Flying with Mountain Winds
- Exiting Downdrafts
- Crossing ridges
- Canyon Flying
- Sensory illusions
- Mountain Airport Operations
- Night flying
- Mountain Flying Safety

Mountain Searching

- Route and ELT searching
- Grid navigation
- Search strategies
- Contour searching
- Steep valley searching
- Effects of lighting
- Actions upon target location
- Crew consideration

Written Examination

- 40 multiple-choice questions
- Closed-book exam
- Covers all material presented in ground school
- Charts needed for reference will be provided
- Seventy-percent passing score
- Successful completion required prior to flying phase

Flight Training

- Discover how aircraft performance changes with altitude
- Learn techniques of mountain flying
- Learn techniques of mountain search flying
- Designed to be accomplished in four sorties
- Specific but flexible training syllabus
- Flown under the supervision of a Mentor Pilot
- Grade sheets annotated following each flight
- Concluded with Form 91 checkride

Support Materials

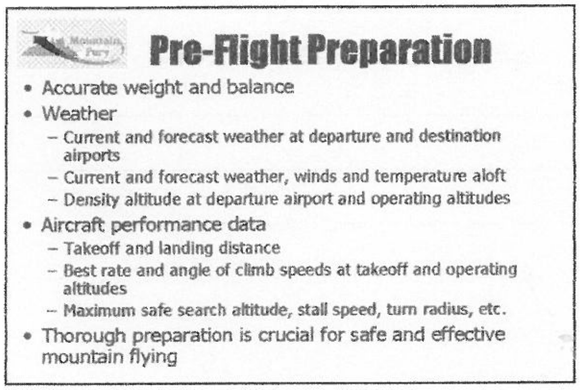
- Ground school training presentation
- Written test
- Videotape
- Course guide
- Briefing guide
- Flight training syllabus
- Applicable regulations

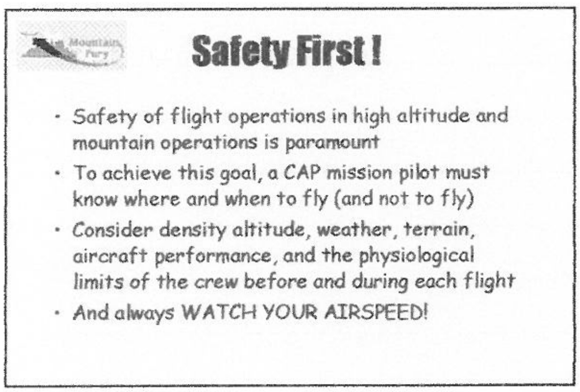
Recurrency Training

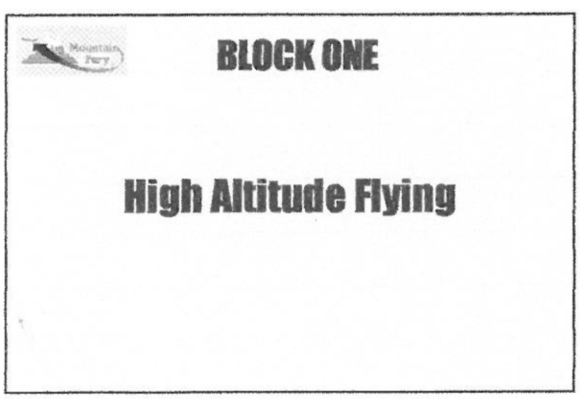
- Recurrency Training
  - Required every two years not involving refresher training
  - Review instructional material
  - Satisfactorily complete written examination
  - Satisfactorily complete Form 91 flight evaluation
- Refresher/Reinstatement Training
  - Required every four years
  - Attend academic training
  - Satisfactorily complete written examination
  - Satisfactorily complete Form 91 flight evaluation

Definition: Mountain Flying

For the purpose of this course, mountain flying constitutes flying and searching in close proximity to precipitous terrain


Pre-Flight Preparation
• Accurate weight and balance
• Weather
– Current and forecast weather at departure and destination airports
– Current and forecast weather, winds and temperature aloft
– Density altitude at departure airport and operating altitudes
• Aircraft performance data
– Takeoff and landing distance
– Best rate and angle of climb speeds at takeoff and operating altitudes
– Maximum safe search altitude, stall speed, turn radius, etc.
• Thorough preparation is crucial for safe and effective mountain flying


Safety First !
• Safety of flight operations in high altitude and mountain operations is paramount
• To achieve this goal, a CAP mission pilot must know where and when to fly (and not to fly)
• Consider density altitude, weather, terrain, aircraft performance, and the physiological limits of the crew before and during each flight
• And always WATCH YOUR AIRSPEED!


BLOCK ONE
High Altitude Flying

High-altitude flight operations differ significantly from those at lower flight levels, primarily due to:

- Lower air pressure
- Lower air temperature
- Stronger winds
- Different weather phenomenon

Pressure Altitude

Pressure altitude is absolute altitude above mean sea level corrected for non-standard atmospheric pressure

Calculating P.A.

PA = H - 925 x (S - 29.92), *where*
PA = Pressure Altitude
H = Absolute Altitude
S = Barometric pressure corrected for altitude

Example:
9,000 absolute altitude, altimeter setting 28.50

PA = 9,000 - 925 x (28.50 - 29.92)
PA = 9,000 - 925 x (-1.42) *Watch your ± sign!*
PA = 9,000 + 1,313
PA = 10,313

Density Altitude

Density altitude is pressure altitude corrected for non-standard temperature

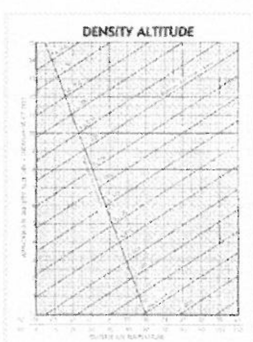
3

Calculating D.A.

DA = PA + 66 x (T - TS), *where*
T = Actual temperature
TS = Standard temperature

Example:
9,000 absolute altitude, 60°F, altimeter setting 28.50

DA = PA + 66 x (60 °F - 22.2°F)
DA = PA + 66 x 37.8
DA = 10,313 (from previous example) + 2,495
DA = 12,808

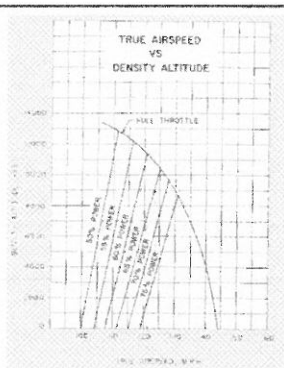


Predicting D.A.

- Methods of determining altimeter setting
  - ATIS or AWOS for closest airport
  - Surface observation from FSS or DUATS
- Methods of determining temperature aloft
  - Consult Winds and Temperatures Aloft forecast
  - Obtain local surface temperature, then subtract 3.5°F for each 1,000 feet of altitude above reporting point

Remember:

As density altitude increases, the difference between indicated airspeed and true airspeed increases



3

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Remember:

As density altitude increases, available horsepower decreases

Horsepower - Cessna 182 -P Model

Density Altitude	Manifold Pressure	Horsepower Available
8,000 ft	20"	65%
10,000 ft.	19"	62%
12,000 ft.	17"	55%

Based upon 2,400 rpm with new engine

Horsepower - Cessna 206 -G Model

Density Altitude	Manifold Pressure	Horsepower Available
8,000 ft	20"	57%
10,000 ft.	19"	55%
12,000 ft.	17"	52%

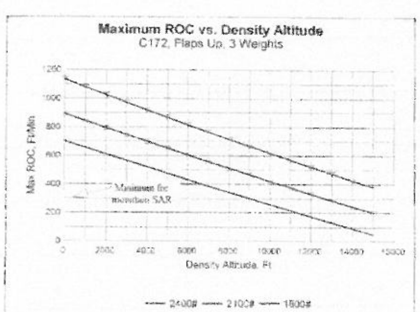
Based upon 2,400 rpm with new engine

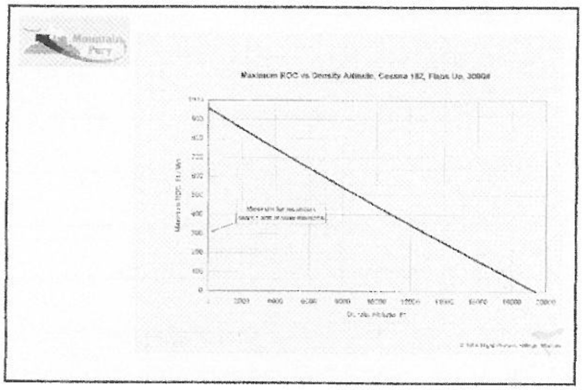
Aircraft Performance

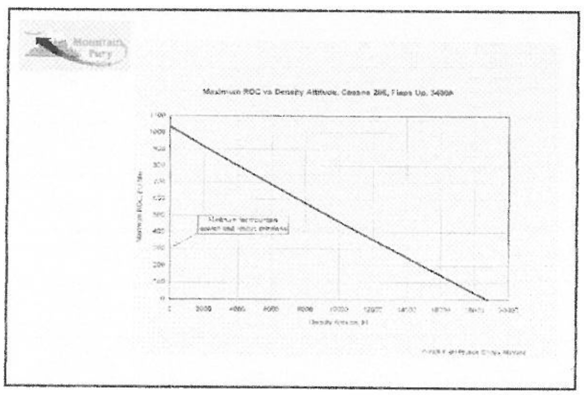
Aircraft performance at high altitude is greatly affected by two factors:

1. Density Altitude
2. Aircraft Weight

PRESSURE ALTITUDE 4,000 FEET			
Temperature	Density Altitude, Feet	ROC @ 2,100 Pounds	ROC @ 2,400 Pounds
10°F	1,600	820	630
60°F	5,000	650	470
100°F	7,500	540	370
PRESSURE ALTITUDE 6,000 FEET			
Temperature	Density Altitude, Feet	ROC @ 2,100 Pounds	ROC @ 2,400 Pounds
10°F	4,000	700	520
60°F	7,500	540	370
100°F	10,000	410	260
PRESSURE ALTITUDE 10,000 FEET			
Temperature	Density Altitude, Feet	ROC @ 2,100 Pounds	ROC @ 2,400 Pounds
10°F	9,000	460	300
60°F	12,400	315	160
100°F	15,000	200	50







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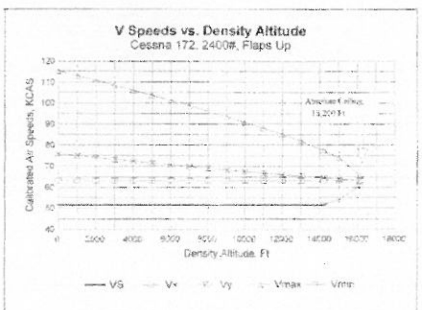
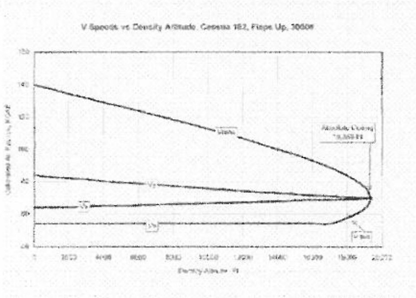
Maximum Safe Operating Altitude

For flight operations in close proximity to precipitous terrain, the maximum safe operating altitude is that altitude at which the aircraft can achieve at least 300-fpm rate of climb

Remember:

As density altitude increases, indicated airspeeds for best <u>angle</u> of climb and best <u>rate</u> of climb change dramatically





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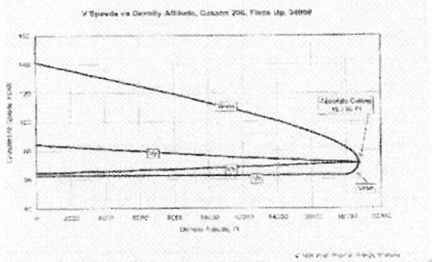
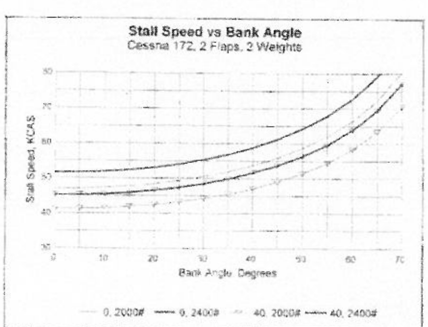


Remember:

Stall speed increases with bank angle and aircraft weight



Aircraft Maneuvering

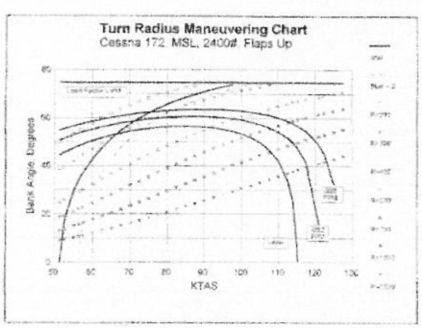
Maneuvering at high altitude and in mountainous environments is complicated and degraded by many factors:

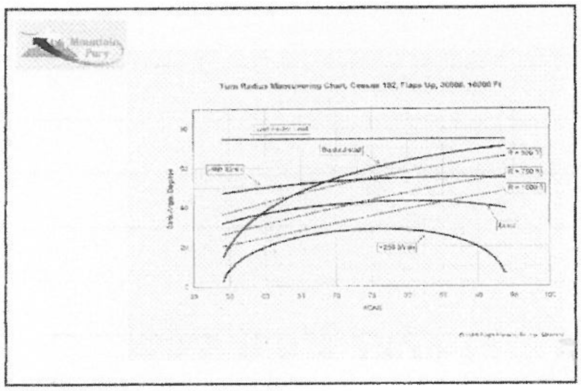
- *Increased true airspeed*
- Increased turn radius
- Vertically and horizontally confining terrain
- Downdrafts, turbulence
- Reduced engine power

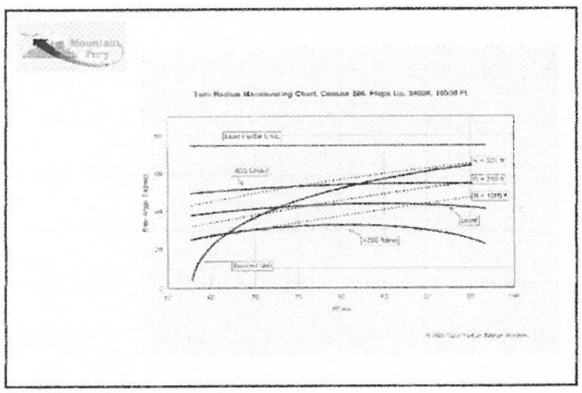
Turn Radius

Aircraft turn radius is affected by a number of related factors, including:

- Aircraft weight
- Bank angle
- True airspeed
- "g" loading
- Density altitude







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Physiological Effects of Altitude

- Oxygen deprivation (hypoxia)
- Sinus pressure
- Ultraviolet radiation

Definition of Hypoxia

Hypoxia is a lack of oxygen at the tissue level of the body due to a decrease of oxygen pressure in inspired air or because of conditions that interfere with the diffusion or absorption of oxygen within the body

Types of Hypoxia

- Histotoxic Hypoxia
  - Interference of the tissue's ability to absorb or metabolize delivered oxygen
  - Often caused by alcohol, narcotics, or poisons
- Hypemic Hypoxia
  - Reduction of the blood's ability to carry oxygen
  - Carbon monoxide is most common cause
  - Other causes: anemia, blood loss, and smoking
- Hypoxic Hypoxia
  - Lack of oxygen in the tissues due to decrease in the partial pressure of oxygen at altitude

Causes of Hypoxia

- Flight at an altitude where there is insufficient partial pressure of oxygen to cause oxygen transfer
- Ingestion or inspiration of drugs that interfere with the blood's ability to absorb or transport oxygen from the lungs to the cells
- Malfunction of the circulatory system
- Positive "g" forces preventing oxygenated blood from reaching the brain
- Mechanical malfunction of supplemental oxygen equipment

Symptoms of Hypoxia

The most common initial symptom is mild euphoria, making the self-detection of hypoxia less likely and more difficult. Every person's symptoms differ in order and severity, but often include:

- Decreased visual acuity
- Mental confusion
- Shallow, rapid breathing
- Cyanosis of the fingernails
- Headache
- Eventual incapacitation, followed by death

Prevention of Hypoxia

- Use lowest practical flight level
- Minimize duration of high-altitude operations
- Allow acclimatization to higher altitudes
- Refrain from alcohol and tobacco products
- Maintain good physical condition
- Use supplemental oxygen

Supplemental Oxygen

- Required for crewmembers when flying between 12,500 and 14,000 MSL for over 30 minutes
- Required for crewmembers at all times when flying above 14,000 MSL
- Must be provided to passengers above 15,000 MSL
- Will have beneficial effects at altitudes well below those required by regulation

Note:

While the regulations require use of supplemental oxygen in terms of absolute altitude, the physiological effects of hypoxia result from DENSITY ALTITUDE. Base your decisions regarding exposure to hypoxia on your calculations of the density altitude at which you are operating.

Sinus Pressure

Air trapped in sinus cavities and the inner ear must be equalized during climbs and descents to prevent pain and tissue damage. Yawning during ascent is usually sufficient, but use of the Valsalva Maneuver during descent may be required:

- Close your mouth and keep it closed
- Pinch your nostrils closed tightly
- Force your tongue against the roof of your mouth
- Exhale forcibly through the upper throat into your nasal cavity until pressure is equalized

Ultraviolet Radiation

- Thin air at higher altitudes allows more damaging UV radiation from the sun to reach your cockpit.
- Protect exposed skin with sunscreen
- Wear sunglasses which block both UV-A and UV-B radiation.

Personal Equipment

- Wear layers of warm clothing
  - Aircraft heater may be ineffective or inoperative
  - Heater may not distribute air evenly throughout the aircraft
  - May be all you retain following rapid egress from aircraft
- Carry water in cockpit to prevent dehydration
- Augment normal aircraft survival gear
  - Mountains become very cold at night, even in the summer
  - Sleeping bag can be a lifesaver, especially if injured
  - High-calorie food necessary in low temperature environment
  - Traveling for water or shelter can be difficult in steep terrain

Block Two

Mountain Weather

Slopes

Most U.S. mountain ranges are oriented north-south, while the prevailing winds are from the west. This causes wind to rise over the ranges then descend on the other side.

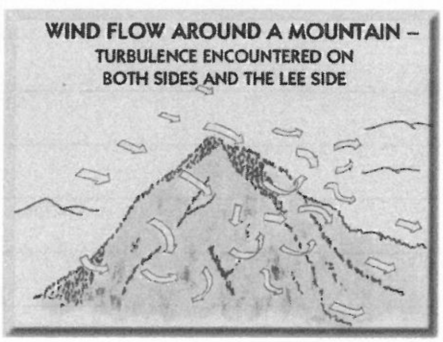
On these ranges, the west side is the "*upslope*" or "*windward*" side, while the east side is the "*downslope*" or "*leeward*" side.

Wind

Visualize moving air as you would flowing water, passing over and around obstacles. Learn to predict updrafts, downdrafts, and turbulence based upon the predictable movement of air in relation to peaks, valleys, passes, and other obstructions.

- Upwind slopes and updrafts tend to be relatively stable and smooth
- Downwind slopes and downdrafts tend to be more random and turbulent
- Wind channels and accelerates through valleys and mountain passes, also causing turbulence

The windward side usually has smooth updrafts



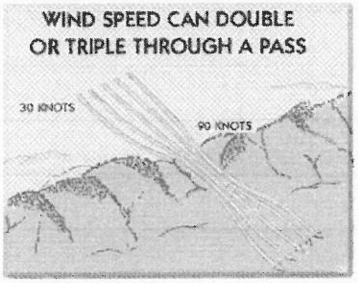
Wind Acceleration

Wind will often accelerate when passing over or through mountains.

Especially in the presence of an inversion layer, rising air will be "squeezed" between the mountain ridges and the overlying air mass, causing a venturi effect which can double the wind velocity.

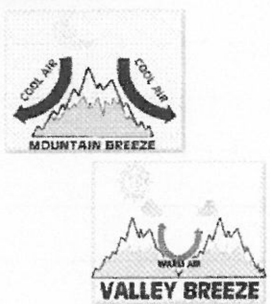
For this reason, steady-state winds aloft in excess of thirty knots can preclude mountain flying.

A similar effect occurs when wind flows through a mountain pass or valley



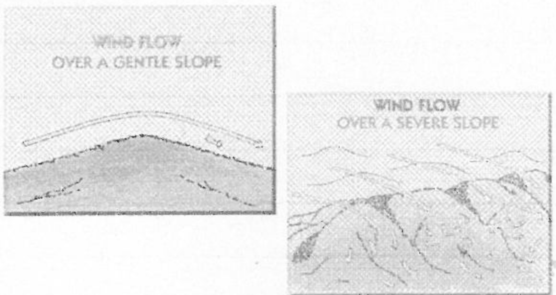
Diurnal Wind Flow

Convection causes wind to flow up valleys in the morning *(Valley Breeze),* then flow down valleys in the afternoon and evenings *(Mountain Breeze).*



Turbulence

- Turbulence in the mountains is usually the result of airflow over, around, or between obstructions
- Severity is often proportional to wind velocity
- Location is usually predictable
  - But there are many exceptions to this rule
- Usually strongest on leeward side
  - Depends on the steepness of the downslope



Standing Wave

When airflow over mountainous terrain meets certain criteria, a "Standing Wave" may result. In such cases, moving air is forced up by terrain and "bounced" off the overlying airmass, after which it descends to bounce off the flat ground and then continues in this manner, sometimes for hundreds of miles.

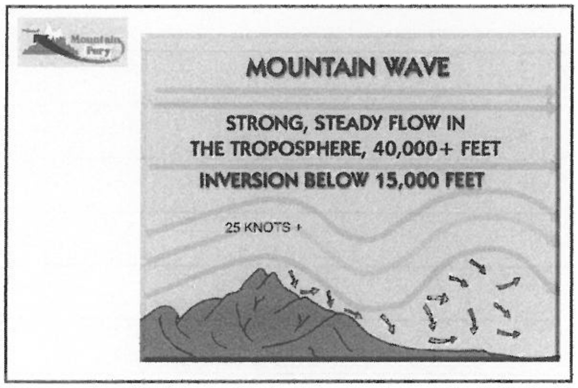
Because the air is accelerated over the mountains and because strong rotor clouds and turbulence often form below this moving airmass on the downwind side of the mountains, extreme caution is indicated when flying in the presence of a standing wave.

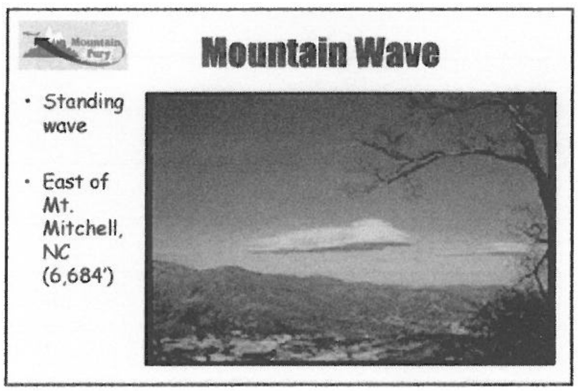
Meteorologists are able to forecast standing waves with a high degree of accuracy, so be sure to ask for this information during your weather briefing.

3

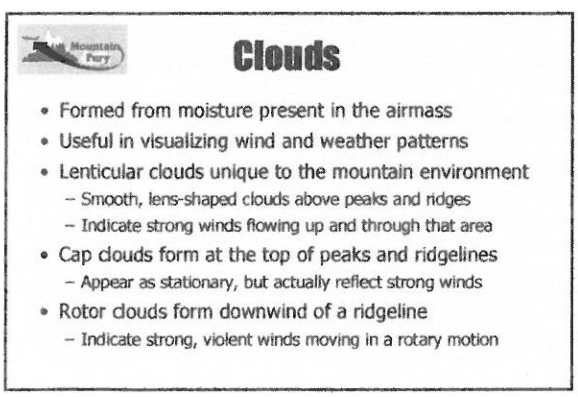
Mountain Wave

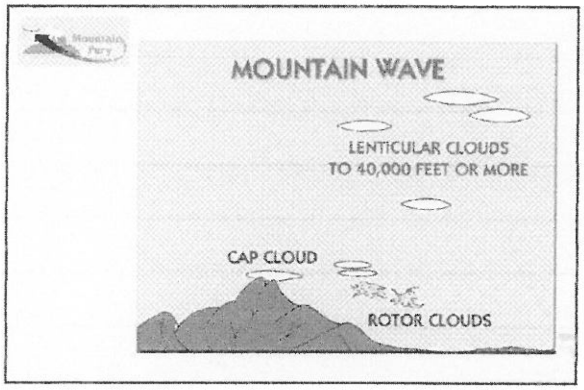
- Mountain wave
- Concord, California

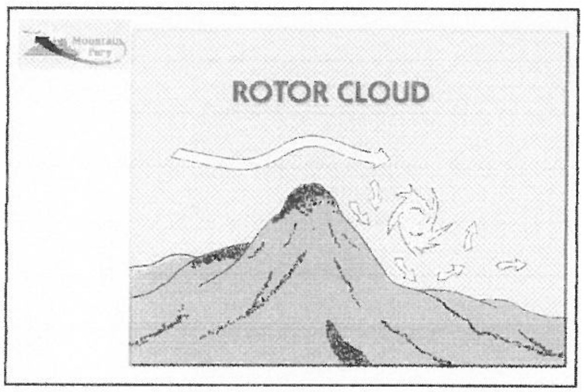


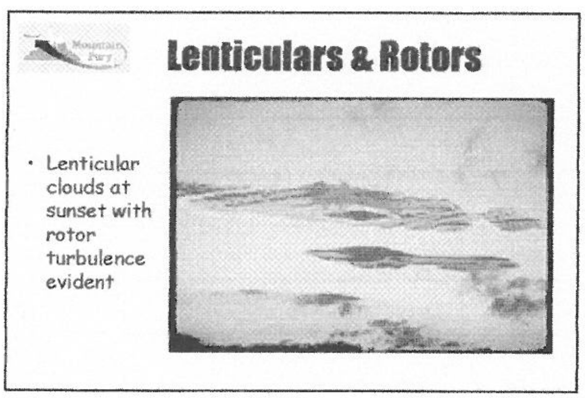


Mt. Mitchell, NC, in the Black Mountains, at 6,684 feet is the highest point east of the Mississippi.




MOUNTAIN WAVE
LENTICULAR CLOUDS
TO 40,000 FEET OR MORE
CAP CLOUD
ROTOR CLOUDS


ROTOR CLOUD


Lenticulars & Rotors
• Lenticular clouds at sunset with rotor turbulence evident

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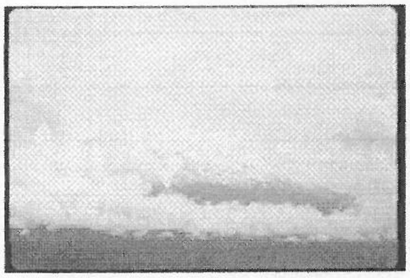
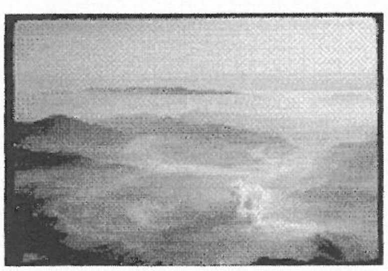


- Standing wave cap cloud over Mt. Shasta, California

Cloud Ceilings

- Ceilings are reported above ground level; in the mountains, this usually means above the valley floor
  - Surrounding terrain often extends into the ceiling
  - Valley floors sometimes rise into the ceiling
- All aircraft forced to fly in valleys and through passes
  - VOR signals may be lost or become unreliable
  - Radio communication will be degraded
  - Increased potential for mid-air collision
- CAP minimum ceiling for VFR flight is 1,000 feet
  - A higher ceiling may be appropriate for mountain flying

Ground Fog



- Typical ground fog with an inversion layer aloft

Ground Fog

- Typical ground fog during the morning hours in a valley

Visibility

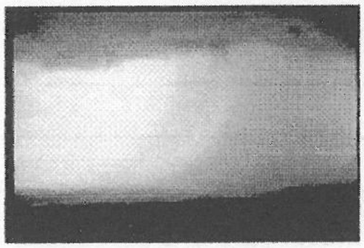
- Reduced visibility is dangerous in the mountains
  - Obstructions can appear quite quickly
    - Power lines, towers, rock outcroppings, other aircraft
  - Situational awareness can be lost
  - Inadvertent IMC can be encountered
- Use caution when flying near rain and snow showers
  - Tend to move and appear in previously clear areas
  - Creates visual illusion of excess altitude
- CAP minimum for VFR flight is three miles
  - Greater visibility appropriate in unfamiliar terrain

Airmass Stability

Stable air tends to rise over obstructions then return to its original level in a fairly orderly manner. Stable air is less likely to result in convective activity and the associated turbulence.

Unstable air has a higher adiabatic lapse (temperature drop) rate when displaced, and therefore tends to continue rising. Expect greater convective activity and turbulence from a moving unstable air mass, especially if it is relatively moist.

Thunderstorm



- Heavy rainstorm
- Note the outflow area

Frontal Thunderstorms

- Adequately forecast
- Lines break up when encountering mountains
  - Rarely encounter imbedded thunderstorms
  - Diminish due to interruption of moist air inflow
- Squall lines do not normally occur near mountains
  - Necessary downflow of cool air is interrupted
- Still dangerous when present
  - Consider canceling flight in these conditions

3

Orographic Thunderstorms

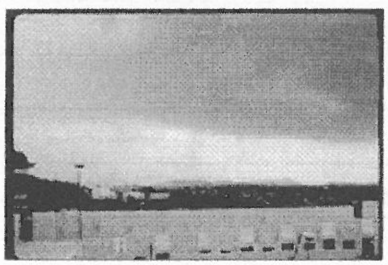
- Formed when air is forced up by terrain
- Requires moist, unstable air to form
- Usually isolated or scattered
- Can build rapidly
- Can occur at any time when conditions are present

Convective Thunderstorms

- Result from rising unstable air
  - Usually forced upward by solar ground heating
- Formative stage in mid-morning
  - Billowing cumulous clouds
  - Light to moderate turbulence beneath bases
- Rapid development by early afternoon
  - Towering and thickening cumulous clouds
  - Increasing turbulence
- Mature thunderstorms are dangerous!
  - Severe turbulence, hail, lightning, downdrafts
  - Remain well clear... at least 10 miles

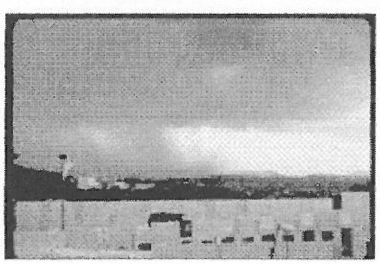
Downburst

- Beginning of a downburst thunder-storm cell, south of Asheville, NC

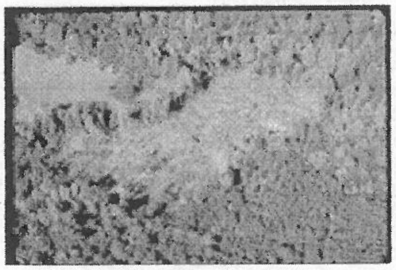


Downburst

- Downburst thunderstorm cell
- Asheville, NC



Downburst



- Trees downed by a severe downburst

Weather Forecasts

- Not as accurate as in the flatlands
  - Fewer reporting stations
  - More localized weather phenomena
- Pilot reports often best source of valid information
- As a general rule, weather best during the morning
- Weather can change quickly in the mountains
- Always have a good escape plan

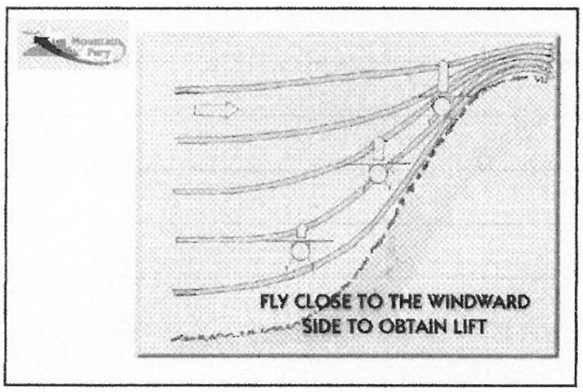
BLOCK THREE

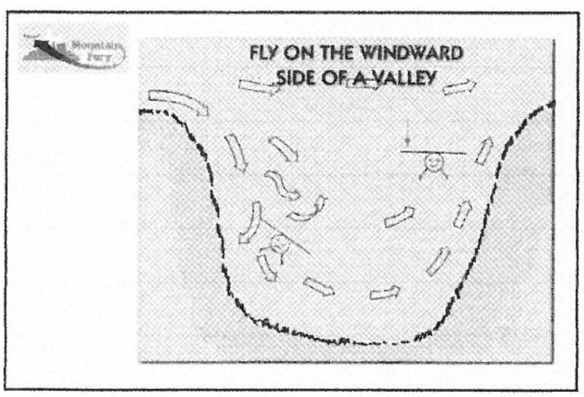
Mountain Flying

3

Flying in Mountain Winds

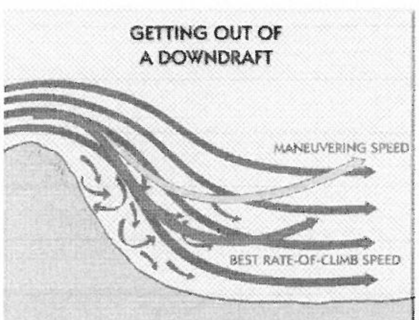
- Determine direction and velocity of steady winds
  - Observe dust, smoke, tree leaves, or aircraft drift
  - At 100 knots ground speed, 6° crab = 10 knot crosswind
- Smoother and easier flying along windward slopes
- Use caution along leeward slopes until tested
  - Downdrafts, turbulence, especially below passes
- Always be in a position to turn toward lower terrain
- Constantly monitor airspeed and vertical velocity
- Slow to maneuvering speed in turbulence





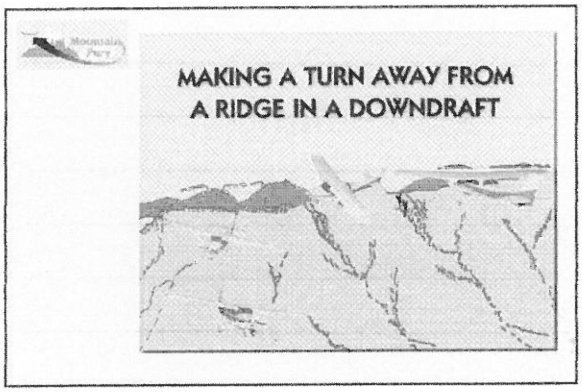
Exiting Downdrafts

- In a strong or sustained downdraft:
  - Turn towards lower terrain
  - Apply maximum power (throttle + propeller pitch)
  - Attain and maintain best rate of climb airspeed
  - Attempt to fly out of downdraft area (downwind usually best)
- If descending faster then your calculated rate of climb:
  - Increase airspeed to rapidly fly out of downdraft area
  - Use cruise speed or, if in turbulence, use maneuvering speed
  - Accept temporary increase in rate of descent



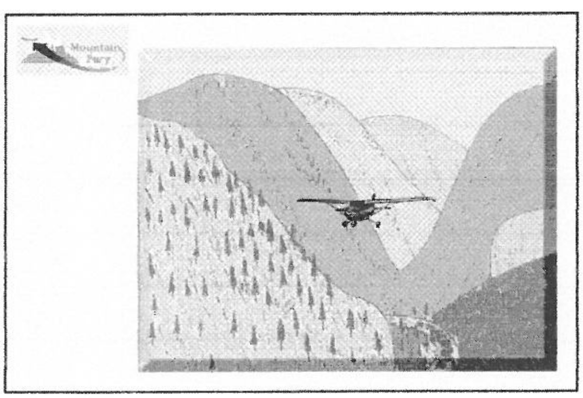
Crossing Ridges

- Approaching ridge from windward side:
  - Fly directly toward ridge
  - If caught in downdraft while crossing ridge, this course will be most direct path away from ridgeline
- Approaching ridge from leeward side
  - Achieve desired altitude well before reaching ridge
  - Approach at 45° angle to allow shortest turn away if caught in downdraft
- Determining relative height
  - If you see more terrain on other side of ridge as you approach, your altitude is greater than that of ridgeline



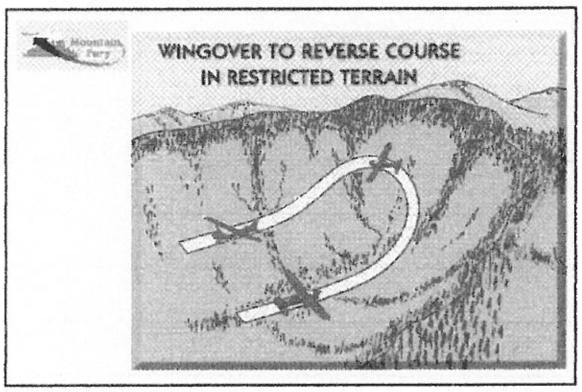
Canyon Flying

- Never fly up a canyon if there is insufficient lateral width to comfortably turn around
- Never fly beyond the "point of no return"
- Always remain in a position to allow a turn toward lowering terrain
- Fly along one side of the canyon (usually the upwind side) to provide the full canyon width to turn around
- Always know your location; side canyons can look like your desired route but can lead to disaster



Course Reversal Maneuver

- May be required in rapidly-rising terrain or rapidly-narrowing canyon
- Pull up to gain altitude and achieve best cornering velocity
- Deploy 10-20° flaps to increase lift
- Rapidly achieve 60° bank and pull to achieve tightest turn radius while maintaining adequate stall margin
- If vertical terrain clearance permits, accept altitude loss during turn to maintain "g" loading and safe airspeed



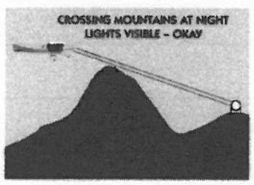
3

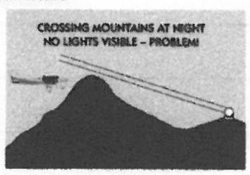
Sensory Illusions

- False horizon
  - Perhaps the greatest cause of mountain mishaps
  - Experienced when flying toward gradually-rising terrain
  - Actual horizon is well below perceived horizon
  - Airspeed decays during unperceived slow climb
- High terrain hidden in shadow
  - Lighting from behind distant high terrain hides closer hill
- Indicated versus true airspeed
  - Perceived airspeed margin due to high groundspeed

Night Flying

- High terrain can "sneak up" on you at night
- Maintain positional awareness at all times
- Terrain clearance must be constantly monitored
  - Optical information is often insufficient
  - Utilize charts, radar services, local knowledge
- Decreasing lights ahead indicates higher ridgeline
- Isolated lights can produce vertigo
- Follow lighted roads
  - Usually run through lowest terrain (beware of tunnels!)
  - Useful in the event of power loss





3

Night Flying

- Follow a road or lighted area when flying over rugged terrain during the night

Mountain Airport Operations

- Often confined spaces and sloped runways
- Plan your pattern to accommodate local conditions
- Traffic patterns usually on side away from terrain
- Thoroughly research local procedures
- Runway surface may be questionable
- Expect unpredictable air currents at low altitudes
- Beware of downdrafts immediately after liftoff
- Conduct circling climb above airport before heading directly toward high terrain

Mountaintop Airport

- Airport on top of a hill
- Land upslope to the north
- A portion of the runway fell down the cliff resulting in a displaced threshold

Mountain Strip

- Airport built on the side of a mountain
- Shear drop offs at both ends
- Avoid strips like this on windy days

Uphill vs. Downhill Takeoff

Use this formula when deciding whether to takeoff downhill with a tailwind or uphill with a headwind. Elect an uphill takeoff if the actual headwind component is greater than the calculated "breakeven headwind."

Breakeven headwind =

$$\frac{\text{Runway slope} \times \text{no-wind TO distance}}{5 \times \text{Liftoff speed in KTAS}}$$

Mountain Flying Safety

- Always exercise good judgement and caution
- Always maintain positional awareness
- Know your aircraft performance capabilities
- Do not exceed your aircraft performance capabilities
- Watch for power lines and their support structures
- Determine the best emergency notification frequency
  - May not be 121.5
  - Consider remote antenna locations, ARTCC frequencies
- Always have a downward path toward lower terrain
- And always WATCH YOUR AIRSPEED!

BLOCK FOUR

Mountain Searching

3

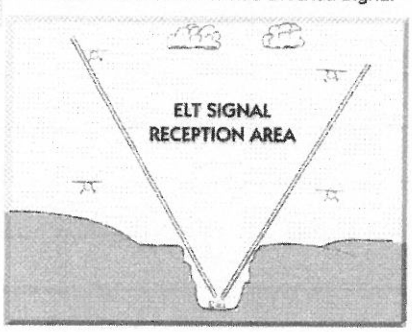
Crash

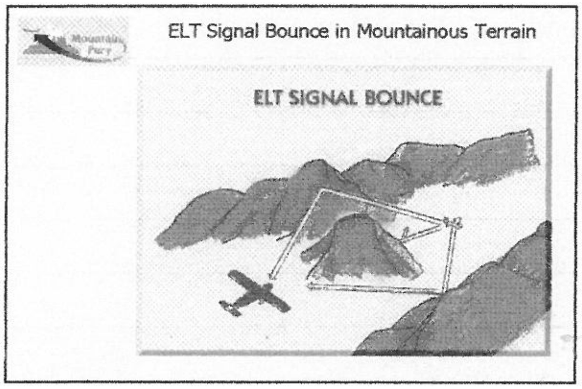
- Due to the foliage, this crash is very difficult to spot from the air

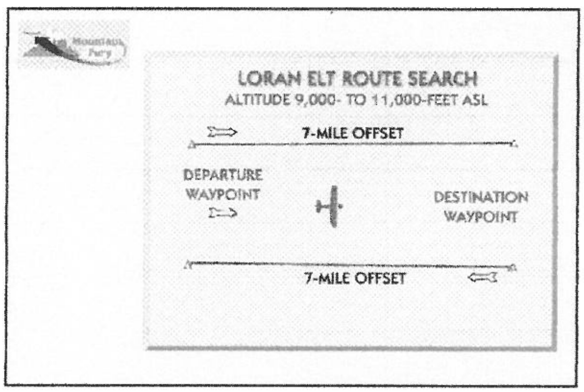
ELT Searches

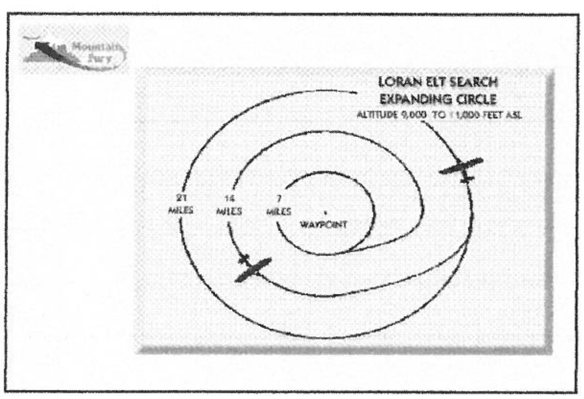
- Conduct search at highest practical altitude
  - Increase chance of detecting ELT located in valley
- Fly straight line along suspected route
  - If no detection, fly 7-mile offsets
- Fly expanding circle over high-probability area
- If deep canyons in area, fly over each one
  - Preclude missing signal confined to vertical propagation
- Signals may only be detectable at certain times
  - Weak batteries may only transmit when warmed by sun

Sufficient Altitude Prevents Blocked Signal




ELT Signal Bounce in Mountainous Terrain
ELT SIGNAL BOUNCE

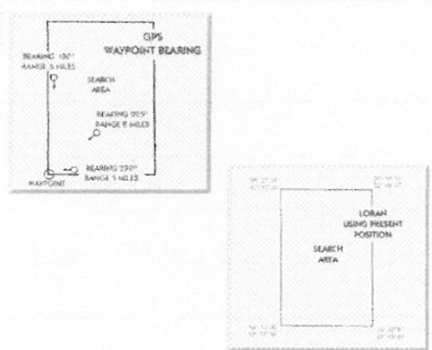

LORAN ELT ROUTE SEARCH
ALTITUDE 9,000- TO 11,000-FEET ASL
7-MILE OFFSET
DEPARTURE
WAYPOINT
DESTINATION
WAYPOINT
7-MILE OFFSET


LORAN ELT SEARCH
EXPANDING CIRCLE
21
MILES
14
MILES
7
MILES
WAYPOINT

3

Grid Navigation

- Use every means available to identify grid area
  - GPS, VOR, visual confirmation of terrain features
- If equipped, set up GPS to remain within grid
  - Monitor bearing and distance from selected corner
- Assess weather and winds in the search area
- Assess grid to determine best search method
  - Will be dictated by terrain features
  - Take the time to plan method for searching each feature
- Record searched areas on chart or hand drawing



Search Strategies

- Ascertain areas of high probability, such as:
  - Natural pathways through the terrain
    - Aircraft often follow valleys and fly through passes
    - Particularly when low ceilings were present
  - False canyons and gradually rising terrain
    - Especially if the pilot was unfamiliar with the terrain
  - Areas of cloud cover or thunderstorm activity
  - First ridge on a direct route between origin and destination
- Consider focusing on these areas before conducting an exhaustive contour search of the grid

Pilot Responsibilities

- Plan and clear the flight path
- Assure proper terrain clearance
- Maintain constant altitude
- Maintain optimal airspeed (about 80 knots)
- Put observers in best position to scan terrain
- Keep track of areas searched
- Identify areas remaining to be searched
- Monitor aircraft systems and performance

Crash location

- Crash in a corn field

3

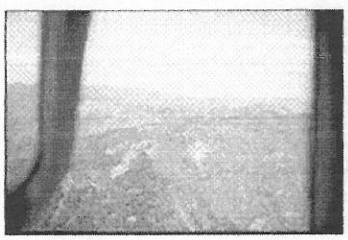
Contour Searching

- Use contour search techniques in mountainous terrain other than canyons and steep valleys
- Begin at the highest elevation
- Maintain a constant altitude while flying adjacent to steep terrain
- Once all terrain at that altitude has been searched, descend 500 feet and continue contour searching
- Put your observers in the optimal position to detect the target

14 Crashes

- East face of 10-mile-long mountain ridge with north/south orientation
- Mountain tops 6,500 feet
- Valley 2,000 feet
- 14 crashes have occurred on this east face ... mostly due to severe downdrafts from westerly winds

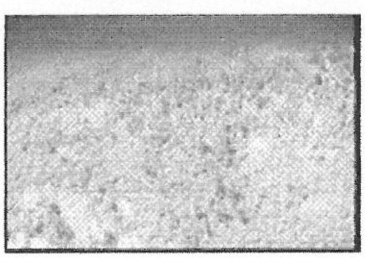
Viking Crash



- Crash site in center
- Mountain top 6,684 feet
- Crash at 6,500 feet
- 43-knot winds
- Bellanca Viking
- Radar showed aircraft descending during approach to the ridge

Crash

- Crash site in center of picture
- Aircraft cut a swath through the trees
- Note fallen & broken trees with rock outcroppings interfere with the search scan

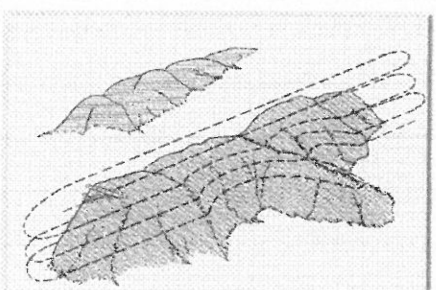


Crash

- This picture is taken from the ground looking back through the path the aircraft traveled
- Remember you may be searching as much for broken and sheared trees as for an actual aircraft

Contour Searching - Cont'd.

- If you encounter a sub-ridge, either:
  - Include it in your current contour search
  - Return later to search it separately
- Two options in searching ridge or mountain:
  - Contour all the way around the terrain before descending
  - Contour one face at a time
- Resist temptation to scan when the terrain is on your side of the aircraft
  - Your job is to safely fly the airplane

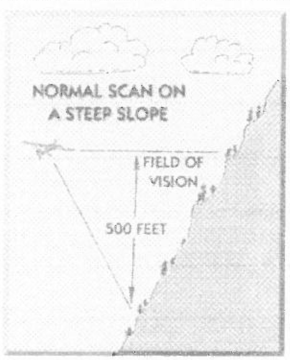


Contour Search

3

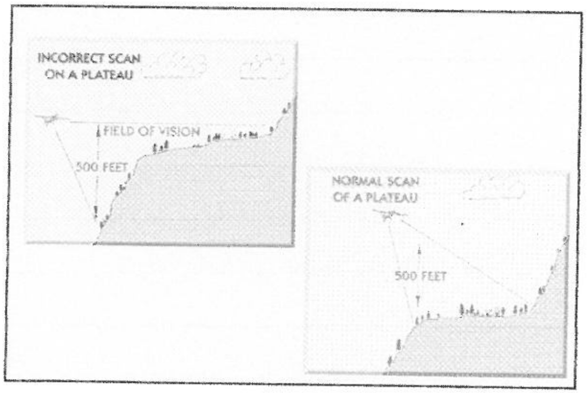
Search Spacing

- 500 feet vertically and laterally is ideal
  - Closer and terrain appears as a blur
  - Farther and objects cannot be detected
- Factors which might prevent this spacing
  - Turbulence, downdrafts, terrain features
- Generally maintain this spacing, following terrain
  - But do not turn into small gullies and ravines
  - Return later to fly a drainage search pattern



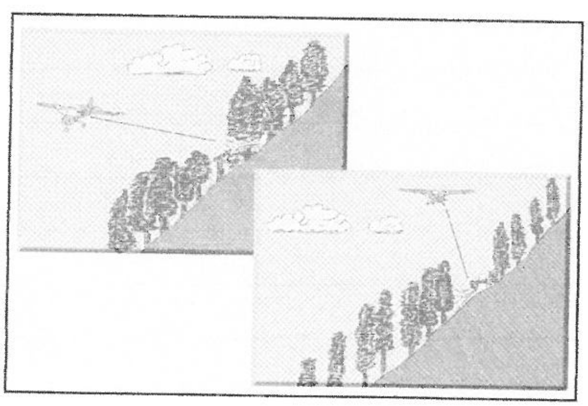
Scanning a Plateau

- Normal search position and spacing inadequate
  - Unique feature requires specific technique
  - Often partially covered with vegetation
  - Must look down into vegetation to detect target
- Interrupt contour search to search this feature
  - Circle back and climb if necessary to view downwards
  - Also attempt to scan under bases of foliage



Scanning in Foliage

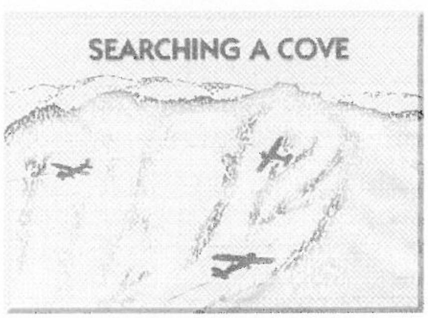
- Difficult to spot target in or below trees
- May have to fly above, then adjacent to each area
  - In pass above, direct observers to look vertically
  - In pass adjacent, direct observers to look horizontally
- Look for indications of a crash
  - Broken trees or limbs
  - Dried leaves



3

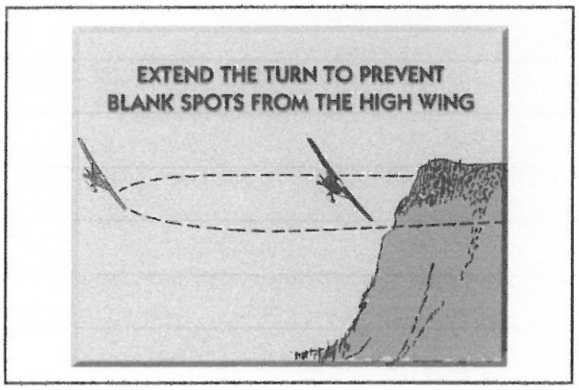
Searching a Cove

- Be certain your aircraft turn radius will allow flying comfortably into and out of the cove
- If too tight, use the drainage search method
- A low-wing aircraft will block the observer's view
- Explain your plan to your crew before entering



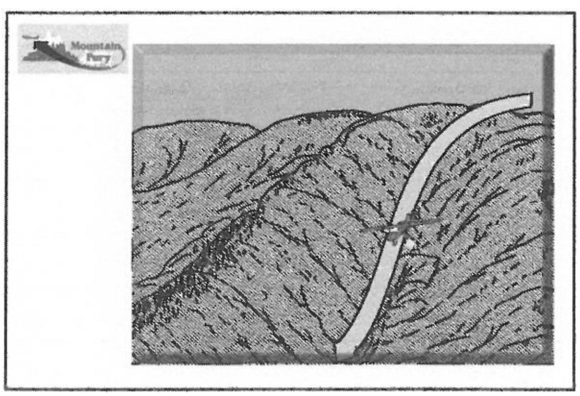
Searching a Promontory

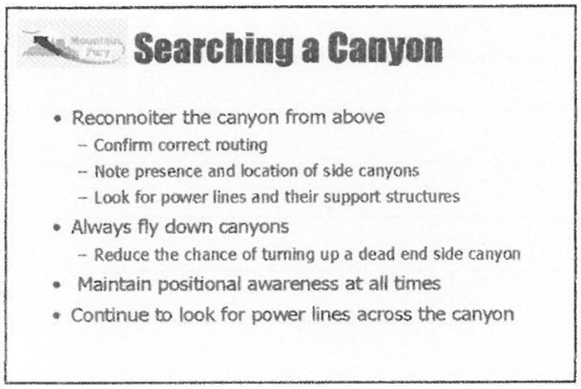
- If the terrain cuts sharply away from your flight path, do not turn sharply to follow it in a high-wing aircraft
  - Temporarily exceed optimal spacing
  - High wing will block observer's view
  - Instead, extend outward, then reverse course to re-approach
- If the terrain cuts sharply into your flight path, do not turn sharply to follow it in a low-wing aircraft
  - Low wing will block observer's view
  - Forced to conduct a drainage search pattern

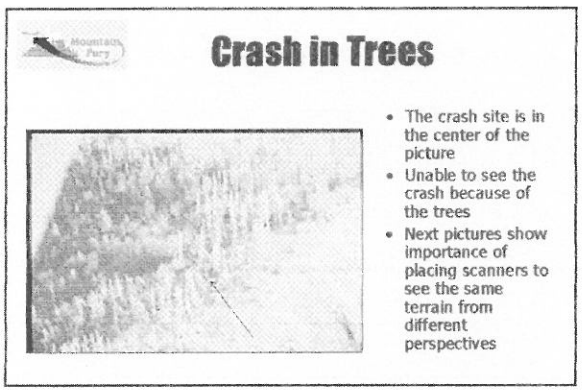


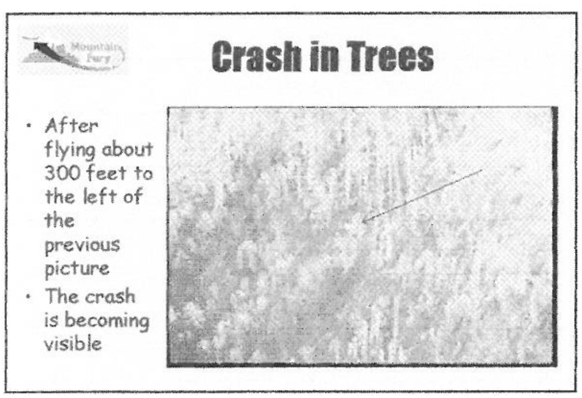
Searching a Drainage

- Required in narrow or steep drainages
- Involves flying straight down the drainage
  - Both observers scan each side simultaneously
- Approach from the top at low airspeed
- Reduce power when beginning descent
- Use partial or full flaps to increase drag
- S-turns allow scanning bottom of drainage




Searching a Canyon
• Reconnoiter the canyon from above
– Confirm correct routing
– Note presence and location of side canyons
– Look for power lines and their support structures
• Always fly down canyons
– Reduce the chance of turning up a dead end side canyon
• Maintain positional awareness at all times
• Continue to look for power lines across the canyon

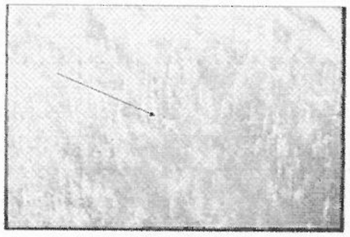

Crash in Trees
• The crash site is in the center of the picture
• Unable to see the crash because of the trees
• Next pictures show importance of placing scanners to see the same terrain from different perspectives


Crash in Trees
• After flying about 300 feet to the left of the previous picture
• The crash is becoming visible

3

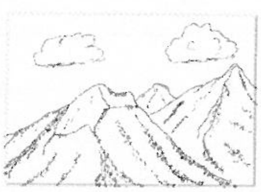
Crash in Trees

- From 500 feet beyond previous picture the crash is visible
- Another 200 feet and the aircraft disappears again
- Thoroughly search heavily wooded areas



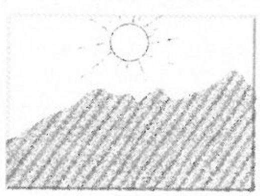
Effects of Lighting

- Shadows can prevent sighting targets
  - Loss of sufficient lighting
  - Loss of contrast
- Direct light may reflect from shiny targets
- Most mountainous terrain is best searched mid-day
- Steep slopes may be best early or late in the day
- Flying in deepening shadows can be dangerous
  - Difficult to judge distance from terrain
  - Difficult to detect layered backlit obstructions



Front Lighting

Back Lighting



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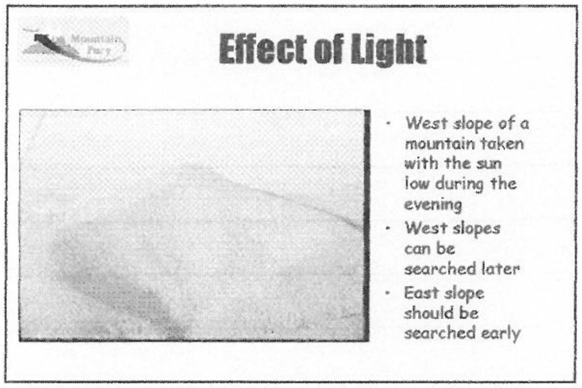
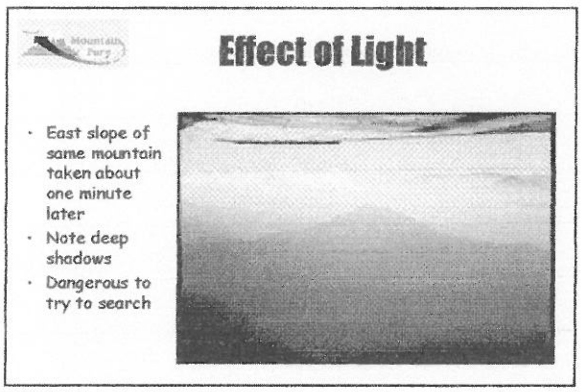
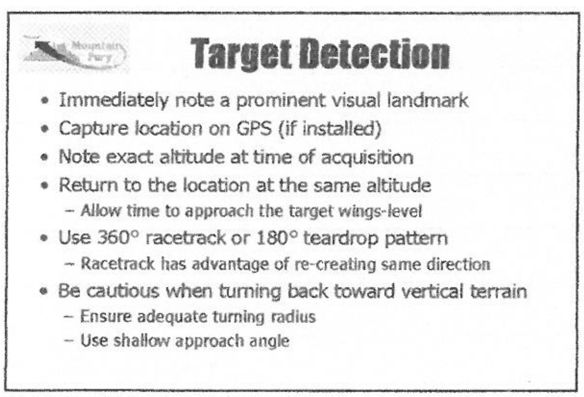
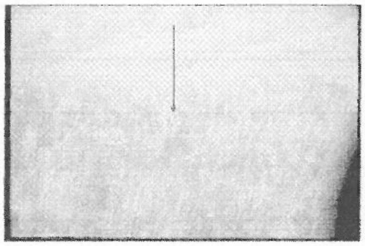

Effect of Light
West slope of a mountain taken with the sun low during the evening
West slopes can be searched later
East slope should be searched early


Effect of Light
East slope of same mountain taken about one minute later
Note deep shadows
Dangerous to try to search


Target Detection
Immediately note a prominent visual landmark
Capture location on GPS (if installed)
Note exact altitude at time of acquisition
Return to the location at the same altitude
– Allow time to approach the target wings-level
Use 360° racetrack or 180° teardrop pattern
– Racetrack has advantage of re-creating same direction
Be cautious when turning back toward vertical terrain
– Ensure adequate turning radius
– Use shallow approach angle

Cessna 206

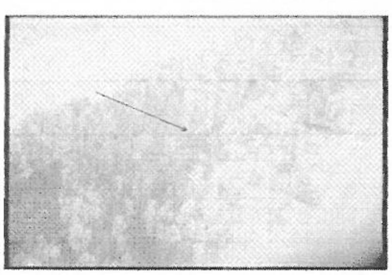


- The Cessna 206 in this picture looks like a trash pile ... not an airplane

Cessna 206

- Close up of the Cessna 206 crash
- Remember, what you are looking for may not resemble an airplane

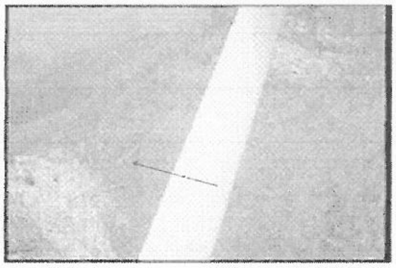
Mooney Crash



- Crash site of a Mooney
- To the left of the crash is a small piece of aircraft lodged in the top of a tree
- The piece of wreckage led to the crash site

Mooney - Winter

- Photo of the Mooney crash site taken during the winter
- Crash site is to the left of the strut half way between two logging roads
- Crash looks like snow

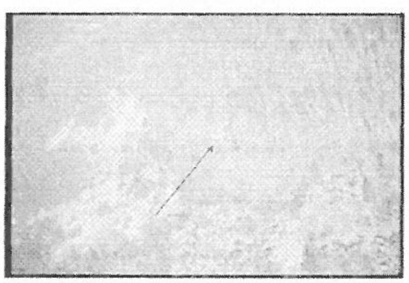


Mooney – Late Spring

- The same Mooney crash site
- Photo taken during the late spring
- Very difficult to locate under these conditions
- If it was a fresh crash there may have been some tree damage to make it easier to find

Cherokee Crash

- Piper Cherokee crash in trees
- Visible at center of picture



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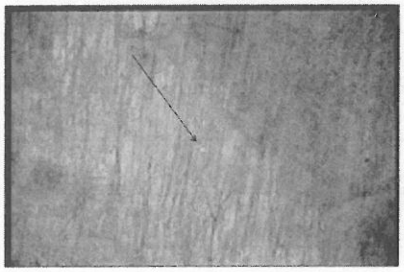
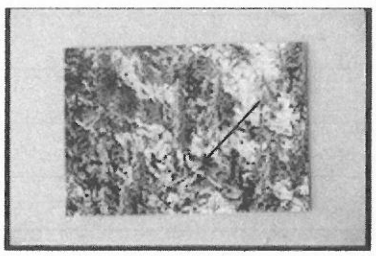
Cessna Crash



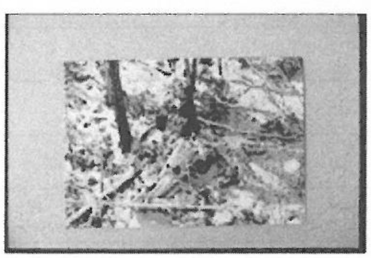
- We spotted the wing panel of a Cessna
- The remainder of the crash was some distance away
- (Indicates in-flight breakup)

Cessna 310 Crash

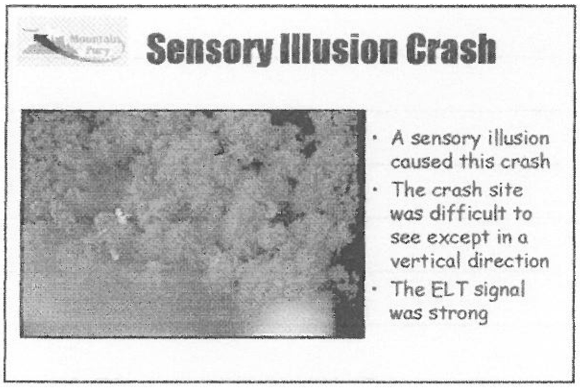
- Can you spot the Cessna 310?
- Photo from a helicopter
- Snow makes the C310 difficult to see in the lower center of the photo

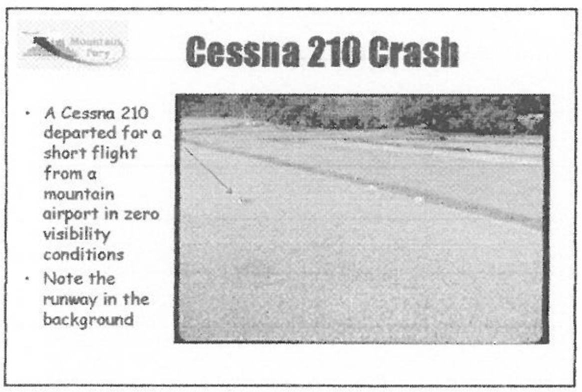


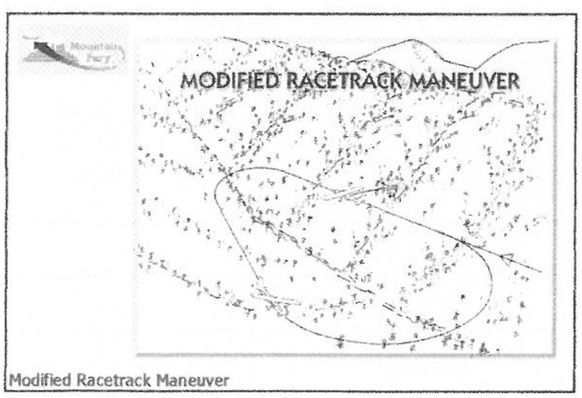
Cessna 310 Crash

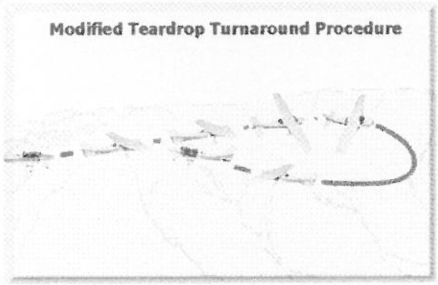


- Flying close to the wreckage, the helicopter blew snow away from the wreckage
- Doubtful that this would have been spotted without the functioning ELT signal


Sensory Illusion Crash
A sensory illusion caused this crash
The crash site was difficult to see except in a vertical direction
The ELT signal was strong


Cessna 210 Crash
A Cessna 210 departed for a short flight from a mountain airport in zero visibility conditions
Note the runway in the background


MODIFIED RACETRACK MANEUVER
Modified Racetrack Maneuver



Crew Consideration

- Ensure entire crew is fit for duty prior to takeoff
- Consult with crew regarding mission accomplishment
  - Correct spacing, flight track, lighting, etc.
- Take periodic breaks from searching
  - Relax, drink, snack, stretch
  - Perform ops check, switch fuel tanks, etc.
- Terminate mission when appropriate
  - Two hours "in-grid" is a practical maximum
  - Upon crewmember airsickness, exhaustion, etc.

Closing Thoughts

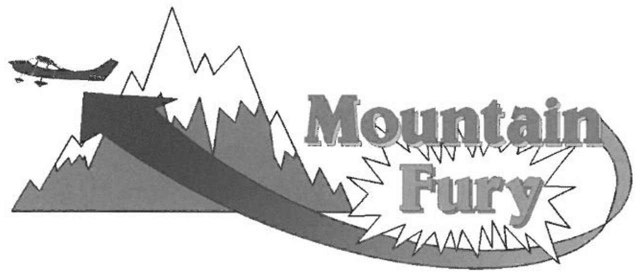
Mountain flying is demanding, yet at the same time very rewarding.

Maintaining awareness of, and proficiency in, the principals and techniques described in this course will allow you to safely and effectively fly and search in the mountains

"So That Others May Live."

3

NOTES:



Aircraft Performance at High Density Altitude

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Introduction

Aircraft performance is quantitative by its very nature. Answers to such questions as: What's the top speed? How fast will it climb? How high can it go and still climb 300 feet per minute? are all numerical. On the other hand, the precise numbers are seldom crucial. Under given atmospheric conditions, with a given airplane in a given configuration at a given weight, there certainly are optimum speeds – speeds for climbing fastest or steepest, for gliding farthest or descending slowest – but being off those speeds a few knots is rarely crucial. So in another sense aircraft performance is a largely practical subject. With experience, we get to know how to urge the best behavior from our airplanes, how much to allow for gusts on landing, how quickly we can bleed off flaps after takeoff. Certainly for ordinary operations at low or medium altitudes, shallow turns, only one passenger, we get to know our airplanes quite well.

In more extreme situations – high density altitude operations, near maximum gross weight, in moderate turbulence, on the "back side of the power curve" – we don't have many hours of direct experience. Maybe only occasional brief periods, perhaps quite some time ago. This document, almost entirely a graphical introduction to propeller aircraft performance, is designed to supplement your feel for your airplane, and how it will behave, in some of these more extreme situations. It is slanted towards fairly high density altitude operations conducted by Civil Air Patrol units during mountain search and rescue sorties. There are a few formulas, often simplified. And of course there are formulas behind each of the graphs.[1] A document chock full of formulas wouldn't do you much good in the cockpit even if you had them memorized. That's no time to compute. So here it will be graphs which carry the content – how airplanes behave differently when loaded to various gross weights and flown at various flaps configurations at various density altitudes.

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[1] Calculations behind the graphs are based on the author's *"Bootstrap Approach"* to predicting performance of propeller-driven aircraft. The theory behind the Bootstrap scheme has appeared in several articles in *Journal of Aircraft* and in *Journal of Aviation/Aerospace Education and Research* over the past few years. See the References. Some leading kitplane manufacturers are using *The Bootstrap Approach* for their performance flight tests and primary certification. Though it's not particularly difficult to understand the theory behind the calculations—high school mathematics suffices for almost all of it—that is not our subject in this publication. Here we are going to strictly focus on the graphs themselves, as examples showing the behavior of one common type airplane under many different circumstances.

The reader is urged to go over the graphs in a state of relaxed attentiveness, taking his or her time. Imagine you're in the airplane under the depicted circumstances – wings level or banked, at high altitude or at low, heavy or light, cruising fast or climbing slow – whatever the graph conditions are. Most of our graphs will be for a typical Cessna 172 with a 160 horsepower engine. That particular sample airplane may not perform much like your own, but that matters very little. The important things are to see, for instance, how performance deteriorates very little if you hang out ten degrees of flaps, or if you bank fifteen degrees; but triple those angles and you've likely got a real problem on your hands! The important points to notice are: What factors make a difference, in what direction, and how much of a difference? Careful cogitation is especially important at the beginning; once the stage has been set, understanding the graphs becomes routine and the process speeds up. CAP Squadrons with a formal or informal Education Officer would do well to put together three to five sessions during which a Squadron member with a good grasp of the technicalities of flight helps others work through the material. The so-called "steady maneuvering charts" are especially complex. Each is made up of about a dozen individual graphs; it takes some time to get their drift and see what they mean in concrete piloting terms.

It is important for the CAP pilot-in-command to have a clear notion how his airplane's performance, such crucial items as:

- rate of climb,
- angle of climb,
- takeoff and landing distances, and
- turning radius

depending on such environmental and pilot-input variables as:

- density altitude,
- aircraft gross weight,
- bank angle, and
- flaps setting.

The pilot should also know, at least approximately, how his airplane's performance V speeds – banked stall speed, speed for best angle of climb, speed for best rate of climb, etc. – vary as those quantities change. The pilot may suddenly need optimal performance. Especially in a mountain setting, wind effects (whether from headwinds, tailwinds, crosswinds, updrafts or downdrafts) are important. Though wind speed and direction are seldom known precisely, at least a rough understanding of the size and direction of wind performance effects is needed. If our airplanes performed very differently whenever speeds were varied two knots, or bank angles were adjusted five degrees, we'd all be dead! By and large, our airplanes are forgiving.

But our main theme – and a primary reason for our writing this document – is that maneuvering in the mountains is, in a sense, doubly dangerous. Particularly in relatively low-powered airplanes. That's because the mountains, intruding into our airy domain, force us to wend our way among them. We get close to the rocks. Then too, the mountains create and modify the weather, often making it more violent than at lower elevations. This increased need to maneuver our aircraft comes – like an overdraft notice from the bank – at just the wrong time! At a time when our airplanes are less capable of maneuvering because of higher winds and higher density altitudes. A double whammy. Then we must be doubly on our guards.

So there will be times, especially in CAP mountain SAR operations, that to stay out of a potentially dangerous situation maximum performance is needed. The pilot who thinks ahead and applies his knowledge of "how airplanes work" has a leg up. The objective in search and rescue operations is not only to find the downed victims and their airplane; the other important goal is for the search airplane to return safely to base, with all "souls on board" still firmly attached to their respective bodies.

What do we mean by "aircraft performance"?

We mean (to define some of the important symbols – for the full List of Symbols, see the end of the document) such items as:

- Distance to lift off (dLO) and landing roll distance (dL);
- Rate of climb (ROC) and flight path angle relative to the horizon (g, Greek small gamma);
- Turning radius R or turning (or yaw) rate w (Greek small omega);
- Various so-called "V speeds" – speed for best angle of climb Vx, speed for best rate of climb Vy, speed for best (longest) glide Vbg, speed for minimum descent rate Vmd, stalling speed VS, maneuvering speed Va, minimum level flight speed Vmin (only when this becomes, as it does at higher altitudes, larger than VS), and maximum level flight speed Vmax.

What determines aircraft performance?

- Aircraft type, condition, and configuration (flaps position df (Greek small delta, sub-f), gear up/down, even cowl flaps position a bit);
- Weight (and balance), selected before departure, then modified by fuel burn;
- Atmospheric air density r (Greek small rho) or one of its surrogates (if you know any one of them, you can find the others), relative air density s (Greek small sigma), or hr (density altitude);
- Air speed V, selected (within limits) by the pilot;
- Power setting P (Greek capital PI, usually 100% (full throttle) when optimum performance is desired), and leaning (usually for best power);
- Propeller speed control n (revolutions per second, rps) or N (revolutions per minute, RPM), usually forward, to maximum RPM, when optimum powered performance is desired;
- Bank angle f (Greek small phi), selected by the pilot;
- Wind direction and speed Vw; and
- Pilot technique.

For a given airplane and configuration, at a given weight and density altitude, in given wind, the pilot needs to know how to adjust air speed V (with elevator control), bank angle f (with aileron and rudder controls), and power setting P (with throttle and propeller speed control), in order to get good performance from his craft.

What is density altitude?

The density altitude here and now, hr, is that altitude in the International Standard Atmosphere (ISA) with our current air density. Almost every item of aircraft performance depends on density altitude hr ("h sub rho"); it is "the altitude the airplane thinks it's at." Three of the four forces acting on the airframe – lift L, drag D, thrust T, but not weight W – depend on hr to various extents. In addition, engine power P falls off with hr. We talk density altitude, rather than air density itself, for ease of understanding. "The current density altitude in the search area is 10,000 feet" makes sense to us. "Air density in the area is currently 0.001755 slugs/ft3," which means the same thing, does not. A main job of this section is to see how much the airplane's performance suffers when you fly it from near sea level to relatively high density altitude.

There is another minor technical problem. We can't measure air density or density altitude directly. There is no simple "density altimeter." But since density of a gas sample depends on its temperature and pressure (ignoring the slight humidity effect), we can get at the density indirectly by measuring temperature (with a thermometer) and pressure (with an altimeter). We measure atmospheric pressure in the same sort of way we measure density, using the concept of pressure altitude hp, the altitude in the ISA which has the same pressure as the pressure we're interested in. Pressure altitude is read by cranking the altimeter setting to 29.92 in. Hg – the "standard setting" – and reading the face of the altimeter. Unfortunately, the formula for getting density altitude from OAT and pressure altitude is fairly complicated. That's why a chart (see Figure 1) is used.

If however one doesn't have the chart there is a quite reasonable approximation formula:

$$h_\rho = h_p + 66(T - T_S) \qquad (1)$$

where T_S is the *standard temperature*, in degrees Fahrenheit, for the given pressure altitude h_p in feet. You remember from ground school that at MSL (mean sea level) T_S = 59°F and drops off about 3.5°F for every thousand feet you go up:

$$T_S = 59 - 0.003566 h_p \qquad (2)$$

Fig 1. Say you want to know the approximate density altitude when OAT is 80°F and pressure altitude is 8000 ft. Go straight up from 80 on the horizontal axis and go straight right from 8000 on the vertical axis. The intersection point does not lie on any of the heavy curves, but is a little over half way from the h_ρ = 10,000 ft curve to the h_ρ = 12,000 ft curve. So the density altitude is approximately 11,100 ft. Eqs. (1) and (2) give h_ρ = 11,269 ft; the exact formula gives h_ρ = 11,074 ft. No practical difference.

4

$$T_S = 59 - 0.003566 h_p$$

Question: If the pressure altitude is 7500 feet and the OAT is 22°F, approximately what is density altitude h_ρ?

Answer: Since the standard temperature at 7500 ft, from Eq. (2), is 32.3°F, and we're 10.3° colder than that, our current density altitude is about, from Eq. (1), 10.3 × 66 = 680 ft lower than our pressure altitude. So, h_ρ = 7500 – 680 = 6820 feet. The accurate answer is 6816 feet. No practical difference. Notice that when it's *colder* than standard the density altitude is *lower* than the pressure altitude. In that cool case, aircraft performance improves.

While density altitude h_ρ gives us a rough intuitive understanding how our airplane is going to behave, we also need other versions of air density to convert KCAS to KTAS (or vice versa) or to see how much engine power has fallen off with altitude. All these factors use *relative air density*, defined as:

$$\sigma = \frac{\rho}{\rho_0} \tag{3}$$

where the standard MSL air density is ρ_0 = 0.002377 slugs/ft^3. Again, the exact connection between σ and h_ρ is fairly complex, but this approximate formula does the job fairly well:

$$\sigma = \left(1 - \frac{h_\rho}{70{,}000}\right)^2 \tag{4}$$

At h_ρ = 10,000 feet, relative density σ is accurately 0.738. Eq. (4) gives 0.735. This approximation is especially useful whenever we need to convert calibrated air speeds into true air speeds,

$$\text{KTAS} = \frac{\text{KCAS}}{\sqrt{\sigma}} = \frac{\text{KCAS}}{1 - \frac{h_\rho}{70{,}000}} = \left(1 + \frac{h_\rho}{70{,}000}\right)\text{KCAS} \tag{5}$$

or need to convert true air speeds to calibrated ones:

$$\text{KCAS} = \sqrt{\sigma}\,\text{KTAS} = \left(1 - \frac{h_\rho}{70{,}000}\right)\text{KTAS} \tag{6}$$

One further use of σ is in finding out, for a given engine RPM, how much our engine power output is diminished by higher density altitude:

$$P(\sigma) = \Phi(\sigma)\,P(\sigma = 1) \equiv \left(\frac{\sigma - C}{1 - C}\right) \times P(\sigma = 1) \tag{7}$$

Constant C = 0.12 is the approximate proportion of indicated power used up in internal engine friction and hardly varies over a wide range of aircraft internal combustion engine sizes. The graphs of Figure 2 give us all these relations (the exact ones, not the approximations, though there's hardly any difference) in one central location. It's time to turn to actual aircraft performance.

4

How Thrust and Drag Vary with Air Speed

Aircraft flight performance eventually gets back to "the four forces": thrust, drag, lift, and weight. General aviation airplanes have such shallow flight path angles that we can almost always say (when wings are level) that lift **L** = weight **W**. (When the airplane is banked through angle ϕ, **L** = **W**/cosϕ.) In either case, since we know **W** and ϕ, the only unknown forces are then thrust **T** and drag **D**. Drag is divided into parasite drag D_P, due to skin friction and pressure or form effects, and induced drag D_i, "drag due to lift." See Figure 3.

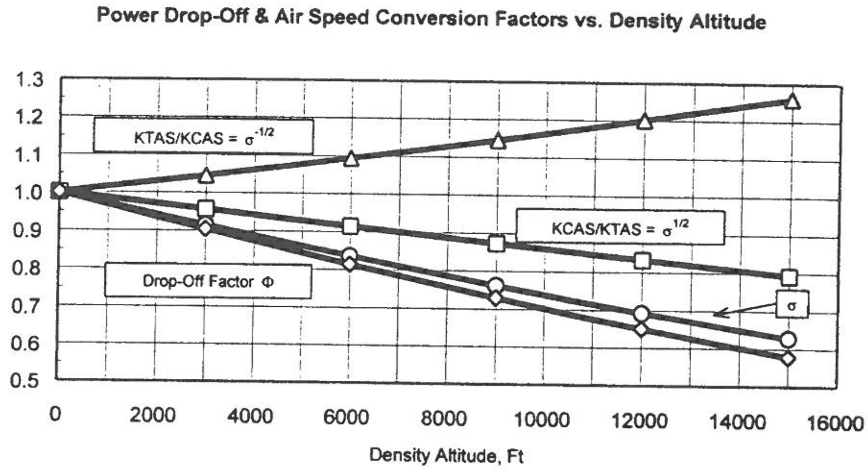

Fig. 2. From these four graphs one can see how much engine power or torque has dropped off, at any given density altitude, and can easily convert from KCAS to KTAS or vice versa.

The difference between thrust and drag, so-called "excess thrust"

$$T_{xs} = T - D \tag{8}$$

is important because the full-throttle speed at which T_{xs} is largest turns out to be V_x, the speed for greatest angle of climb (in calm air). See Figure 4.

There are several other interesting features in Figure 4. Since climbing depends on thrust being larger than drag, level flight is only possible at speeds where **T** = **D**, where the graphs of those two quantities cross. In this low altitude case the lower speed for level flight, V_{min}, is "not operational." That's because stall speed V_S is quite a bit higher than V_{min} (51 as against 34 KCAS); therefore one cannot get to V_{min}. In other cases, however, especially at high density altitude, V_{min} may be obtainable. Notice that V_{max}, the high speed of level flight, is in this case about 115 KCAS.

4

If the engine quits, then thrust T = 0 and $T_{xs} = -D$. Then the best angle one can achieve, the smallest negative angle, is where drag *D* is a minimum. In Figure 4 that occurs, for this weight, at 72 KCAS.

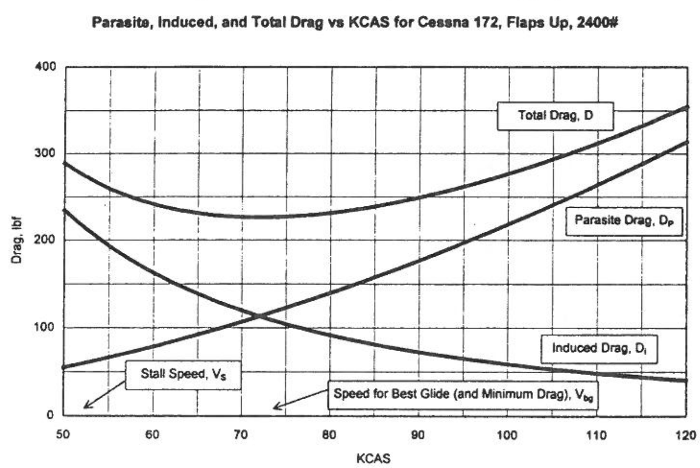

Fig. 3. Parasite drag goes up as the square of air speed. Induced drag, on the other hand, varies *inversely* with the square of air speed, as $1/V^2$. The speed at which $D_P = D_i$ is the speed at which total drag *D* is smallest. That is also V_{bg}, the speed for best (longest) glide in still air.

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Power Available P_{av} and Power Required P_{re}

It is also useful to look at graphs of so-called "power available," thrust times true air speed, *TV*, and of "power required," drag times true air speed, *DV*. And at their difference, "excess power," P_{xs}. See Figure 5.

These new power graphs, while related to the earlier graphs of forces, are not completely redundant. They feature some new and different and interesting *V* speeds. V_y, speed for greatest climb rate, is where P_{xs} is greatest (that's also where the slopes of the graphs of P_{av} and P_{re} are equal). Flying at speeds below V_y, the pilot is "on the back side of the power curve" or "in the region of reversed command," where in order to climb faster he or she must push the stick *forward*. Quite a few books say we shouldn't inhabit that region, but in fact we do it all the time. We normally takeoff at a speed around 1.15 V_S, which is a bit below V_x and *considerably* below V_y. Then, to climb out and reach cruise altitude fairly quickly we push the stick forward to get to V_y. There is no harm being "on the back side of the power curve" as long as we know we are there and how to respond.

In the power-available/power-required picture there is no change as regards V_{min} and V_{max}; those are again the speeds at which the P_{av} and P_{re} graphs cross. Speed for minimum descent rate, V_{md}, is the speed where power required is minimum.

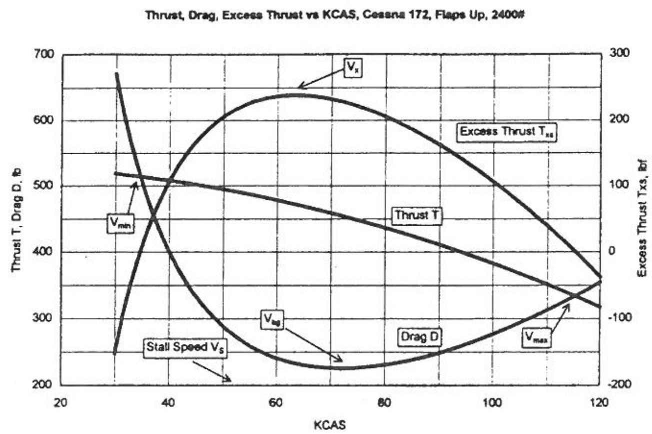


Fig. 4. Thrust and drag graphs cross at V_{min} and V_{max}, the two speeds for level flight (for this airplane under these circumstances). V_x, speed for greatest angle of climb, is where excess thrust peaks. V_{bg} is where drag is minimum.

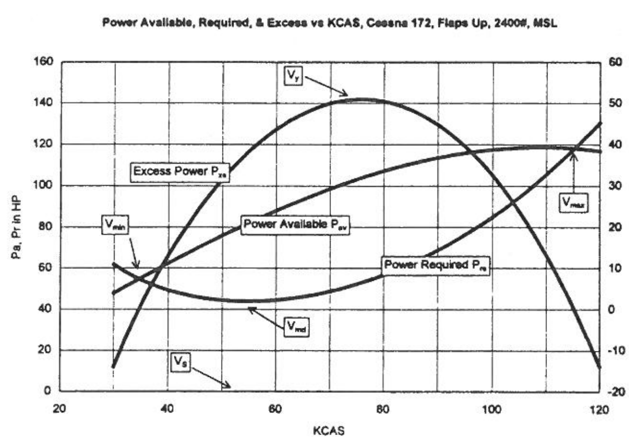


Fig. 5. Excess power P_{xs} peaks at V_y, speed for best rate of climb. Minimum power required is at V_{md}, speed for minimum (gliding) descent rate.

Fig. 5. Excess power P_{xs} peaks at V_y, speed for best rate of climb. Minimum power required is at V_{md}, speed for minimum (gliding) descent rate.

4

You probably saw graphs of power available and power required in your Private Pilot ground school. One reason those are usually emphasized over graphs of thrust and drag is that one can get values of V_{bg} and V_x (as well as of V_{md} and of V_y) from graphs of, respectively, P_{re} and P_{xs}. See Figures 6 and 7.

Rate of Climb vs KTAS, Cessna 172, Flaps Up, 2400#, MSL

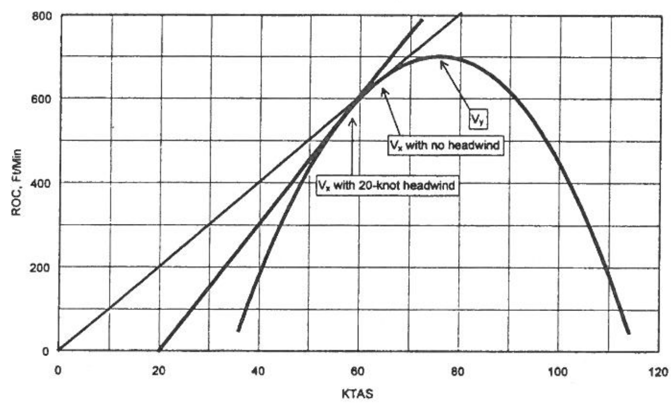


Fig 6. Excess power Pxs, divided by weight W, gives rate of climb. Dropping a tangent line onto the excess power graph gives the maximum value of Pxs/V, which is excess thrust Txs. Where that tangent line hits is therefore speed for best angle of climb Vx. Since we care about motion over the ground, starting that tangent line at say 20 KTAS, instead of at zero, gives us the correct picture for flying into a 20-knot headwind. Because of a slight geometric approximation we made, this picture breaks down when the wind speed gets close to our air speed.

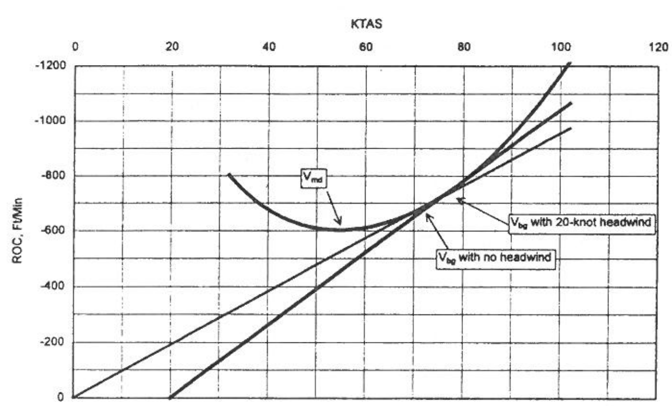
So far all these graphs have been for one kind of airplane at only one weight and one density altitude, and only for full throttle (or, in some cases, no throttle, gliding). And only for wings level. That's fine for orientation, but we eventually need to get a feeling for how things change (for the better!) if weight is reduced and (for the worse!) if we climb up higher and/or bank.

Effects of Weight, Bank Angle, Flap Setting, & Density Altitude on P_{av} & P_{re}

Let's start with weight. If you lower gross weight, the lift you need also diminishes. Therefore induced drag (drag due to lift) goes down. Therefore total drag goes down and, consequently, so does power required. By the same token, excess thrust T_{xs} and excess power P_{xs} increase. The ultimate effect is that we get better performance from the airplane. See Figure 8.

Fig. 7. This is the same sort of graph as Figure 6, but for the gliding case. Here excess power is

Gliding Rate of Climb vs KTAS, Cessna 172, Flaps Up, 2400#, MSL



just $-DV$ and so dropping a tangent line gives the maximum value of $-D$, the minimum of D, and hence speed for best glide V_{bg}. If we're gliding into a 20-knot headwind, we'd better speed up about 5 KTAS. That "add one-fourth of the wind speed" rule of thumb is a good approximation for winds which are "not too large." There will be more on the subject of wind effects on some V speeds later.

The effect is more pronounced at low speeds because that is where induced drag is greatest. With lower weight, since the gap between P_{av} and P_{re} is larger, rate of climb is increased. If you could get the airplane to weigh only half as much, you could climb much more than twice as fast. Lowering gross weight also increases maximum level flight speed, but only very slightly. In high mountain searches it is imperative that we reduce gross weight as much as safety (having sufficient fuel and survival gear) allows. Figure 8, remember, is at MSL; at higher density altitudes the weight effect is even more apparent.

For most performance purposes, banking the airplane has much the same effect as adding weight. See Figure 9. The formula, for those who remember their trigonometry (the rest of you can ask your daughter, or grandson), is:

$$L = \frac{W}{\cos \phi} \qquad (9)$$

but here's a table to help make that real. The required lift is some factor times actual weight W.

Bank Angle	Lift Required
0	W
10	1.015 W
20	1.064 W
30	1.155 W
40	1.305 W
50	1.556 W
60	2.000 W
70	2.924 W

Table 1. The numeric factors are "load factors" *n*. When banked 60° you're pulling 2 *gs* in order to stay level.

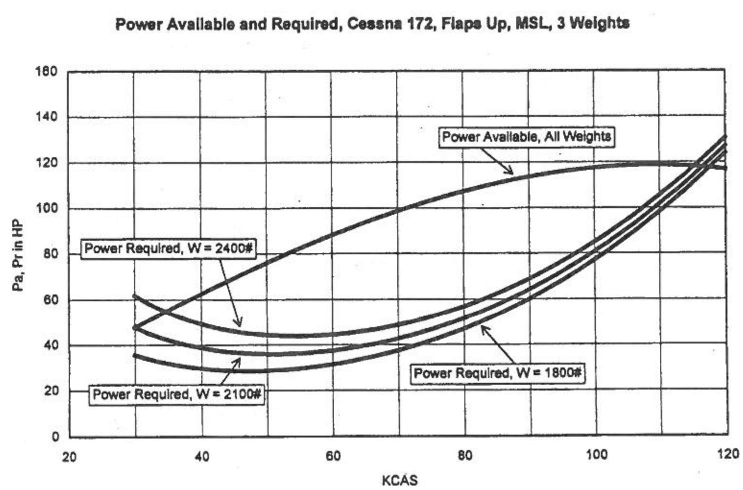


Fig. 8. Your engine doesn't know how much the airplane weighs. But lift does. More weight means more induced drag means higher power required, especially at slower speeds.

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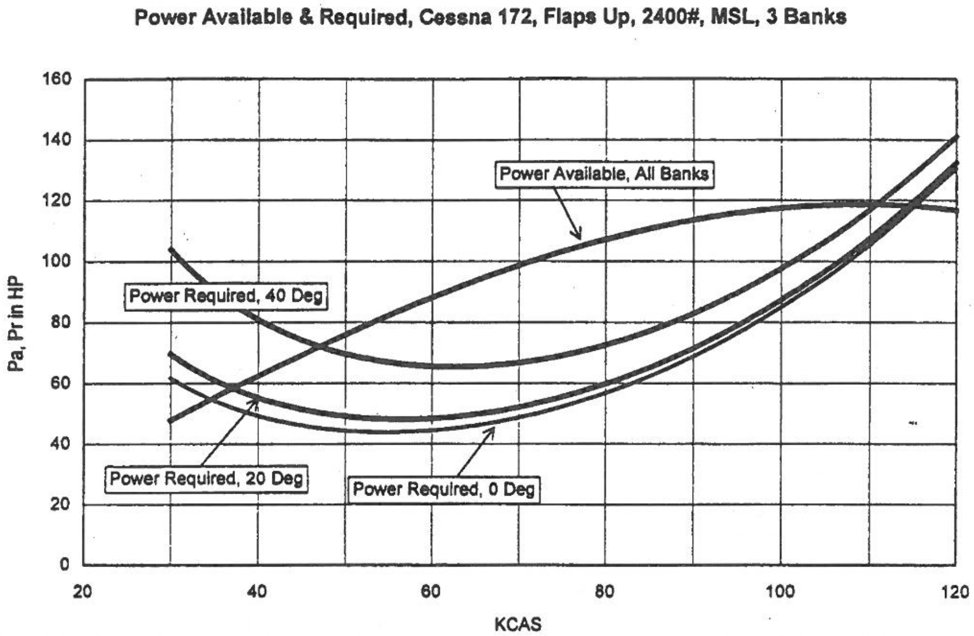


Fig. 9. To keep from accelerating downwards, when you bank to angle ϕ, lift must increase from near weight W to the larger value $W/\cos\phi$. Then, just as in the case of actual added weight, induced drag increases. And all the rest of it. Climb performance suffers. But this effect can be useful during a drainage search using a forward slip.

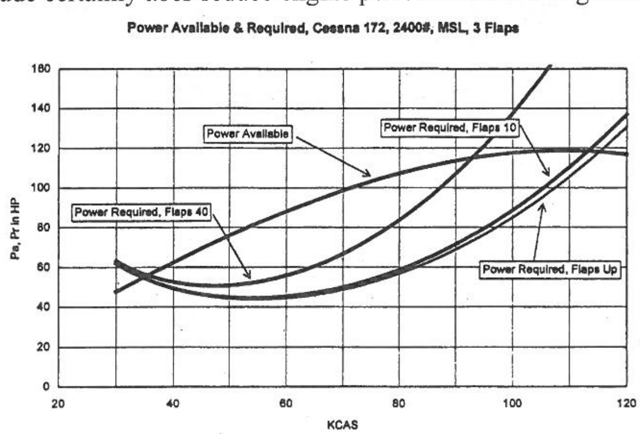
To stay more or less in level flight, while banked, you need a little back stick to add to your wings' angle of attack, to get more lift. This adds to induced drag just the way added weight did. Notice here that a 20° bank hardly has any performance effect at all. But banking 40° is like adding about 30% to your airplane's gross weight. And, just as adding weight does, banking increases stall speed, reducing your safety margin; we'll treat that effect below. High mountains are no place for extreme maneuvers.

Extending flaps adds to parasite drag (unlike weight and banking, which added to induced drag). The effect is greater at greater air speeds. Figure 10 shows how much the airplane's maximum level flight speed is reduced at full flaps; in this case, from about 115 KCAS down to about 92.

Still, for a tight turn, that lower speed might be just the ticket. Notice that flaps 10° hardly brings any performance deficit at all. Each additional "notch" of flaps adds increasingly smaller *increments* of lift and adds increasingly greater *increments* of drag. So it's certainly *not* the case that "if a little flap is good, a lot of flap is better." Not at all. Use flaps with moderation.

Weight, banking, and hanging out flaps had no effect on thrust or on power available. But, since it's an air-breathing engine, higher density altitude certainly *does* reduce engine performance. See Figure 11.

Fig. 10.



Recommended short takeoff flaps setting, for this airplane, is 10°. One can see why.

Climb performance is hardly affected. Flaps 40° is another matter, adding lots of drag. But, except in an emergency, using flaps as speed brakes is not a good idea.

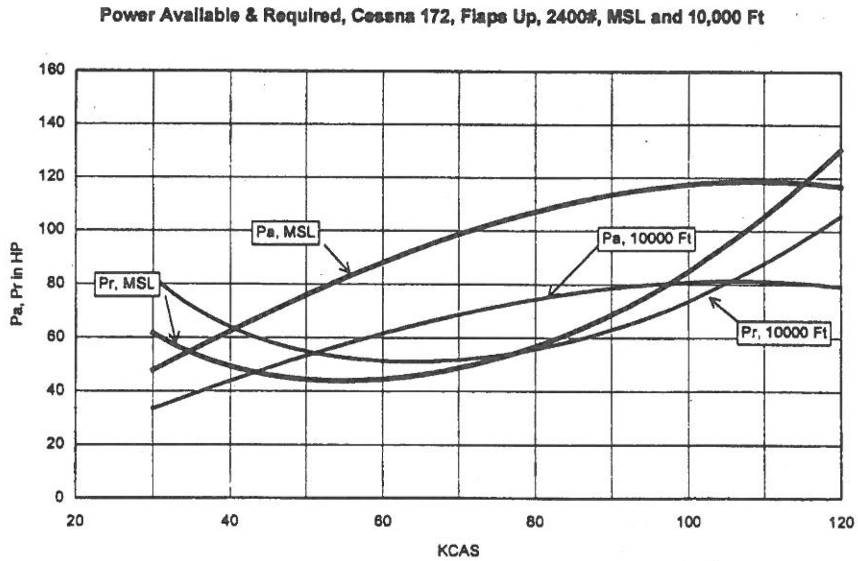


Fig. 11. Here, for the first time, we start to see the deleterious performance effects of high density altitude. In SAR operations, we don't much care about diminished top speed, but the great loss of excess power, in going say from sea level to 10,000 feet, is a serious concern. Reducing gross weight is the only antidote.

The effect of high density altitude on power required is more complicated: induced drag goes up and parasite drag goes down. But the main thing to notice is that P_{xs}, the gap between P_{av} and P_{re}, is much smaller at 10,000 feet than it was at MSL. That means a smaller best rate of climb and a smaller best climb angle.

In summary, your aircraft's speed and climb performance is best at:

- Low weight
- Wings level or small bank angles
- Flaps up
- Low density altitude

You can't pick mountain search elevations (although Mission Coordinators should be restricting relatively under-powered aircraft from the higher search locations), but if possible you should search higher altitudes earlier in the day, before the air heats up. Remember that each 1°F of OAT adds about 66 feet in density altitude; 30° warmer translates to 2000 feet higher. If your airplane is relatively underpowered for mountain work, as is the Cessna 172 we've been using as our example, keep your gross weight low if you have to go up into the high hills on a hot summer afternoon. Wait, or unweight!

How Stall Speed Depends on Weight, Bank Angle, and Flaps

Density altitude *per se*, assuming nothing else is changed, has no effect on *calibrated* stall speed. Your airplane stalls, say at 51 KCAS, whether it's at sea level or at 12,000 feet. Now of course the *true* stalling air speed rises with increased altitude and so, on approach to landing at say $1.3V_{S0}$, you'll have a higher approach ground speed (assuming the same wind) when up high. But since wings work on dynamic pressure (the same way air speed indicators do) there won't be any difference in instrument indications.

The stall speed situation with weight, bank angle, and flaps setting is fundamentally different. Regardless of weight, bank angle, or air speed, the wing stalls at the same critical angle of attack, α_S, where the lift coefficient takes on its maximum possible value. From the basic lift equation, specialized here to level flight,

$$L = W = \frac{1}{2}\rho V_S^2 S\, C_{LMax} \qquad (10)$$

we can see that W/V_S^2 is a constant for the same airplane in the same flaps configuration. So if weight *W* goes up then so too, though less quickly, does V_S.

Banking raises stall speed because lift *L* must go from *W* to *W*/cosϕ when some of the lift, the horizontal portion, is used to provide the force needed for turning. Extending flaps *lowers* stall speed because doing so makes for a larger wing and/or increases the angle of attack of part of the wing while maintaining the same *body* angle of attack. Figure 12 has some of the details.

Calibrated stall speed increases as the:

- Square root of gross weight; as the
- Inverse square root of the cosine of the bank angle; and as the
- Inverse square root of the maximum lift coefficient.

It's also necessary to remember that C_{Lmax} goes up as the flaps deflection angle increases and that cosϕ *decreases* as bank angle ϕ increases.

We tend to think of stalling as "a bad thing" and it is, especially when close to terrain and there's little room for recovery. But stalling is not *all* bad. In gusts or turbulence, at altitude, it's preferable to have the wing stall than to have it bent or broken by too-strong aerodynamic forces. Most of our normal category airplanes are certificated to withstand an upwards acceleration of 3.8 *g*s, when flaps are up, without permanent damage to the structure. With flaps down, that's usually reduced to a *load factor limit* of 3 *g*s. Flying level, one would pull 3.8 *g*s if banked 74.7° and would pull 3 *g*s if banked 70.5°. Maneuvering speed V_a is defined as the airplane's stall speed at the load factor limit bank angle. We will have more to say on this subject when we take up maneuvering.

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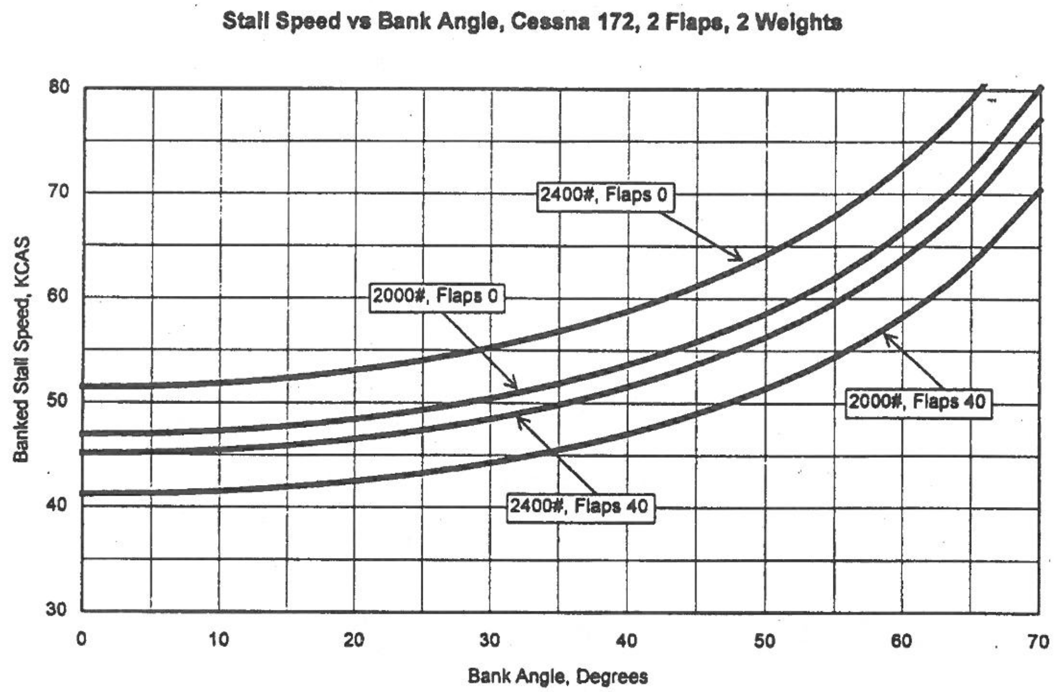

Fig. 12. Banking brings a performance penalty similar to adding gross weight. The 2000 pound airplane, banked 35°, has about the same stall speed as the 2400 pound airplane with wings level. But hanging out 40° of flaps, on the heavier airplane, more than makes up for the weight difference. At least as far as stall characteristics are concerned.

Rate of Climb, ROC: A Figure of Merit for SAR Missions

To successfully and reliably conduct mountain search and rescue flights, at least three items are required:

- Good pilot;
- Good airplane; and
- Good mission management.

Non-pilots often choose maximum level flight speed as the criterion for how "good" an airplane is. In mountain search and rescue work we're not concerned with fostering competition between aircraft types, but we are keenly interested in only sending out airplanes which can get the job done safely and effectively. Maximum rate of climb (that is, ROC at V_y), under the conditions of the proposed mission, has been selected as the criterion for a "good enough" airplane for the job; the cutoff is:

$$\text{Max rate of climb} = ROC_{max} \geq 300 \text{ ft/min} \quad (11)$$

The fine print is that the airplane, with its initial planned weight on station, at the highest density altitude it is likely to encounter there, flaps up and wings level, should be able to climb at 300 ft/min or better. This means that Mission Coordinators may need to send only their higher performance aircraft to the higher search elevations. And they may need to restrict weight of less powerful aircraft to minimal crew size and/or restrict time on station by requiring smaller initial fuel loads. While general aviation aircraft typically use 100 ft/min to define their "service ceiling," they have essentially no margin for maneuvering under that lumbering condition. Military aircraft often use 300 ft/min as their service ceiling.

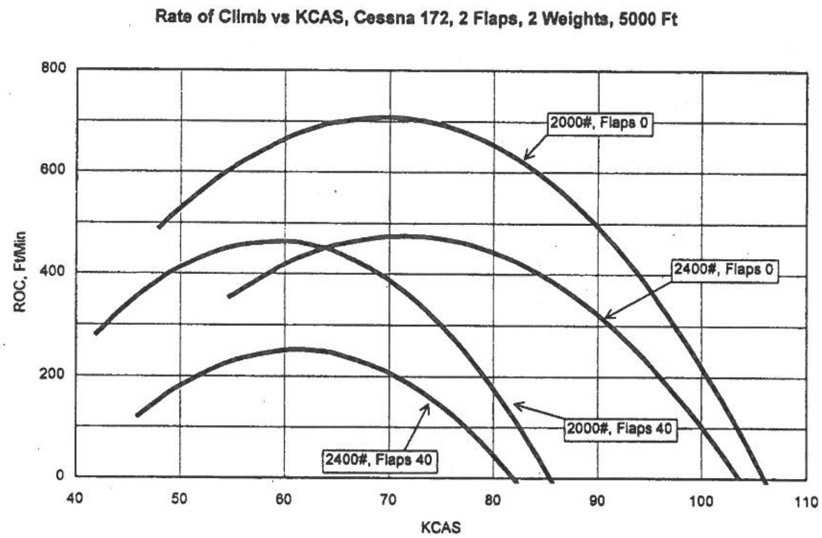

Fig. 13. With maximum rates of climb well above 300 ft/min, our Cessna 172, flaps up, has no trouble qualifying for a search mission at density altitude 5000 feet. Notice that V_y, speed for best rate of climb, is somewhat lower for lighter aircraft.

Fig. 13. With maximum rates of climb well above 300 ft/min, our Cessna 172, flaps up, has no trouble qualifying for a search mission at density altitude 5000 feet. Notice that V_y, speed for best rate of climb, is somewhat lower for lighter aircraft.

So let's get acquainted with rate of climb (not just *maximum* rate of climb) and how it depends on air speed, density altitude, gross weight, flaps setting, and bank angle. Figure 13 is for our sample Cessna 172 at a moderate altitude of 5000 feet. It shows the typical cap-shaped dependence of rate of climb on air speed, with quite different graphs for the same airplane laboring under different weights and different drag coefficients due to flaps settings. As expected, the lighter airplane, in clean configuration, has the best climb performance.

Any airplane, at full throttle at a particular weight and flaps deflection angle, and with wings banked through a particular angle, has an "absolute banked ceiling," the greatest altitude at which it can maintain level flight (the speed must be correct!) at that bank angle. Alternatively, one could take the airplane to some particular density altitude, say 8000 feet, and find out what the largest bank angle the airplane would maintain (at given weight and flaps setting) before starting to descend. This could be an alternate and more general figure of merit and could be used to predict how high the airplane could fly before losing its capability of climbing, wings level and flaps up, at 300 ft/min. But one figure of merit is enough! Figure 14 shows graphically how rate of climb is very much influenced by bank angle.

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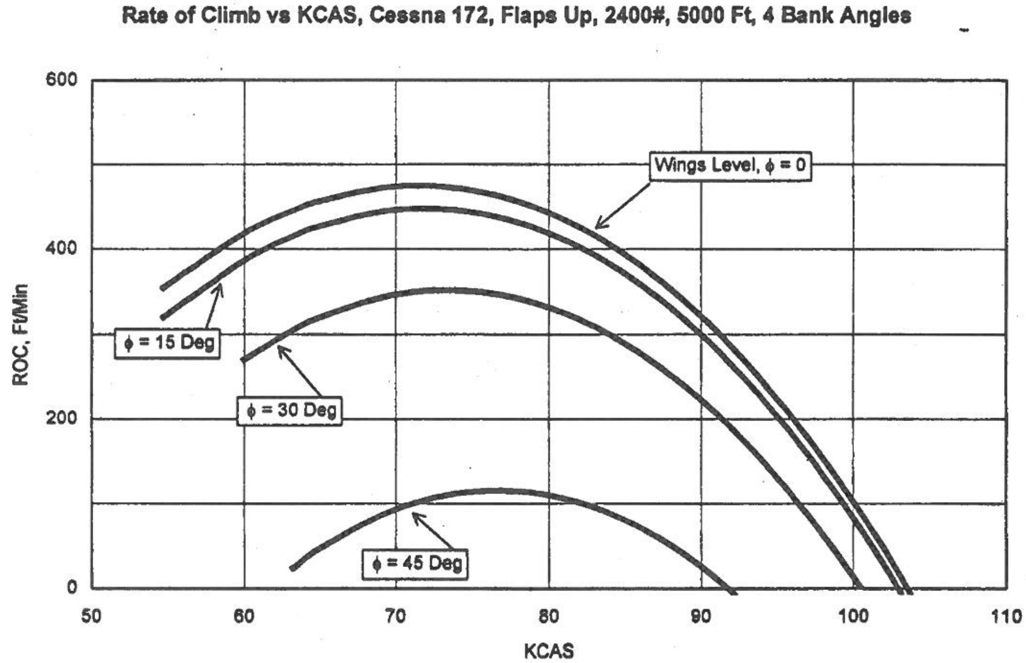

Fig. 14. Banking through angle ϕ, for most purposes, is the same as adding weight, increasing it from *W* up to *W*/cosϕ. These four curves all end, on the left, at the corresponding banked stall speeds.

Figure 15 takes a direct look – for density altitudes 0, 5000, and 10,000 feet – at rate of climb for our sample Cessna 172 at 2400 pounds, flaps up, wings level. Notice that this airplane, at gross weight 2400 lbs does not qualify for a search mission at 10,000 ft. Weight would need to be reduced to about 2100 lbs for it to have a 300 ft/min best rate of climb. Also notice that, as density altitude increases, calibrated V_y decreases. This makes sense from the following point of view. In the Bootstrap Approach, calibrated V_x, for given weight, does not change with altitude. (It does not even change with *throttle setting*, but that is another story.) Since at the absolute ceiling there can be only one air speed, calibrated V_y, which is generally greater than calibrated V_x, must decrease with increased density altitude.

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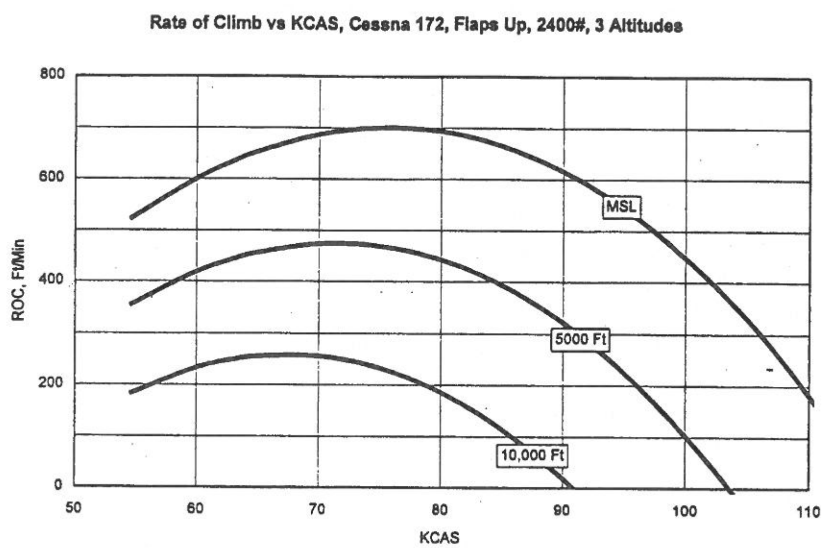


Fig. 15. This graph is relaxing in that it shows that missing V_y by a couple of knots has relatively little effect on rate of climb. On the other hand, it shows that climbing at the MSL value of V_y, at say 10,000 ft, does lower performance moderately. Pilots need to have an approximate notion how their *V* speeds depend on such variables as density altitude and gross weight.

Maximum rate of climb decreases almost linearly with density altitude. See Figure 16. A fully-loaded (2400 pound) Cessna 172 is able to climb 700 ft/min at sea level but only about 300 ft/min at 9000 feet. At that weight, and to follow our recommended mountain search performance restriction, it shouldn't search above 9000 feet. But notice the performance boost given by reducing weight by 300 pounds! At 2100 pounds, the airplane is OK to search up to 12,600 feet. Lowering gross weight is the easiest and cheapest performance-enhancing "modification" you can make.

Angle of Climb, γ

Angle of climb is often more important that rate of climb. Avoid climbing towards rising terrain. Circle, to gain altitude, first. Or, go around and search *down* the valley or canyon. If you are trying to climb as steeply as possible, V_x is the proper speed. We'll have more to say on several *V* speeds below. Angle of climb is tied closely – though they certainly are not the same thing – to rate of climb. It's sufficiently accurate, for these small angles, to calculate flight path angles using this approximation:

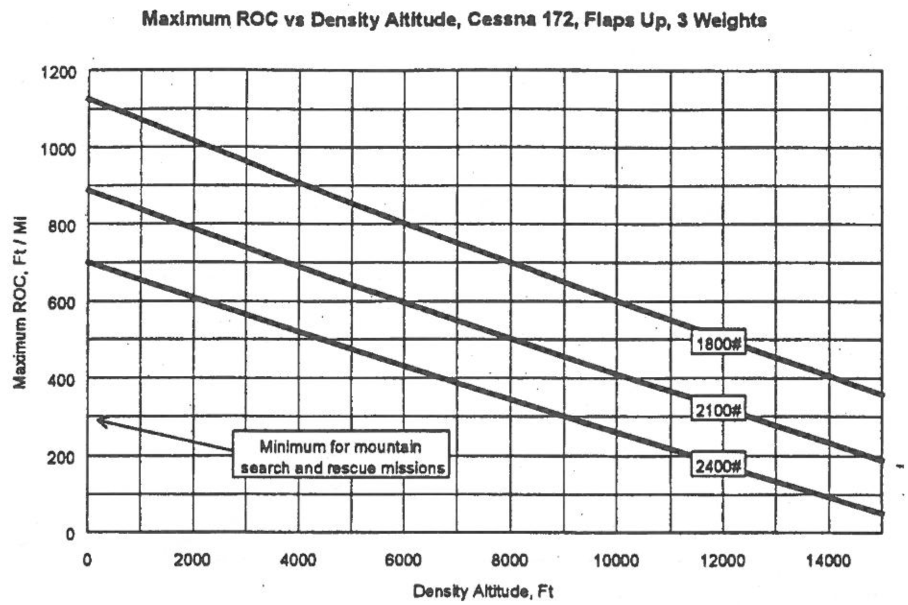


Fig. 16. Maximum rate of climb follows an almost straight line relationship with density altitude. But don't forget that V_y, the speed for best rate of climb, decreases a little (in calibrated terms) as density altitude increases. The main point of this graph, however, is to point out the benefit, in climb performance, in leaving out a few hundred pounds.

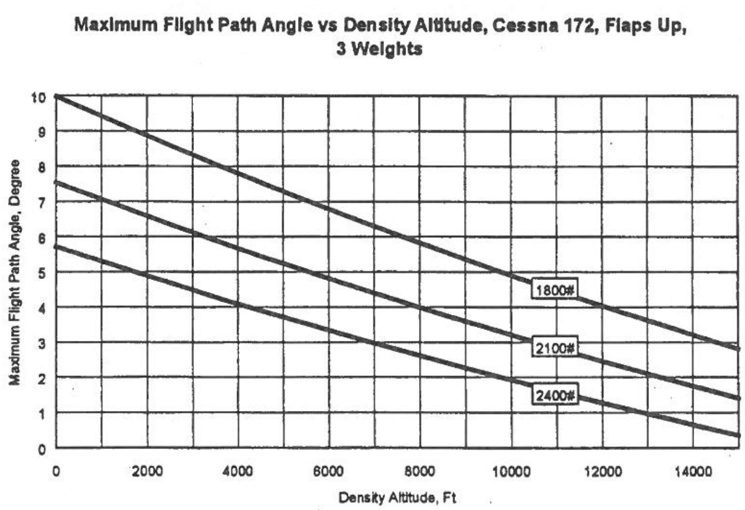


Fig. 17. Best angle of climb also falls off, though not as linearly, with density altitude. V_x, speed for best climb angle, in calibrated terms, for fixed-pitch propeller airplanes, does not noticeably vary. Again, performance is improved with lighter weight.

$$\text{Angle of climb, degrees} = \gamma = 0.566 \times \left(\frac{\text{ROC, ft/min}}{V\text{, KTAS}}\right) \quad (12)$$

Eq. (12) also works, making, of course, the obvious changes, for descents.

Question: If you're climbing at 500 ft/min at 4000 feet (density altitude) and your air speed is 90 KCAS, what is your approximate climb angle?

Answer: To get air speed in KTAS, multiply by $(1+ h_\rho/70000) = 1.06$ to get $V = 95$ KTAS. Next, $0.566 \times (500/95) = 2.98° = 3.0°$. The exact answer is 2.97°. You'll usually be close enough using Eq. (12) with multiplier 0.5 instead of 0.566.

Yes, that's a small angle! The climb rate is well below the maximum possible for the Cessna 172, even fully loaded at this altitude. Moreover, the speed is much higher than $V_x = 63$ KCAS (for 2400 pounds). But then again, none of these general aviation propeller aircraft are going to climb at 30° like the jets can. Not even your buddy's Bonanza! The important point is that you don't necessarily get large climb angles from large rates of climb. Climbing at 300 ft/min at 60 KTAS gives you the same flight path angle as climbing at 500 ft/min at 100 KTAS. Greater air speed carries you *into the obstacle* quicker.

V Speeds vs Density Altitude, Cessna 172, Flaps Up, 2400#

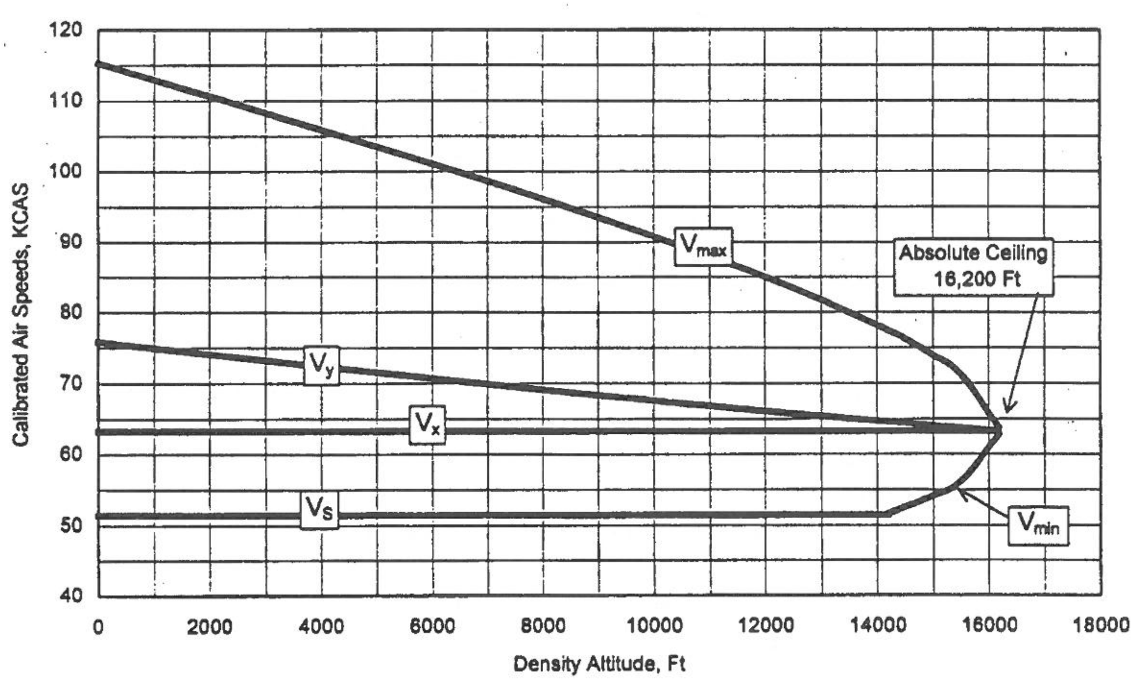


Fig. 18. Airplanes can't get to their absolute ceiling (unless dropped there by some higher-flying entity) but, if they could, they could only stay with one air speed, Vx. Vmin, the low speed for level flight, is only operational (attainable) at very high altitudes, when it has finally comes out from behind the shadow of stall speed VS. Notice that this graph features calibrated air speeds. That because those are closest to what one reads from his or her air speed indicator. And also because the V speed picture is simpler when expressed in calibrated terms.

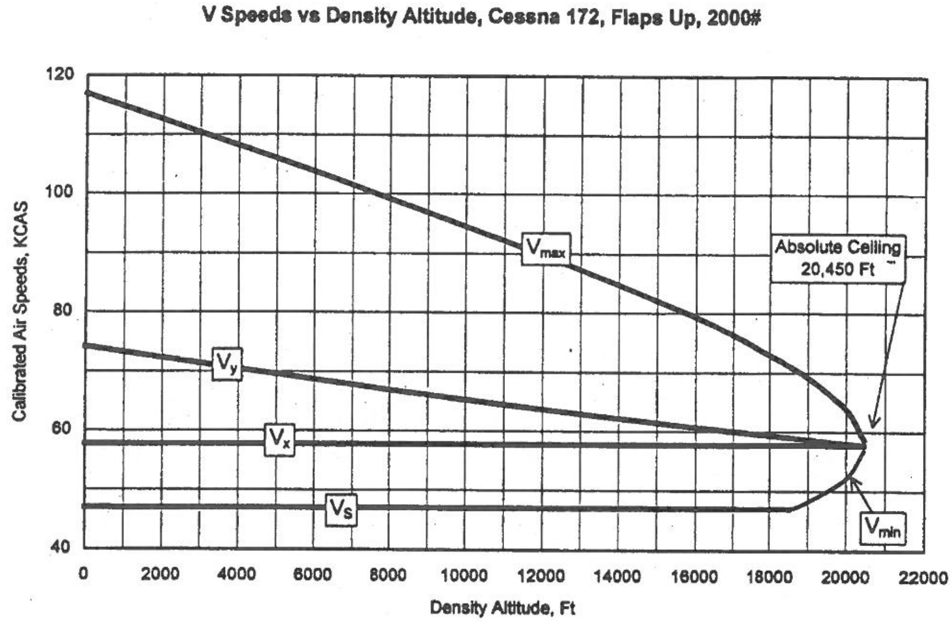


Fig. 19. Except for our having lowered the airplane's gross weight from 2400 pounds to 2000 pounds, this situation is identical with Figure 18. Level top speed Vmax has gone up a tiny bit and, as mentioned, Vx and VS have gone down to Ö(2000/2400) = 0.913 of their former values. Notice that the absolute ceiling has risen considerably, from about 16,000 feet to around 20,450 feet. "Wider is better" may be true for automobiles but, for airplanes, it's "Lighter is better!"

V Speeds Depend on Weight and (For Some) on Density Altitude

Let's first summarize the wings-level *V* speeds we're interested in:

- V_S, stall speed;
- V_x, speed for best (highest) angle of climb (in calm air);
- V_y, speed for best rate of climb;
- V_{max}, fastest level flight speed;
- V_{min}, slowest level flight speed;
- V_{bg}, speed for best (longest) glide (in calm air);
- V_{md}, speed for minimum descent rate.

Four of these – V_S, V_x, V_{bg}, and V_{md} – remain *constant*, when expressed as calibrated air speeds (KCAS), as density altitude changes. And each of the four goes up with gross weight in the same way, at the square root of the weight. Approximately, if you add 10% to your weight you add 5% to each of those *V* speeds. So in the next two graphs below, while we keep V_S and V_x as points of reference, we won't bother to feature V_{bg} or V_{md}. And don't forget that V_{md} is always 76% of V_{bg}. In many airplanes V_{md} is quite close to V_S (54.7 KCAS as against 51.4 KCAS, for our Cessna 172 at 2400 pounds).

Figures 18 and 19 show the five *powered* V speeds, and how they depend on density altitude, for our sample Cessna 172 at two different weights.

So far the effects on *V* speeds due to headwinds or tailwinds has not been taken into account. Wind only effects the two cases in which we're referencing motion with respect to the ground: V_x and V_{bg}. We'll take up the question of those *V* speeds in wind next. There's also the question of the effects of downdrafts and, to a small extent, updrafts.

Don't Fly Up a Rising Slope!

The CAP mountain SAR suggestion or prohibition "Never fly up a rising slope!" comes from the simple geographical fact that mountain terrain generally rises faster than our airplanes can climb. A glance at a topographic map will show that terrain leading up to even an ordinary mountain highway pass may climb at a 10% grade. That's 5.7°. That's what our sample Cessna 172 can do, at V_x under standard conditions (MSL, maximum gross weight, no wind). In real mountains, at high elevation, one won't outclimb the terrain without an upwards head start.

Now add a headwind following the terrain, which means – a downdraft! Granted, the headwind will steepen the climb angle a bit, but here let's focus on the rate of climb it takes to outclimb that downdraft. That same headwind means you'll be in the downdraft a longer time. Through passes, Venturi effects commonly double (or even triple) wind speeds, so let's consider a reasonable 30 knot (50 ft/sec) headwind through the pass. On a 10% slope, that translates to a 5 ft/sec (300 ft/min) downdraft. Heavily loaded, and at higher density altitudes, our airplanes are seldom going to be able to win that struggle! Table 2 contains further numerical examples for various terrain slopes and wind speeds. The admonition "Don't proceed into rising terrain!" makes sense. Gain altitude by circling early. Then fly to the head of the valley or canyon turn around, and do your search on the way back down.

Table 2. Sink rates, in ft/min, for various wind speeds and mountain slope gradients or angles. It's unlikely, with even moderate headwinds and moderate terrain slopes, that you'll be able to out-

Wind Speed at Pass, Knots	Slope 1: 20, 2.9°	Slope 1: 10, 5.7°	Slope 1: 5, 11.3°
20	101	203	405
30	152	304	608
40	203	405	810
50	253	504	993
60	303	605	1192

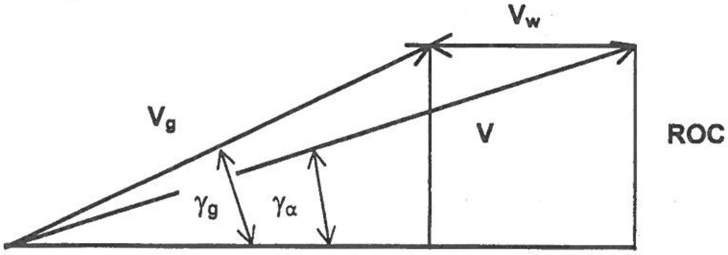
climb the combination of terrain and downdraft.

Wind Effects on Vx and Vbg

Now let's take a look at the subtler problem of wind effects on speeds for best climb and glide angles. Take a look at Figure 20 to get a clear idea of the speed vector diagram for V_x in the direct headwind case; from it you should be able to draw examples of the other three cases mentioned above. We earlier used graphs of rate of climb (obtained from graphs of excess power P_{xs}), showing a graphical procedure one can use to determine these two *V* speeds when confronted with a headwind or tailwind. From dropping tangent lines onto the graphs for the separate powered and gliding cases, it was clear that:

- Speed for best angle of climb in a headwind, Vxh, is less than Vx (no additional subscript means no wind); the headwind sets you back, steepening your angle;
- Speed for best angle of climb with a tailwind, Vxt, is greater than Vx; you need to speed up in order to give the tailwind less time to push you forward into the terrain;
- Speed for best glide in a headwind, Vbgh, is greater than Vbg; speed up so the headwind won't have time to steepen your glide path; and
- Speed for best glide with a tailwind, Vbgt, is less than Vbg; slow down so the tailwind can push you along over the earth, making your glide path shallower.

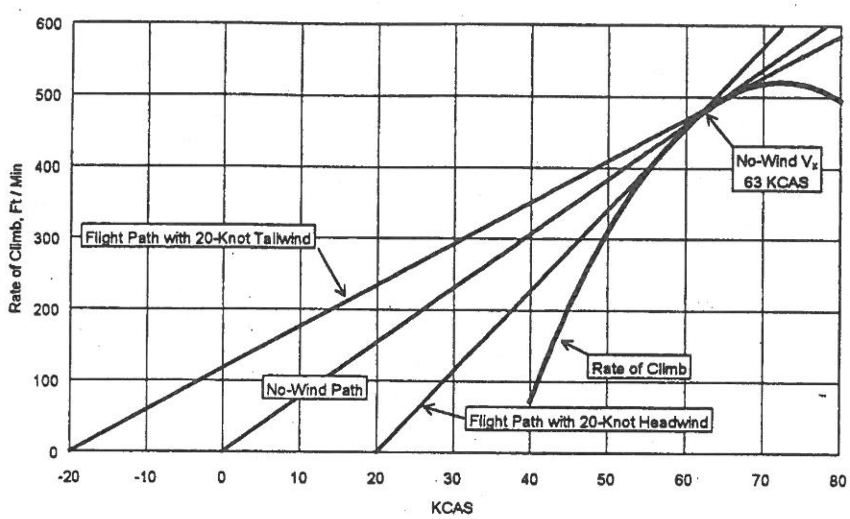
Fig. 20. Speed vectors and flight path angles (with respect to the ground and to the air) in a headwind. The larger angle $?_g$ is the one which counts. To climb most steeply in a headwind reduce speed, about one-fourth of the headwind speed, below the no-wind value of V_x.



One can only come up with rough "rules of thumb" for attaining "best angles" when, in the field, you have a headwind or tailwind. We can calculate any given situation (see Figure 23) but during an actual search operation there are too many variables you don't know precisely – the speed of the headwind or tailwind, the airplane, configuration, weight, density altitude. So this is not a calculation appropriate in the cockpit! Still, by studying the graphs, you can get a feeling for the directions and rough sizes of the effects. Figures 21 and 22 give more extended examples. In mountain search and rescue operations, gliding is not nearly as important as powered flight. We include the glide side partly for completeness (emergency use!) and partly because it is relevant to landing.

When the headwind or tailwind is accompanied by a downdraft or updraft, matters get even worse. Take for example a downdraft (see Figure 24). It's pushing you into the ground at so many feet/minute, so you need to speed up (relative to the direct headwind value V_{xh}) to attain V_{xhd} (speed for best angle of climb with a headwind with a downdraft). Table 3 gives directions the various *V* speeds move, and angle effects, for every possible case. While it is worthy of mention, there's no reason to commit it to memory: too many variables again. In best glide angles like γ_{bghd} (flight path angle for best glide with a headwind with a downdraft), saying it's greater than γ_{bgh} is meant in the

Rate of Climb and Tangent Lines, Cessna 172, Flaps Up, 2400#, 4000 Ft



strict algebraic sense, as –3 is greater than –5. A greater glide angle is less negative, a shallower angle.

Fig. 21. For V_{xh} in a 20-knot headwind, one slows a bit below the no-wind V_x speed. Having done that, you have a steeper best angle of climb than in the no-wind case. "Out in the field," the speed triangle is precisely the same shape as the space triangle.

Wind Situation	Speed for Best Angle of Climb	Best Climb Angle	Speed for Best Glide Angle	Best Glide Angle
Direct Headwind	$V_{xh} < V_x$	$\gamma_{xh} > \gamma_x$	$V_{bgh} > V_{bg}$	$\gamma_{bgh} < \gamma_{bg}$
Direct Tailwind	$V_{xt} > V_x$	$\gamma_{xt} < \gamma_x$	$V_{bgt} < V_{bg}$	$\gamma_{bgt} > \gamma_{bg}$
Headwind w/ Downdraft	$V_{xhd} > V_{xh}$	$\gamma_{xhd} < \gamma_{xh}$	$V_{bghd} > V_{bgh}$	$\gamma_{bghd} < \gamma_{bgh}$
Headwind w/ Updraft	$V_{xhu} < V_{xh}$	$\gamma_{xhu} > \gamma_{xh}$	$V_{bghu} < V_{bgh}$	$\gamma_{bghu} > \gamma_{bgh}$
Tailwind w/ Downdraft	$V_{xtd} > V_{xt}$	$\gamma_{xtd} < \gamma_{xt}$	$V_{bgtd} > V_{bgt}$	$\gamma_{bgtd} < \gamma_{bgt}$
Tailwind w/ Updraft	$V_{xtu} < V_{xt}$	$\gamma_{xtu} > \gamma_{xt}$	$V_{bgtu} < V_{bgt}$	$\gamma_{gbtu} > \gamma_{bgt}$

Table 3. This table is strictly for reference and to check the answers you get by drawing speed vector diagrams like Figures 20 and 24. Laid on top of this confusion is the possibility of cross winds, but those are accommodated by crabbing to the appropriate "wind correction angle."

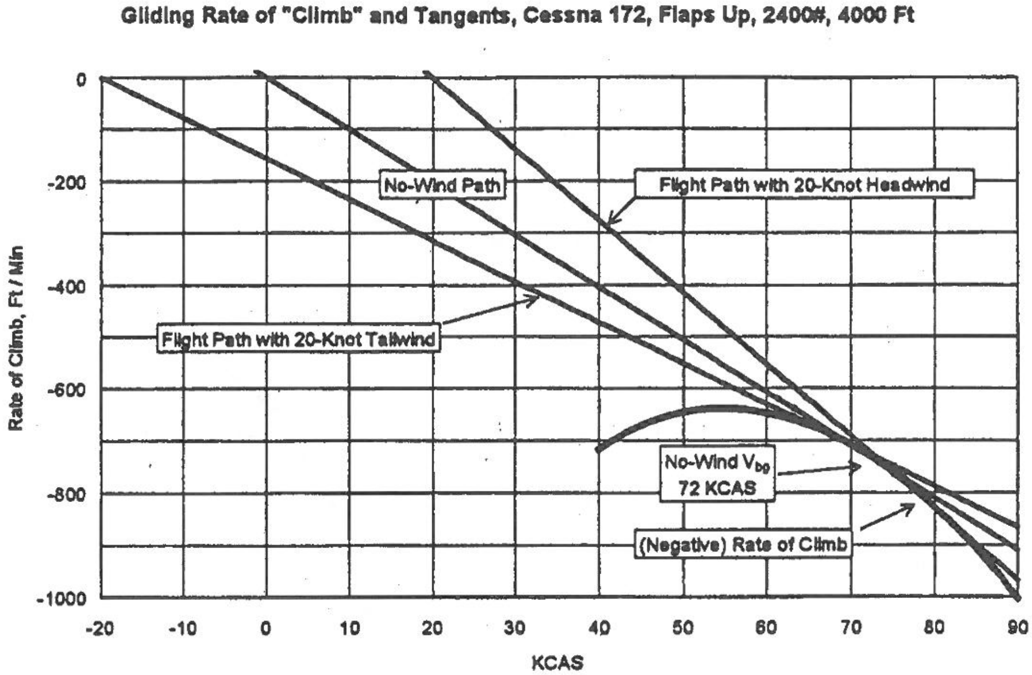


Fig. 22. For V_{bgt} with a 20-knot tailwind, the pilot should slow a bit below the no-wind V_{bg} speed. The diagram also shows that he or she will then have a shallower glide angle than in the no-wind case.

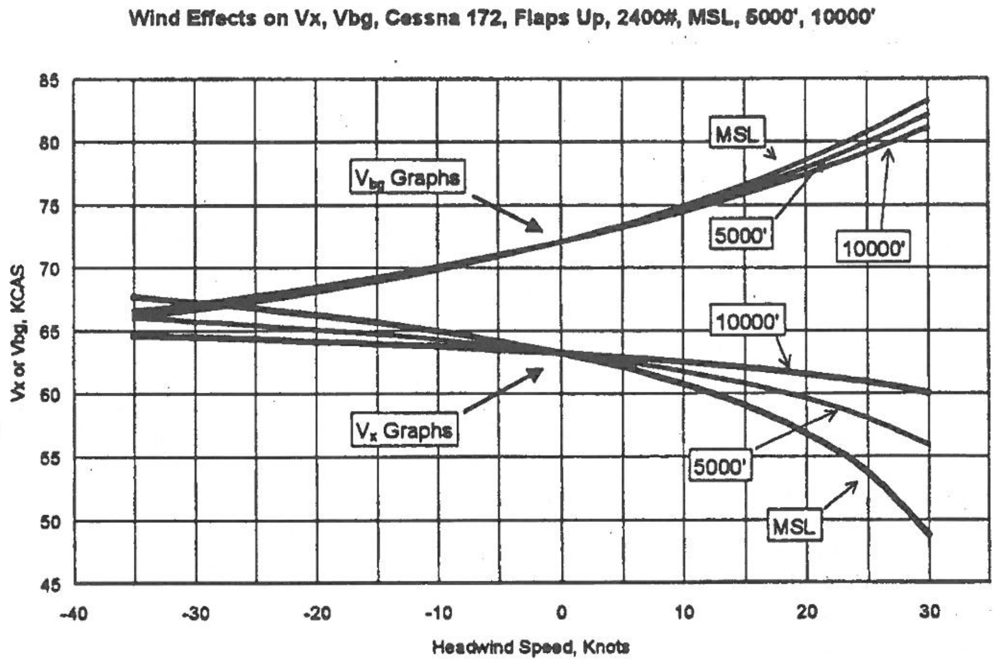


Fig. 23. The only reason density altitude splits the best glide graphs is that we've plotted calibrated air speeds vertically and wind speeds, which are *ground* speeds of the air, horizontally. As it is, the splits here are negligible. The best angle of climb graphs, however, especially for hefty headwinds, really are split. The effect at low density altitude, everything else being equal, is much greater. But for mountain operations, luckily we're in the case where V_x varies, due to headwinds or tailwinds, relatively less.

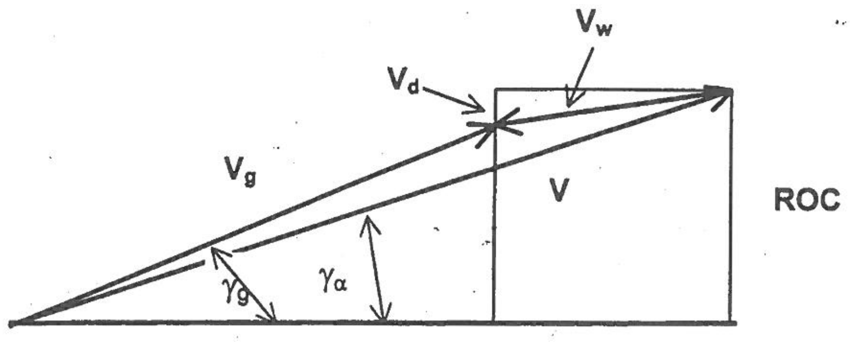


Fig. 24. Speed vectors and flight path angles (with respect to the ground and to the air) in a headwind with a vertical downwards component. This is a side view. Relative to the direct headwind case one would want to speed up a little, to keep the downdraft from pushing the airplane down into the terrain.

With wind effects on V_x (and on somewhat less important V_{bg}) now under control, we can turn to the crucial topic of maneuvering at high density altitude.

Maneuvering

Maneuvering means turns: level turns to a new course, course reversals, ascending and descending turns. In a confined mountain setting we are likely to be interested in fairly tight turns of relatively small radius *R*. To turn with small radius requires turning at low speed *V* and with large bank angle ϕ. The formula for radius *R* of a coordinated turn is:

$$R = \frac{V^2}{g \tan\varphi} \tag{13}$$

While we won't be using this formula explicitly, it is implicit in much of the work below. In fact Eq. (13) is fully accurate only for level turns; if the flight path angle g is not zero – the airplane is climbing or descending – then an additional factor cosg, which makes R very slightly larger, appears in the denominator. Along with tight turns go large turn rates, but since we typically have more time than space we'll focus only on the turn radius.

4

Maneuvering also means aerobatic maneuvers of one type are another – in this mountain search context, some sort of course reversal maneuver, and pull-ups, are the most likely – but we won't go into those. For safely performing any relatively extreme maneuver, the theory of aircraft performance is relatively unimportant in comparison with instructor demonstration and student practice. We are going to stick with so-called "steady maneuvers," unaccelerated except for the usual centripetal acceleration causing a turn.

There's still a lot to talk about. An airplane makes coordinated turns by banking, starting to move sideways, and then letting the new relative wind hit the tail and enough of the fuselage (that part behind the center of gravity) to force the airplane to yaw into the wind. A little rudder is usually necessary to assure coordinated flight (the airplane pointed in the same direction it's moving).

The banked wings, banked via aileron action, tilts the lift force vector off the vertical and towards the inside of the turn. Since less lift is then directed upwards, some back stick is necessary to maintain level flight. Back-stick increases the wing angle of attack and (normally) provides more lift for the same air speed. The 'normally' hedge is of course to remind you that if you exceed the wing's critical angle of attack the wing will stall. Then you'll get less lift rather than more. Much less!

There is a second danger in banking too far, especially at high density altitude, which is subtler and more insidious: the airplane may start to descend. Not stalled, just descending. The wrong response then is to add yet more back-stick. As we will explain and show graphically, added back-stick will only make the situation worse. The correct response is to level the wings a bit.

Those rocks off to the side are getting close! Yes, but perhaps those rocks underneath are getting close too! The moral is: think ahead. It's perfectly possible to get the kind of small airplanes we fly in CAP mountain search operations into a tight place from which there is no possibility of maneuvering successfully. We'd like to think that in that case you could always "park" the airplane on some approximately flat spot, making a precautionary semi-crash landing, but even that may not be in the cards or on the topographic map. The best instrument you have in the airplane is your brain: Think ahead! Follow Sparky Imeson's famous dictum and admonition:

Always stay in a position where, even with idle throttle,
you could successfully turn towards lowering terrain.
– Sparky Imeson

(You wouldn't actually *make* that turn with idle throttle; that condition just gives you an additional safety factor.) Now back to details on maneuvering performance. The first kind of graph which is important, at least temporarily, is the venerable V-n diagram or chart. It shows the air speeds V and load limits n (essentially bank angles, since $n = 1/\cos\phi$) important to structural damage or failure and important to the airplane's stalling. Most normal category aircraft have a flaps-up structural damage load limit of $n = 3.8$; this corresponds to a level turn at bank angle $\phi = 74.7°$. With flaps down – down any amount – the damage limit is often $n = 3.0$; this corresponds to a level turn at bank angle $\phi = 70.5°$.

The V-n diagram depends on the airplane's weight and flaps setting and has different portions for ordinary and inverted flight. Figure 25 shows such a diagram for our sample Cessna 172 for one weight (2400 pounds) and one flaps setting (retracted). The airplane's maneuvering speed V_a is the speed where the structural damage load limit line crosses the stall limit curve; here, V_a = 100 KCAS. The importance of V_a is that, in rough air, you should slow to (or below) that speed. At those low speeds the airplane's wing will stall rather than become damaged structurally. V_{ne} is the airplane's "never exceed" speed.

Figure 26 is an expanded portion of Figure 25 with an expansion to two weights and two flaps settings but with restriction to ordinary flight at or above $n = 1$.

V-n Chart, Positive & Negative Limits, Cessna 172, Flaps Up, 2400#

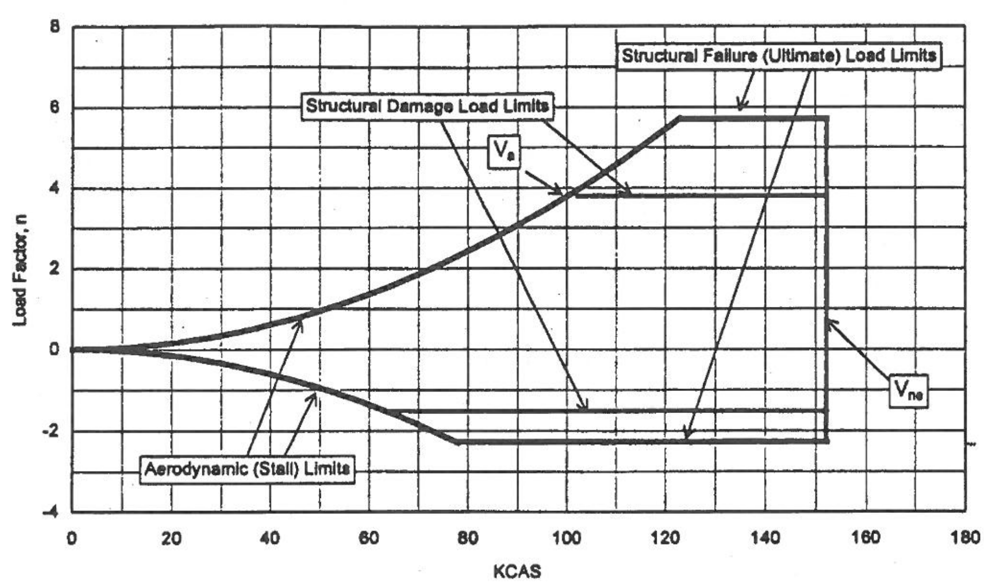


Fig. 25. Except for giving meaning to the concept of maneuvering speed V_a, this V-n chart is not of great use to the mountain search and rescue pilot. Unless of course he or she is performing fairly violent pull-ups and other semi-aerobatic maneuvers.

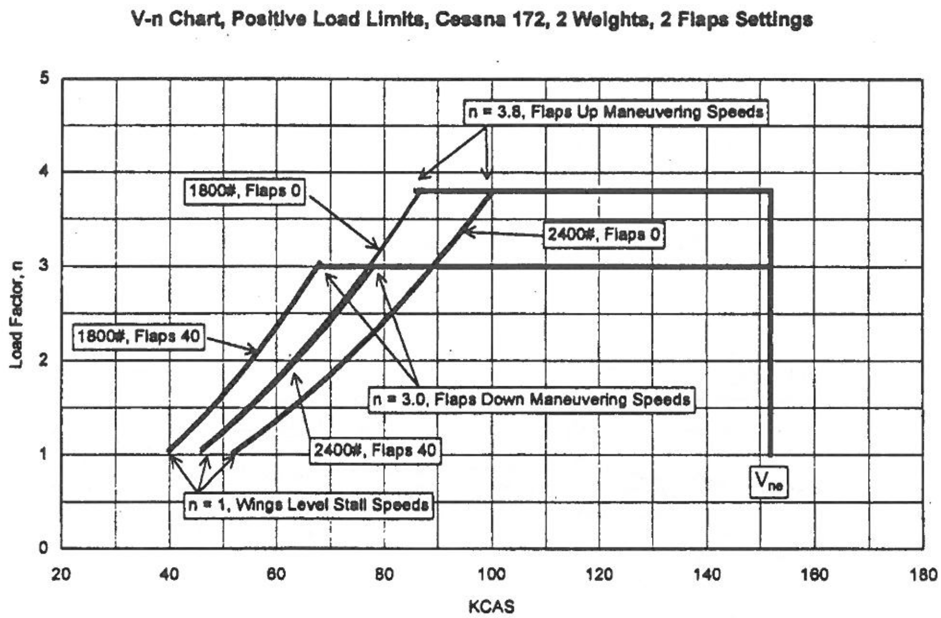


Fig. 26. With flaps up, lowering weight from 2400 pounds to 1800 pounds reduces V_a from 100 KCAS to 83 KCAS. With flaps all the way down, $\delta_f = 40$, V_a at 2400 pounds is about 77 KCAS and V_a at 1800 pounds is about 67 KCAS.

Steady Maneuvering Charts

Now we come to a useful graph, though quite complicated, and one of the most safety-important features we shall present. That is the so-called "steady maneuvering chart." For relatively underpowered airplanes like this one, these will all be full power charts. For starters, and just to get the big picture, see Figure 27. There is a high region (very large bank angles) where trying to stay level will produce such large-g turns that you risk damaging your airframe. You won't be going there. To the left of the curved stall line, slanting up and to the right, is the region in which the wing is stalled. You might sometime go there, but only momentarily. To the right of the stall line, in the main non-damage area, you won't be stalled. Then there is the question of your flight path: climbing, level, or descending? The cap-shaped curve is all the places (in the non-stalled region) at which your airplane (full throttle!) can fly level. Below that, smaller bank angles, it can climb; above that, larger bank angles, it will descend. That is the big picture for steady maneuvering charts.

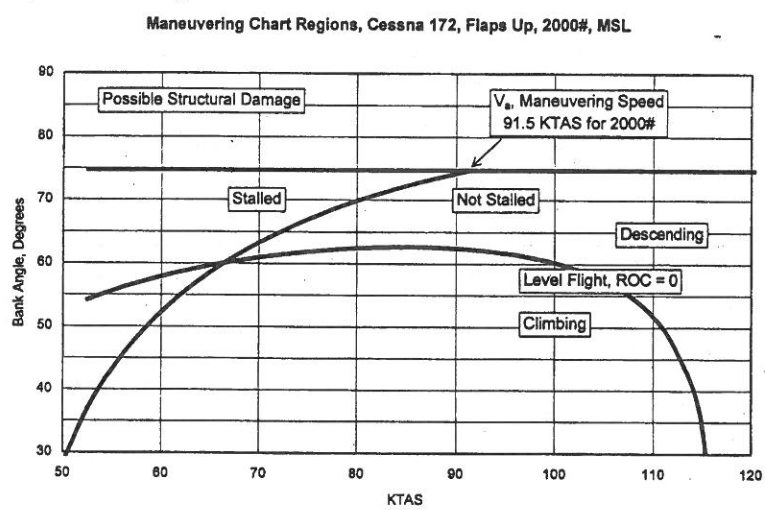


Fig. 27. What if you were at 80 KTAS, climbing, wings level, and decided to bank? Even at a 60° bank (with this light airplane, and at MSL) you'd still be climbing a bit as you turned. At about 63°, you'd be making a level turn. If you banked as much as 65°, you'd start descending a bit. At 70°, the wing would stall. Then all "steady" bets would be off.

4

For further details, see Figure 28. For variety, this time we've chosen gross weight 2400 pounds; notice that the level flight curve has moved down, to somewhat smaller bank angles. In addition, we've added a stall buffer line 5 KTAS to the right of the stall line. Nobody wants to fly right *at* the stall angle of attack! Various rate-of-descent curves have also been added. If you're comfortable descending 500 ft/min, your smallest turn radius is at about 82 KTAS and banked about 63°; bank much more than that and you'll stall (at this speed). Slow down much (at this bank angle) and you'll also stall. Those several icon-dotted curves for various turn radius values are the final addition.

Turn Radius Maneuvering Chart, Cessna 172, Flaps Up, 2400#, MSL

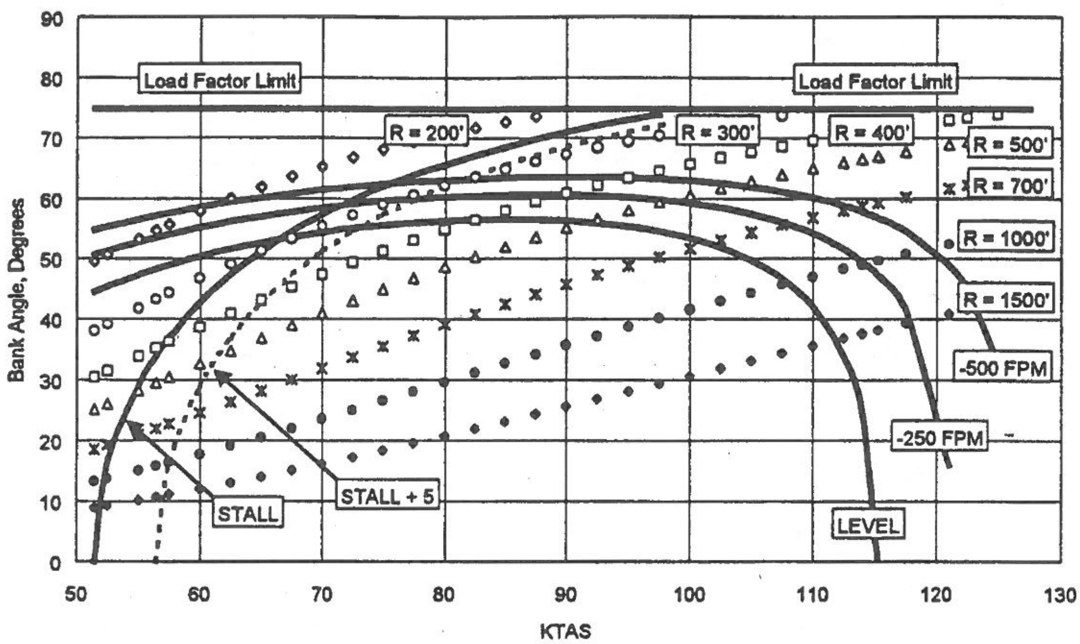


Fig. 28. This time the airplane is 400 pounds heavier than in Figure 27. The stall speed curve has moved right a bit. The level turn curve now peaks lower, near $\phi = 56°$, and a small amount slower, at 85 KTAS. The tightest turn, R somewhat less than 300 ft., occurs at maneuvering speed (about 99 KTAS) banked 74°. But little is lost, since the $R = 300$ ft. curve parallels the stall curve, by turning at, say, 78 KTAS banked only 60°. Letting the pilot discern such subtleties without laborious calculation is a major benefit of these maneuvering charts.

There is also a turn *rate* form of the steady maneuvering chart, but we'll skip that. It's important to remember that it would take about a dozen of these individual charts to give the full maneuvering envelope picture of your airplane. That's because each chart is only good for given values of weight, density altitude, and flaps setting.

So far we've only taken a look at steady maneuvering charts at low altitude. Figure 29 moves the same airplane up to 12,000 feet. Now it can only bank 32° in a level turn, at about 68 KCAS. That means level turn radius is quite restricted. The tightest level turn, without violating the stall buffer area, would be at about 60 KCAS, banked about 30°; there $R = 800$ feet.

Next we move the airplane up even more, to its (100 ft/min maximum rate of climb) service ceiling. See Figure 30. Suppose the airplane is climbing, wings level, at that rate. V_y is 80 KTAS = 65 KCAS; the airplane is at the short curve (point A) down on the speed axis. Now assume that a rapidly rising canyon floor, or some obstruction up ahead, calls for a course reversal. If the pilot suddenly banks 30°. Then the airplane would start descending (still at 65 KCAS) at about 100 ft/min. This is at the 'B' in Figure 31. But that's no good. There are rocks below! So he pulls back on the stick or control column. Increased induced drag slows the airplane and, moreover, he starts descending a little *faster*. He pulls back a bit more. Soon (only a few seconds later) he runs into the banked stall curve (point 'C' in Figure 31) at 55 KCAS. Not a pretty picture.

Turn Radius Maneuvering Chart, Cessna 172, 12000 Ft, Flaps Up, 2400#

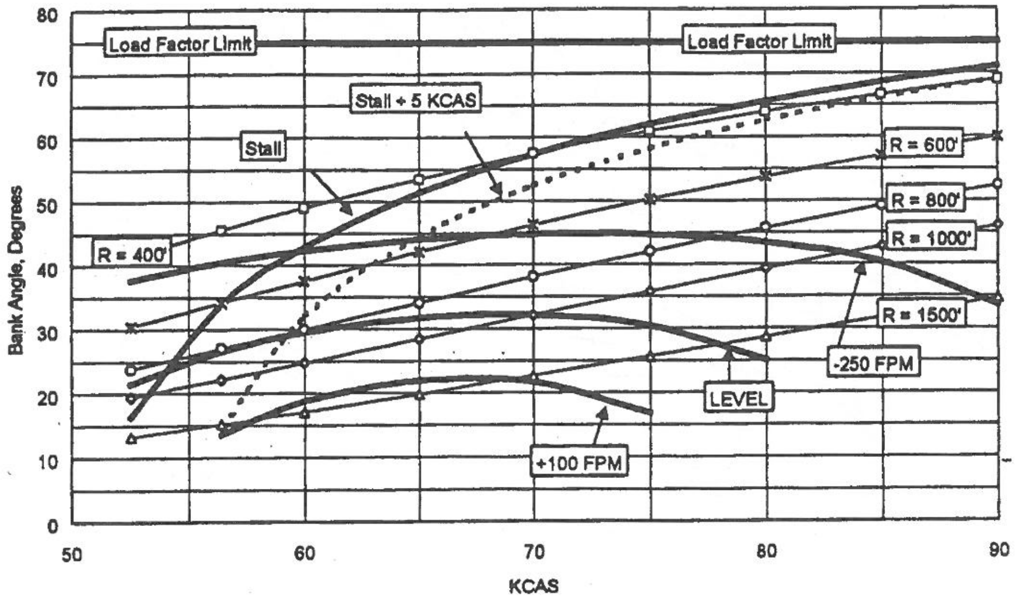


Fig. 29. If you had room below, but less to the side of the canyon, you might opt for turning at 65 KCAS banked 45°; then *R* would be somewhat less than 600 feet.

Maneuvering Chart, Cessna 172, Flaps Up, 2400#, Service Ceiling 13773 Ft

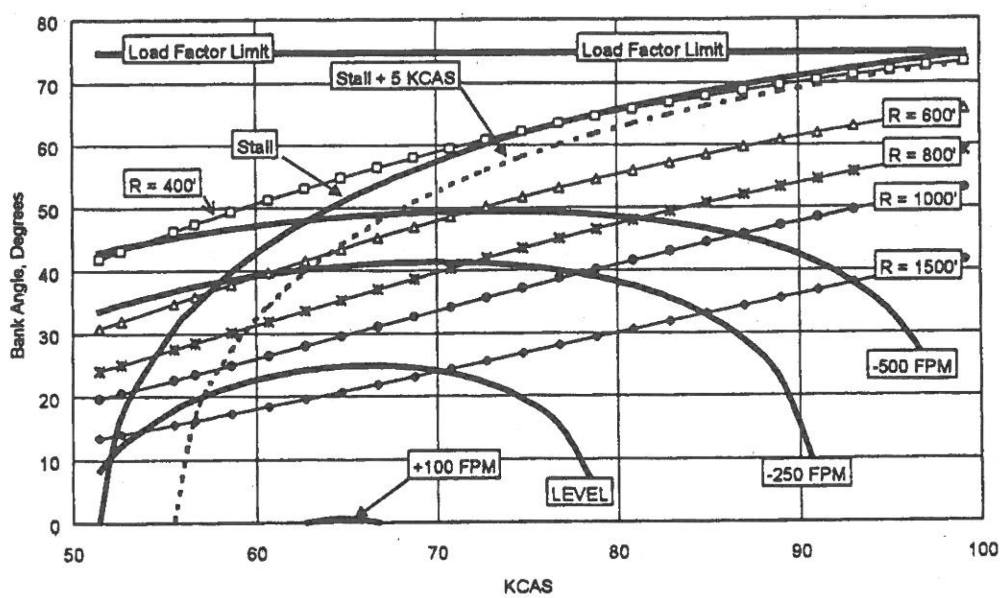


Fig. 30. At this high altitude the airplane can barely manage 100 ft/min climb rate. To turn while staying level, a 25° bank is all it can afford (at about 66 KCAS). That level turn would have radius about 1300 ft. Trying to turn shorter will mean descending. Depending on the terrain, a moderate descent rate might be acceptable.

4

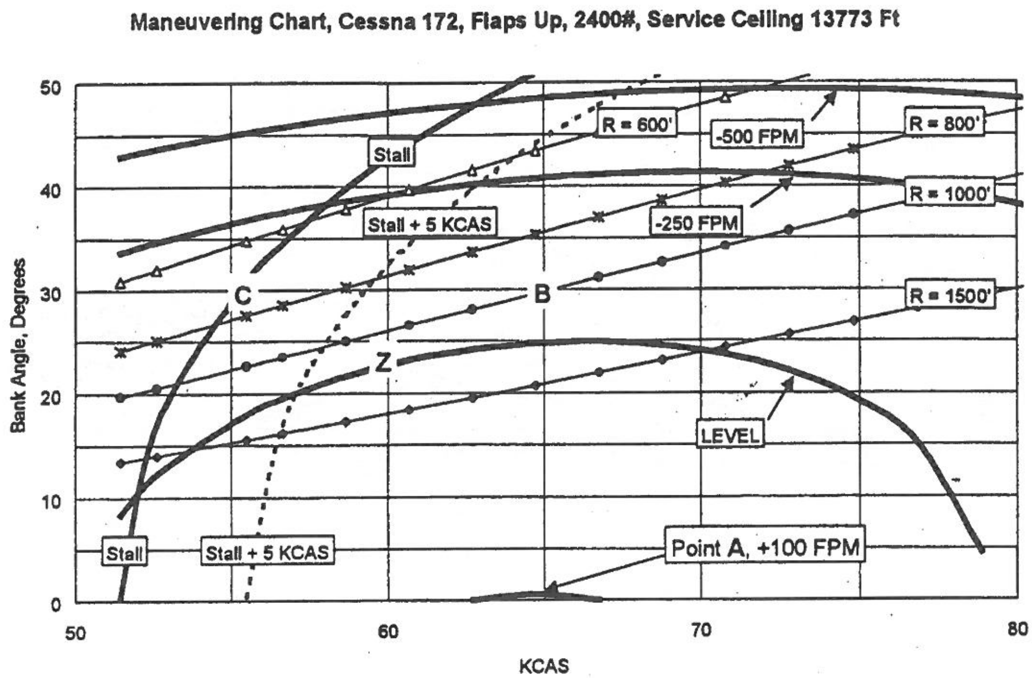


Fig. 31. This is an enlargement of part of Figure 30. Now let's think positively. What *should* this CAP search pilot have done to turn around? Notice point 'Z'. If he had banked a little less, 23° instead of 30°, and pulled back enough to slow to 60 KCAS, he'd have been able to turn level. Granted his turn radius, about 1200 feet, is nothing to shout about. Also notice that it's better than you would get by slowing all the way to stall speed (52 KCAS banked 11°). Studying steady maneuvering charts will convince you that you must think ahead about how to avoid getting yourself and your crew into such tight spots in relatively low performance airplanes.

If you run into this type of dangerous high altitude maneuvering situation there is, unless you have enough excess air speed that you can afford to turn some of it into altitude (which is seldom the case), essentially only one corrective action you can immediately take: **Level the wings**. At least to more nearly level.

Takeoff and Landing

Takeoff and landing performances – especially landing, where pilot technique plays such a large part – are much more complicated than steady-flight performance. Several new forces modify or supplement those – weight, lift, thrust, and drag – of pure flight:

- Ground effect modifies both lift and drag, the aerodynamic components.
- Runway surface reaction, opposing whatever part of the airplane's weight is not counteracted by lift, and
- Rolling/braking friction.

For these airplanes, we can ignore the fact that a tiny bit of thrust goes into spooling up the wheels and tires. The net force accelerating the airplane, taking off, is:

$$F_{Net} = \text{Thrust} - \text{Drag} - \text{Friction} \qquad (14)$$

Not all runway surfaces are created equal. Taking off or landing on tall grass, or moderate mud, is quite a bit different than on concrete. Lift and weight modify the friction force. Wind modifies the drag force. Finally, the runway may be tilted, uphill or down. If the runway slopes up at angle θ, a portion of the weight, $W \sin\theta$, also retards the airplane. We've dealt with wind effects, so those are not completely new.

Because of this increased complexity, we are not going to treat takeoff and landing in great detail. Our treatment will emphasize *relative* takeoff and landing distances – relative, that is, to distances when at maximum gross weight and at sea level on flat dry concrete. Adjustments will then be made for the major higher altitude mountain strip phenomena:

- Softer runway surfaces,
- Uphill/downhill runways,
- High density altitude, and
- Modification, due to headwinds or tailwinds, of the usual 70/50 takeoff rule.

Takeoff comes first. Let us outline the force scene. Unless there is perceptible headwind, the airplane feels no lift and no drag at the beginning of the takeoff roll. Rolling friction is then at a maximum, but it slowly diminishes as lift takes weight off the tire/runway interface (and the wheel bearings). Thrust, for these propeller-driven aircraft, is maximum at the beginning of the takeoff roll. Near the end of that roll, drag is getting up to its maximum takeoff value, lift is starting to equal weight and, consequently, rolling friction is vanishing. Thrust has been decreasing but is still sizeable. Figure 32 gives most of the force picture, against air speed, for a Cessna 172, 2400 pounds, short field takeoff flaps setting 10°, on a level concrete runway, no wind, at sea level.

Figure 33 is the same picture with one difference – at 6000 feet instead of at sea level. Essentially all that has transpired is that engine power has diminished and, therefore, thrust is less at the higher altitude.

Quite a few measures of aircraft performance vary as W/σ, the ratio of weight to relative air density sigma. Distance to lift off is an important exception. Because density altitude effects both the airframe's aerodynamics and the engine's output, minimum distance to lift off is approximately given, in terms of weight and air density, by:

$$d_{LO} = \frac{AW^2}{\sigma(\sigma - BW)} \qquad (15)$$

The trouble with Eq. (15) is that almost every airplane type has its own values of "constants" A and B. (Those are most easily "back-engineered" from known distances to lift off for two known weight/altitude situations, but that would get us into more mathematical detail than he have time for here.) Figure 34 gives the relative picture (relative, that is, to standard maximum gross weight and standard air density) for three gross weights. You can interpolate for others. Notice that distance to lift off d_{LO} doubles, everything else being equal, between MSL and 9000 feet.

4

Takeoff Force Components vs Airspeed, Cessna 172, Flaps 10, 2400#, MSL, Flat Dry Concrete, No Wind

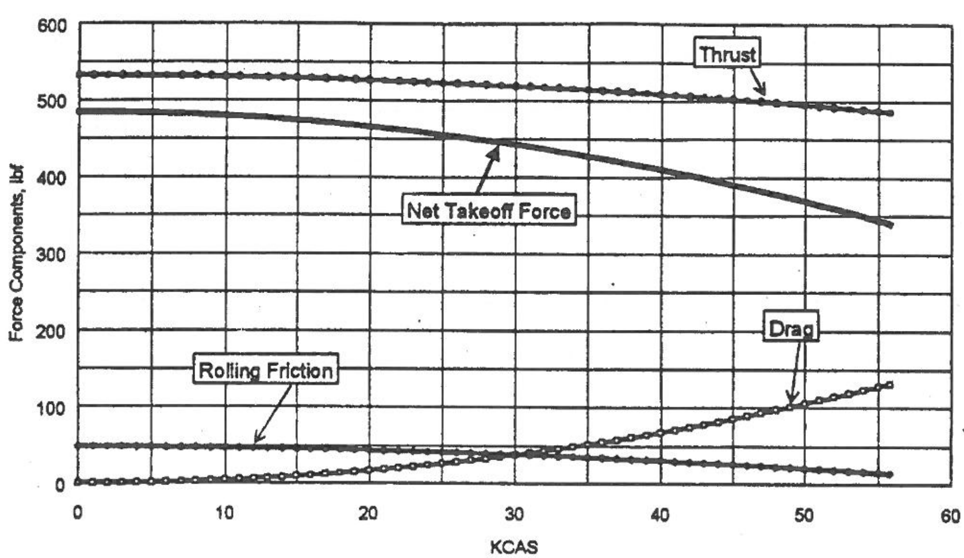


Fig. 32. If the runway is softer, the friction force is larger, in proportion to the value of the rolling friction coefficient. See Table 4. For instance rolling friction in tall grass is about five times as great as on dry smooth concrete.

Runway Surface Type	Rolling Friction Coefficient μ
Dry smooth concrete	0.02
Broken–up dry asphalt	0.03
Hard dirt	0.04
Short grass	0.05
Wet concrete or asphalt	0.05
Tall grass	0.10
Soft field	0.20

Table 4. Approximate rolling friction coefficients for common runway surfaces.

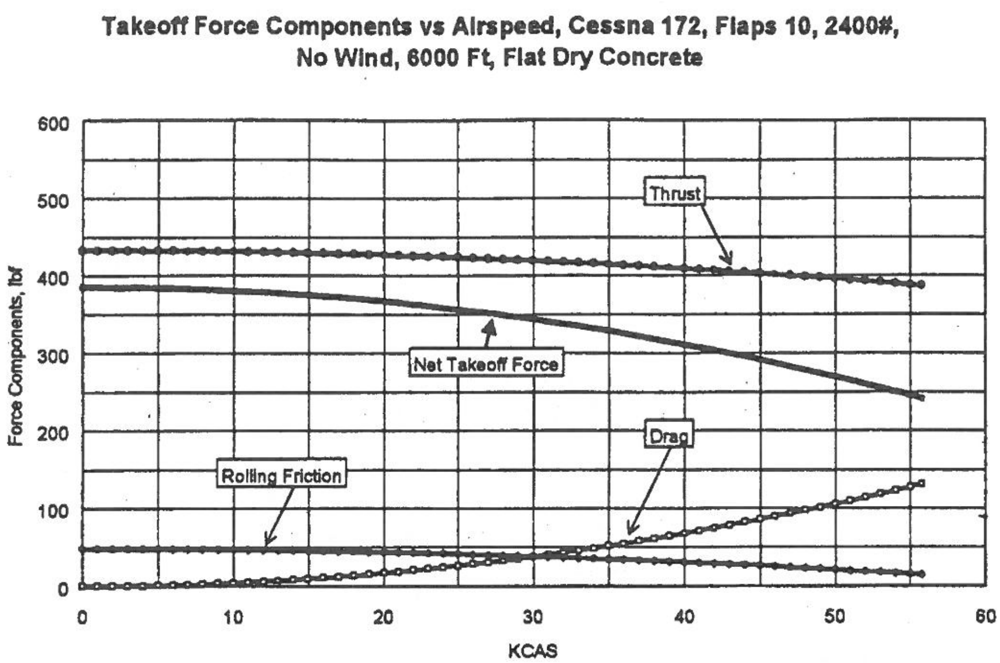


Fig. 33. Higher altitudes produce two takeoff effects. In the rarer air, thrust is diminished. And ground speed at lift off is greater because *true* air speed is higher for the same calibrated air speed. It's calibrated air speed that counts.

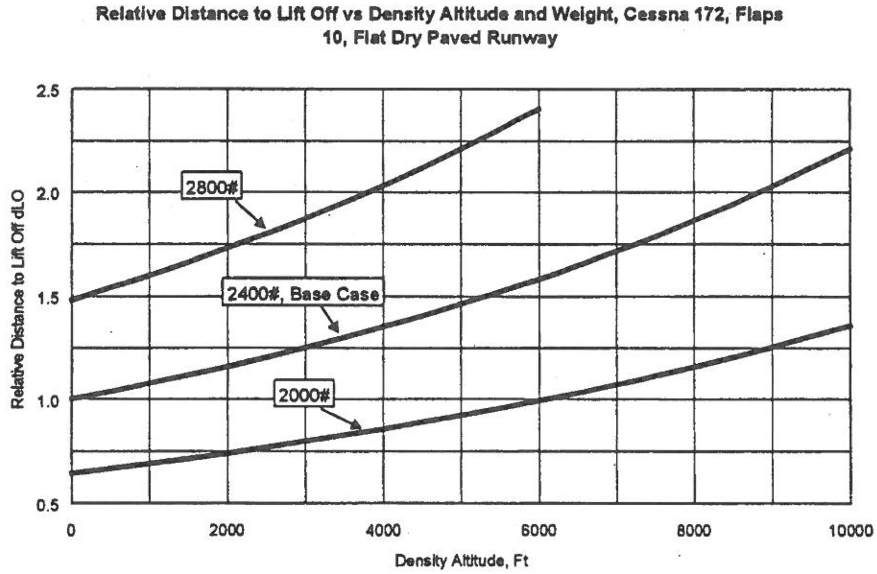


Fig. 34. Overloading the airplane by 17%, from 2400 pounds to 2800 pounds, increases distance to lift off by 50%. On the other hand, reducing weight from 2400 pounds to 2000 pounds gives you the same takeoff performance at 6000 feet which you otherwise would have had only at sea level.

Minimum landing roll is considerably simpler than for takeoff – since the engine plays little role – and hence does not increase with density altitude nearly so much. Landing roll goes as:

$$d_L = \frac{CW}{\sigma} \qquad (16)$$

where C is another constant depending on the airplane (and has no relation to an earlier C having to do with the engine's power drop-off factor). Constant C can be back-engineered from a known landing situation. This time, though repetition and averaging are encouraged, one such landing will do the job.

4

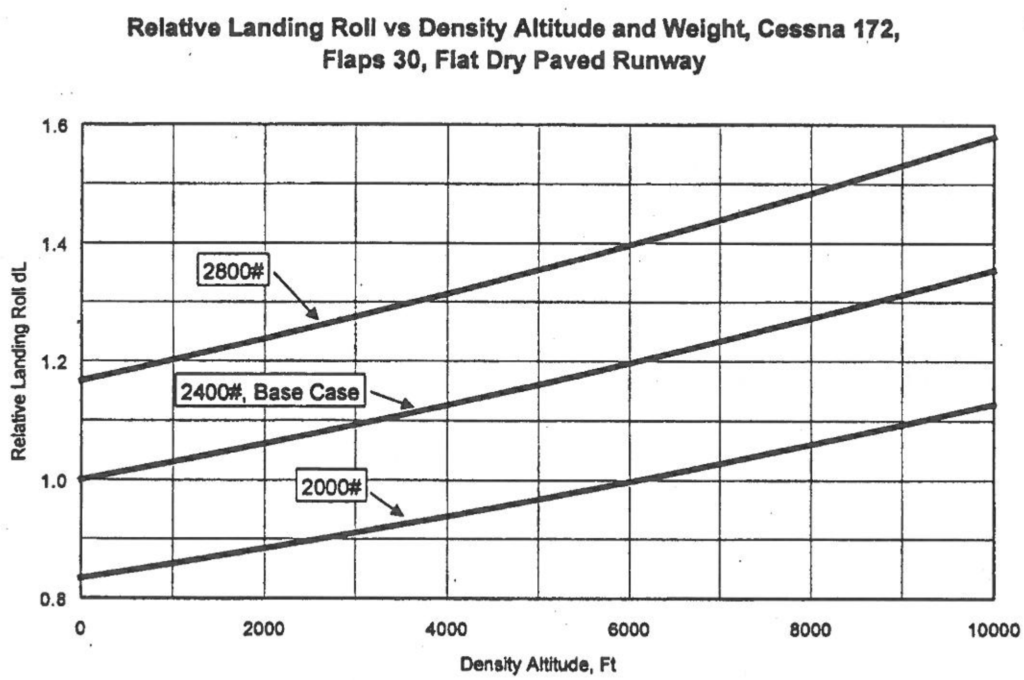


Fig. 35. Landing roll is approximately proportional to W/σ, the ratio of gross weight to relative air density. That makes relative landing roll roughly linear with density altitude.

Of our four special topics, we've disposed of the questions of differing surface types and the effect of density altitude. On to the next.

When is it better to takeoff uphill, into the wind, rather than downhill with the wind? There is a complicated formula to answer that question, but the following simplified version is accurate enough:

$$V_{hw}^{breakeven} = \frac{\theta^{\circ}\, d_{LO}(\text{no wind, no slope})}{5\, V_{LOT}} \qquad (17)$$

The so-called "breakeven headwind speed," on the left in Eq. (17), is in knots. V_{LOT} is the airplane's true liftoff airspeed. Liftoff speed is usually given as a calibrated air speed, but for our purposes here must be translated to KTAS.

Here's an example. Say that your distance to lift off under current conditions, but assuming a level runway and calm winds, would be 1000 feet. Further assume V_{LOT}, at this current density altitude, is 65 KTAS. Finally, assume the runway is sloped 2°. The calculation on the right of Eq. (17) then gives 6.2 knots. That means that, with a 6.2 knot wind straight down the runway, it wouldn't matter whether you took off uphill into the wind or downhill with the wind; the effects of wind and slope would cancel. But if the wind were any stronger than 6.2 knots, you should takeoff uphill into it; if any weaker than 6.2 knots, you should takeoff downhill with that tailwind. Of course post-lift-off terrain clearance considerations may very well tilt your decision towards one direction or the other. Or could even ("one-way strips) completely eliminate any option.

Our last special topic involves the venerable "70/50" takeoff rule. That normally reads: "If you have not gotten up to at least 70% of your liftoff speed by the time you have 50% of the usable runway behind you, abort the takeoff."

That rule is based on the airplane's being "uniformly" accelerated, from rest to V_{LO} (normally about 115% of the stall speed), during the takeoff run. We've seen that thrust drops off during the run, but on the other hand so does opposing friction. But opposing drag picks up quite a bit during the takeoff roll. Still and all, uniform acceleration is a moderately good approximation.

4

The problem with the standard 70/50 rule comes with a substantial headwind. (Granted, headwinds help takeoffs, so you may not need to worry about this refinement.) If your liftoff speed were 60 KCAS, for instance, and you were taking off into a 40 knot headwind, 70% of 60 is 42 KCAS. That's only requires 2 knots of ground speed, which you might attain in say ten feet of takeoff roll. Would you then feel secure taking off on a twenty-foot long runway? Of course not. And of course, with that large a headwind, takeoff from a realistic strip would not be a problem!

Nevertheless, the correct rule, when taking off into a headwind or with a tailwind, is that by the time half the runway is behind you, your calibrated air speed must be no less than:

$$0.707\, V_{CLO} \pm 0.293 \sqrt{\sigma}\, V_w \qquad (18)$$

V_{CLO} is the calibrated liftoff speed, σ the usual relative air density, and V_w the wind speed component down the runway. The + sign is used if it's a headwind, the – sign if a tailwind. A shorter and less pedantic version of this amended 70/50 rule, for the more likely headwind case, is:

Speed at midpoint of available runway must be at least (70% liftoff speed + 30% calibrated headwind speed).

This completes our treatment of takeoff and landing performance. And, in fact, brings us to the end of our brief graphical introduction to the subject of aircraft performance at high density altitude.

Summary

Safe flying can only be accomplished through proper pilot/crew attitude combined with knowledge. Here we've focused only on the requisite knowledge. That's the easy part. In spite of the idiosyncrasies of individual aircraft, the noise of instrument errors, the jumble of terrain, and the waywardness of wind, aircraft performance – within the limits of accuracy and precision needed to keep us out of trouble while accomplishing our search mission – follows well-known physical principles. Our goal has been to lay out those principles in practical and easily understood form. Suggestions for additional topics, or improvement of those treated here, are always welcome.

List of Symbols

C	Power/torque drop-off parameter
C_{LMax}	Maximum lift coefficient
D	Drag
D_i	Induced drag
D_P	Parasite drag
d_L	Landing roll distance
d_{LO}	Distance to lift off
h	Altitude
h_p	Pressure altitude
h_ρ	Density altitude
ISA	International Standard Atmosphere
L	Lift
LF	Load factor
MSL	Mean Sea Level
n	Propeller r.p.s., load factor
N	Propeller RPM
p	Pressure
P_a	Power available
P_{av}	Power available
P_r	Power required
P_{re}	Power required
P_{xs}	Excess power
R	Radius of turn
ROC	Rate of climb
T	Temperature, Thrust
T_S	Standard (ISA) temperature
T_{xs}	Excess thrust
V	Air speed
V_a	Maneuvering speed
V_{bg}	Speed for best glide
V_{max}	Maximum level flight speed
V_{md}	Speed for minimum descent rate
V_{min}	Minimum level flight speed
V_{ne}	Never exceed speed
V_S	Stall speed
V_W	Wind speed
V_x	Speed for best angle of climb
V_y	Speed for best rate of climb
W	Gross aircraft weight
W_0	Standard aircraft gross weight

Subscripts

h	Headwind
t	Tailwind
u	Updraft
d	Downdraft

Greek Letters

γ	**Flight path angle (gamma)**
δ_f	**Flaps deflection angle (delta sub-f)**
Φ	**Power/torque altitude drop-off factor (Phi)**
φ	**Bank angle (phi)**
Π	**Proportion of full throttle (Pi)**
ρ	**Air density (rho)**
σ	**Relative air density (sigma)**
ω	**Turn rate (omega)**

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4

* Calculations behind the graphs are based on the author's "Bootstrap Approach" to predicting performance of propeller-driven aircraft. The theory behind the Bootstrap scheme has appeared in several articles in *Journal of Aircraft* and in *Journal of Aviation/Aerospace Education and Research* over the past few years. See the References at the end of this document. Some leading kitplane manufacturers are using The Bootstrap Approach for their performance flight tests and primary certification. Though it's not particularly difficult to understand the theory behind the calculations – high school mathematics suffices for almost all of it – that is not our subject in this publication. Here we are going to strictly focus on the graphs themselves, as *examples* showing the behavior of one common type airplane under many different circumstances.

NOTES:

"MOUNTAIN FURY" FLYING GRADESHEET

PILOT'S NAME ______________________________ CAPSN ______________ rev 1.0 8/98

INSTRUCTOR'S NAME ______________________________

S - Satisfactory T - Training Required U - Unsatisfactory Progress

UNIT / ITEM	FLIGHT NUMBER →	1	2	3	4	5	6	COMMENTS
	DATE >							

shaded box: item recommended for this flight

UNIT / ITEM	1	2	3	4	5	6
1 Basic Aircraft Performance						
a. Preflight Preparations						
I. Weather status, turbulence prediction, flight plan/procedure						
II. Aircraft preflight: acft equipment, Wt&Bal, emergency/survival gear						
III. Evaluate pilot's tolerance to high altitudes / verify availability of O_2						
IV. Discuss power settings, V-speeds, takeoff run/abort point; calc. density alt., Vy, expected ROC						
b. Take-off and Climb Out						
I. Before T.O., record altimeter error						
II. If D.A. >= 3,000 ft, lean-mixture per POH (norm aspirated only), use proper flap setting						
III. Have pilot identify takeoff /abort point on field and departure routing rationale						
IV. Compare actual rate of climb with predicted value						
c. Airplane Configurations and Power Setting vs. Airspeed						
I. Level flight @ search speed, slow flight, m.c.a., flaps up/search setting, standard rate turns; perform @ medium and high altitude (>9000 feet)						
II. Config change: flap/gear/power w/ constant heading, altitude, airspeed Note power required to maintain constant altitude, simulate go-around						
III. Determine speed for max ROC with gear down / full flaps						
IV. Maximum effort descents to counter updrafts; high drag / slip						
d. Operations at Search Ceilings						
I. Climb to (or simulate with pwr setting for 300 fpm climb) level flight at search ceiling						
II Perform approach to stall, normal stalls in clean configuration, normal recoveries						
III Demo effect of turn, trim, change of airspeed						
IV. Perform minimum radius, constant altitude 180° turns right and left						
V. Perform modified wingover 180° turn; compare radius, altitude loss, forward distance traveled to above as a technique for course reversal in a box canyon.						
VI. If time permits, repeat above at simulated (not actual) service ceiling (100 fpm ROC) & absolute ceiling						
e. Takeoffs and Landings						
I. Takeoffs/landings, 3 minimum including short field, soft field, power-off approaches						
II. Land at 2-3 different airports. Observe altimeter error from original setting						
III. For each takeoff, calc. takeoff distance, identify abort/takeoff markers, allow 100% distance margin, calculate Vr, Vx, Vy; perform max effort takeoff						
2 Advanced Aircraft Performance						
a. Technical Flying Demonstrations/ Practice						
I. Turn radius for 30°, 45°, and 60° canyon turn technique, emphasize 30° max for search, 45° to establish position, reserve 60° for emergency escape						
II. Course reversal w/ minimum alt loss after engine failure (45° bank, slowest safe speed)						
III. Distance estimation using straight line flight and known diameter turn						
IV. AT SAFE ALTITUDE simulated controlled impact w/terrain w/ & w/o engine power						
V. Crosswind estimation by crab angle, verify with electronics if possible						
VI. "Ridge soaring" technique (teardrop pattern) for searching ridge faces						
VII. ROC difference between using sea level max gross wt Vy, and Vy corrected for wt & altitude						
VIII. Simulated downdraft escape - soaring technique: speed up in downdrafts						
IX. Repeat turn demos at high altitude						
X. Repeat climb demos at high altitude						

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5

"MOUNTAIN FURY" FLYING GRADESHEET

PILOT'S NAME ____________________ CAPSN __________ rev 1.0 8/98

INSTRUCTOR'S NAME ____________________

S - Satisfactory T - Training Required U - Unsatisfactory Progress

UNIT / ITEM	FLIGHT NUMBER / DATE >	1	2	3	4	5	6	COMMENTS
3 High Altitude Takeoff/Landing, Mountain Navigation, Up/Downdrafts								
a. High Altitude Takeoffs and Landings								
I. Takeoffs/landings, 3 minimum including short field, soft field, power-off approaches								
II. On the ground at high-altitude airports, note wind chill factor and expected night time temps, describe protective clothing/equipment needed for survival after forced landing								
b. Terrain Navigation								
I. Establish altitude close to terrain but well above obstructions. Evaluate usefulness / compare capabilities of each nav device + pilotage & DR								
II. Demonstrate navigation using sectional/WAC charts (pilotage)								
III. Simulated equipment failures / troubleshooting								
IV. If scattered / broken clouds present, discuss options to maintain safe VFR operations								
V. Discuss the importance of flight at maneuvering speed (Va) in turbulence. Note that Va generally decreases with decreasing gross weight								
c. Updraft and Downdraft Locations and Magnitudes								
I. In level flight in stable air, establish search airspeed, record power setting								
II. Locate the downdraft and updraft areas during flight through a valley or canyon which lies perpendicular to the direction of the prevailing wind								
III. Fly to leeward side of a ridge into downdraft area, maintain altitude/power. Note reduced airspeed, increased pitch from climb against downdraft								
IV. Repeat above on windward side of a ridge in updraft; maintain altitude/power. Note increased airspeed, decreased pitch from dive against updraft.								
V. Repeat leeward side (downdraft) transit, maintain search speed; Note altitude loss / VSI reading showing downdraft intensity.								
VI. Repeat leeward side (downdraft) transit, establish max ROC configuration. Observe that ROC obtained is max ROC for the conditions minus magnitude of the downdraft								
d. High – Altitude / Unfamiliar Field Approach / Landing								
I. Survey unfamiliar field for winds, obstacles, rwy condition, best approach								
II. Max power check (for go-around) on downwind leg - adjust mixture								
III. Note need for wider pattern and higher descent rate on final due to higher true airspeed with same indicated air speed as at sea level								
IV. At each field, observe altimeter error in reading field elevation w/out local altimeter setting								
V. Practice short field, soft field and idle power landings, and an aborted landing.								
e. High Altitude / Unfamiliar Field Takeoff								
I. If the runway has visible slope, taxi to runway ends to obtain elevations, divide difference by rwy length to get slope (Ex.: 80' / 2000' = .04 or 4%)								
II. Before takeoff, lean for max power during a full power runup as per POH, calc. takeoff distances, identify abort/takeoff markers, allow 100% distance margin, calculate Vr, Vx, Vy; perform max effort takeoff								
III. Compare actual distances to predicted takeoff run, 50' point								

"MOUNTAIN FURY" FLYING GRADESHEET

PILOT'S NAME ______________________ CAPSN ____________ rev 1.0 8/98

INSTRUCTOR'S NAME ______________________

S - Satisfactory T - Training Required U - Unsatisfactory Progr

UNIT / ITEM	FLIGHT NUMBER / DATE >	1	2	3	4	5	6	COMMENTS
4 High Altitude Search								
a. Pre-flight Discussions – flight planning to/from the grid + grid search								
I. Operations briefing								
II. Air ops assigning a grid and flight releases								
III. Best route to and from the search grid area								
IV. Types of search patterns for assigned grid based upon terrain, wx, acft performance, etc. considerations / procedure to search the assigned grid								
V. Determine probability of detection based upon planned flight								
VI. Review search effectiveness factors								
VII. Use of sectional charts and navigational equipment - LORAN, GPS, VOR, etc.								
c. Identifying the Grid Area								
I. Identify assigned grid through dead reckoning and navigational aids								
II. Over-fly the grid at altitude / identify corners								
III. Note aircraft performance at this higher altitude, winds, turbulence, etc.								
IV. Modify original plan as appropriate for searching the grid area.								
V. Review sighting characteristics								
VI. Review ground-to-air and air-to-ground signals								
VII. Have crew record time off, time to grid, time in grid, etc. (use mission sortie data sheet)								
VIII. Review communications procedures – air-to-air; air-to-ground, etc.								
IX. Review role of ground teams								
X. Situational awareness of aircraft / crew								
X1. Make turns – shallow and steep far enough away from any terrain and note the turn radius, time to turn and effect on the aircraft performance.								
d. Searching in the Grid Area								
I. Fly from highest elevation in grid; by pre-flight or amended plan.								
II. Demonstrate various search methods apropos terrain - contour, creeping line, etc.								
III. Emphasize low and slow does not generate the best probability of detection								
IV. Review safe search air speeds based upon aircraft, weight, flight conditions, etc.								
V. Emphasize safe altitudes and always having an escape route or out.								
VI. Review with crew procedures for tracking route and helping pilot.								
VII. Discuss scanning techniques based upon the terrain being covered.								
VIII. Emphasize the pilot is to fly, observers and scanners are to scan								
IX. Verify winds aloft by time to fly from one side of the grid to the other, crab angle; verify ground track /winds with navigational aids.								
e. Return to Base								
I. Debrief with operations to include completing paperwork								
II. Debrief pilot and crew on flight, lesson learned, how to improve								
III. Review aircraft performance and other factors to include weather								
IV. Summarize findings.								
f. If possible, perform practice ELT search in mountainous area								
g. If possible, perform practice air-ground coordination exercise with CAP vehicles/ personnel in known locations for the pilot and crew to identify								

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Mountain Fury

Mountain Fury
Mountain Search Flying
Course Syllabus

Goals

1. Pilots who complete this program will be able to perform with precision and confidence all of the tasks and flight maneuvers required for safe and efficient performance of mountain search operations.
2. The flight training should be accomplished at the least possible cost in money and time, with the least amount of paperwork consistent with the course objectives.
   a) Flight training should be conducted in the trainee's local area to the maximum extent possible.
   b) Paperwork should be limited to those items that are needed to confirm that the course material has been covered adequately, plus those items which will be useful to the participants for future reference.

Implementation

The flight training program consists of four sorties. The first two sorties cover basic and advanced techniques for flying an airplane to its maximum level of performance. Flight operations for the first two sorties will be conducted at high MSL altitudes but should be conducted **well away from terrain**. In keeping with goal 2a, these sorties may be flown in the trainee's local area. Trainees will fly these sorties with a **CAP check pilot** who has completed the Mountain Fury course.

The third and forth sorties cover high altitude airport operations and flight and search operations in high terrain areas. These sorties are intended to be flown from a high-altitude search base in conjunction with the final segment of a Mountain Fury training course.

The flying syllabus is presented in both detail and outline form. The detail form contains in depth descriptions of maneuvers and procedures. It is intended for detailed study on the ground so that course participants may clearly understand the course objectives and what is expected of them. The outline form is a concise description of the items in the detail form. It is intended to be used in flight as a checklist and data recording form as an aid to the instructor to help ensure that all training objectives are accomplished.

DO THE PAPERWORK FOR EACH SORTIE
BEFORE ONE EVEN THINKS OF GETTING IN THE AIRCRAFT

Aircraft to be Used

The same make and model aircraft should be used for each of the sorties and the Form 91 check ride for the Mountain Fury Program.

First Sortie

Objectives

1. Develop trainee's ability to plan and execute a flight to a high search altitude.
2. Develop awareness of aircraft performance by comparing aircraft handbook performance to actual performance.
3. Introduce and develop skills in executing maximum performance maneuvers.
4. Refresh skills in maximum performance takeoffs and landings.

Timeline

The Mountain Fury ground training course must be successfully completed prior to beginning the first sortie of this flight training program. Both the ground training course and sorties one and two must be successfully completed prior to attending a week-end Mountain Fury course for sorties three and four.

The trainee should expect to spend at least one hour in preflight planning for this sortie prior to meeting with the instructor. The trainee and instructor should plan on an additional hour of discussions and briefing prior to the commencement of the flight. Sortie one will require one and one half to two hours of flight time. Finally, a debrief and completion of paperwork will require one additional hour.

Detailed Description of First Sortie

Preflight Preparation

A considerable amount of preparation is required of the trainee pilot prior to this sortie. This is intended to allow the prediction of aircraft performance and comparison of predictions with actual performance. These items should be completed prior to meeting with the instructor pilot so that the sortie can be accomplished as expeditiously as possible.

Obtain the following information from the instructor pilot and enter it on the outline/data form:

✔ The instructor's weight and the weight of his/her personal equipment

✔ The location or locations in which the sortie will be flown.

Weight and Balance

Obtain data on the aircraft needed to complete a weight and balance computation. Perform a weight and balance calculation including planned fuel load, weights of the trainee and instructor and their personal equipment. Enter the gross weight, CG, maximum allowable gross weight and percent difference of the operating weight from maximum gross weight on the outline/data form. Note that a forward CG position produces a higher stall speed. This should be considered in calculating stall speeds below.

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Airspeed Calculations

Calculate critical airspeeds at sea level (or the airport elevation) through 12,000 feet density altitude and fill these in on the outline/data form. These include Vx, Vy, Va, stall speeds for flaps up and normal search configuration (typically 10 to 20 degrees of flap), best glide speed, and stall speeds in a 45 degree and 60 degree bank turn. Also calculate and record the expected takeoff distance. Record this information on the outline / recording form.

Weather Briefing

Obtain a standard briefing for the area in which the sortie will be flown. A DUAT briefing is preferred as it assures that all available weather information is obtained. Print out the briefing or record information from the briefing form on the outline/data form so that the briefing and conditions may be discussed with the instructor pilot. Prepare and file a flight plan for the sortie.

Preflight Briefing

Safety. Safety is of paramount concern to everyone. If weather at the time of the sortie is of any concern postpone the sortie for another day. Complete the CAP personal safety matrix prior to the flight. Once again, if the score is high and not suitable for flight (unacceptable), postpone the flight for another day. While flying the sortie, the air work should be conducted at an altitude far away from any obstacles and well above terrain. A minimum clearance of 3,000 feet AGL is suggested. Sufficient altitude to recover from an inadvertent stall/spin is needed.

Verify that appropriate survival equipment is on board, and that both crewmembers have clothing suitable to spend the night in the open if an off-airport landing occurs.

Weather. The trainee should provide the instructor with his/her personal assessment of the weather conditions based on the contents of a standard weather briefing . Specific items needed include forecast clouds and weather, winds and temperatures aloft, and the presence of turbulence. The instructor should obtain an independent briefing so that the trainee's assessment can be evaluated.

Flight Plan. The trainee should review the flight plan (filed earlier) with the instructor, and review route and airport departure procedures.

Aircraft Preflight. If possible, the preflight inspection should be performed in the presence of the instructor. Any non-standard equipment (radios, oxygen, survival gear) should be discussed to ensure familiarity of both pilots with that equipment. Any inoperative equipment should be identified and assessed as to whether it is required for the flight. Review the weight and balance calculations performed by the trainee and verify that the aircraft is loaded within limits.

High altitude physiology. The instructor should asses the trainee pilot's probable tolerance to high altitudes. Factors to consider are the altitude of the trainee's home, the trainee's physical condition and health, smoking, and recent time living at high altitude. Verify availability / non-availability of oxygen equipment and whether it is working properly before flight.

Aircraft Performance. Discuss power settings, maximum rates of climb (and associated airspeeds) estimated takeoff distance and takeoff abort point. The instructor should review the pre-flight data entered by the trainee on the outline / data form. Select an altitude at which to perform high altitude maneuvers. This should be between 8,000 and 12,000 feet depending on expected aircraft performance and availability of oxygen for the crew. Compare this to the density altitudes calculated from the winds aloft forecast during preflight preparation and note the indicated altitude that will be needed to achieve the desired density altitude.

Complete a CAP safety inspection form for the aircraft.

Takeoff and Climb out

If density altitude is 3,000 feet or higher, have pilot perform engine lean-out (normally aspirated engines only, in accordance with the POH) for takeoff, and determine proper flap settings.

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Have the trainee identify takeoff and abort points on the field, and review the departure routing. The instructor pilot should note the actual takeoff point relative to the predicted takeoff point and record the difference on the recording form. To estimate the distance, count the number of seconds that liftoff occurs before or after reaching the predicted liftoff point. You may convert this time to distance during the post flight review by multiplying the rotation speed in knots true airspeed (KTAS) by the number of seconds from the expected takeoff point and multiply by 1.7 to get distance in feet.

> Example: 5 seconds past the expected liftoff point with a rotation speed of 70 knots true
> $5 * 70 / 1.7 = 595$ feet.

The trainee should establish a climb at Vy. Wait for the VSI to stabilize and record the initial rate of climb on the data form. Alternatively, you can time one minute of climb and record the altitude gained. This is a more accurate method than using the VSI.

Climb to at least 3,000 feet AGL or 5,000 feet DA (whichever is higher) for the first set of maneuvers.

Airplane Configurations and Power Setting vs. Airspeed

The first set of maneuvers is intended to provide a performance baseline for comparison to these maneuvers when flown at mountain search altitudes.

Establish search airspeed (approximately 85 KIAS, as appropriate to the aircraft) with flaps up. Record the power setting required for this airspeed.

Perform medium bank turns (30° of bank) left and right.

Extend flaps to search setting (10-25° flap, as appropriate to the aircraft). Record power setting required for this airspeed.

Extend landing gear (for retracts) and full flaps, fly at normal speed for approach to landing and maintain level flight. Record power required.

Simulate a go-around by applying full power with gear/flaps down. Fly at the speed listed in the POH for Vy max gross weight with gear and flaps up. Record the rate of climb obtained.

Maintain the climb and slow down in 5 knot increments. Note the airspeed which produces the greatest rate of climb in this configuration, and record this airspeed and the rate of climb achieved.

Raise the gear and flaps. Perform a departure stall with full power. Resume level flight.

Slow flight: Decrease airspeed to just above stall speed — intermittent activation of the stall warning horn is OK. Perform turns left and right in a shallow bank (10-15°) with coordinated use of the rudder.

Perform an approach to landing stall with power off.

Resume level flight with flaps at search setting. Resume search airspeed.

Descents:

Reduce power to idle, extend full flaps at normal approach speed. Record rate of descent.

Increase speed to approach speed for flaps up. Raise flaps. Perform a maximum effort slip. Record the rate of descent.

Resume coordinated flight and transition to a climb with full power.

Operations at Search Ceilings

The goal of these maneuvers is to show how aircraft performance and handling change at high elevation search altitudes.

Climb to the altitude selected in preflight preparation to give the desired density altitude to simulate high altitude mountain search. Use the airspeed for Vy that you calculated for this altitude and weight. Record the rate of climb for comparison to POH figures.

Repeat the steps above to observe and record the power settings for level flight with flaps up, partial flaps, and full flaps with gear down. Apply full power and record the rate of climb. Resume level flight.

The following maneuvers are intended to simulate aircraft performance at the search ceiling (e.g., the altitude at which the aircraft climbs at 300 feet per minute with full power).

Retract the gear and flaps, and reduce power so that the rate of climb is 300 feet per minute. Record the power setting.

Perform a departure stall at this power setting.

Resume level flight. Reduce power to idle, perform an approach to landing stall.

Resume level flight at normal search speed.

Perform and time a canyon turn as described below. If you desire to add power during this maneuver, use as a maximum the power setting that was needed to maintain a 300 fpm climb at this altitude. Record the time required to complete this turn. If altitude is lost while performing this maneuver, record the altitude loss on the data form.

Perform a modified wing-over as described below and record the altitude loss, if any. Discuss the subjective results of this maneuver and those of the canyon turn.

Takeoffs and Landings

The goal of these maneuvers is to hone your skills in maximum performance takeoffs and landings. The increased proficiency will be very useful for the high altitude airport operations conducted during sorties 3 and 4.

Perform at least 3 takeoffs and landings, including short and soft field takeoffs and landings, and power off approach / landing. Estimate and record actual landing distance for short and soft field landings.

Post flight Debrief

Review the data recorded during the flight for comparison to POH data. This provides the trainee with an objective look at how much of the book performance he or she can obtain. Compare estimated to actual values for takeoff and landing distances, rates of climb, and time to complete 180 degree turns. Time and airspeed can be used to calculate the turn diameter. Also review the power settings needed to maintain level flight with flaps and landing gear up and down, and the airspeed that produced the best rate of climb with flaps and gear down. This review should aid the trainee in more fully understanding the performance capability of the airplane.

Fill out the Flying Grade sheet for maneuvers performed in this sortie. Mark an "S" for satisfactory performance, "T" or more training required, and "U" for unsatisfactory performance. The grade of "T" should be used when performance is marginally acceptable or the trainee shows signs of improvement but is not yet proficient. "U" should be used when the trainee is experiencing considerable difficulty and maneuvers are deemed unsafe or unacceptable.

Satisfactory performance is a judgment call on behalf of the Check Pilot. If the pilot understands the requirements and can execute those requirements in accordance with the FAA test standards for his rating in the judgment of the Check Pilot, the pilot's records should be endorsed to move on to the next phase of the program.

The check pilot needs to endorse the Mountain Fury completion certificate when this first sortie section has been successfully completed.

Set up a schedule for more training as needed or for sortie number 2.

Detailed Description of Emergency Course Reversal Maneuvers:

The Canyon Turn (steep turn)

The canyon turn is an **emergency maneuver** used to reverse course with a level turn that requires the least possible distance in turn diameter. It also requires the least forward distance. When properly executed this maneuver approaches the structural certification limit (2.0 g with flaps deployed) and aerodynamic limit (stall speed) of the aircraft to obtain the minimum achievable turn diameter. **It should only be used to escape from emergency situations** such as turning into a narrow valley in which the aircraft can not outclimb the terrain, or when the aircraft has been inadvertently maneuvered to head directly into terrain at very close distance.

For any turn, the diameter of the turn increases by the square of the airspeed and decreases with the tangent of the bank angle. The net result is that the tightest turn that an aircraft can make in level flight is at the **steepest bank angle** which can be safely flown at the **smallest margin above stall speed that the pilot can safely maintain**. There are limits to how much bank angle can be used, however. Since induced drag increases with increasing bank angle, very steep bank angles will require more power than may be available, and this will cause the aircraft to descend during such a turn even if full power is used. The g load produced by a very steep bank can also exceed the structural limitations of the aircraft. And finally, a very steep bank is difficult to maintain accurately and makes it difficult to perform this maneuver precisely.

Search operations are usually conducted with partial flap extension to improve stall margin and deck angle at search airspeed. Since all normal category light aircraft have at least a 2-g load limit with flap extension, all such aircraft can safely use a **60-degree bank** for this maneuver. Also, the **decrease in stall**

speed from using a partial flap setting allows the maneuver to be flown at a slower speed than with flaps up. For most aircraft this will allow a turn to be made with flaps in a smaller diameter than at a steeper bank angle with flaps up.

The **ideal entry speed** for the maneuver is one that is **slightly higher than the stall speed in a 60-degree bank**. The stall speed in a 60-degree bank is 1.4 times the stall speed in level flight. To calculate the entry speed, multiply the CALIBRATED stall speed for the amount of flaps you're using from the POH by 1.4 and add 5 to 10 knots (depending on your skill level). Here are some typical speeds for common CAP aircraft:

Cessna 182: 81 to 86 KIAS

Cessna 172: 75 to 80 KIAS

Cessna 206: 92 to 97 KIAS

Stall speed varies by model year, so you should **check your POH** for applicability. Also note that **stall speed decreases as aircraft weight decreases** by approximately **half the percentage decrease in aircraft gross weight**. Thus when flying at lighter weights than maximum gross slower entry airspeeds may be used. If the conditions are turbulent higher speeds are necessary in order to maintain a safe margin above stall speed.

The safest way to begin this maneuver is from level flight, without attempting a pitch up before rolling in. If you have a small amount of excess airspeed over the optimum entry airspeed, you can bleed that speed off as you maintain altitude in the turn. If you have a large amount of excess airspeed you may want to pull up to slow down first, but it's best to return the nose to a level attitude before rolling into the turn as this minimizes the chances for an inadvertent stall.

Since this maneuver is flown with the wing at a high angle of attack, the induced drag is increased which also increases the power required to maintain level flight. **The power required will often exceed the power available,** even at full throttle. Still, an early and smooth application of full power will aid in performing the maneuver with the least possible loss of altitude.

You should be looking outside of the aircraft, slightly to the side of nose. Note the horizon picture relative to the cowl as you roll in to the turn as this shows you the approximate pitch attitude to maintain through the turn. If you raise the nose unintentionally the aircraft can stall before the maneuver is completed. If you let the nose drop you may lose an excessive amount of altitude before completing the turn.

Roll the aircraft to approximately 60 degrees of bank with aileron and coordinated use of rudder. **Keep the ball centered** — an uncoordinated stall from this attitude could be fatal at low altitude. Upon reaching this bank angle reduce aileron input to neutral or as necessary to maintain the bank angle. As you roll in apply just enough back pressure to maintain the pitch attitude you saw before you began the roll. To achieve the minimum possible turn radius smoothly increase back pressure on the control yoke until the stall warning begins to sound, then stop increasing back pressure. If the nose starts to drop, roll out slightly until the nose rises to the entry attitude, then roll back in to a 60 degree bank. Begin to roll out when safely headed away from terrain.

If performed correctly, 180 degrees of turn will be accomplished in about 11 seconds in a C-182 at a search altitude of 10,000 feet density altitude. For a C-172, it will be about 10 seconds, and for a C-206 about 12 seconds. The forward travel would be equivalent to that of flying straight ahead for less than 4 seconds. This is indeed a very tight turn.

The Modified Wingover

The modified wing-over is another emergency maneuver used to reverse course in a small amount of space. The name of this maneuver is deceptive — the only things it shares in common with the wing-over known to aerobatic pilots is its name and the general appearance of the maneuver. It is vastly different in execution however, and its goals are different as well. **<u>You should not attempt this maneuver on your own before you have received dual instruction on it unless you have training and proficiency in spin recoveries</u>**.

As with the canyon turn, this maneuver **should only be used to escape from emergency situations**. The maneuver is highly dynamic, with constant changes of pitch, bank, heading, and airspeed. If you do not handle the controls as described here, you stand a very good chance of executing a stall/spin which would likely be fatal if entered at typical search altitudes.

This maneuver is designed to use the natural stability of the aircraft in pitch and bank to let the aircraft fly itself out of danger while minimizing pilot control inputs that could lead to a departure from controlled flight (i.e. stall/spin).

Enter the maneuver from normal search airspeed with an **abrupt pull-up to approximately 30 degrees of pitch attitude**. At this point, **fully release back pressure** on the yoke and **apply moderate rudder pressure** in the desired direction of turn. **Ailerons should remain neutral** throughout the maneuver. Some pilots completely let go of the yoke after the pull-up to ensure that they make no inadvertent aileron or elevator inputs. The goal of using the controls this way is to not apply hazardous control inputs due to the excitement of escaping from a dangerous situation.

As soon as you release back pressure the natural pitch stability of the airplane will cause the nose to start to come back down. Airspeed will be decreasing however as the nose is still above level flight attitude. The airplane will not stall though, as there is no up elevator to cause the wing to exceed its stall angle of attack. The natural yaw-roll stability of the airplane will cause the rudder pressure to roll the airplane into a bank. The ball on the turn coordinator will stay centered and the aircraft will remain in coordinated flight because there is no adverse yaw from the ailerons (which have remained centered). If you apply back pressure or aileron here you risk stalling the aircraft in uncoordinated flight with potentially disastrous consequences.

Rudder pressure should be eased off as the bank angle exceeds 45 degrees, and then reversed as needed to keep the bank angle from exceeding 60 degrees. By this time the nose of the aircraft will be falling through level and the heading should be passing through 90 degrees of turn. You may need to apply back pressure at this point to keep the nose from dropping too low which will lead to an excessive loss of altitude and a wider turn. Recover from the turn with back pressure and coordinated aileron and rudder to assume a safe heading away from terrain.

> Note: This technique does not work well with all airplanes used in search operations. Some have an over banking tendency in the turn which will cause the bank angle to exceed 60 degrees of bank. These aircraft and some others with strong pitch stability will also tend to nose down rapidly after back pressure is released. This will produce excessive altitude loss and increase in speed before the turn is completed. You should practice this maneuver in the aircraft in which you fly search to determine whether it works for you in that aircraft. If not, do not use this maneuver.

This maneuver produces a small radius turn with low g-force because turning occurs at a low airspeed while the nose is high. **Stalls are unlikely as the aircraft is being flown "unloaded,"** i.e., with the wing not being required to fly at a high angle of attack to produce increased lift. If you do not release back pressure, the angle to attack of the wing will increase and the airplane could stall. If you limit the bank angle in the turn to 45 degrees, the airplane will not reach 90 degrees of heading change before the nose drops through level flight. The result will be a much wider turn and excessive loss of altitude before the turn is completed.

If performed correctly, the diameter of the turn will be similar to that obtained from using the canyon turn described above. You cannot use this maneuver, though, when searching just below a cloud deck as you would enter the clouds during the pull-up. This turn also uses up more distance in the forward direction than the canyon turn as there is a delay from the initial pull-up to the initiation of the turn. The gain in altitude will usually not increase terrain clearance as the climb angle of the airplane will usually be less than the angle of a mountain with steep terrain. Still, this maneuver his some merits. You should practice both turn techniques until you are proficient at them, and then decide which you prefer to use under a variety of conditions.

MOUNTAIN FURY
SORTIE NUMBER ONE
OUTLINE / DATA RECORDING FORM

PILOT ____

CHECK PILOT ____

Check Pilot Number _________

Date of Sortie _______________ **Aircraft Type** __________

Location ___________________

Preflight Preparation

Verify the following have been performed, and data entered on recording form.

Discuss and review as necessary:

- ❒ Weight and balance
- ❒ Airspeed calculations
- ❒ Weather briefing
- ❒ Preflight briefing
  - ❒ Safety, including personal matrix, survival equipment and clothing
  - ❒ Weather, including clouds, winds, temperatures and turbulence
  - ❒ Flight plan, discussed and filed
  - ❒ Aircraft preflight — discuss non-standard equipment, oxygen, inop equipment
  - ❒ High altitude physiology — discuss pilot's adaptation, health and condition, smoking
  - ❒ Aircraft performance — discuss and fill-in recording form with performance predictions
  - ❒ Safety inspection form — verify completed

Fill in the blanks before the flight

Weights:

Aircraft Basic Empty Weight __________

Trainee __________

Trainee's Equipment __________

Instructor __________

Instructor's Equipment __________

Other items in aircraft __________

Fuel load __________

Gross Weight __________

Maximum Gross Weight __________

Empty CG __________

CG as loaded __________

Within CG / Weight limits (Y/N)? __________

CG in forward 30% of range (higher stall speed) ? __________

Percent Difference from Max Gross Weight __________

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Airspeeds:

For max gross weight: ------------------------- density altitude -------------------------------

	sea level	6,000’	8000’	10,000’	12,000’
Vx	_______	_______	_______	_______	_______
Vy	_______	_______	_______	_______	_______
Vy ROC from POH	_______	_______	_______	_______	_______
Stall speed flaps up		_______			
Stall speed, search configuration		_______			
Stall speed, search config, 45° bank			^ x 1.2	_______	
Stall speed, search config, 60° bank			^ x 1.4	_______	
Canyon turn entry airspeed			^ + 10 =	_______	

Va_______

Best glide _______

For actual takeoff weight, reduce above airspeeds by 1/2 percent difference from max gross weight):

------------------------- density altitude -------------------------------

	sea level	6,000’	8000’	10,000’	12,000’
Vx	_______	_______	_______	_______	_______
Vy	_______	_______	_______	_______	_______
Stall speed flaps up		_______			
Stall speed, search configuration		_______			
Stall speed, search config, 45° bank			^ x 1.2 _______		
Stall speed, search config, 60° bank			^ x 1.4 _______		
Canyon turn entry airspeed		^ + 10 =	_______		

Va_______

Best glide _______

From Winds Aloft Forecast (FD)	3000’	6000’	9000’	12000’
Wind/Temperature	_______	_______	_______	_______
Density altitude (calculate)	_______	_______	_______	_______

Desired density altitude for high altitude maneuvers (8-12,000 feet) _______

Indicated altitude (approximate) for above density altitude _______

(NOTE: this is the indicated altitude you will use for this sortie)

Altimeter setting _______

Field elevation _______

Temperature _______

Density Altitude _______

Expected takeoff distance (ground roll): _______

Expected landing distance (over 50’ obstacle, short field technique): _______

Total time flown on this sortie: _______

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FLYING THE SORTIE

(Fill in the blanks in-flight)

Before engine start:

Altimeter error _______

(set altimeter to local setting if available, record difference to known field elevation)

Takeoff and Climbout

- ❒ If DA > 3000', lean engine before takeoff as per POH
- ❒ Note estimated takeoff point before beginning takeoff roll.
- ❒ Estimate distance (or time) of liftoff from expected point
  distance (or seconds) beyond expected liftoff point _______
- ❒ Establish Vy, record actual ROC obtained after takeoff _______

Airplane Configurations and Power Setting vs Airspeed

- ❒ Level off at least 3000 AGL or 5,000 DA (whichever is higher)
- ❒ Fly at search airspeed with flaps up (~85 KIAS)
  record power settings: _________ MP _______ RPM
- ❒ Extend flaps to search setting (10-25°), maintain airspeed,
  record power settings: _________ MP _______ RPM
- ❒ Extend gear and full flaps, fly at normal speed for approach to landing, maintain altitude.
  record power settings: _________ MP _______ RPM
- ❒ Apply full power and fly at Vy for max gross weight, gear and flaps down.
  record rate of climb obtained: ______
- ❒ Decrease speed in 5 knot increments (while staying above stall). Record the rate of climb achieved to find actual Vy at this weight/altitude with gear/flaps down:
  Airspeed _______ ROC_______
  Airspeed _______ ROC _______
  Airspeed _______ ROC _______
- ❒ Raise the gear and flaps. Perform a departure stall with full power.
- ❒ Slow flight: Decrease airspeed to normal approach speed. Perform turns left and right.
- ❒ Perform an approach to landing stall with power off.
- ❒ Resume level flight with flaps at search setting. Resume search airspeed.

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Descents:

- ❒ Reduce power to idle, extend full flaps at normal approach speed.
  record rate of descent: ______
- ❒ Increase speed to approach speed for flaps up. Raise flaps. Perform a maximum effort slip.
  record the rate of descent: _______
- ❒ Resume coordinated flight and transition to a climb with full power.

Operations at Search Ceilings

- ❒ Climb to the altitude selected in preflight preparation to give the desired density altitude to simulate high altitude mountain search. Use the Vy airspeed previously calculated for this altitude and weight. Record the rate of climb obtained: ________
- ❒ Level off at desired search altitude.
- ❒ Fly at search airspeed with flaps up (~85 KIAS)
  Record power settings: _________ MP _______ RPM
- ❒ Extend flaps to search setting (10-25°), maintain airspeed
  Record power settings: _________ MP _______ RPM
- ❒ Extend gear and full flaps, fly at normal speed for approach to landing, maintain altitude.
  Record power settings: _________ MP _______ RPM
- ❒ Apply full power and fly at Vy for best climb as recorded above, gear and flaps down
  Record rate of climb obtained: ______
- ❒ Raise gear and flaps, reduce power so that the rate of climb is 300 feet per minute.
  Record the power setting: _________ MP _______ RPM
- ❒ Perform a departure stall at this power setting.
- ❒ Resume level flight. Reduce power to idle, perform an approach to landing stall.
- ❒ Resume level flight.
- ❒ Perform and time a canyon turn, using no more power than recorded above for the 300 fpm climb. Record the time to complete this turn: ________.
  Altitude lost, if any: _______
- ❒ Perform a modified wing-over, as described below. Compare results to the canyon turn.
  Record altitude lost, if any: _______

Takeoffs and Landings

Perform at least 3 takeoffs and landings, including:

- ❒ Short field takeoffs/landing. Estimate and record distance over 50 foot obstacle:
  Takeoff: _______ Landing: _______
- ❒ Soft field takeoff/landing. Estimate and record distance over 50 foot obstacle:
  Takeoff: _______ Landing: _______
- ❒ Power off approach/landing. Estimate and record distance over 50 foot obstacle: _______

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Post flight Debrief

- ❒ Compare estimated performance to actual performance for:
- ❒ Takeoff and landing distances
- ❒ Rate of climb on takeoff and at search altitude
- ❒ Rate of climb difference from using Vy for max gross versus Vy adjusted for weight.
- ❒ Discuss results from practice of canyon turn and modified wing over
- ❒ Complete applicable portions of Flying Grade sheet
- ❒ Instructor Pilot: Endorse trainee's records and completion certificate

NOTES:

Mountain Fury
Mountain Search Flying
Course Syllabus

Second Sortie : Advanced Aircraft Performance

Objectives

1. Develop trainee's proficiency in normal and emergency turn techniques for high altitude search operations.
2. Develop trainee's knowledge of effect of altitude on turn and climb performance.
3. Develop trainee's ability to estimate wind speed and turn distances.
4. Introduce and develop techniques for controlled impact with terrain, ridge search procedures, and downdraft escape.

Timeline

The trainee should expect to spend at least 45 minutes in preflight planning for this sortie prior to meeting with the instructor. The trainee and instructor should plan on an additional hour of discussions and briefing prior to the commencement of the flight. Sortie two will require one and one half to two hours of flight time. Finally, a debrief and completion of paperwork will require one additional hour.

Detailed Description of Second Sortie

Preflight Preparation

A considerable amount of preparation is required of the trainee pilot prior to this sortie. This is intended to allow the prediction of aircraft performance and comparison of predictions with actual performance. These items should be completed prior to meeting with the instructor pilot so that the sortie can be accomplished as expeditiously as possible.

Obtain the following information from the instructor pilot and enter it on the outline/data form:

- The instructor's weight and the weight of his/her personal equipment
- The location or locations in which the sortie will be flown.

Weight and Balance

Obtain data on the aircraft needed to complete a weight and balance computation. Perform a weight and balance calculation including planned fuel load, weights of the trainee and instructor and their personal equipment. Enter the gross weight, CG, maximum allowable gross weight and percent difference of the operating weight from maximum gross weight on the outline/data form. Note that a **forward CG position produces a higher stall speed**. This should be considered in calculating stall speeds below.

Airspeed and turn performance calculations

Calculate critical airspeeds at sea level (or the airport elevation) through 12,000 feet density altitude and fill these in on the outline/data form. These include Vx, Vy, Va, stall speeds for flaps up and normal search configuration (typically 10° to 25° of flap), best glide speed, and stall speeds in a 45° and 60° bank turn. Also calculate and record the expected distances required to complete 30°, 45° and 60° turns at low and high altitude. Record this information on the outline/recording form.

> Note: When calculating canyon turn diameter and entry speed, CALIBRATED stall speed must be used. The resulting entry speed in calibrated airspeed must be converted into INDICATED airspeed for use in flight. For most aircraft used by CAP, the difference between calibrated airspeed and indicated airspeed at stall speed is fairly large, but at the canyon turn entry airspeed it is very small. If INDICATED stall speed is used for the calculations, the calculated canyon turn entry speed will be about 15 knots too slow.

Weather Briefing

Obtain a standard briefing for the area in which the sortie will be flown. A DUAT briefing is preferred as it assures that all available weather information is obtained. Print out the briefing or record information from the briefing form on the outline/data form so that the briefing and conditions may be discussed with the instructor pilot. Prepare and file a flight plan for the sortie.

Preflight Briefing

Safety. Safety is of paramount concern to everyone. If weather at the time of the sortie is of any concern postpone the sortie for another day. Complete the CAP personal safety matrix prior to the flight. Once again, if the score is high and unacceptable, postpone the flight for another day. While flying the sortie the air work should be conducted at an altitude far away from any obstacles and well above terrain. An altitude of 3,000 feet AGL is suggested. Sufficient altitude to recover from an inadvertent stall/spin is needed.

Verify that appropriate survival equipment is on board, and that both crewmembers have clothing suitable to spend the night in the open if an off-airport landing occurs.

Weather. The trainee should provide the instructor with his/her personal assessment of the weather conditions based on the contents of a standard weather briefing . Specific items needed include forecast clouds and weather, winds and temperatures aloft, and the presence of turbulence. The instructor should obtain an independent briefing so that the trainee's assessment can be evaluated.

Flight Plan. The trainee should review the flight plan (filed earlier) with the instructor, and review route and airport departure procedures.

Aircraft Preflight. If possible, the preflight inspection should be performed in the presence of the instructor. Any non-standard equipment (radios, oxygen, survival gear) should be should be discussed to ensure familiarity of both pilots with that equipment. Any inoperative equipment should be identified and assessed as to whether it is required for the flight. Review the weight and balance calculations performed by the trainee and verify that the aircraft is loaded within limits.

Aircraft Performance. Discuss power settings, maximum rates of climb (and associated airspeeds) estimated takeoff distance and takeoff abort point. The instructor should review the preflight data entered by the trainee on the outline / data form. Select an altitude at which to perform high altitude maneuvers. This should be between 8,000 and 12,000 feet depending on expected aircraft performance and availability of oxygen for the crew. Compare this to the density altitudes calculated from the winds aloft forecast during preflight preparation and note the indicated altitude that will be needed to achieve the desired density altitude.

Discuss turn effects of bank angle, airspeed and altitude on turn performance. Review the trainee's calculations for turn diameters.

Discuss procedures for:

- Power-off course reversal
- Ridge search technique
- Distance estimation technique.

Complete a CAP safety inspection form for the aircraft.

A note on record keeping

This sortie requires that a substantial amount of data be collected and recorded in flight. The goal is that the trainee obtain a quantitative measure of the aircraft performance that he or she can obtain so that the benefits of using these procedures and techniques be fully understood. The items that need to be recorded consist of either times in seconds, distances or altitudes in feet, and occasionally a heading or ground speed off of a navigation radio. In all but one case only one number need be recorded per maneuver, so this work should not constitute a major distraction for the instructor. If however the instructor feels that this would compromise his or her ability to instruct or maintain the safety of the flight, it would be reasonable to add another crewmember to the flight whose sole duty would be to record data. If an additional crewmember is needed, it would be best to select the lightest possible person so that aircraft weight can be minimized and thus have the least possible effect on aircraft performance.

Turning and Climb Performance Demonstrations

The goal of the turning maneuvers is to demonstrate the relative turn performance obtained at various bank angles, airspeeds and altitudes. The first set of maneuvers is intended to provide a performance baseline for comparison to flying these maneuvers at mountain search altitudes. The second set will show how that performance changes at high altitude.

Depart the airport and proceed to the practice area. Climb to a safe altitude to perform these maneuvers. 3000' AGL is recommended as sufficient for recovery from incorrectly flown maneuvers yet low enough to show differences in performance versus when these maneuvers are repeated at high altitude.

Establish search airspeed (approximately 85 KIAS, as appropriate to the aircraft) with flaps at search setting (10-25°). A series of 180° turns will be flown to demonstrate the effect of bank angle on the time needed to complete the turn. These times will be converted to turn diameter

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during the postflight debriefing for comparison with the performance calculations made before the flight.

It is important to keep in mind that:

- 30° is the maximum bank angle that should be used while searching
- 45° is the maximum bank angle that should be used for establishing position, and
- 60° bank angle should be reserved for emergency escape and is the maximum that should be used.

Perform and time 180° turns at 30°, 45°, and 60° of bank. Record the time to complete each turn.

Perform and time a canyon turn (using the technique described in Sortie Number One) at minimum safe speed above stall for 180° of heading change at 60° of bank. Record the time to complete the turn. This turn should take less time and distance than the three turns above.

The next series of maneuvers are power-off course reversals. The goal is to learn the technique that will allow a course reversal with a minimum loss of altitude following an engine failure. You would probably want to use such a maneuver when the engine loses power or fails while headed toward higher terrain. These maneuvers show that the conventional technique of flying at best glide speed in a shallow bank is not optimal.

Reduce power to idle, establish best glide speed, and perform a 180 degree turn at 30° of bank. Record the altitude lost in turn, then climb back to 3000' AGL. Repeat this maneuver at 45° of bank again at best glide speed. Record the altitude lost in turn, then climb back to 3000' AGL.

This next maneuver demonstrates the optimal technique. It should produce an altitude loss of less than half of the 30° bank turn at best glide speed. Reduce power to idle. Perform a 180 degree turn at 45° of bank at the slowest airspeed which you can safely maintain without stalling. Record altitude lost in the turn.

The above set of turning maneuvers will be repeated at a higher altitude to demonstrate the effect of altitude on turn radius and altitude lost in a power off course reversal. The climb performance will be checked at the beginning and end of the climb to demonstrate the effect of airspeed on rate of climb and to establish the actual rate of climb achieved.

Enter a climb using the airspeed for Vy at sea level, maximum gross weight with flaps up. After the VSI stabilizes, record the rate of climb. An alternative and more accurate method to obtain the rate of climb is to climb for 1 minute and record the actual change in altitude.

Return to the previous altitude. Enter a climb using the airspeed for Vy for the current density altitude and weight as you calculated during your preflight preparations. Record the rate of climb achieved.

Continue the climb to the altitude selected before the flight for the desired density altitude to simulate high altitude search. Cruise-climb airspeed may be used if desired to keep the engine from becoming too hot. When you reach the pre-selected altitude, change to the airspeed listed in the POH for Vy at sea level, maximum gross weight. After the VSI stabilizes, record the rate of climb.

Return to pre-selected altitude. Enter a climb using the airspeed for Vy for the current density altitude and weight, and record the rate of climb. Return to the pre-selected altitude.

Repeat each of the turn maneuvers described above and record the results. The data will be reviewed after the flight so that the trainee can more fully appreciate the change in aircraft performance. Again, fly at search airspeed (~85 KIAS) with flaps at search setting (10-25°).

For reference, these maneuver are:

- 180° turns at 30°. 45°, and 60° of bank,
- A canyon turn flown at 60° of bank and the minimum safe airspeed above stall,
- Power-off course reversals at 30° and 45° of bank at best glide speed,
- Power-off course reversal at 45° of bank at the minimum safe airspeed above stall.

Simulated Controlled Impact

On rare occasion during mountain search operations a collision with terrain may become unavoidable. This might be due to weather closing in rapidly, an errant turn toward terrain, or a mechanical problem. Under such circumstances it can save your life to know how to impact the terrain with minimum energy to allow the smallest chance of injury, or at least minimize injuries. This maneuver is an emergency procedure for that situation. It simulates rolling out of a turn just prior to impact and then pulling up to reduce airspeed to the minimum possible without stalling.

Climb back to the pre-selected search altitude and resume flight at search airspeed (~85 KIAS) with flaps at search setting (10-25°). Enter a turn with 30° of bank.

Roll-out to wings level, then simultaneously apply full power and smoothly raise the nose to achieve level flight with the stall warning horn sounding. Hold this airspeed for at least 10 seconds. Recover to level flight.

Repeat this maneuver starting with throttle at idle and best glide airspeed.

Simulated Downdraft Escape

Up and downdrafts are common in mountainous areas. It is inevitable that downdrafts will be encountered that exceed the climb performance of the aircraft. The following maneuver is intended to simulate the effect of a downdraft and have the trainee respond by using an appropriate technique to minimize altitude loss. Glider technique is used, which dictates that airspeed be increased to quickly fly out of the area of the downdraft.

Resume flight at search airspeed (~85 KIAS) with flaps at search setting (10-25°)

Simulate a downdraft by either reducing power and increasing drag (extend gear) and/or point to the VSI and state that the aircraft is descending at 1000 fpm (or twice the aircraft's expected rate of climb, whichever is higher).

Increase power slightly and change speed to Vy. This simulates the effect of trying to climb against a strong downdraft. Note the rate of climb (should still be a descent).

Simulate a downdraft escape by lowering the nose and increasing speed to Va, and then to normal cruise speed (raising flaps and gear if necessary). The aircraft will be descending at a faster rate at the higher airspeeds, but the increased speed will result in leaving the downdraft area more quickly and produce a smaller total altitude loss.

Distance and Crosswind Estimation

It is often useful during search flying to be able to estimate distances on the ground. This skill can be used to determine whether there is sufficient room to fly into a particular area or to direct ground crews to a particular point. It is also important to be able to judge winds in the search area as they can present a hazard to search operations. These maneuvers are intended to develop skills in judging distances and winds.

Distance estimation by flying in a straight line:

Descend to 1000 to 2000 feet AGL (consistent with safety for the weather conditions). Select two prominent points on the ground that are approximately 1000 feet apart based on your visual approximation of that distance. It would be ideal if you can determine the exact distance between two such points through other means, such as from a topographic chart or ground survey or GPS data.

Fly at an airspeed that yields 100 knots ground speed (but no slower than normal search indicated airspeed) and take up a position and heading to fly a course to cross the two points. Record the time it takes to fly between the two points. Each 6 seconds corresponds to 1000 feet.

Distance estimation with turn radius:

Fly to a position that is perpendicular to the previous course abeam one of the points. Fly over the point and enter a 45° turn toward the second point. Note the position over the ground upon completing 180 degrees of turn. At 100 knots true airspeed and a 45° bank the turn radius is about 1000 feet (actually 890 feet). Each 10 knots of wind will move the end point of the turn by about 280 feet.

Crosswind Estimation:

Select a road or ridge which is perpendicular to the wind direction.

Fly at an airspeed that yields 100 knots ground speed (but no slower than normal search indicated airspeed) and fly along (while safely above) the road or ridge. Record the ridge alignment and crab angle.

Each 10 knots of crosswind component will produce 6° of crab. Divide the crab angle by 6 and multiply by 10 to find the crosswind component.

If GPS, LORAN, or DME is available use that equipment to find the wind velocity. Turn into the wind and record the ground speed, then turn 180 degrees and record ground speed again. The difference in ground speeds is the wind velocity. During post flight debrief; use a crosswind chart or calculator to determine the crosswind component.

"Ridge Soaring" Search Technique

Searching a ridge has some inherent hazards as you are in close proximity to high terrain that often rises more steeply than the aircraft can climb. Thus it is important that ridges be searched in a manner that minimizes the chances of flying into that terrain. The glider community has developed a technique for safely exploiting the lift that can be found on the windward sides of ridges. This is called ridge soaring. The aircraft is flown parallel to the ridge until the end is reached, then a turn is made away from the ridge through about 225°. This puts the aircraft pointing back toward the ridge at a 45-degree angle. The aircraft is then turned in the opposite direction for 45° so that it is once again flying parallel to the ridge but now in the opposite direction from the first pass. If strong winds are blowing toward the ridge the initial turn should be less than 225° as the wind will increase the angle of the ground track toward the ridge. The most important features of this technique are that the aircraft never heads directly toward the terrain and is never more than 45° of turn from flying away from the ridge. This maneuver is practiced here for familiarity. Its use is recommended whenever a point or area on a ridge needs to be viewed repeatedly.

Select a ridge (or road as a simulated ridge). Fly along the windward side of the ridge and practice making a series of teardrop turns (approximately 225° of heading change) with the start of the turn away from the ridge, followed by a turn away from the ridge to end up paralleling the ridge in the opposite direction. The instructor should emphasize importance of always turning away from the ridge and scanning for traffic.

Postflight Debrief

Review the data recorded during the flight for comparison to POH data and calculated turn performance. This provides the trainee with an objective look at how much of the book performance he or she can obtain. Compare estimated to actual values for rates of climb and time and distance to complete 180 degree turns. Compare the altitude lost using 30° and 45° bank angles at best glide speed to that lost when turning at 45° of bank and minimum safe airspeed. This review should aid in the trainee in more fully understanding the actual performance capability of the airplane. Also review the pilot's results in estimating distance using time for distance and by using turn diameter.

Fill out the Flying Grade sheet for maneuvers performed in this sortie. Mark an "S" for satisfactory performance, "T" or more training required, and "U" for unsatisfactory performance. The grade of "T" should be used when performance is marginally acceptable or the trainee shows signs of improvement but is not yet proficient. "U" should be used when the trainee is experiencing considerable difficulty and maneuvers are deemed unsafe or unacceptable.

Satisfactory performance is a judgment call on behalf of the check pilot. If the pilot understands the requirements and can execute those requirements in accordance with the FAA test standards for his rating in the judgment of the check pilot, the pilot's records should be endorsed to move on to the next phase of the program.

The check pilot should endorse the Mountain Fury completion certificate when this first training section (sorties one and two) has been completed successfully.

Set up a schedule for more training if needed.

Detailed Description of Emergency Power-off Course Reversal Maneuver:

If your engine fails or loses power for any reason while flying over inhospitable terrain at a low altitude, your first priority will likely be to turn the aircraft toward lower terrain with the minimum possible loss of altitude. This will give you the greatest chance of dealing with the problem or simply more time to find a better place to land. Most pilots will try to do this by flying at best glide speed with a shallow to moderate bank angle. This is not the optimum technique however.

The turn technique to produce a minimum altitude loss while reversing course with power off is to use a 45° bank at the slowest airspeed you can fly while staying safely above stall speed. In simplified terms, you can think of the 45° bank as the best balance between using the lift of the wing for turning and keeping the airplane up. Best glide speed is not desirable as it produces the longest glide distance, but that's not what you want in this case. You're looking for the least altitude lost in the turn, not the greatest distance you can fly while turning. For a given bank angle, the slower you fly, the faster the rate of turn. The minimum rate of altitude loss is usually at a speed that is fairly close to stall speed. Thus while in a 45° bank at slow airspeed the airplane turns rapidly while descending relatively slowly, with the result being the smallest altitude loss possible to reverse course.

If this maneuver is performed correctly in a C-172, course can be reversed in less than 250 feet at 10,000 feet density altitude. In a C-182, in less than 350 feet. At best glide in a 30° bank, the altitude loss would be over 750 feet for the C-172, and over 1000 for a C-182. This is a big difference when conducting search operations at or below 1000 feet AGL.

If the engine fails, as soon as you realize you need to turn you should begin that turn and roll to a 45° bank. Hold the nose up to bleed off airspeed as you turn until you hear the stall warning horn or reach the slowest speed at which you're comfortable flying under the conditions. At this point you should adjust back pressure on the yoke to maintain the desired airspeed. Relax back pressure and transition to best glide speed once you're heading in the desired direction.

Some pilots try to pull up after the engine failure to try to trade airspeed for altitude before they begin the turn. If you're heading toward higher terrain this is not a good idea as you'll be going in the wrong direction that much longer. In any case, the altitude gain from a pull-up is usually fairly small, especially when you're starting from search airspeed. In addition, a pull-up makes the maneuver more complicated and will require more of your attention at a time when you have other things to think about, like finding a good place to land or getting the engine restarted. Keeping things simple will raise the chances of successfully dealing with this emergency.

MOUNTAIN FURY
SORTIE NUMBER TWO
OUTLINE / DATA RECORDING FORM

PILOT ____

CHECK PILOT ____

Check Pilot Number _________

Date of Sortie _______________ **Aircraft Type** __________

Location ___________________

Preflight Preparation

Verify the following have been performed, and data entered on recording form. Discuss and review as necessary:

Weight and balance
Airspeed calculations
Weather briefing
Preflight briefing

- safety, including personal matrix, survival equipment and clothing
- weather, including clouds, winds, temperatures and turbulence
- flight plan, discussed and filed
- aircraft preflight — discuss non-standard equipment, oxygen, inop equipment
- aircraft performance — discuss and fill in recording form with performance predictions
- safety inspection form — verify completed

Fill in the blanks before the flight

Weights:

Aircraft Basic Empty Weight	__________
Trainee	__________
Trainee's Equipment	__________
Instructor	__________
Instructor's Equipment	__________
Other Items in Aircraft	__________
Fuel Load	__________
Gross Weight	__________
Maximum Gross Weight	__________
Empty CG	__________
CG as Loaded	__________
Within CG/Weight limits (Y/N)?	__________
CG in forward 30% of Range (higher stall speed)?	__________
Percent Difference from Max Gross Weight	__________

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Airspeeds for max gross weight:

	density altitude				
	sea level	6,000'	8000'	10,000'	12,000'
Vx	_______	_______	_______	_______	_______
Vy	_______	_______	_______	_______	_______
Vy ROC from POH	_______	_______	_______	_______	_______

Stall speed flaps up, KCAS _______

Stall speed, search configuration (flaps), KCAS _______

Stall speed, search config, 45° bank ↳ x 1.2 = _______

Stall speed, search config, 60° bank ↳ x 1.4 = _______

Canyon turn entry airspeed KCAS ↳ + 10 = _______

Canyon turn entry airspeed KIAS (use table in POH/AFM) _______

Va _______

Best glide _______

For actual takeoff weight, reduce airspeeds above by 1/2 the percent difference from max gross weight):

	density altitude				
	sea level	6,000'	8000'	10,000'	12,000'
Vx	_______	_______	_______	_______	_______
Vy	_______	_______	_______	_______	_______

Stall speed flaps up, KCAS _______

Stall speed, search configuration (weight, flaps), KCAS _______

Stall speed, search config, 45° bank ↳ x 1.2 = _______

Stall speed, search config, 60° bank ↳ x 1.4 = _______

Canyon turn entry airspeed KCAS ↳ + 10 = _______

Canyon turn entry airspeed KIAS (use table in POH/AFM) _______

Va _______

Best glide _______

From Winds Aloft Forecast (FD)	3000'	6000'	9000'	12000'
Wind/Temperature	_______	_______	_______	_______
Density altitude (calculate)	_______	_______	_______	_______

Desired density altitude for high altitude maneuvers (8-12,000 feet) _______

Indicated altitude (approximate) for above density altitude _______

(NOTE: this is the indicated altitude you will use for this sortie)

Altimeter setting _______

Field elevation _______

Temperature _______

Density Altitude _______

Calculate turn diameters at search airspeed: (DA = density altitude, results are in feet)

45° bank at sea level: (Airspeed (KIAS) ^{2} / 11.26) x 2 = _______

30° bank at sea level: 45° bank distance x 1.75: ↳ x 1.75 = _______

60° bank at sea level: 45° bank distance x 0.6: ↳ x 0.6 = _______

45° bank at search altitude: (increases by 2% per 1000 feet Density Altitude above sea level)

((Airspeed (KIAS) x (1 + (.02 x DA in K feet)) ^{2} / 11.26) x 2 = _______

30° bank at search altitude: 45° bank distance x 1.75: ↳ x 1.75 = _______

60° bank at search altitude: 45° bank distance x 0.6: ↳ x 0.6 = _______

Total time flown on this sortie: _______

EXAMPLE: C-182Q, @2612 lb, 2950 lb max gross weight

Airspeeds for max gross weight: ------------------- density altitude -------------------------

	sea level	6,000'	8000'	10,000'	12,000'
Vx	54	59	60	62	64
Vy	78	74	73	72	71
Vy ROC from POH	1010	680	570	460	350
Stall speed flaps up, KCAS		59			

Stall speed, search configuration (flaps), KCAS ___57 (10° flaps)

Stall speed, search config, 45° bank ↳ x 1.2 = ___68

Stall speed, search config, 60° bank ↳ x 1.4 = ___80

Canyon turn entry airspeed KCAS ↳ + 10 = ___90

Canyon turn entry airspeed KIAS (use table in POH/AFM) ___91

Va ___111 Best glide ___70

For actual takeoff weight, reduce airspeeds above by 1/2 the percent difference from max gross weight): ---------------------------- density altitude -------------------------------

	sea level	6,000'	8000'	10,000'	12,000'
Vx	51	56	56	58	60
Vy	73	70	69	68	67

Stall speed flaps up, KCAS ___56

Stall speed, search configuration (weight, flaps), KCAS ___54

Stall speed, search config, 45° bank ↳ x 1.2 = ___65

Stall speed, search config, 60° bank ↳ x 1.4 = ___76

canyon turn entry airspeed KCAS ↳ + 10 = ___86

canyon turn entry airspeed KIAS (use table in POH/AFM) ___87

Va ___104

Best glide ___66

From Winds Aloft Forecast (FD)	3000'	6000'	9000'	12000'
Wind/Temperature	0314 ~17	0618+19	0721+12	0624+04
density altitude (calculate)	3,926	7,820	10,700	13,471

Desired density altitude for high altitude maneuvers (8-12,000 feet) _______

Indicated altitude (approximate) for above density altitude _______

(NOTE: this is the indicated altitude you will use for this sortie)

Altimeter setting ___29.85

Field elevation ___1,531

Temperature ___25 C

Density Altitude ___3,035

Calculate turn diameters at search airspeed: (DA = density altitude, results are in feet)

45° bank at sea level: (Airspeed (KIAS) ^{2} / 11.26) x 2 = ___1,283 (@ 85 KIAS)

30° bank at sea level: 45° bank distance x 1.75: ↳ x 1.75 = ___2,246

60° bank at sea level: 45° bank distance x 0.6: ↳ x 0.6 = ___770

45° bank at search altitude: (increases by 2% per 1000 feet Density Altitude above sea level)

((Airspeed (KIAS) x (1 + (.02 x DA in K feet)) ^{2} / 11.26) x 2 = ___1,848 (@85KIAS/10K')

30° bank at search altitude: 45° bank distance x 1.75: ↳ x 1.75 = ___3,234

60° bank at search altitude: 45° bank distance x 0.6: ↳ x 0.6 = ___1,109

Total time flown on this sortie: _______

FLYING THE SORTIE
(Fill in the blanks in-flight)

Takeoff and Climbout

- ❑ Proceed to practice area.
- ❑ Level off at least 3000 AGL

Turning and Climb Performance Demonstrations

Low altitude turn performance

- ❑ Fly at search airspeed (~85 KIAS) with flaps at search setting (10-25°)
- ❑ Perform & time a 180° turn at 30° bank. Record the time to complete the turn: _______
- ❑ Perform & time a 180° turn at 45° bank. Record the time to complete the turn: _______
- ❑ Perform & time a 180° turn at 60° bank. Record the time to complete the turn: _______
- ❑ Perform & time a canyon turn at minimum safe speed above stall for 180° of heading change at 60° of bank. Record the time to complete the turn: _______

- ❑ Reduce power to idle, establish best glide speed.
- ❑ Perform a 180 degree turn at 30° of bank. Record altitude lost in turn: _______
- ❑ Climb back to 3000' AGL.
- ❑ Reduce power to idle, establish best glide speed.
- ❑ Perform a 180 degree turn at 45° of bank. Record altitude lost in turn: _______
- ❑ Climb back to 3000' AGL.
- ❑ Reduce power to idle.
- ❑ Perform a 180 degree turn at 45° of bank at the slowest airspeed which you can safely maintain without stalling. Record altitude lost in turn: _______

Climb Performance

- ❑ Enter a climb using the airspeed for Vy at sea level, maximum gross weight with flaps up. After the VSI stabilizes, record the rate of climb (or climb for 1 minute and record actual climb): _______
- ❑ Return to previous altitude. Enter a climb using the airspeed for Vy for the current density altitude and weight. Record the rate of climb: _______
- ❑ Climb to the altitude selected before the flight for the desired density altitude.
- ❑ Enter a climb using the airspeed for Vy at sea level, maximum gross weight. After the VSI stabilizes, record the rate of climb (or climb for 1 minute and record actual climb): _______
- ❑ Return to previous altitude. Enter a climb using the airspeed for Vy for the current density altitude and weight. Record the rate of climb: _______

High altitude turn performance

- ❑ Return to previous altitude and level off at search airspeed (~85 KIAS) with flaps at search setting (10-25°)

- ❑ Perform & time a 180° turn at 30° bank. Record time to complete turn: _______
- ❑ Perform & time a 180° turn at 45° bank. Record time to complete turn: _______
- ❑ Perform & time a 180° turn at 60° bank. Record time to complete turn: _______
- ❑ Perform & time a canyon turn at minimum safe speed above stall for 180° of heading change at 60° of bank. Record the time to complete the turn: _______
- ❑ Reduce power to idle, establish best glide speed.
- ❑ Perform a 180 degree turn at 30° of bank. Record altitude lost in turn: _______
- ❑ Climb back to the pre-selected search altitude.
- ❑ Reduce power to idle, establish best glide speed.
- ❑ Perform a 180 degree turn at 45° of bank. Record altitude lost in turn: _______
- ❑ Climb back to the pre-selected search altitude.
- ❑ Reduce power to idle.
- ❑ Perform a 180 degree turn at 45° of bank at the slowest airspeed which you can safely maintain without stalling. Record altitude lost in turn: _______

Simulated Controlled Impact

- ❑ Resume flight at search airspeed (~85 KIAS) with flaps at the search setting (10-25°)
- ❑ Enter a turn with 30° of bank.
- ❑ Roll-out to wings level, then simultaneously apply full power and smoothly raise the nose to achieve level flight with the stall warning horn sounding. Hold this airspeed for at least 10 seconds.
- ❑ Recover to level flight.
- ❑ Resume flight at search airspeed (~85 KIAS) with flaps at the search setting (10-25°)
- ❑ Reduce power to idle and change to best-glide airspeed.
- ❑ Enter a turn with 30° of bank.
- ❑ Roll-out to wings level, then smoothly raise the nose to achieve level flight with the stall warning horn sounding. Hold this airspeed for at least 10 seconds.
- ❑ Recover to level flight.

Simulated Downdraft Escape

- ❑ Resume flight at search airspeed (~85 KIAS) with flaps at the search setting (10-25°)
- ❑ Simulate a downdraft by either reducing power and increasing drag (extend gear) and/or point to the VSI and state that the aircraft is descending at 1000 fpm (or twice the aircraft's expected rate of climb, whichever is higher).
- ❑ Increase power slightly and change speed to Vy. Note rate of climb.
- ❑ Simulate downdraft escape by lowering the nose and increasing speed to Va, and then to normal cruise speed (raising flaps and gear if necessary). Note rate of descent at each speed.

Distance and Crosswind Estimation

Distance Estimation:

- ❑ Descend to 1000 to 2000 feet AGL (consistent with safety for wx conditions). Select two prominent points on the ground that are approximately 1000 feet apart.
- ❑ Fly at an airspeed that yields 100 knots ground speed (but no slower than normal search indicated airspeed) and take up a position and heading to fly a course to cross the two points. Record the time it takes to fly between the two points: _______
- ❑ Fly to a position that is perpendicular to the previous course abeam one of the points.
- ❑ Fly over the point and enter a 45 degree turn toward the second point. Note the position over the ground upon completing 180 degrees of turn.

Crosswind Estimation:

- ❑ Select a road or ridge which is perpendicular to the wind direction.
- ❑ Fly at an airspeed that yields 100 knots ground speed (but no slower than normal search indicated airspeed) and fly along (while safely above) the road or ridge. Record the magnetic direction of the ridge: _______ Record the crab angle: _______
- ❑ Estimate crosswind component (10 knots per 6° of crab): _______
- ❑ If GPS, LORAN or DME is available, turn into the wind, and record the ground speed: _______ turn 180 degrees, record ground speed: _______ Difference in ground speeds: _______

"Ridge Soaring" Search Technique

- ❑ Select a ridge (or road as a simulated ridge)
- ❑ Fly along the windward side of the ridge and practice making a series of teardrop turns (approximately 225° of heading change) with the start of the turn away from the ridge, followed by a turn away from the ridge (of approximately 45°) to parallel the ridge in the opposite direction.
- ❑ Emphasize importance of always turning away from the ridge and scanning for traffic.

Postflight Debrief

Compare estimated performance to actual performance for:

- ❑ Time to make a 180° turn using various bank angles and canyon turn technique at low and high altitudes
- ❑ Calculate and compare approximate turn diameter for each turn. Diameter in feet = true airspeed (in knots) X seconds for 180° turn X 1.1. Note effect of bank angle, speed and altitude on turn radius
- ❑ Compare altitude lost in power-off 180° using turns at best glide speed vs minimum speed turn.

Mountain Fury
Mountain Search Flying
Course Syllabus

Third Sortie : High Altitude Takeoff/Landing, Mountain Navigation, Up/Downdrafts

Objectives

1. Develop trainee's proficiency in maximum performance takeoffs and landings at high altitude airports.
2. Develop trainee's ability in mountain pilotage, dead reckoning and use of navigation equipment.
3. Develop trainee's awareness of locations and ability to deal with up and downdrafts while conducting search operations.

Timeline

The trainee should expect to spend at least 45 minutes in preflight planning for this sortie prior to meeting with the instructor. The trainee and instructor should plan on an additional hour of discussions and briefing prior to the commencement of the flight. Sortie three will require one and one half to two hours of flight time. Finally, a debrief and completion of paperwork will require one additional hour.

Detailed Description of Third Sortie

Preflight Preparation

A considerable amount of preparation is required of the trainee pilot prior to this sortie. This is intended to allow the prediction of aircraft performance and comparison of predictions with actual performance. These items should be completed prior to meeting with the instructor pilot so that the sortie can be accomplished as expeditiously as possible.

Obtain the following information from the instructor pilot and enter it on the outline/data form:

- The instructor's weight and the weight of his/her personal equipment
- The location or locations in which the sortie will be flown.

Weight and Balance

Obtain data on the aircraft needed to complete a weight and balance computation. Perform a weight and balance calculation including planned fuel load, weights of the trainee and instructor and their personal equipment. Enter the gross weight, CG, maximum allowable gross weight and percent difference of the operating weight from maximum gross weight on the outline/data form. Note that a forward CG position produces a higher stall speed. This should be considered in calculating stall speeds below.

Airspeed and performance calculations

Calculate critical airspeeds from the airport elevation through the highest altitude expected to be flown on this sortie and fill these in on the outline/data form. These include Vx, Vy, Va, stall speeds for flaps up and normal search configuration (typically 10° to 25° of flap), best glide speed, and stall speeds in a 45° and 60° bank turn. Determine from the POH the density altitude at which the aircraft will climb at 300 feet per minute. Record this information on the outline/recording form.

> Note: When calculating canyon turn diameter and entry speed, CALIBRATED stall speed must be used. The resulting entry speed in calibrated airspeed must be converted into INDICATED airspeed for use in flight. For most aircraft used by CAP, the difference between calibrated airspeed and indicated airspeed at stall speed is fairly large, but at the canyon turn entry airspeed it is very small. If INDICATED stall speed is used for the calculations, the calculated canyon turn entry speed will be about 15 knots too slow.

Weather Briefing

Obtain a standard briefing for the area in which the sortie will be flown. A DUAT briefing is preferred as it assures that all available weather information is obtained. Print out the briefing or record information from the briefing form on the outline/data form so that the briefing and conditions may be discussed with the instructor pilot. Prepare and file a flight plan (or mission flight plan) for the sortie.

Airport Information:

Since this sortie will be flown from a high altitude airport or search base, it is likely that the trainee will not be familiar with the airports to be used. The AFD or other reference should be used to gather information on runway lengths, elevation (at each end), slope, obstructions, and approach and departure patterns. Actual or forecast temperatures should be obtained or estimated and density altitudes should be calculated. Record this information on the outline/data recording form.

Preflight Briefing

Safety. Safety is of paramount concern to everyone. If weather at the time of the sortie is of any concern, postpone the sortie for another day. Complete the CAP personal safety matrix prior to the flight. Once again, if the score is high and unacceptable, postpone the flight for another day.

Unlike the first two sorties, this sortie will be flown at relatively low AGL altitudes over high terrain. An altitude of at least 2,000 feet AGL is suggested for navigation exercises. Use a minimum of 1,000 feet AGL for up and downdraft exercises.

Verify that appropriate survival equipment is on board, and that both crewmembers have clothing suitable to spend the night in the open if an off-airport landing occurs. Note wind chill factors and expected night time temperatures. Carriage of sleeping bags and some form of shelter (tarp or tent) is highly recommended for flight operations in mountainous areas.

Weather. The trainee should provide the instructor with his/her personal assessment of the weather conditions based on the contents of a standard weather briefing. Specific items needed include forecast clouds and weather, winds and temperatures aloft, and the presence of turbulence. The instructor should obtain an independent briefing so that the trainee's assessment can be evaluated.

Flight Plan. The trainee should review the flight plan (filed earlier) with the instructor, and review route and airport departure procedures.

Aircraft Preflight. If possible, the preflight inspection should be performed in the presence of the instructor. Any non-standard equipment (radios, oxygen, survival gear) should be discussed to ensure familiarity of both pilots with that equipment. Any inoperative equipment should be identified and assessed as to whether it is required for the flight. Review the weight and balance calculations performed by the trainee and verify that the aircraft is loaded within limits.

Aircraft Performance. Discuss power settings, maximum rates of climb (and associated airspeeds) estimated takeoff distance and takeoff abort point. The instructor should review the preflight data entered by the trainee on the outline/data form. Verify that the density altitude expected in the practice search area will be at or below the search ceiling for the aircraft. If flight above 10,000 feet is planned, oxygen should be available and used by the crew.

Discuss turn effects of bank angle, airspeed and altitude on turn performance. Review the trainee's calculations for turn diameters.

Complete a CAP safety inspection form for the aircraft.

Takeoffs and Landings

The takeoffs and landings practiced in the first sortie of the program will be repeated to demonstrate the effect of high density altitude on aircraft performance. **An airport with a density altitude of at least 6,000 feet is preferred** for effective training.

Note points along the runway that correspond to the distance required for ground roll, 50 foot obstacle clearance height, and takeoff abort point before beginning each takeoff run. **At least 75 percent of indicated takeoff speed must be obtained by half way down the runway or the aircraft will not lift off on the runway remaining**. Estimate the distance (or time) differences from the predicted takeoff point/obstacle clearance height to the actual distances. Record this information on the outline/data form. Make the same estimates for landing distances, note actual distances and record this data on the form. Short field and soft field takeoffs and landings should be performed, as well as at least one power-off approach and landing.

Terrain Navigation

Accurate navigation in mountain areas is very important but it has unique challenges. Enroute altitudes will usually be at a lower AGL altitude than in low terrain areas, thus the appearance of ground features is different and it is more difficult to obtain a big-picture view of the terrain. Conventional electronic navigation aids such as VOR and DME may not be usable due to the signals being blocked by terrain. GPS and LORAN are less effected by terrain, but this equipment can fail or be subject to signal outage. For these reasons it is important that the search pilot be skilled in visual navigation (pilotage). The goal of the following exercise is to develop skills in pilotage and use of electronic navigation aids.

Climb to an altitude that is at least 2000 AGL for the route to the practice search area. While enroute and on reaching the grid, attempt to continuously determine position with pilotage and dead reckoning. Try to use each piece of navigation equipment and assess whether it provides a usable indication in the search area.

While enroute, the instructor should simulate several equipment failures or emergencies. The simplest and safest method of simulating such failures is to announce an anomalous reading of an instrument or a condition, such as: The alternator is showing a discharge; oil pressure has dropped to zero; engine temperatures are nearing redline. It is also reasonable to change the heading indicator or radio frequency when the trainee is not watching. The goals are to increase the trainee's monitoring skills and demonstrate the effects of mild hypoxia and high workload on troubleshooting skills.

Also while enroute, the instructor should give hypothetical weather problems (e.g., if there were clouds here at XXXX MSL, or visibility was at 4 miles and decreasing, what would you do?). Discuss options to maintain safe VFR operations and whether IFR escape is possible.

Updraft/downdraft locations and magnitudes

In the following maneuvers the aircraft will be deliberately flown in areas expected to contain up and downdrafts. The goals are to give the trainee experience in locating such conditions and to allow recognition of aircraft performance characteristics which can indicate the presence of lift and sink. When the aircraft is flown in areas of downdrafts particular attention should be devoted to identifying escape routes to lower terrain. If downdrafts are consistently of intensity that produce a descent against full power climbs, either move further away from terrain or abort the flight and return to base. Training flights are not a time to take unnecessary risks.

The first task is to establish a baseline of performance for still-air conditions. Establish level flight in stable air (away from areas of up and downdrafts) at search airspeed (~85 KIAS or Vy + 10, whichever is higher) with flaps at search setting (10-25°). Record the power setting on the outline/data form.

Next the aircraft will be flown in areas of downdraft to show their effects. Locate a valley or canyon with an axis perpendicular to the prevailing wind. The usual pattern of conditions is for the windward slopes to have areas of updrafts and the leeward slopes have downdrafts. If winds are light, solar heating can alter this pattern, with bright areas generating lift and dark ones having sink. Have the pilot point out expected areas where up and downdrafts would be expected.

Fly parallel to the leeward side of a ridge into a downdraft area. Maintain airspeed and power setting and allow the aircraft to change altitude. This shows the magnitude of the sink. Record the rate of descent.

Fly out of the downdraft area, climb back to the starting altitude and return to the leeward side of the ridge. Maintain the previous power setting and change pitch and airspeed as needed to maintain altitude. Note the change in airspeed and pitch resulting from the climb against the downdraft. Record the airspeed.

Apply full power and transition to Vy for the aircraft weight and density altitude. Record the rate of climb. This shows the effect of downdrafts on aircraft climb performance.

The above series of maneuvers will next be repeated in an area of updrafts. Fly away from the ridge and out of the downdraft. Climb back to the original altitude and fly to the windward side of a ridge.

Slow to search speed as above, and set the power to what it was in the first step of this section. Maintain airspeed and the power setting, allowing aircraft to change altitude. This shows the magnitude of the lift. Record the rate of climb.

Fly out of updraft area, descend to starting altitude and return to the windward side of the ridge. Maintain altitude and the power setting. Note the change in airspeed and pitch resulting from a dive against the updraft. Record the airspeed.

Apply full power, transition to Vy for the aircraft weight/density altitude. Record the rate of climb. This shows the value of flying along windward sides of ridges to gain climb performance.

High - Altitude/Unfamiliar Field Approach and Landing

Proceed to the another high altitude airport. Fly over the field at least 1000 feet higher than the highest obstacle in the area using a rectangular pattern if possible. Note the wind conditions (through changes in crab angle and turn radius), approach and departure obstacles, condition of runway, and best approach path. Trainee and instructor should discuss the best way to approach the airport given the conditions.

Proceed to the downwind leg for landing. Adjust the mixture control so that maximum power is available should a go-around become necessary. Test climb performance with a full-power climb. If the **sustained rate of climb** obtained is **less than 300 feet per minute**, do not land — there is insufficient climb performance for a safe go-around on departure. Sustained rate of climb means climb performance in a constant airspeed climb which is not the result of trading airspeed for altitude.

The instructor should direct the pilot's attention to the need for a wider landing pattern/higher rate of descent due to the higher true airspeed produced by flight at high density altitude. Reminder: the **indicated approach speed to be used at high altitude airports is the same speed as used at low altitude airports**. Turbulence or wind shear would favor adding some speed to the normal approach speed.

Perform a normal landing. After clearing the runway, note and record the altimeter reading. Compare this to the known field elevation (from the sectional chart). Record the difference from the known field elevation. Reset the altimeter to field elevation.

High - Altitude/Unfamiliar Field Takeoff

If the runway has a visible slope, taxi to each end of runway and record the altimeter readings. Calculate the percentage of runway slope as follows.

Slope = (difference in height of runway ends/runway length) x 100

Example: (80' difference/2000' runway) x 100 = 4% slope.

Determine the takeoff distance taking into account the slope, wind, and obstructions.

Prior to takeoff, lean the mixture and perform a full power run-up (in accordance with any procedures or limitations contained in the aircraft handbook). If conditions are significantly different than those expected when the preflight calculations were made, recalculate the takeoff distance for the current conditions.

Allow 100 percent margin for required distance. If the runway length is not at least twice as long as the distance required, do not takeoff. Either wait for improved conditions (more headwind, cooler temperatures) or off-load weight to reduce the required takeoff distance.

Identify points along the runway that can be easily recognized (taxiways, windsocks, hangars, etc.) that correspond to the required distance needed for takeoff. Pick specific objects along the runway to identify the expected takeoff point, abort point (if not in the air by that point, abort the takeoff) and position where you expect to be 50 feet AGL.

Review the airspeeds for rotation, Vx, and Vy before takeoff.

Perform a short field/obstacle clearance takeoff. Record the distance (or time) past the markers you selected for your takeoff point and distance to clear a 50' obstacle.

If time permits, practice a soft field takeoff/landing at this airport.

After completing these tasks at this airport, return to the search/training base.

Postflight Debrief

Compare the actual distances obtained for takeoff/landing to predicted distances. If time past a takeoff marker was used instead of distance, you may convert this time to distance by multiplying the rotation speed in knots true airspeed by the number of seconds from the expected takeoff point and multiply by 1.7 to get distance in feet. For time past a 50' obstacle clearance marker, use the average of the liftoff speed and speed at 50' (converted to true airspeed) instead of rotation speed in the above equation.

Discuss trainee performance during pilotage exercises, simulated emergencies, possible effects of hypoxia/fatigue. Discuss the causes of any errors that were made, how they were detected and how they were corrected. If the pilot had more difficulty than usual in dealing with problems, it might have been due to mild hypoxia and is an indicator that oxygen should be used on future flights at these altitudes.

Review aircraft performance obtained during flight in up and downdrafts. Note that changes in airspeed needed to maintain level flight can be used as indicators of the presence of up and downdrafts. Deviation from expected performance is often the first sign of a problem of some kind.

Discuss use of available lift for increased climb performance. Note how much less time is needed for a climb to search or enroute altitude if available lift is used, or if sink is avoided.

Review the operations conducted at the unfamiliar airport. Note altimeter errors recorded. This is a reminder that flying by indicated MSL may not provide the desired AGL altitudes desired if a local altimeter setting is not available. Compare the recorded takeoff and landing distances to pre-flight estimates. This provides a good metric for judging the merit of other POH calculations.

Fill out the Flying Gradesheet for maneuvers performed in this sortie. Mark an "S" for satisfactory performance, "T" or more training required, and "U" for unsatisfactory performance. The grade of "T" should be used when performance is marginally acceptable or the trainee shows signs of improvement but is not yet proficient. "U" should be used when the trainee is experiencing considerable difficulty and maneuvers are deemed unsafe or unacceptable.

The check pilot should endorse the trainee's records to show completion of this sortie.

MOUNTAIN FURY
SORTIE NUMBER THREE
OUTLINE/DATA RECORDING FORM

PILOT ____

CHECK PILOT ___________________________________

Check Pilot Number _________

Date of Sortie _______________ **Aircraft Type** __________

Location ___________________ **Second Airport** ___________________

Preflight Preparation

Verify the following have been performed, and data entered on recording form.

Discuss and review as necessary:

- ❒ Weight and balance
- ❒ Airspeed calculations
- ❒ Weather briefing
- ❒ Preflight briefing
  - ❒ Safety, including personal matrix, survival equipment and clothing
  - ❒ Weather, including clouds, winds, temperatures and turbulence
  - ❒ Flight plan, discussed and filed
  - ❒ Aircraft preflight — discuss non-standard equipment, oxygen, inop equipment
  - ❒ Aircraft performance — discuss and fill in recording form with performance predictions
  - ❒ Safety inspection form — verify completed

Fill in the blanks before the flight

Weights:

Aircraft Basic Empty Weight	__________
Trainee	__________
Instructor	__________
Instructor's Equipment	__________
Other Items in Aircraft	__________
Fuel Load	__________
Gross Weight	__________
Maximum Gross Weight	__________
Empty CG	__________
CG as Loaded	__________
Within CG/Weight limits (Y/N)?	__________
CG in Forward 30% of Range (higher stall speed)?	__________
Percent Difference from Max Gross Weight	__________

Departure Airport: Short-field Technique:	ground run	over 50' obstacle
Expected takeoff distance:	_________	_________
Expected landing distance:	_________	_________

Secondary airport: short field technique:	ground run	over 50' obstacle
Expected takeoff distance:	_________	_________
Expected landing distance:	_________	_________

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Airspeeds for max gross weight:

	------ density altitude ------				
	sea level	6,000'	8000'	10,000'	12,000'
Vx	_______	_______	_______	_______	_______
Vy	_______	_______	_______	_______	_______
Vy ROC from POH	_______	_______	_______	_______	_______

Stall speed flaps up, KCAS _______
Stall speed, search configuration (flaps), KCAS _______
Stall speed, search config, 45° bank ↳ x 1.2 = _______
Stall speed, search config, 60° bank ↳ x 1.4 = _______
canyon turn entry airspeed KCAS ↳ + 10 = ______
canyon turn entry airspeed KIAS (use table in POH/AFM) ______

Va _______
Best Glide _______

For actual takeoff weight, reduce airspeeds above by 1/2 the percent difference from max gross weight):

	------ density altitude ------				
	sea level	6,000'	8000'	10,000'	12,000'
Vx	_______	_______	_______	_______	_______
Vy	_______	_______	_______	_______	_______

Search ceiling (altitude for 300 fpm ROC): _______
Stall speed flaps up, KCAS _______
Stall speed, search configuration (weight, flaps), KCAS _______
Stall speed, search config, 45° bank ↳ x 1.2 = _______
Stall speed, search config, 60° bank ↳ x 1.4 = _______
Canyon turn entry airspeed KCAS ↳ + 10 = ______
canyon turn entry airspeed KIAS (use table in POH/AFM) ______

Va _______
Best glide _______

From Winds Aloft Forecast (FD)	3000'	6000'	9000'	12000'
Wind/Temperature	_______	_______	_______	_______
density altitude (calculate)	_______	_______	_______	_______

Altimeter setting _______
Field elevation _______
Temperature _______
Density Altitude _______

Calculate turn diameters at search airspeed: (DA = density altitude, results are in feet)
45° bank at sea level: (Airspeed (KIAS) ^{2}/11.26) x 2 = _______
30° bank at sea level: 45° bank distance x 1.75: ↳ x 1.75 = _______
60° bank at sea level: 45° bank distance x 0.6: ↳ x 0.6 = _______

45° bank at search altitude: (increases by 2% per 1000 feet Density Altitude above sea level)
((Airspeed (KIAS) x (1 + (.02 x DA in K feet)) ^{2}/11.26) x 2 = _______
30° bank at search altitude: 45° bank distance x 1.75: ↳ x 1.75 = _______
60° bank at search altitude: 45° bank distance x 0.6: ↳ x 0.6 = _______

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Total time flown on this sortie: _______

FLYING THE SORTIE
(Fill in the blanks in-flight)

Takeoffs and Landings

Perform at least 3 takeoffs and landings, including:

- ❒ Short field takeoffs/landing. Estimate and record distance over 50 foot obstacle:
  takeoff: _______ landing: _______
- ❒ Soft field takeoff/landing. Estimate and record distance over 50 foot obstacle:
  takeoff: _______ landing: _______
- ❒ Power off approach/landing. Estimate and record distance over 50 foot obstacle:
  ____

Terrain Navigation

Climb to an altitude that is at least 2000 AGL for the route to the practice search area.
While enroute and on reaching the grid, attempt to determine position with pilotage, dead reckoning, and each piece of navigation equipment.
Simulate (verbally) several equipment failures or emergencies.
Present weather problems and discuss methods of handling them.

Maneuvering Review

- ❒ Climb to an altitude that is at least 3000 AGL, at a position well away from terrain
- ❒ Practice turns at 30° and 45° of bank angle at search airspeed
- ❒ Practice emergency canyon turn and/or modified wing over

Updraft/downdraft locations and magnitudes

- ❒ Establish level flight in stable air (away from areas of up and downdrafts) at search airspeed (~85 KIAS or Vy + 10, whichever is higher) with flaps at search setting (10-25°). Record power setting: _______
- ❒ Locate a valley or canyon with an axis perpendicular to the prevailing wind. Have the pilot point out expected areas of up and downdrafts (windward/leeward slopes, bright/dark slopes).
- ❒ Fly parallel to the leeward side of a ridge into a downdraft area. Maintain airspeed and power setting, allowing aircraft to change altitude. Record rate of descent:
  ____
- ❒ Fly out of downdraft area, climb back to starting altitude and return to the leeward side of the ridge. Maintain altitude and power setting. Note change in airspeed and pitch resulting from climb against the downdraft. Record airspeed: _______
- ❒ Apply full power, transition to Vy for the aircraft weight/density altitude. Record the rate of climb: _______
- ❒ Fly away from the ridge and out of the downdraft. Climb back to the original altitude and fly to the windward side of a ridge.
- ❒ Slow to search speed as above, and set the power to what it was in the first step of this section. Maintain airspeed and power setting, allowing aircraft to change altitude. Record rate of climb: _______
- ❒ Fly out of updraft area, descend to starting altitude and return to the windward side of the ridge. Maintain altitude and power setting. Note change in airspeed and

pitch resulting from dive against the updraft. Record airspeed: _______

- ❐ Apply full power, transition to Vy for the aircraft weight/density altitude. Record the rate of climb: _______

High - Altitude/Unfamiliar Field Approach and Landing

- ❐ Proceed to the another high altitude airport. Over-fly at least 1000 AGL from highest obstacle, in rectangular pattern.
- ❐ Note wind conditions, approach and departure obstacles, condition of runway, best approach path.
- ❐ Proceed to downwind leg for landing. Adjust mixture for best power for a go-around. Test climb performance with a full-power climb. If sustained ROC is < 300 fpm, do not land.
- ❐ Call pilot's attention to need for wider landing pattern/higher rate of descent due to higher true airspeed due to high density altitude.
- ❐ Perform normal landing. After clearing runway, record altimeter reading: _______ Record difference from known field elevation: _______ Reset altimeter to field elevation.

High - Altitude/Unfamiliar Field Takeoff

- ❐ If runway has visible slope, taxi to each end of runway. Record altimeter readings: departure end: _______ approach end: _______ Difference: _______
- ❐ Calculate percent runway slope: (difference/runway length) x 100
Example: (80' difference/2000' runway) x 100 = 4% slope: _______
- ❐ Determine takeoff distance taking into account slope, wind, and obstructions.
- ❐ Prior to takeoff, lean mixture and perform full power run-up (as per POH).
- ❐ Recalculate takeoff distance for current conditions: _______
- ❐ Allow 100 percent margin for required distance. Identify abort, takeoff and 50' markers along runway.
- ❐ Review airspeeds for: rotation, Vx, and Vy.
- ❐ Perform short field takeoff. Record distance (or time) past markers for:
takeoff roll: _______
distance to 50' altitude: _______
- ❐ If time permits, practice soft field takeoff/landing.
- ❐ Return to base.

Postflight Debrief

- ❐ Compare actual distances obtained for takeoff/landing to predicted distances.
- ❐ Discuss performance during pilotage exercises, simulated emergencies, possible effects of hypoxia/fatigue.
- ❐ Review aircraft performance obtained during flight in up and downdrafts. Note changes in airspeed to maintain level flight as indicators of the presence of up/downdrafts.
- ❐ Discuss use of available lift for increased climb performance.

- ❐ Review operations at second airport. Note altimeter errors recorded. Compare actual takeoff/landing distances to pre-flight estimates.
- ❐ Complete applicable portions of Flying Grade Sheet

NOTES:

Mountain Fury
Mountain Search Flying
Course Syllabus

Fourth Sortie : High Altitude Search

Objectives

1. Develop trainee's proficiency in planning and execution of mountain search sorties.
2. Develop trainee's ability in mountain pilotage, dead reckoning and use of navigation equipment.
3. Enhance trainee's awareness of safety in search operations.

Timeline

The trainee should expect to spend at least one hour in preflight planning for this sortie prior to meeting with the instructor. The trainee and instructor should plan on an additional hour of discussions and briefing prior to the commencement of the flight. Sortie four will require one and one half to two hours of flight time. Finally, a debrief and completion of paperwork will require one additional hour.

Detailed Description of Fourth Sortie

Preflight Preparation

Every search sortie requires preparation if it is to be flown safely and efficiently. Standard search sortie preparation should be completed including use of planning forms and mission flight plans before beginning the flying part of this sortie. In addition, since this is a training flight, the information required on the outline/data form should also be filled in prior to flight so that the trainee will have a thorough understanding of the conditions and expected aircraft performance. The trainee should complete as many of these planning tasks as possible prior to meeting with the instructor pilot so that the sortie can be accomplished as expeditiously as possible.

Obtain the following information from the instructor pilot and enter it on the outline/data form:

- The instructor's weight and the weight of his/her personal equipment (and that of any other crew members);
- The location or locations in which the sortie will be flown.

Weight and Balance

Obtain data on the aircraft needed to complete a weight and balance computation. Perform a weight and balance calculation including planned fuel load, weights of the trainee and instructor (and any other crewmembers) and their personal equipment. Enter the gross weight, CG, maximum allowable gross weight and percent difference of the operating weight from maximum gross weight on the outline/data form. Note that a forward CG position produces a higher stall speed. This should be considered in calculating stall speeds below.

Airspeed and performance calculations

Calculate critical airspeeds from the airport elevation through the highest altitude expected to be flown on this sortie and fill these in on the outline/data form. These include Vx, Vy, Va, stall speeds for flaps up and normal search configuration (typically 10° to 25° of flap), best glide speed, and stall speeds in a 45° and 60° bank turn. Determine from the POH the density altitude at which the aircraft will climb at 300 feet per minute. This is the search ceiling. Record this information on the outline/recording form.

Note: When calculating canyon turn diameter and entry speed, CALIBRATED stall speed must be used. The resulting entry speed in calibrated airspeed must be converted into INDICATED airspeed for use in flight. For most aircraft used by CAP, the difference between calibrated airspeed and indicated airspeed at stall speed is fairly large, but at the canyon turn entry airspeed it is very small. If INDICATED stall speed is used for the calculations, the calculated canyon turn entry speed will be about 15 knots too slow.

Weather Briefing

Obtain a standard briefing for the area in which the sortie will be flown. A DUAT briefing is preferred as it assures that all available weather information is obtained. Print out the briefing or record information from the briefing form on the outline/data form so that the briefing and conditions may be discussed with the instructor pilot. Prepare and file a flight plan (or mission flight plan) for the sortie.

Airport Information:

Since this sortie will be flown from a high altitude airport or search base it is likely that the trainee will not be familiar with the airport. The AFD or other reference should be used to gather information on runway lengths, elevation (at each end), slope, obstructions, and approach and departure patterns. Actual or forecast temperatures should be obtained or estimated and density altitudes should be calculated. Record this information on the outline/data recording form.

Preflight Briefing

Safety. Safety is of paramount concern to everyone. If weather at the time of the sortie is of any concern, postpone the sortie for another day. Complete the CAP personal safety matrix prior to the flight. Once again, if the score is high and unacceptable, postpone the flight for another day.

This sortie will be flown as if it were an actual mountain search flight. An altitude of at least 2,000 feet AGL is suggested for flight enroute and the initial grid survey. Use a minimum of 1,000 feet AGL while searching.

Verify that appropriate survival equipment is on board and that all crewmembers have clothing suitable to spend the night in the open if an off-airport landing occurs. Note wind chill factors and expected night time temperatures. Carriage of sleeping bags and some form of shelter (tarp or tent) is highly recommended for flight operations in mountainous areas.

Weather. The trainee should provide the instructor with his/her personal assessment of the weather conditions based on the contents of a standard weather briefing . Specific items needed include forecast clouds and weather, winds and temperatures aloft, and the presence of turbulence. The instructor should obtain an independent briefing so that the trainee's assessment can be evaluated.

Flight Plan. The trainee should review the mission flight plan with the instructor, and review route and airport departure procedures.

Aircraft Preflight. If possible, the preflight inspection should be performed in the presence of the instructor. Any non-standard equipment (radios, oxygen, survival gear) should be should be discussed to ensure familiarity of both pilots with that equipment. Any inoperative equipment should be identified and assessed as to whether it is required for the flight. Review the weight and balance calculations performed by the trainee and verify that the aircraft is loaded within limits.

Aircraft Performance. Discuss power settings, maximum rates of climb (and associated airspeeds) estimated takeoff distance and takeoff abort point. The instructor should review the preflight data entered by the trainee on the outline/data form. Verify that the density altitude expected in the practice search area will be at or below the search ceiling for the aircraft. If flight above 10,000 feet is planned, oxygen should be available and used by the crew.

Discuss turn effects of bank angle, airspeed and altitude on turn performance.

Plan the sortie using the Sortie Briefing Checklist and Mission Sortie Planning Sheet (included in the Mountain Fury Course materials).

Complete a CAP safety inspection form for the aircraft.

Takeoffs and Enroute

Note points along the runway that correspond to the distance required for ground roll and 50 foot obstacle clearance height, as well as an abort point before beginning the takeoff run. Note the actual takeoff point and 50 foot heights during the takeoff. These provide confirmation that expected aircraft performance is being obtained.

Record the time off and all other information usually recorded during a search sortie.

A safe altitude should be used while flying to and from the assigned grid. Use an altitude that is at least 2000' AGL.

The enroute portion of the flight is a good time to practice navigation skills. The trainee should continuously monitor position with pilotage and dead reckoning. Electronic navaids should also be used to verify position and correct function of this equipment.

Identifying the Grid Area

Every grid search sortie should begin with a survey of the grid to verify visual landmarks for the corners and to assess current weather conditions. Find the corners of the search area through pilotage (using sectional or topographic charts) and verify position with navigation equipment. Visual references should be primary, as their use allows the pilot to look outside and avoid terrain as opposed to being head down in the cockpit looking at an instrument display.

Look for the presence of wind, turbulence, or weather factors that could effect the safe and efficient search of the grid. It is far better to be aware of wind and turbulence at 2000' above the highest point in the grid than it is to first discover adverse conditions while down in the valleys and canyons of the grid. If there are significant safety concerns, modify the planned search or discontinue the flight as necessary.

Check aircraft performance with climb at Vy adjusted for weight and altitude: Record rate of climb. If the climb performance is not at least 300 feet per minute, the aircraft is above its search ceiling and search operations should not be conducted in that area. If there are any doubts about the capability of the aircraft to safely search in this area, return to the mission base.

It's useful to verify that pilot performance is up to the task as well, before flying in close proximity to terrain. A little practice will also increase pilot proficiency and hence increase safety. Move to a position that is well away from high terrain. Practice turns at 30°, 45° and the emergency canyon turn technique.

Searching in the grid area

Search the grid in accordance with normal mountain search procedures. This would normally include searching the highest terrain first. Climb to at least 1000' above highest terrain in the grid before beginning the search.

Search the grid in accordance with the pre-flight plan or any modifications made to the plan during the grid survey.

Demonstrate and practice various methods of searching consistent with terrain. This would include contour search, drainage and canyon search, ridge search and flat-land methods such as creeping line and expanding square. Use methods appropriate to the local terrain.

Proper airspeed and altitude should be maintained. The recommended search speed for the aircraft should be used, and minimum altitudes maintained. Typical search speed is 80-85 KIAS with 10-25° of flap, with minimum altitudes of 500' to 1000' AGL depending on the location and local Wing regulations. Flight that is "low and slow" does not produce the best probability of detection even though it may be tempting to get closer to a possible target. POD will not increase, but risk will be higher.

It is primarily the search pilot's responsibility to record the area's searched, but the observer may perform this function to aid the pilot. The observer may perform other tasks as well. The responsibilities and expectations of each crew member should be discussed so that no critical tasks are missed. The primary job of the pilot is to fly the aircraft. All other tasks are secondary. The observer's and scanner's primary job is to search visually. It's critical that the pilot does not become an observer leaving no one flying the airplane.

Discuss scanning procedures applicable to terrain in the grid. The trainee should know which scanning procedures are applicable to each type of terrain so that the aircraft can be positioned for effective search.

It is extremely important that the search pilot be able to recognize significant winds aloft as they are indicators of possible turbulence and other risk factors. The pilot should calculate the actual winds aloft by timing flight from one side of grid to the other and estimate crosswind by observing the crab angle. At 100 knots ground Speed, each 6° of crab angle is equal to 10 knots of crosswind component. Calculate the winds aloft and record them on the outline/data form. Then verify these values by using electronic navigation aids such as GPS, LORAN or DME.

Record the velocity and direction of the wind.

Optional Tasks

If a practice ELT is available and time and logistics permit, a practice ELT search should be performed. Discuss techniques and strategy though in the preflight briefing.

If an aircrew locates a possible target, ground crews may be called in to make a positive ID of the object. In such cases, air crews may need to communicate with ground crew members to direct them to the target site. If time and logistics permit, air-ground coordination should be practiced with CAP vehicles/ground team members. This should include radio communication and visual signals.

Return to Base

The sortie is not over until the aircraft safely returns to base. Record the time of leaving the grid. Proceed back to the search base via the planned route and at an altitude of at least 2000' AGL. Record the landing time.

Postflight Debrief

Even a perfectly flown sortie has no value if the information obtained is not passed on to base personnel. Debrief the flight with operations including completing mission paperwork. After this the trainee and instructor should discuss the flight to maximize the learning value of the flight.

Discuss with the pilot and crew what they did and how they may improve performance. Observations from each crewmember should be sought for their perceptions and insights.

Review actual aircraft performance versus predicted performance. Any differences will be valuable in making improved performance predictions on future search flights.

Discuss winds or turbulence encountered, and any weather or other factors that effected the flight. Unexpected turbulence, downdrafts or wind shear should be reviewed so that its source can be recognized in advance on future flights.

Fill out the Flying Grade Sheet for maneuvers performed in this sortie. Mark an "S" for satisfactory performance, "T" or more training required, and "U" for unsatisfactory performance. The grade of "T" should be used when performance is marginally acceptable or the trainee shows signs of improvement but is not yet proficient. "U" should be used when the trainee is experiencing considerable difficulty and maneuvers are deemed unsafe or unacceptable. The check pilot should endorse the trainee's records to show completion of this sortie.

MOUNTAIN FURY
SORTIE NUMBER FOUR
OUTLINE/DATA RECORDING FORM

PILOT ____

CHECK PILOT ____

Check Pilot Number ________

Date of Sortie ______________ **Aircraft Type** _________

Location __________________

Preflight Preparation

Verify the following have been performed, and data entered on recording form. Discuss and review as necessary:

- ❒ Weight and balance
- ❒ Airspeed calculations
- ❒ Weather briefing
- ❒ Preflight briefing
  - ❒ Safety, including personal matrix, survival equipment and clothing
  - ❒ Weather, including clouds, winds, temperatures and turbulence
  - ❒ Flight plan, discussed and filed
  - ❒ Aircraft preflight — discuss non-standard equipment, oxygen, inop equipment
  - ❒ Aircraft performance — discuss and fill in recording form with performance predictions
  - ❒ Safety inspection form — verify completed

Fill in the blanks before the flight

Weights:

Aircraft Basic Empty Weight	__________
Trainee	__________
Trainee's Equipment	__________
Instructor	__________
Instructor's Equipment	__________
Other Items in Aircraft	__________
Fuel Load	__________
Gross Weight	__________
Maximum Gross Weight	__________
Empty CG	__________
CG as Loaded	__________
Within CG/Weight limits (Y/N)?	__________
CG in Forward 30% of range (higher stall speed) ?	__________
Percent Difference from Max Gross Weight	__________

Short-field technique:	ground run	over 50' obstacle
Expected takeoff distance:	_________	_________
Expected landing distance:	_________	_________

Airspeeds:

For max gross weight:

	density altitude				
	sea level	6,000’	8000’	10,000’	12,000’
Vx	_______	_______	_______	_______	_______
Vy	_______	_______	_______	_______	_______
Vy ROC from POH	_______	_______	_______	_______	_______

Stall speed flaps up, KCAS _______

Stall speed, search configuration (flaps), KCAS _______

Stall speed, search config, 45° bank ↳ x 1.2 = _______

Stall speed, search config, 60° bank ↳ x 1.4 = _______

Canyon turn entry airspeed KCAS ↳ + 10 = ______

Canyon turn entry airspeed KIAS (use table in POH/AFM) ______

Va _______

Best glide _______

For actual takeoff weight, reduce airspeeds above by 1/2 the percent difference from max gross weight):

	density altitude				
	sea level	6,000’	8000’	10,000’	12,000’
Vx	_______	_______	_______	_______	_______
Vy	_______	_______	_______	_______	_______

Search ceiling (altitude for 300 fpm ROC): _______

Stall speed flaps up, KCAS _______

Stall speed, search configuration (weight, flaps), KCAS _______

Stall speed, search config, 45° bank ↳ x 1.2 = _______

Stall speed, search config, 60° bank ↳ x 1.4 = _______

Canyon turn entry airspeed KCAS ↳ + 10 = ______

Canyon turn entry airspeed KIAS (use table in POH/AFM) ______

Va _______

Best glide _______

From Winds Aloft Forecast (FD)	3000’	6000’	9000’	12000’
Wind/Temperature	_______	_______	_______	_______
Density Altitude (calculate)	_______	_______	_______	_______

Altimeter setting _______

Field elevation _______

Temperature _______

Density Altitude _______

Search ceiling (pressure altitude with climb of 300 fpm): _______

Total time flown on this sortie: _______

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FLYING THE SORTIE
(Fill in the blanks in-flight)

Takeoff and Enroute

- ❒Note expected takeoff points and abort point and find visual markers alongside the runway. Note actual versus expected takeoff points and 50' heights.
- ❒Record time off: _______
- ❒Climb to an altitude that is at least 2000 AGL for the route to the practice search area.
- ❒While enroute and on reaching the grid, attempt to determine position with pilotage, dead reckoning, and each piece of navigation equipment.
- ❒Record time entering grid: _______

Identifying the Grid Area

- ❒Find the corners of the search area through pilotage (using sectional or topographic chart) and verify position with navigation equipment.
- ❒Observe presence of wind, turbulence, or weather factors that could effect the safe and efficient search of the grid. If there are significant safety concerns, modify the planned search or discontinue the flight as necessary.
- ❒Check aircraft performance with climb at Vy adjusted for weight and altitude: Record rate of climb: _______
- ❒Move to a position well away from high terrain. Practice turns at 30°, 45° and emergency canyon turn technique.

Searching in the grid area

- ❒Climb to at least 1000' above highest terrain in the grid.
- ❒Begin searching the grid in accordance with the pre-flight plan or in-flight amended plan.
- ❒Demonstrate and practice various methods of searching consistent with terrain.
- ❒Emphasize that "low and slow" does not produce the best POD
- ❒Review procedures for tracking route and helping pilot.
- ❒Discuss scanning procedures applicable to terrain in the grid.
- ❒Emphasize crew responsibilities: pilot flies, observer and scanners scan.
- ❒Calculate winds aloft by timing flight from one side of grid to the other and estimating crosswind with crab angle: Record estimated wind: _______
- ❒Verify winds aloft with electronic navaids. Record wind: _______

Optional Tasks

- ❒Practice ELT search in mountainous area.
- ❒Air-ground coordination exercise with CAP vehicles/ground team members.

Return to Base

- ❐ Record time leaving grid: _______
- ❐ Record landing time: _______

Postflight Debrief

- ❐ Debrief with operations including completing mission paperwork.
- ❐ Discuss with pilot and crew what they did and how they may improve performance.
- ❐ Review actual aircraft performance versus predicted performance.
- ❐ Discuss winds or turbulence encountered, any weather or other factors that effected the flight.
- ❐ Instructor Pilot: endorse trainee's records and completion certificate