Air Trek North

Multi Engine Add-On
Ground Material

Definitions

- • **VR – Rotation speed. The speed at which back** pressure is applied to rotate the airplane to a takeoff attitude.
- • **VLOF – Lift-off speed. The speed at which the** airplane leaves the surface. (Note: some manufacturers reference takeoff performance data to VR, others to VLOF.)
- • **VX – Best angle of climb speed. The speed at** which the airplane will gain the greatest altitude for a given distance of forward travel.
- • **VXSE – Best angle-of-climb speed with one** engine inoperative.
- • **VY – Best rate of climb speed. The speed at** which the airplane will gain the most altitude for a given unit of time.
- • **VYSE – Best rate-of-climb speed with one engine** inoperative. Marked with a blue radial line on most airspeed indicators. Above the single-engine absolute ceiling, VYSE yields the minimum rate of sink.
- • **VSSE – Safe, intentional one-engine-inoperative** speed. Originally known as safe single-engine speed. It is the minimum speed to intentionally render the critical engine inoperative.
- • **VMC – Minimum control speed with the critical** engine inoperative. Marked with a red radial line on most airspeed indicators. The minimum speed at which directional control can be maintained under a very specific set of circumstances outlined in 14 CFR part 23, Airworthiness Standards. Under the small airplane certification regulations currently in effect, the flight test pilot must be able to (1) stop the turn that results when the critical engine is suddenly made inoperative within 20° of the original heading, using maximum rudder deflection and a maximum of 5° bank, and (2) thereafter, maintain straight flight with not more than a 5° bank. There is no requirement in this determination that the airplane be capable of climbing at this airspeed. VMC only addresses directional control. Further discussion of VMC as determined during airplane certification and demonstrated in pilot training follows in minimum control airspeed (VMC) demonstration. [Figure 12-1]

Propeller Basics

- Featherable
- Increased oil pressure decreases pitch (low pitch)
- Loss of oil pressure puts propeller to full feather. 81deg for BE-76.
- A windmilling propeller at low pitch is like a disk, providing extremely high drag possibly making operation uncontrollable due to the high drag.

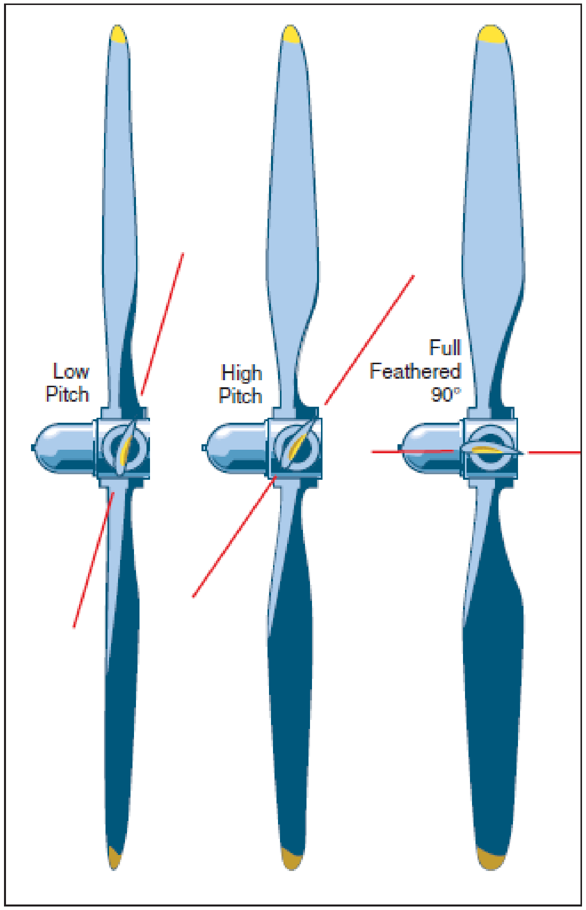


Figure 12-2. Feathered propeller.

Propeller Basics

- Full Feathering
- Counterweighted
- Oil Pressure to Decrease Pitch
- A constant Supply of Oil Keeps the Propeller from Feathering
- Enables the Propeller to Feather if Oil Pressure is Lost or a Propeller Governor fails.

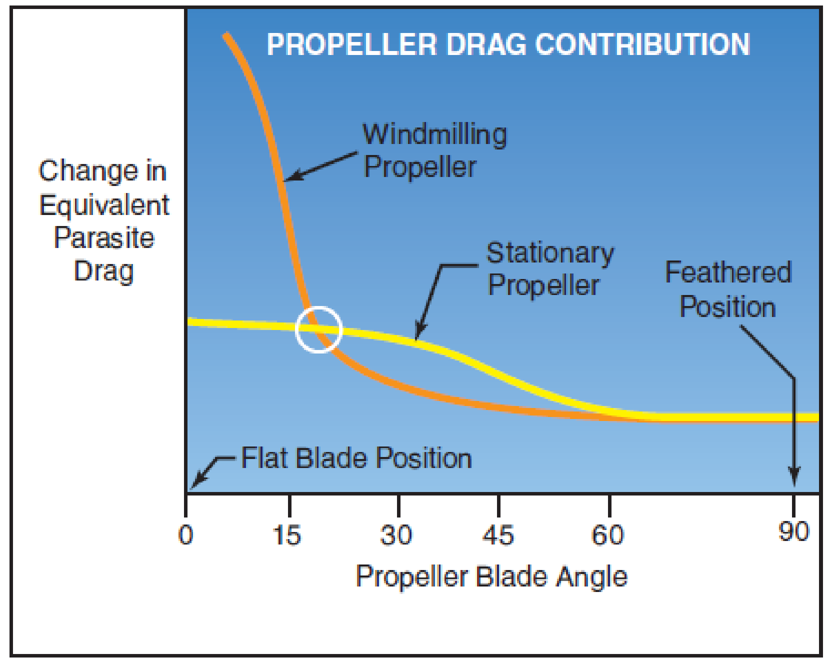
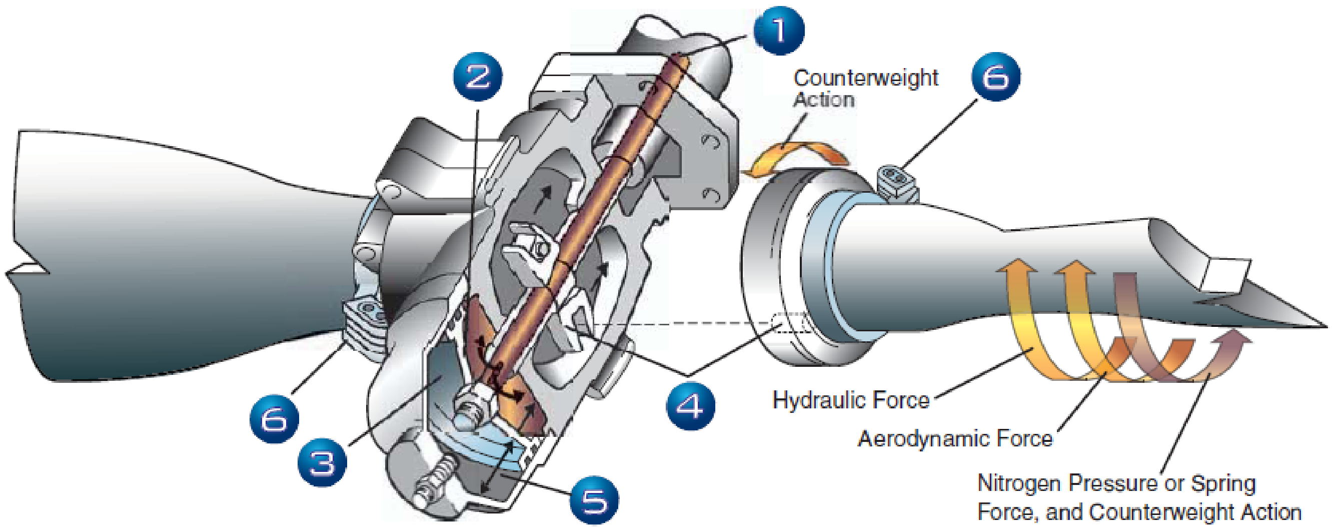


Figure 12-3. Propeller drag contribution.

Propeller Hub



1. High-pressure oil enters the cylinder through the center of the propeller shaft and piston rod. The propeller control regulates the flow of high-pressure oil from a governor.
2. A hydraulic piston in the hub of the propeller is connected to each blade by a piston rod. This rod is attached to forks that slide over the pitch-change pin mounted in the root of each blade.
3. The oil pressure moves the piston toward the front of the cylinder, moving the piston rod and forks forward.
4. The forks push the pitch-change pin of each blade toward the front of the hub, causing the blades to twist toward the low-pitch position.
5. A nitrogen pressure charge or mechanical spring in the front of the hub opposes the oil pressure, and causes the propeller to move toward high-pitch.
6. Counterweights also cause the blades to move toward the high-pitch and feather positions. The counter-weights counteract the aerodynamic twisting force that tries to move the blades toward a low-pitch angle.

Propeller Basics

- What Drives to High Pitch (Low or Zero RPM)
  - Counterweights
  - Spring and Nitrogen Charge
  - Lack of Oil Pressure against the Spring and Nitrogen Charge
- What Drives to Low Pitch (high RPM)
  - Aerodynamic Forces (wind)
  - Oil Pressure
  - Unfeathering Pins Activate on Shutdown approximately 800RPM

BE-76 Propeller Info

- Hartzell constant speed propeller – 2-bladed aluminum alloy
- HC-M2YR-2CEUF/FC7666A (Left)
- HC-M2YR-2CLEUF/FJC7666A (Right)
- Woodward hydraulic governor (L210650) and (R210652)
- Diameter: 76in Normal
- Minimum allowed for repair: 74in
- 2-Hartzell 76”-74”, counter-rotating, constant-speed props, full feathering
- Governors (sends oil pressure to/from the hub)
- Springs, dome pressure, counterweights send props to high-pitch, low-Rpm
- Oil Pressure is acting against spring and dome pressure to set low pitch/high RPM
- Underspeed (climb) – Flyweights in, pilot valve opens, oil into hub, sets low-pitch/Higher RPM
- Overspeed (descent) – Flyweights out, pilot valve closes, oil out of hub, Nitrogen and spring pushes back, high pitch/low RPM
- Feathered – Pilot valve opens, oil out of hub (spring, nitrogen, and flyweights), prop to highest pitch/low RPM to total stoppage
- Feather Stops – latches come out at approx. 800 RPM and below to prevent feathering on the ground
- Pitch Setting at 30in Station:
  - Low: 12.1O +/- 0.1O
  - High: 17O – 20O
  - Feather: 81O +/- 1O
- Hartzell spinner assembly C2285-3P and C2285-3PL
- Springs and dome pressure hold props in high pitch/low RPM
- Oil pressure holds props in low pitch/high RPM
- Underspeed (Climb)
  - Flyweights come in
  - Pilot valve opens
  - Oil pressure into hub
  - Slides on groves less pitch, higher rpm
- Overspeed (Descent)
  - Flyweights out
  - Pilot valve closes
  - Oil pressure returns to reservoir
  - Nitrogen, spring pushes back
  - Props move to higher pitch, lower RPM
- Feather
  - Pilot valve lets oil pressure drain
  - Spring, Nitrogen, Counterweights
  - Feather
  - Feathering latches
- Constant speed props
  - Pros: less wear, more efficient, increased performance and fuel efficiency
  - Cons: maintenance, cost, complexity

Un-feathering Accumulators

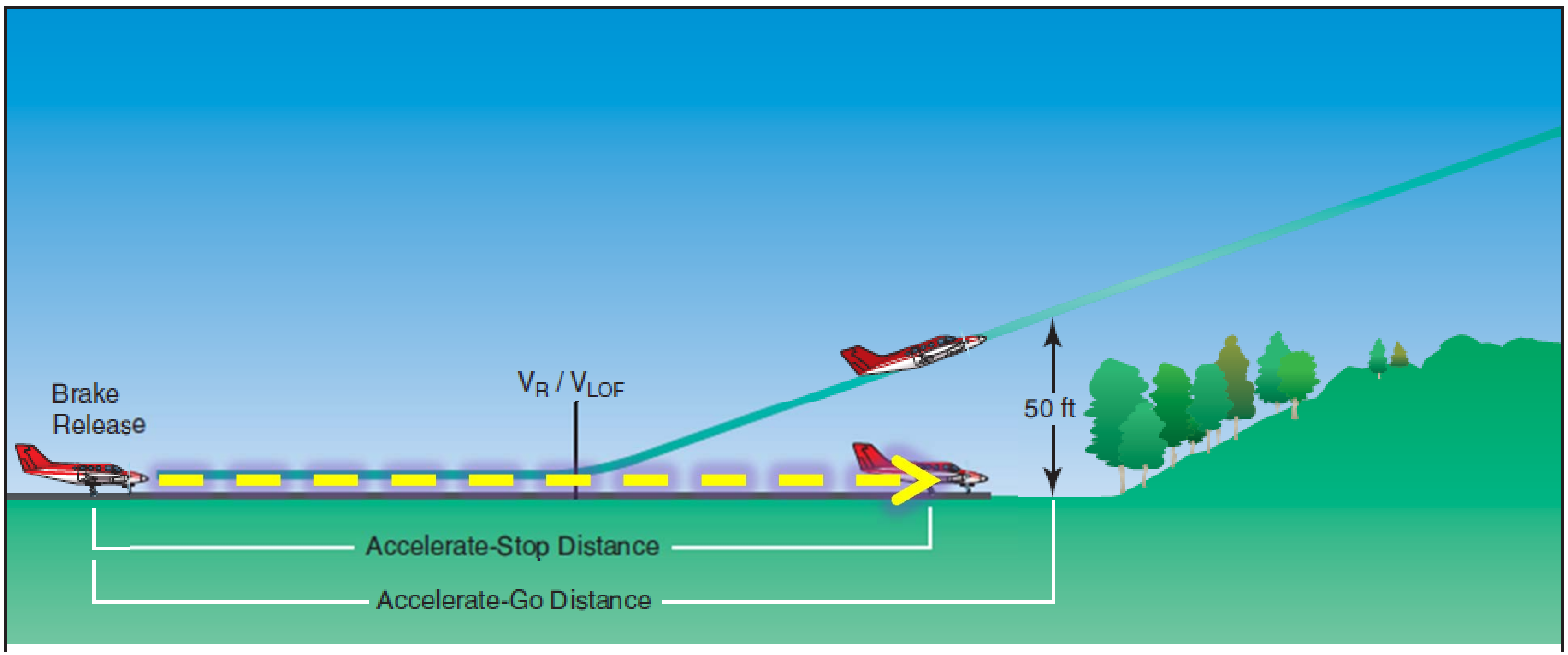
- Stores a reserve of high pressure to give us a one shot push out of feather, then airspeed against the lower pitch prop starts a windmill to start the engine
- The high pressure oil is helped by a spring and nitrogen charge
- If fuel and ignition are present, the engine will start.
- High Oil Pressure from the Governor recharges the Accumulator just moments after engine rotation begins.

Combustion Heater

- It is a small furnace in the nose that burns fuel from the right tank.
- Provides heat to the cabin and defrost to the windshield.
- Automatic over-temperature protection is provided. Cannot be reset from the cabin.
- A cool down period is required.
  - Blower is utilized if cool down is conducted during ground operations.

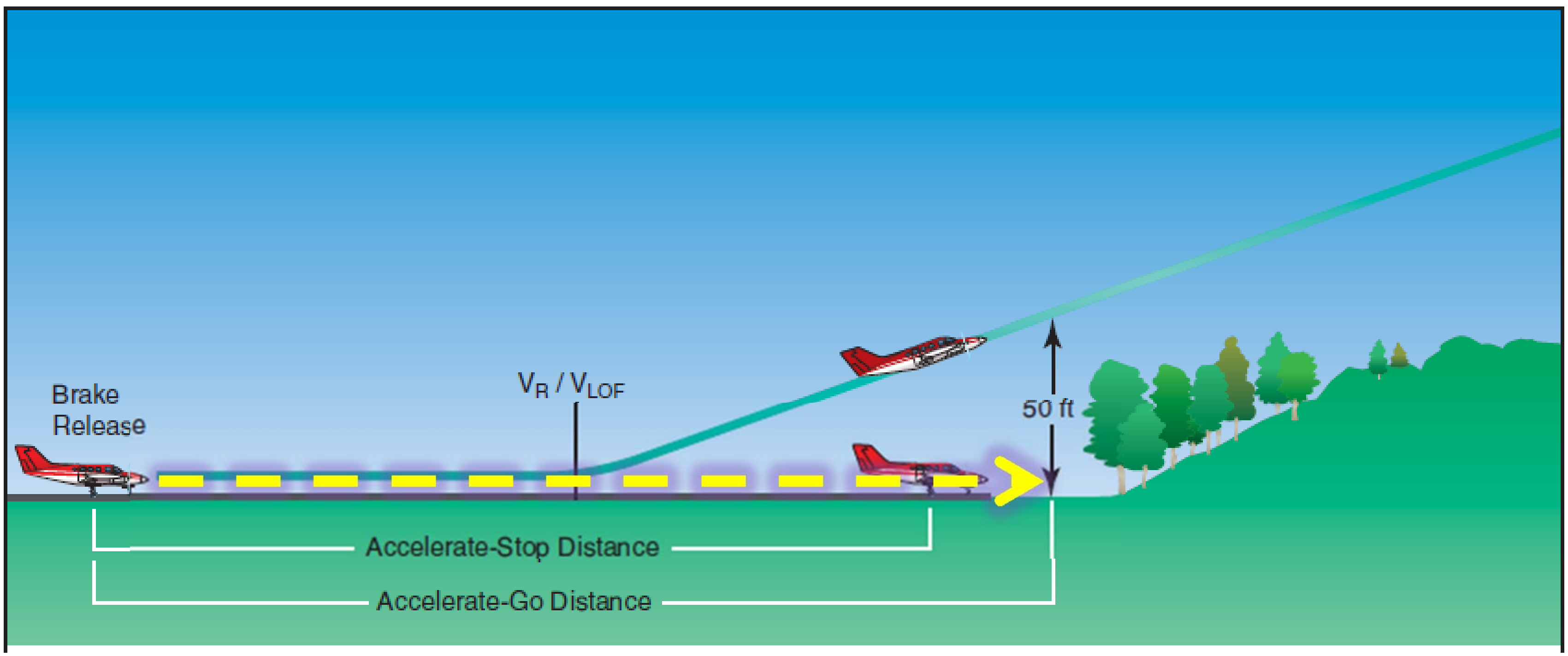
Accelerate-Stop Distance

is the runway length required to accelerate to a specified speed (either VR or VLOF, as specified by the manufacturer), experience an engine failure, and bring the airplane to a complete stop.



Accelerate-GO Distance

is the horizontal distance required to continue the takeoff and climb to 50 feet, assuming an engine failure at VR or VLOF, as specified by the manufacturer.



Climb Gradient

- is a slope most frequently expressed in terms of altitude gain per 100 feet of horizontal distance, whereupon it is stated as a percentage. A 1.5 percent climb gradient is an altitude gain of one and one-half feet per 100 feet of horizontal travel.
- Climb gradient may also be expressed as a function of altitude gain per nautical mile, or as a ratio of the horizontal distance to the vertical distance (50:1, for example).

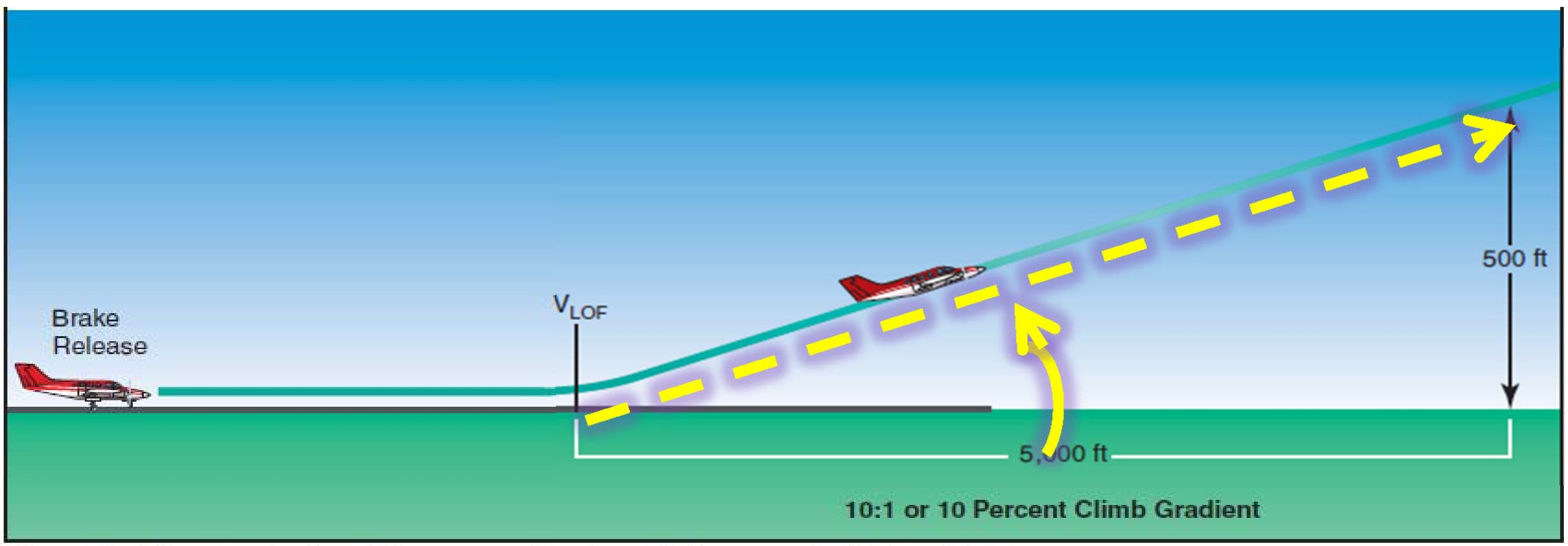


Figure 12-5. Accelerate-stop distance, accelerate-go distance, and climb gradient.

Service Ceiling

- **All-engine service ceiling of multiengine airplanes**
  - the highest altitude at which the airplane can maintain a steady rate of climb of 100 f.p.m. with both engines operating.
- **All-engine absolute ceiling**
  - climb is no longer possible.
- **Single-engine service ceiling**
  - can no longer maintain a 50 f.p.m. rate of climb with one engine inoperative.
- **Single-engine absolute ceiling**
  - climb is no longer possible.

- BE-76 Service Ceiling
  - Twin Engine: 19,600 @ 3900lbs
  - Single-Engine: 6,200 @ 3900lbs
  - Single-Engine: 10,300 @ 3400lbs

Engine Failure After Lift Off

- Regulations do not require that runway lengths be equal to or greater than acc-stop distances.
  - For safety, this should be a min runway length.
- the option of continuing the takeoff probably does not exist unless the published single-engine rate-of-climb performance is at least 100 to 200 f.p.m.

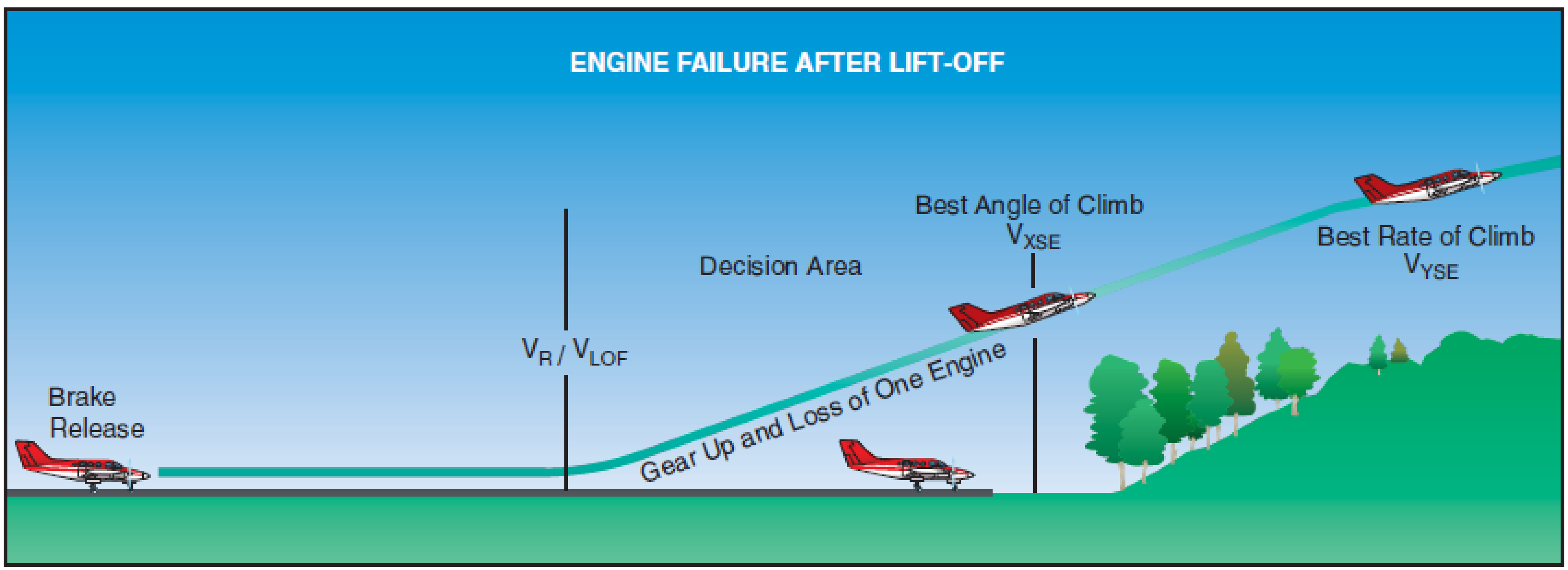


Figure 12-6. Area of decision.

Take Off and Climb Profile

- Use 1000ft instead of 500ft for Cruise Climb Profile Change for safety margin

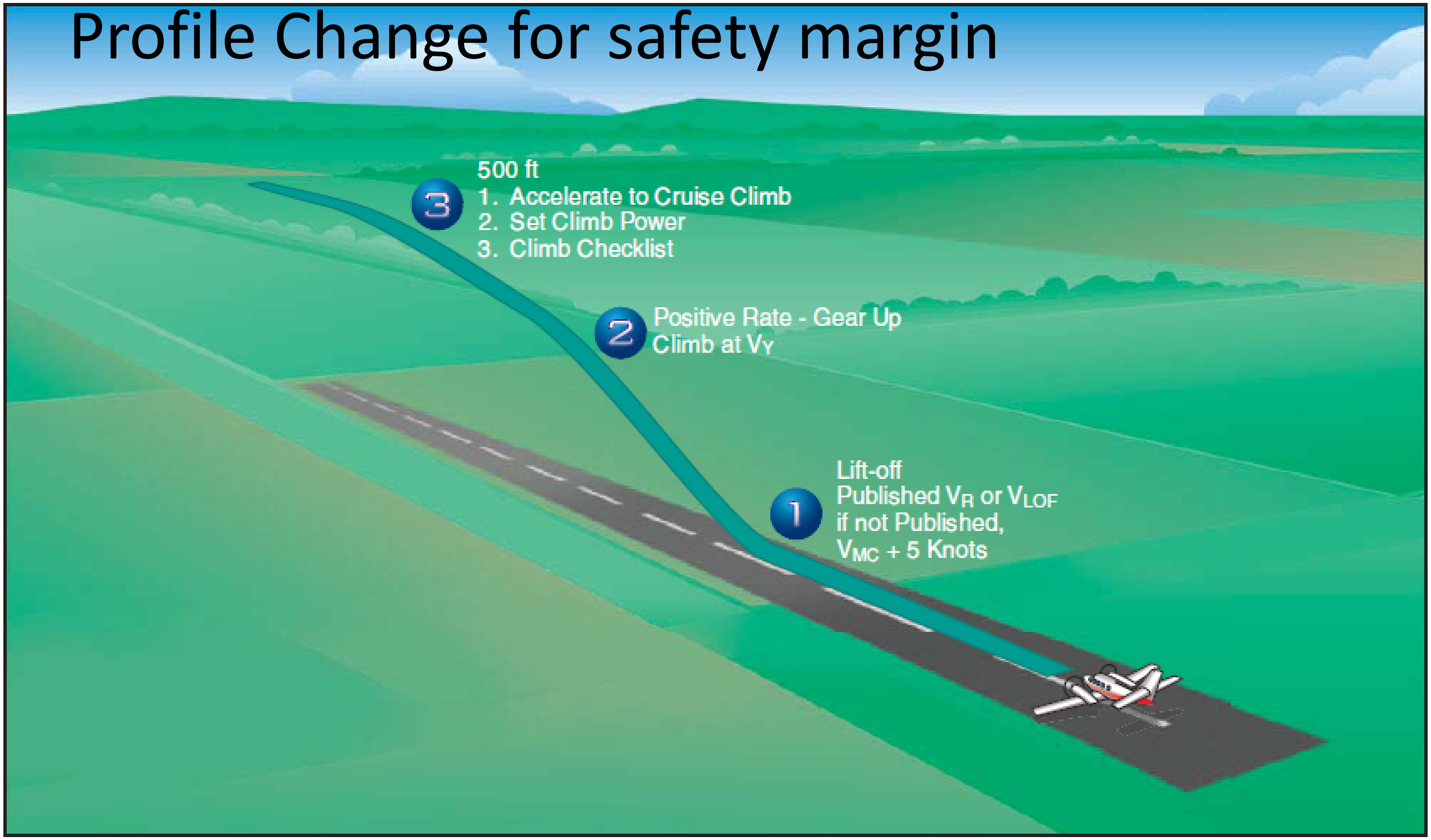


Figure 12-7. Takeoff and climb profile.

Approach & Landing Profile

- Full Stall Landings Should be Avoided.
- Except for short field landings, land with a slight amount of power and pull power to idle as mains touch the runway.

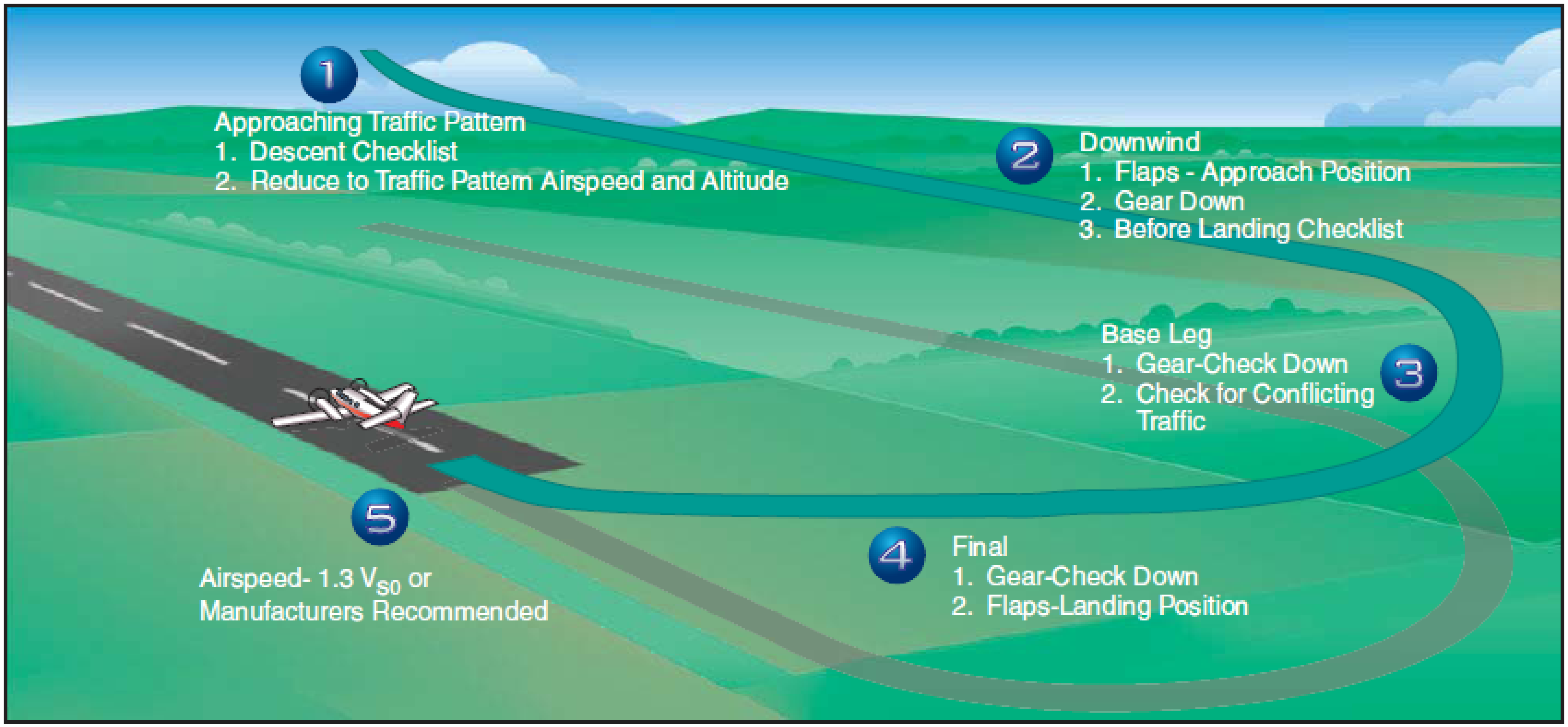


Figure 12-8. Normal two-engine approach and landing.

Short Field Take Off and Climb

- Similar to Single Engine
  - Power full with brakes on
  - Release brakes
  - Rotate at Vr
  - Climb at Vx until obstacle is clear, then Vy

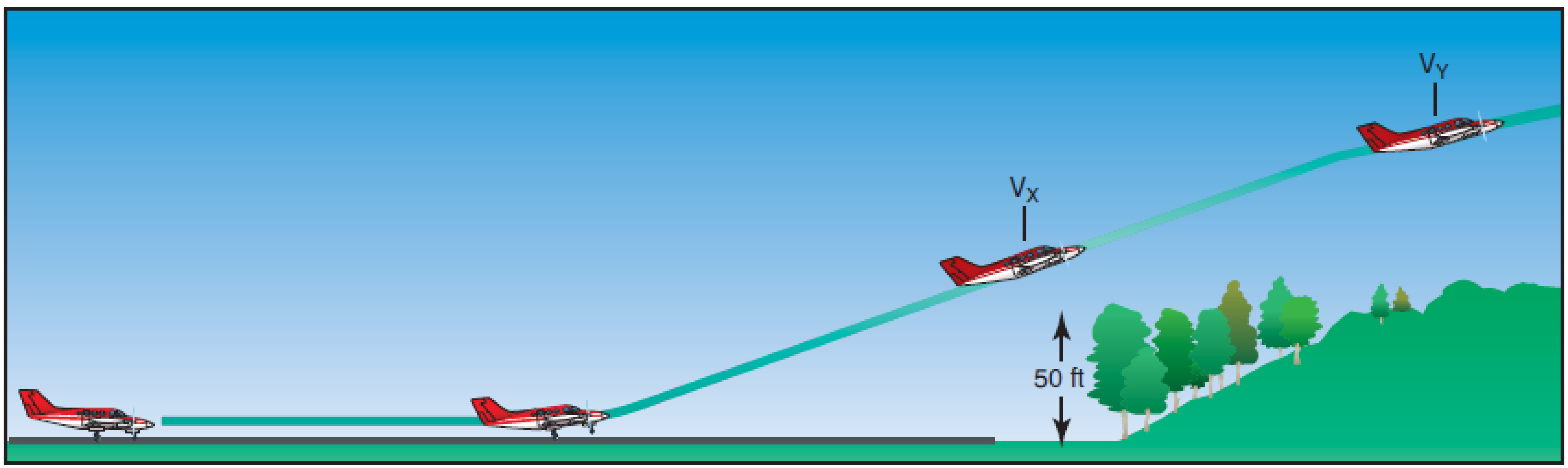


Figure 12-9. Short-field takeoff and climb.

Go Around

- Be careful, gear retraction speed is 112kts.
- Flaps should be retracted before the landing gear for two reasons.
  - First, on most airplanes, full flaps produce more drag than the extended landing gear.
  - Secondly, the airplane will tend to settle somewhat with flap retraction, and the landing gear should be down in the event of an inadvertent, momentary touchdown.
- A slight turn to offset the climb and parallel the runway is required so any traffic on the runway can be monitored

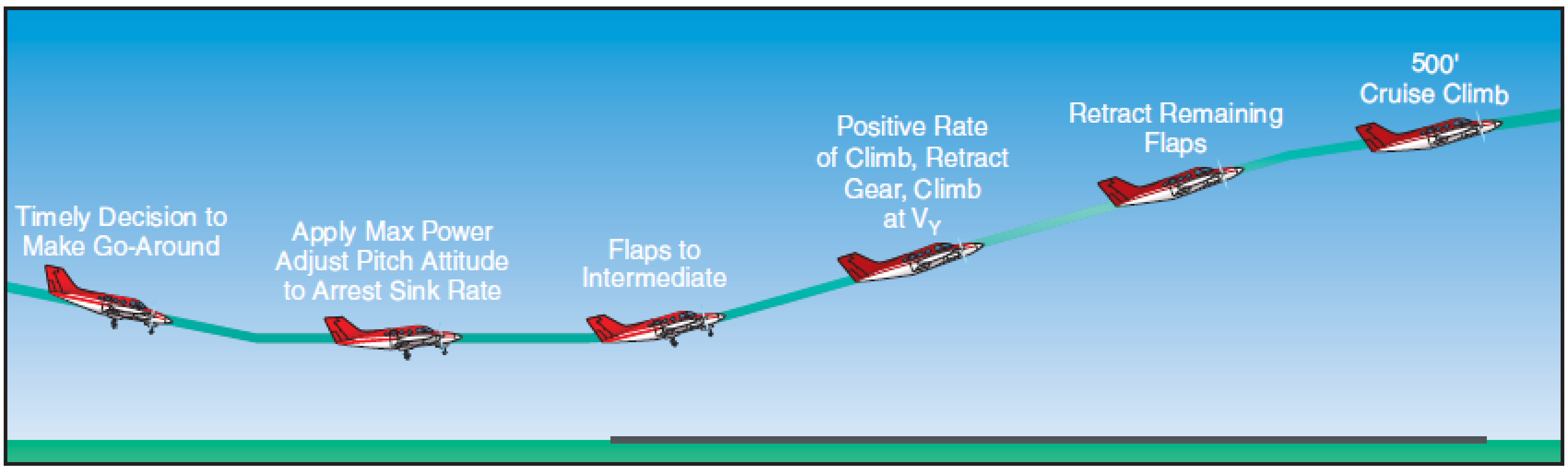


Figure 12-10. Go-around procedure.

3 Scenarios
Engine Failure after Lift-off

- ***Landing Gear Still DOWN***
  - Close both throttles and land on the remaining runway or overrun
- ***Landing Gear Selector UP*** – Inadequate Climb Performance
  - When operating near or above the single-engine ceiling and an engine failure is experienced shortly after lift-off, a landing must be accomplished on whatever essentially lies ahead.
  - Remaining airborne, bleeding off airspeed in a futile attempt to maintain altitude is almost invariably fatal.
  - Analysis of engine failures on takeoff reveals a very high success rate of off-airport engine inoperative landings when the airplane is landed under control. Analysis also reveals a very high fatality rate in stall-spin accidents when the pilot attempts flight beyond the performance capability of the airplane.
- ***Landing Gear Selector UP*** – Adequate Climb Performance
  - If the single-engine rate of climb is adequate, the procedures for continued flight should be followed. There are four areas of concern:
    1. **control,**
    2. **configuration,**
    3. **climb, and**
    4. **checklist.**

Landing Gear DOWN
Engine Failure after Lift-off

- Maintain directional Control
- Land on remaining runway or overrun

Figure 12-11. Engine failure on takeoff, landing gear down.

Landing Gear Up
Inadequate Climb Performance

- When operating near or above the single-engine ceiling and an engine failure is experienced shortly after lift-off, a landing must be accomplished on whatever essentially lies ahead.
- Remaining airborne, bleeding off airspeed in a futile attempt to maintain altitude is almost invariably fatal.
- Analysis of engine failures on takeoff reveals a very high success rate of off-airport engine inoperative landings when the airplane is landed under control.
- Analysis also reveals ***a very high fatality rate*** in stall-spin accidents when the pilot attempts flight beyond the performance capability of the airplane.

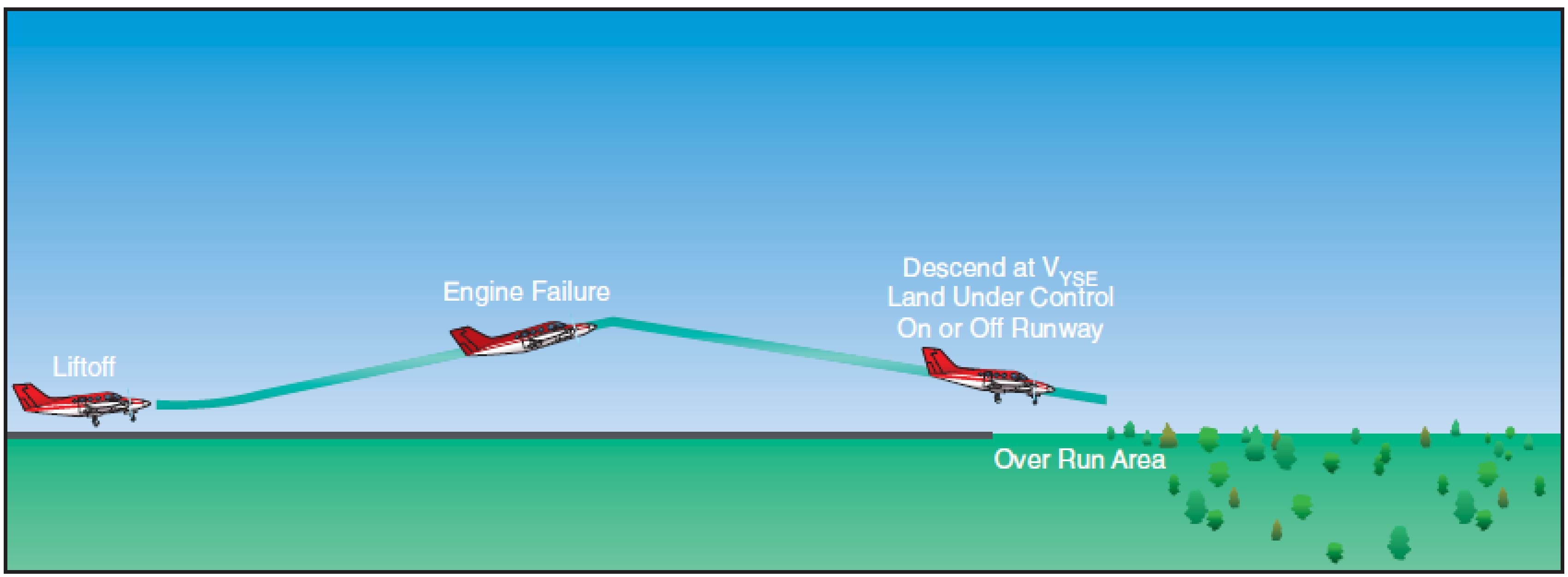


Figure 12-12. Engine failure on takeoff, inadequate climb performance.

Engine Failure Configuration

The memory items from the “engine failure after takeoff” checklist [Figure 12-14] should be promptly executed to configure the airplane for climb. The specific procedures to follow will be found in the AFM/POH and checklist for the particular airplane. Most will direct the pilot to

1) Obtain VYSE,
2) SET takeoff power,
3) RETRACT the flaps and landing gear,
4) IDENTIFY the failed engine,
5) VERIFY the failed engine
6) FEATHER the failed engine for least drag

The “identify” step is for the pilot to initially identify the failed engine. Confirmation on the engine gauges may or may not be possible, depending upon the failure mode. Identification should be primarily through the control inputs required to maintain straight flight, not the engine gauges. The “verify” step directs the pilot to retard the throttle of the engine thought to have failed. No change in performance when the suspected throttle is retarded is verification that the correct engine has been identified as failed. The corresponding propeller control should be brought fully aft to feather the engine.

ENGINE FAILURE AFTER TAKEOFF	
Airspeed	**Maintain V_{YSE}**
Mixtures	**RICH**
Propellers	**HIGH RPM**
Throttles	**FULL POWER**
Flaps	**UP**
Landing Gear	**UP**
Identify	**Determine failed engine**
Verify	**Close throttle of failed engine**
Propeller	**FEATHER**
Trim Tabs	ADJUST
Failed Engine	SECURE
As soon as practical	LAND

Bold - faced items require immediate action and are to be accomplished from memory.

Figure 12-14. Typical “engine failure after takeoff” emergency checklist.

Landing Gear Up
Adequate Climb Performance

ENGINE FAILURE AFTER TAKEOFF

Airspeed	**Maintain V_{YSE}**
Mixtures	**RICH**
Propellers	**HIGH RPM**
Throttles	**FULL POWER**
Flaps	**UP**
Landing Gear	**UP**
Identify	**Determine failed engine**
Verify	**Close throttle of failed engine**
Propeller	**FEATHER**
Trim Tabs	ADJUST
Failed Engine	SECURE
As soon as practical	LAND

Bold - faced items require immediate action and are to be accomplished from memory.

Figure 12-14. Typical "engine failure after takeoff" emergency checklist.

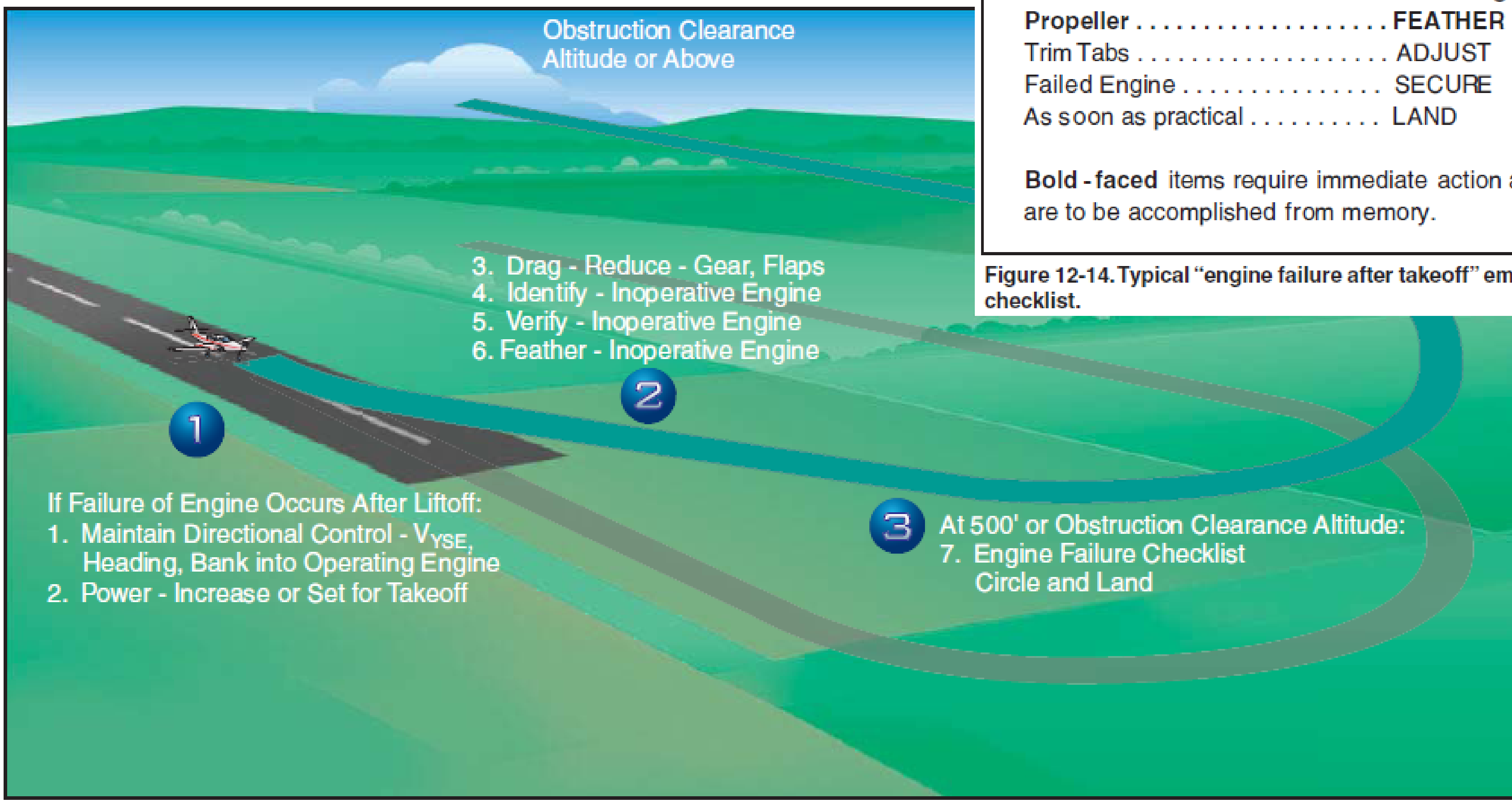


Figure 12-13. Landing gear up—adequate climb performance.

Single Engine Climb

As soon as directional control is established and the airplane configured for climb, the bank angle should be reduced to that producing best climb performance. Without specific guidance for zero sideslip, a bank of 2° and one-third to one-half ball deflection on the slip/skid indicator is suggested. VYSE is maintained with pitch control. As turning flight reduces climb performance, climb should be made straight ahead, or with shallow turns to avoid obstacles, to an altitude of at least 400 feet AGL before attempting a return to the airport.

Engine Failure Checklist

Having accomplished the memory items from the "engine failure after takeoff" checklist, the printed copy should be reviewed as time permits.

The "securing failed engine" checklist [Figure 12-15] should then be accomplished. Unless the pilot suspects an engine fire, the remaining items should be accomplished deliberately and without undue haste.

Airplane control should never be sacrificed to execute the remaining checklists. The priority items have already been accomplished from memory.

SECURING FAILED ENGINE	
Mixture	IDLE CUT OFF
Magnetos	OFF
Alternator	OFF
Cowl Flap	CLOSE
Boost Pump	OFF
Fuel Selector	OFF
Prop Sync	OFF
Electrical Load	Reduce
Crossfeed	Consider

Figure 12-15. Typical "securing failed engine" emergency checklist.

Engine Failure during Cruise

Not all engine failures or malfunctions are catastrophic in nature (catastrophic meaning a major mechanical failure that damages the engine and precludes further engine operation). Many cases of power loss are related to fuel starvation, where restoration of power may be made with the selection of another tank.

An orderly inventory of gauges and switches may reveal the problem. Carburetor heat or alternate air can be selected. The affected engine may run smoothly on just one magneto or at a lower power setting. Altering the mixture may help. If fuel vapor formation is suspected, fuel boost pump operation may be used to eliminate flow and pressure fluctuations.

Although it is a natural desire among pilots to save an ailing engine with a precautionary shutdown, the engine should be left running if there is any doubt as to needing it for further safe flight.

Engine Failure
Above Absolute Single Engine Ceiling

If the airplane is above its single-engine absolute ceiling at the time of engine failure, it will slowly lose altitude. The pilot should maintain VYSE to minimize the rate of altitude loss. This “drift down” rate will be greatest immediately following the failure and will decrease as the single-engine ceiling is approached.

Due to performance variations caused by engine and propeller wear, turbulence, and pilot technique, the airplane may not maintain altitude even at its published single-engine ceiling. Any further rate of sink, however, would likely be modest.

Single Engine Approach and Landing

- Similar to Twin Engine Ops
  - Altitudes
  - Airspeeds
  - Key Positions
- Difference from Twin Engine Ops
  - Higher than normal power setting on remaining engine
  - Asymmetrical thrust
  - Landing gear extended at abeam point
  - Airspeed no slower than Vyse
  - Long, flat approaches are to be avoided
  - Final flap setting can be delayed until landing is assured
  - Once landing is assured, slow to 1.3Vso or per POH/AFM.

Don’t Do Single Engine Go Arounds

Single-engine go-arounds must be avoided.

As a practical matter in single-engine approaches, once the airplane is on final approach with landing gear and flaps extended, it is committed to land. If not on the intended runway, then on another runway, a taxiway, or grassy infield.

The light-twin does not have the performance to climb on one engine with landing gear and flaps extended. Considerable altitude will be lost while maintaining VYSE and retracting landing gear and flaps. Losses of 500 feet or more are not unusual.

If the landing gear has been lowered with an alternate means of extension, retraction may not be possible, virtually negating any climb capability.

Engine Inop Flight Principles

- Best single engine climb performance achieved with
  - Vyse
  - Maximum Power
  - Minimum Drag
    - Flaps up
    - Gear up
    - Inop engine propeller feathered
    - Minimum sideslip
- To achieve zero sideslip and max climb performance we use
  - Yaw of rudder
  - Horizontal component of lift from banking

Drag Factors on the Beechcraft Duchess

Full Flaps:	-400FPM approx.
Windmilling Prop:	-400FPM approx.
Gear Extended:	-150 FPM approx.

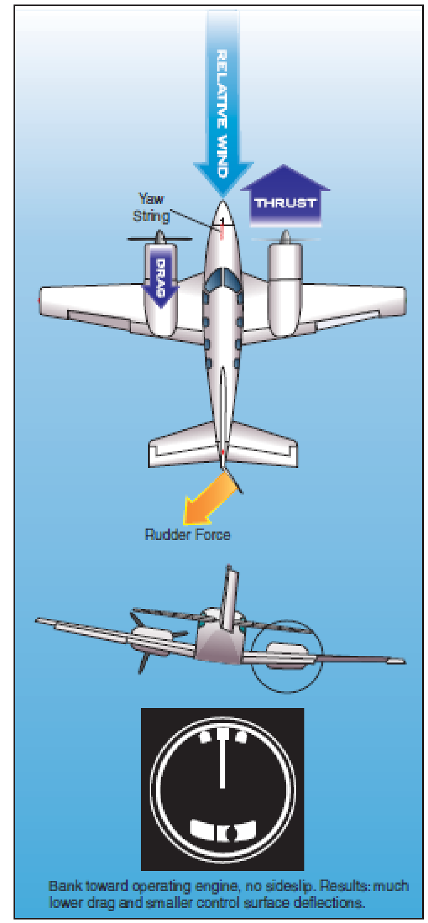


Figure 12-18. Zero sideslip engine-out flight.

1 of 2 Incorrect Scenarios One Engine Inop

- Wings level
- Large rudder force to keep ball centered
- Results in sideslip towards inop engine
- Vmc will be significantly higher
  - This is how we will demonstrate Vmc in the air
- Climb performance is degraded

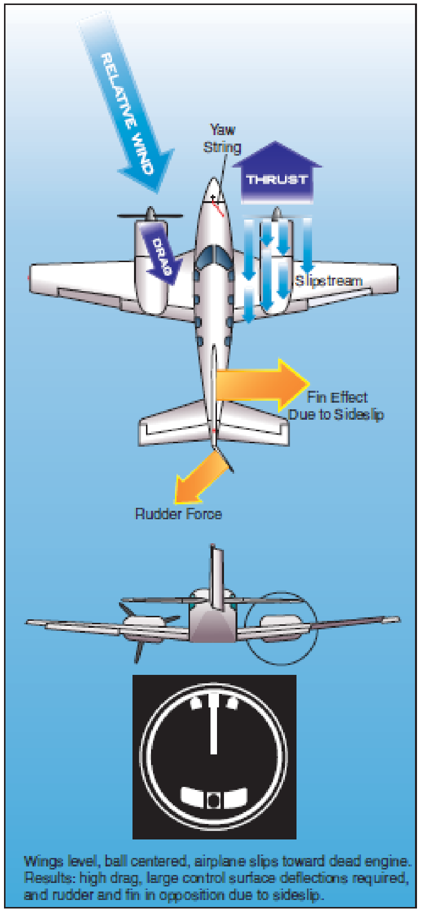


Figure 12-16. Wings level engine-out flight.

2nd of 2 Incorrect Scenarios One Engine Inop

- Wings banked 8-10deg's into operative engine
- No rudder force
- Results in sideslip towards operating engine
- Large ball displacement
- Vmc will be significantly higher
- Climb performance is degraded due to sideslip drag

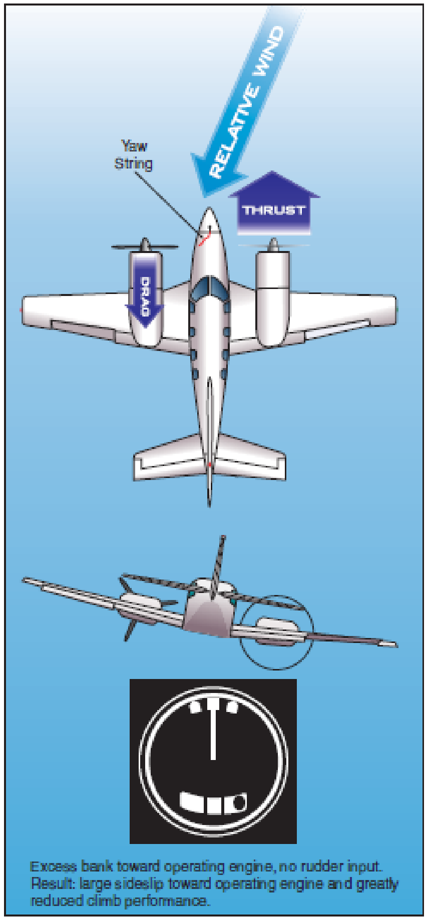


Figure 12-17. Excessive bank engine-out flight.

Correct Scenarios
One Engine Inop

- Wings banked ~2deg's into operative engine
- Rudder force to maintain directional control
- Results in zero sideslip
- Small ball displacement of about ½ a ball diameter
- Vmc will be slightly higher than published
  - Published Vmc was certified with a maximum of 5deg of bank.
- Results in maximum climb performance

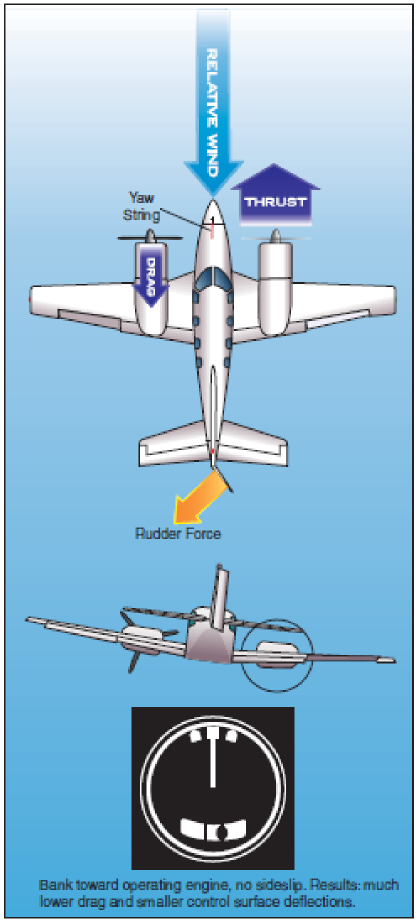


Figure 12-18. Zero sideslip engine-out flight.

Three Major Accident Factors in OEI flight at low altitudes and airspeed

- Pilots must be extra cautious of the following during takeoff and landing
  - Loss of directional control
  - Loss of performance
  - Loss of airspeed
- Simulated loss of engine will NOT be performed during slow flight or stalls

Critical Inop Engine

- Critical engine: The engine failure that has the most adverse effect on directional control
- Conventional Twins
  - Both props rotate clockwise as they do in a single
  - Critical engine failure will be the left engine due to P-factor
    - Descending blade has more thrust than the ascending blade when under power and nose pitched up.
    - The descending blade of the right engine has a longer arm from the CG and so has more torque than the descending blade of the left engine.
    - Thus, when the right engine is the operative engine, it has more asymmetrical thrust than an operative left engine (see fig below)
- Counter Rotating Props
  - The BE-76 (Duchess) has counter rotating props
    - Left engine rotates clockwise
    - Right engine rotates counter-clockwise
    - Results in P-factor thrust to have minimum arm length from CG for both engines
  - No critical engine is present since each engine's thrust, due to P-factor, has the same arm from the CG

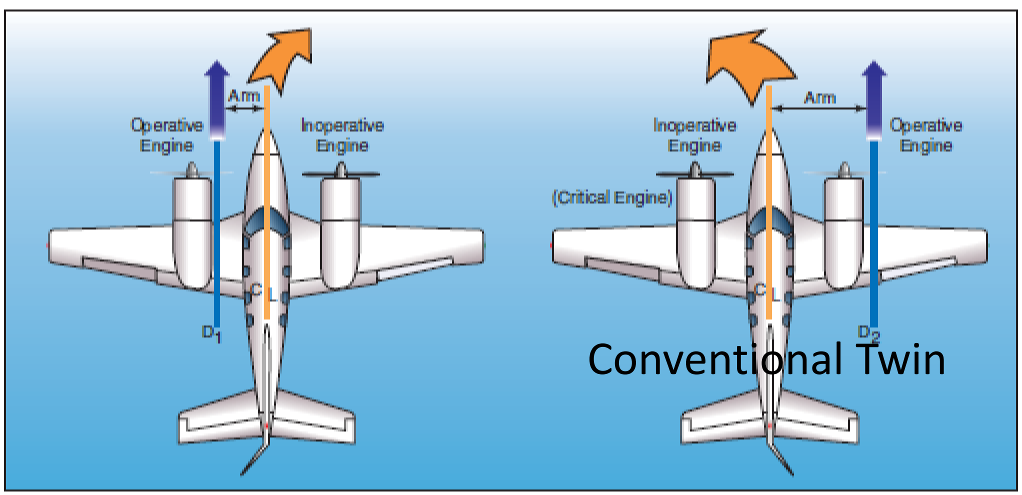


Figure 12-19. Forces created during single-engine operation.

P	Factor
A	Accelerated Slipstream
S	Spiraling Slipstream
T	Torque

4 Factors Make Left Engine Critical

- P-Factor
  - Torque from right engine has a larger arm than torque from left engine since the greatest torque is on the descending blade
- Spiraling Slipstream
  - Spiraling slipstream does not hit the rudder from right engine, only left engine
- Accelerated Slipstream
  - Propwash provides more lift on the operating engine
- Torque
  - For every action, there is an equal and opposite reaction. If the right engine rotates clockwise, then the the opposite reaction is to roll the engine/wing to left.

- http://media.avit.und.edu/f4_Inop%20Engine%20Trainer/f1_Inop%20Engine/060302/critical.html

- When losing the critical engine, both directional control and performance will suffer. In discussing directional control problems, the focus is on the concept of Vmc. In discussing performance, the focus is on the concept of Vyse. It is important to keep the two ideas separate to fully understand them.

Vmc was determined under the following conditions

1. Max power on operative engine
   – Provides for the most asymmetrical thrust
2. Windmilling propeller on inop engine
   – Provides for most asymmetrical drag due to the disc effect of a windmilling propellor
3. Most infavorable weight
   – As weight moves to max gross, Vmc decreases
4. Most infavorable CG
   – As CG moves aft, the rudder arm becomes shorter and the effectiveness of the rudder to maintain directional control.
   – Vmc decreases as CG moves forward.
   – Vmc increases as CG moves aft.
5. Landing gear retracted
   – Extended landing gear aids in directional control and decreases Vmc
6. Flaps and cowl flaps in takeoff position
   – Usually this is zero flaps and cowl flaps open.
   – Adding flaps increases symmetrical drag and thus Vmc decreases
7. Bank angle max of 5deg's
   – VMC increases 3 kts for each deg of bank angle
   – 5deg's is not zero sideslip and doesn't give max climb performance
8. Sea Level
   – As altitude increases, the HP/weight ratio decreases and thus, asymmetrical thrust decreases which lowers Vmc
9. Maximum of 150lbs of rudder pressure
   – Increase in rudder pressure decreases Vmc

VMC vs Density Altitude

- From the chart to the right, Vmc decreases as density altitude increases
  - However, stalling speed (Vs) remains the same with increasing altitude
- We always want to do our Vmc demo's while remaining in the yellow
  - However, Vmc demo's must be done to always be 3000ft AGL or greater per regulation.
  - BE-76 POH/AFM requires Vmc demo to be at least 5000ft AGL.
- We never want to do our Vmc demo's while in the orange area
  - Recovery is difficult
  - This is basically a spin entry maneuver due to the control inputs and entering a stall
  - Spins occur in this area of orange
  - Spin recovery in a twin is difficult if not impossible
  - Spin entry will be sudden with the plane going inverted
- How do we maintain safety at high altitudes during Vmc demo's?
  - We will use wings level instead of 5deg of bank to ensure we loose directional control first before a spin (yellow area indicated by "yaw occurs first")

No Solo Touch N Go’s

- There will be no solo Touch N Go’s
- Touch N Go’s should not be considered until the student has at least 15 landings in make and model and then, only with an instructor present.
- Touch N Go’s with an instructor should be done with
  - Student running the throttles and yoke
  - Instructor handling the flaps and trim

Other Publications

- AC 61-84b Preflight
- AC 91-13 Cold Weather Ops
- AC 91-55 Reduction of aircraft elec system failures during starting
- AC 90-42 Traffic advisories at airports without control towers
- AC 61-9B Pilot Transition Courses for complex single engine and light twin engine airplanes
- AC 90-66 Traffic patterns at airports without towers
- AC 150/5340-1 Stds for airport markings
- AC 150/5340/18 Stds for airport sign systems
- FAA-P-8740-19
- FAA-S-8081-6C MEI PTS
- FAA-S-8081-12C Commercial PTS

Pre-Take Off Briefing

Departure Apt	***VFR Appr Apt***	***IFR Appr Apt***
Metar Wind Dir	Metar Wind Dir	Metar Wind Dir
Metar Wind Speed	Metar Wind Speed	Metar Wind Speed
Metar Visibility	Metar Visibility	Metar Visibility
Metar Sky	Metar Sky	Metar Sky
Altimeter	Altimeter	Altimeter
Taxi Route	Taxi Route	Taxi Route
Squawk Code	Squawk Code	Squawk Code
Takeoff Brief	***VFR Appr Brief***	***IFR Appr Brief***
TO Distance	Runway in use	Runway in use
Acc/Stop Distance	Runway Length	Approach to use
Acc/Go Distance	Landing Distance	Navaid/Freq
Runway Length	App Speed	Final App Course
Liftoff Speed	Pattern Entry	GS Inter/FAF Alt
Initial Climb Speed	Right or Left Pattern	DA/MDA
Initial Heading	Pattern Altitude	TDZE
Initial Altitude	Taxi Route	Airspeed/Flaps
Initial Heading	Notams	Missed App Pt
SE FPM Climb		Missed Procedure
SE Service Ceiling		Procedure Notes
Emerg Proc TO		Runway Length
Emerg Proc Cruise		Landing Distance

Air Trek North

Multi Engine Add-On
Ground Material