# FAA-P-8740-19 — Flying Light Twins Safely

Date: **9/78** Initiated by: **AFS-800**

## Introduction

The major difference between flying a twin engine and a single engine airplane is knowing how to manage the flight if one engine loses power for any reason. Safe flight with one engine-out requires an understanding of the basic aerodynamics involved — as well as proficiency in engine-out procedures.

## Loss of Power on One Side

Loss of power from one engine affects both climb performance and controllability of any light twin.

## Climb Performance

Climb performance depends on an excess of power over that required for level flight. Loss of power from one engine obviously represents a *50%* loss of power but, in virtually all light twins, climb performance is reduced by at least *80%*. ***(See*** Figure *1)*

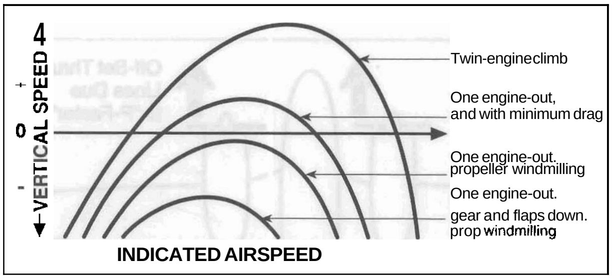


***Figure 1. Effect of one engine-out and airplane configuration on vertical speed***

The amount of power required for level flight depends on how much drag must be "overcome" to sustain level flight. It's obvious, that if drag is increased because the gear and flaps are down and the prop windmilling, more power will be required. Not so obvious, however, is the fact that drag also increases as the square of the airspeed while power required to maintain that speed increases as the cube of the airspeed. ***(See*** Figure 2).

Thus, climb performance depends on four factors:

- Airspeed — too little or too much will decrease climb performance.
- Drag — gear, flaps, cowl flaps, prop and speed.
- Power — amount available in excess of that needed for level flight.
- Weight — passengers, baggage and fuel load greatly affect climb performance.

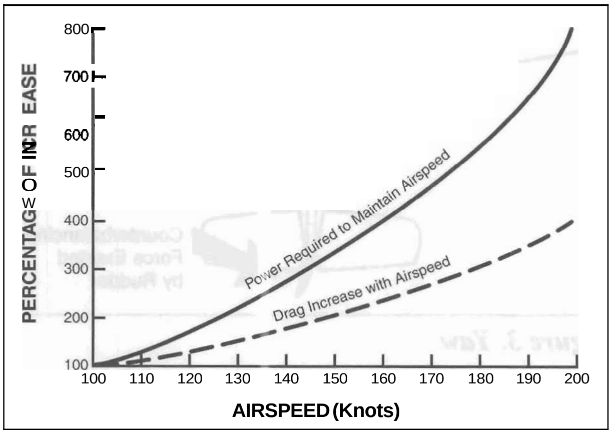


***Figure 2. Effect of airspeed on drag — and power required to maintain that airspeed while in level flight***

## Yaw

Loss of power on one engine also creates yaw due to asymmetrical thrust. Yaw forces must be balanced with the rudder. (See Figure 3)

### Roll

Loss of power on one engine reduces prop wash over the wing. Yaw also affects the lift distribution over the wing causing a roll toward the "dead" engine. (See Figure 4) These roll forces may be balanced by banking into the operating engine.

### Critical Engine

The critical engine is that engine whose failure would most adversely affect the performance or handling qualities of the airplane. The critical engine on most U.S. light twins is the left engine as its failure requires the most rudder force to overcome yaw. At cruise, the thrust line of each engine is through the propeller hub.

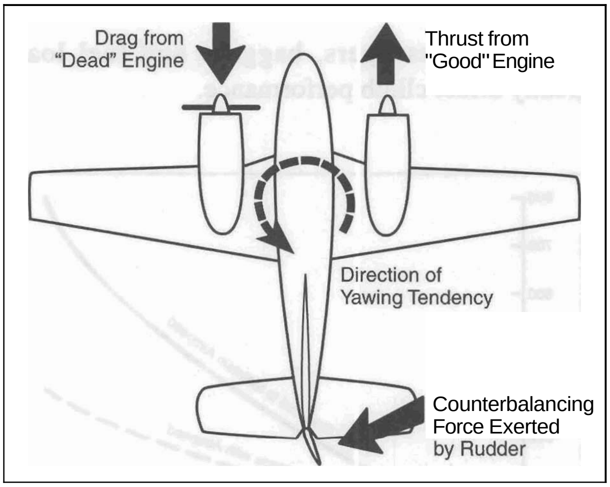


*Figure 3. Yaw*

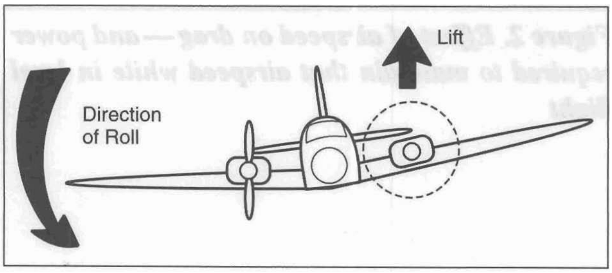


*Figure 4. Roll*

But, at low airspeeds and at high angles of attack, the effective thrust centerline shifts to the right on each engine because the descending propeller blades produce more thrust than the ascending blades (P-factor). Thus, the right engine produces the greatest mechanical yawing moment and requires the most rudder to counterbalance the yaw.

## Key Airspeed for Single Engine Operations

Airspeed is the key to safe single engine operations. For most light twins there is an:

- airspeed below which directional control cannot be maintained.
  $V_{MCA}$
- airspeed below which an intentional engine cut should never be made.
  $V_{SSE}$
- airspeed that will give the best single engine rate of climb (or the slowest loss of altitude).
  $V_{YSE}$
- airspeed that will give the steepest angle of climb with one engine-out.
  $V_{XSE}$

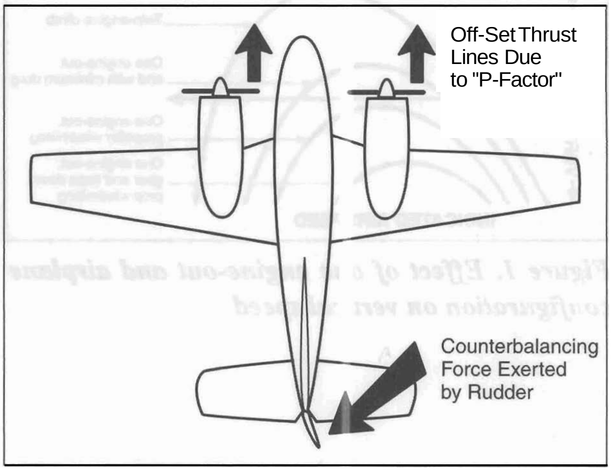


***Figure 5. Engine Thrust Line Shifts to Right at Low Airspeeds and at High Angles of Attack***

### Minimum Control Speed Airborne ($V_{MCA}$)

$V_{MCA}$ is designated by the red radial on the airspeed indicator and indicates the minimum control speed, airborne at sea level. $V_{MCA}$ is determined by the manufacturer as the minimum airspeed at which it's possible to recover directional control of the airplane within 20 degrees heading change and, thereafter, maintain straight flight, with not more than 5 degrees of bank if one engine fails suddenly with:

- Takeoff power on both engines,
- Rearmost allowable center of gravity,
- Flaps in takeoff position,
- Landing gear retracted,
- Propeller windmilling in takeoff pitch configuration (or feathered if automatically featherable).

However, sudden engine failures rarely occur with all of the factors listed above and, therefore, the actual $V_{MCA}$ under any particular situation may be a little slower than the red radial on the airspeed indicator. However, most airplanes will not maintain level flight at speeds at or near $V_{MCA}$. Consequently, it is not advisable to fly at speeds approaching $V_{MCA}$ except in training situations or during flight tests.

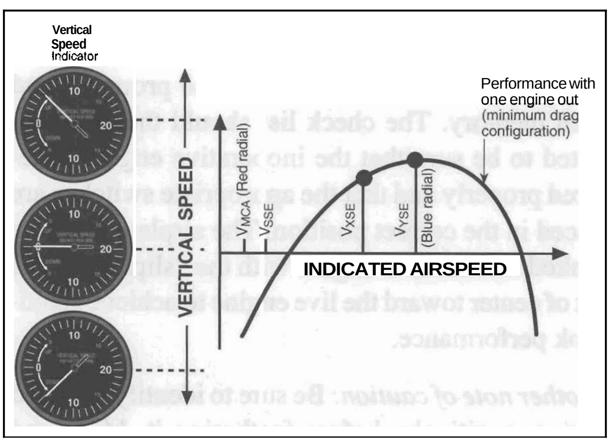


*Figure 6. Key Single Engine Airspeeds*

### Intentional One Engine Inoperative Speed ($V_{SSE}$)

$V_{SSE}$, is specified by the airplane manufacturer in new Handbooks and is the minimum speed at which to perform intentional engine cuts. Use of $V_{SSE}$ is intended to reduce the accident potential from loss of control after engine cuts at or near minimum control speed. $V_{SSE}$ demonstrations are necessary in training but should only be made at a safe altitude above the terrain and with the power reduction on one engine made at or above $V_{SSE}$. Power on the operating (good) engine should then be set at the position for maximum continuous operation. Airspeed is reduced slowly (one knot per second) until directional control can no longer be maintained or the first indication of a stall obtained. (*See* Figure 7)

Recovery from flight below $V_{MCA}$ is made by reducing power to idle on the operating (good) engine, decreasing the angle of attack by dropping the nose, accelerating through $V_{MCA}$, and then returning power to the operating engine and accelerating to $V_{YSE}$, the blue radial speed.

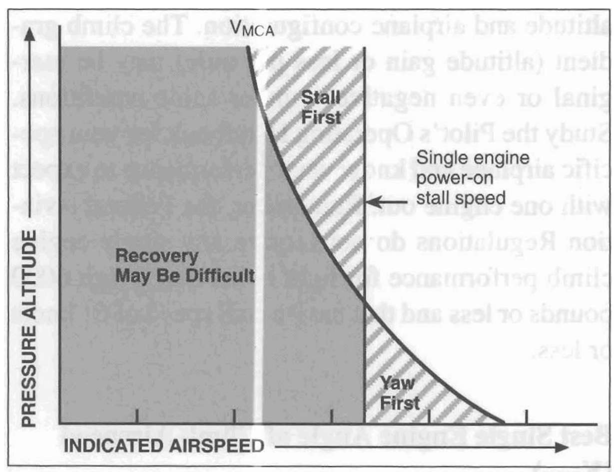


***Figure 7. Relationship Between Stall Speed and $V_{MCA}$ for Aircraft with Normally Aspirated Engines***

### Best Single Engine Rate of Climb Speed ($V_{YSE}$)

$V_{YSE}$ is designated by the blue radial on the airspeed indicator. $V_{YSE}$ delivers the greatest gain in altitude in the shortest possible time, and is based on the following criteria:

- critical engine inoperative, and its propeller in the minimum drag position.
- operating engine set at not more than maximum continuous power.
- landing gear retracted.
- wing flaps in the most favorable (i.e., best lift/drag) ratio position.
- cowl flaps as required for engine cooling.
- airplane flown at recommended bank angle.

Drag caused by a windrnilling propeller, extended landing gear, or flaps in the landing position will severely degrade or destroy single engine climb performance. Single engine climb performance varies widely with type of airplane, weight, temperature, altitude and airplane configuration. The climb gradient (altitude gain or loss per mile) may be marginal or even negative — under some conditions. Study the Pilot's Operating Handbook for your specific airplane and know what performance to expect with one engine out. Remember, the Federal Aviation Regulations do not require any single engine climb performance for light twins that weigh 6000 pounds or less and that have a stall speed of 61 knots or less.

### Best Single Engine Angle of Climb Airspeed ($V_{XSE}$)

$V_{XSE}$ is used only to clear obstructions during initial climbout as it gives the greatest altitude gain per unit of horizontal distance. It provides less engine cooling and requires more rudder control than $V_{XSE}$.

## Single Engine Service Ceiling

The single engine service ceiling is the maximum altitude at which an airplane will climb, at a rate of at least 50 feet per minute in smooth air, with one engine feathered. New Handbooks show service ceiling as a function of weight, pressure altitude and temperature while the old Flight Manuals frequently use density altitude.

The single engine service ceiling chart should be used during flight planning to detennine whether the airplane, as loaded, can maintain the Minimum Enroute Altitude (MEA) if IFR, or terrain clearance if VFR, following an engine failure.

## Basic Single Engine Procedures

Know and follow, to the letter, the single engine emergency procedures specified in your Pilot's Operating Handbook for your specific make and model airplane. However, the basic fundamentals of all the procedures are as follows:

- Maintain aircraft control and airspeed at all times. This is cardinal rule No. 1.
- Usually, apply maximum power to the operating engine. However, if the engine failure occurs during cruise or in a steep turn, you may elect to use only enough power to maintain a safe speed and altitude. If the failure occurs on final approach, use power only as necessary to complete the landing.
- Reduce drag to an absolute minimum.
- Secure the failed engine and related subsystems.

The first three steps should be done promptly and from memory. The check list should then be consulted to be sure that the inoperative engine is secured properly and that the appropriate switches are placed in the correct position. The airplane must be banked into the live engine with the "slip/skid" ball out of center toward the live engine to achieve Handbook performance.

*Another note of caution:* Be sure to identify the dead engine, positively, before feathering it. Many red faced pilots — both students and veterans alike have feathered the wrong engine. Don't let it happen to you. Remember: First, identify the suspected engine (i.e., "Dead foot means dead engine"); second, verify with cautious throttle movement; then feather. But be sure it is dead and not just sick.

## Engine Failure on Takeoff

If an engine fails before attaining liftoff speed, the only proper action is to discontinue the takeoff. If the engine fails after liftoff with the landing gear still down, the takeoff should still be discontinued if touchdown and rollout on the remaining runway is still possible.

If you do find yourself in a position of not being able to climb, it's much better to pull the power on the good engine and land straight ahead than try to force a climb and lose control.

Pilot's Operating Handbooks have charts that are used in calculating the runway length required if the engine fails before reaching liftoff speed and may have charts showing performance after liftoff such as:

- Accelerate-Stop Distance. That's the distance required to accelerate to liftoff speed and, assuming failure to engine at the instant that liftoff speed is attained, to bring the airplane to a full stop.
- Accelerate-Go Distance. That's the distance required to accelerate to liftoff speed and, assuming failure of an engine at the instant liftoff speed is attained, to continue the takeoff on the remaining engine to a height of 50 feet.

Study your accelerate-go charts carefully. No airplane is capable of climbing out on one engine under all weight, pressure altitude and temperature conditions. Know, before you take the actual runway, whether you can maintain control and climbout if you lose an engine while the gear is still down. It may be necessary to off-load some weight, or wait for more favorable temperature or wind conditions.

## When to Fly $V_X$, $V_Y$, $V_{XSE}$, and $V_{YSE}$

During normal two engine operations, always fly $V_Y$ (or $V_X$ if necessary for obstacle clearance) on initial climbout. Then, accelerate to your cruise climb airspeed, which may be $V_Y$ plus 10 to 15 knots after you have obtained a safe altitude. Use of cruise climb airspeed will give you better engine cooling, increased inflight visibility and better fuel economy. However, at the first indication of an engine failure during climbout, or while on approach, establish $V_{YSE}$ or $V_{XSE}$, whichever is appropriate. (Consult your Handbook or Flight Manual for specifics).

## Summary

Know the key airspeeds for your airplane and when to use them:

$V_{MC}$ (Red Radial) — never fly at or near this airspeed except in training or during flight test situations.

$V_{SSE}$ never intentionally cut an engine below this airspeed.

$V_{YSE}$ (Blue Radial) — always fly this airspeed during a single engine emergency during climbout (except when necessary to clear an obstacle after takeoff) and on final approach until committed for landing.

$V_{XSE}$—Fly $V_{XSE}$ to clear obstacles, then accelerate to $V_{YSE}$.

Know the performance limitations of your airplane, including its:

- accelerate-stop distances,
- accelerate-go distances,
- single engine service ceiling, and
- maximum weight for which single engine climb is possible.

Know the basic single engine emergency procedures:

- Maintain control of the airplane by flying at the proper airspeed.
- Apply maximum power, if appropriate.
- Reduce drag (includes feathering).
- Complete engine-out checklist.

And finally, put your knowledge into practice with a qualified instructor pilot observing and assisting you. Engine failures can be handled competently and safely by proficient pilots. Keep your proficiency up and every flight in a multiengine airplane should be a safe one.