

Course Notes



Multi-Engine Safety Review



Multi-Engine Safety Review

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Overview

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Safe operation of multi-engine aircraft starts with a solid understanding of how an engine failure affects *control* and *performance*. This course reviews these concepts, but be sure to consult the Pilot's Operating Handbook (POH) or Airplane Flying Manual (AFM) for your specific airplane.

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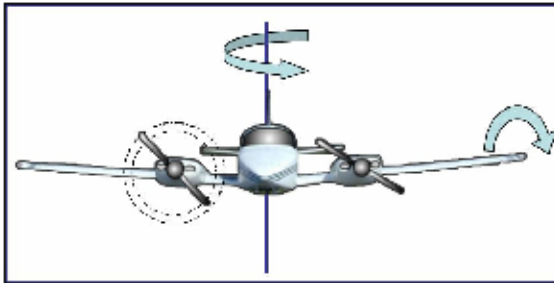


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Critical Concepts

Engine Loss and Aircraft Control



In light twin, loss of power on either engine results in:

Yaw. Asymmetric thrust results in yaw toward the failed engine.

Roll. Loss of airflow causes a roll toward the failed engine.

also create drag.

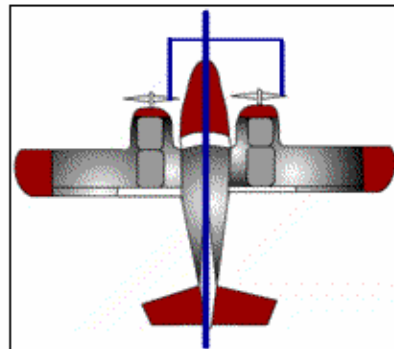
The dead engine's windmilling prop will

The Critical Engine

In a conventional light twin with both engines turning clockwise, the descending blade of the right prop creates asymmetric thrust (***P-factor***) at a greater distance from the airplane's center of gravity than the descending blade on the left prop.

Because the right engine thus produces a greater yawing force, failure of the left engine would have a greater adverse effect on aircraft control and performance. The left is therefore considered to be the ***critical engine***.

(Note: Twins with a counter-rotating right engine do not have a "critical engine.")





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Control Considerations

Minimum Control Speed (V_{mc}, or "Redline")

Engine loss leads to yaw and roll toward the dead engine. The pilot must use rudder and ailerons to regain control.

Since the control effectiveness of rudder and ailerons is related to airflow, the pilot must maintain an airspeed that will provide enough control authority to counter yaw and roll.



The minimum control airspeed - *V_{mc}* - is the *minimum* speed at which directional control can be maintained with a bank of no more than 5 degrees when:

- The critical engine is inoperative with prop windmilling, and
- The remaining engine is operating at takeoff power.

The published V_{mc} value is designated by a red radial line near the low speed end on most airspeed indicator.

Important: The published V_{mc} value is determined under a very specific set of circumstances defined in 14 CFR Part 23, so it is important to understand that the actual V_{mc} will vary depending on conditions and circumstances encountered.

Related Media for this Section



Criteria for Establishing V_{mc}
[14 CFR 23 Criteria for Establishing V_{mc}.pdf \(21.54 KB\)](#)



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Basic Performance

Best Single Engine Rate of Climb (Vyse, or "Blueline")

The published V_{mc} value is established under very specific conditions (*see previous section*), so actual V_{mc} can vary.



When operating on only one engine, your target airspeed should be **Vy_{se}**, which is the speed for "best rate of climb with a single engine." Vy_{se} is designated on the airspeed indicator with a blue radial line and often referred to as "blueline."

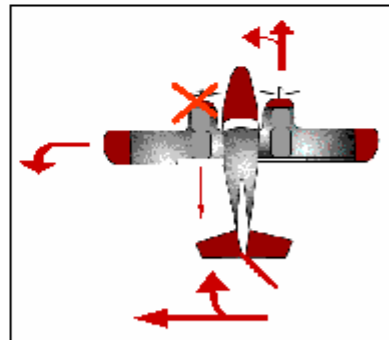
Vy_{se} *theoretically* provides the greatest altitude gain when only one engine is working, but it does not guarantee that you will be able to climb on one engine. In general, the best you can realistically

expect from Vy_{se} is level flight, or smallest rate of descent.

Zero Sideslip

The pilot uses rudder to counteract yaw from a failed engine, but the operating engine still produces forward thrust, and the deflected rudder produces "sideways lift." Together, these two forces create a sideslip in the direction of the failed engine. Sideslip significantly increases drag, which is bad for both aircraft control and aircraft performance.

To achieve zero sideslip, "raise the dead" engine by banking approximately 2 degrees into the good engine. Because of asymmetric thrust, the inclinometer -- "ball" -- will be deflected toward the good engine by about one-half of its diameter in a zero sideslip condition.



Related Media for this Section



Multi-Engine Aerodynamics Interactive (Flash) for Windows

[ME Interactive.exe](#) (810.71 KB)



Multi-Engine Aerodynamics Interactive (Flash) for MacIntosh

[ME Interactive.hqx](#) (1.41 MB)



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Twin Takeoff Performance

General

Takeoff planning is essential for any airplane you fly, but there are special considerations for flying a light twin.



For normal takeoff, use the manufacturer's recommended rotation speed (V_r). If V_r is not published, add at least 5 knots to the published V_{mc} .

Never try to fly before reaching V_{mc} . If an engine fails below that speed, the rudder will not be effective enough to counteract the yaw resulting from asymmetric thrust, and you will not be able to control the airplane.

Always review emergency procedures in case you lose an engine on liftoff. Download the takeoff briefing guide below for items to review.

Related Media for this Section

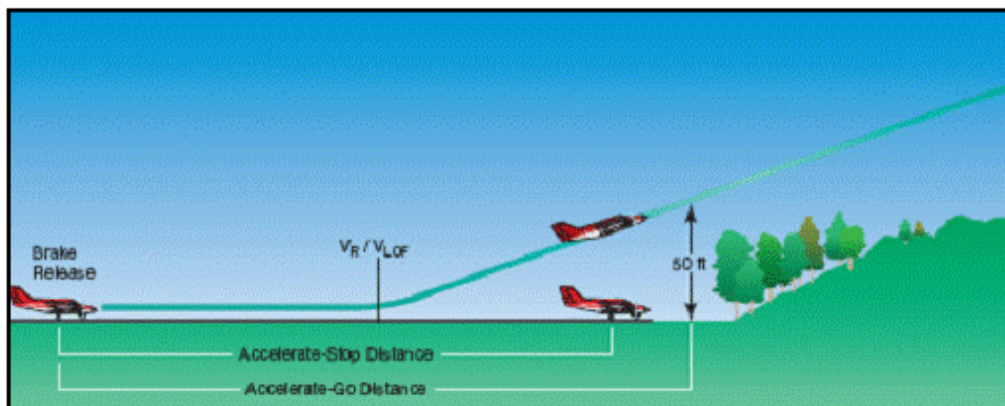


Multi-Engine Takeoff Briefing Checklist

[Twin Takeoff Briefing Checklist v2.pdf](#) (27.18 KB)

Accelerate-Stop Distance

Accelerate-Stop Distance is the runway required to accelerate to V_r and bring the aircraft to a complete stop, assuming that you experience an engine failure right at V_r .



Accelerate-stop distance charts are in the POH or AFM for your aircraft. These charts were developed under specific conditions (e.g., paved, level, dry runway) and power settings, and different conditions will not produce the same results.



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Accelerate-stop distance charts are in the POH or AFM for your aircraft. These charts were developed under specific conditions (e.g., paved, level, dry runway) and power settings, and different conditions will not produce the same results.

Accelerate-Go Distance

Accelerate-Go Distance is the runway required to accelerate to V_r and, assuming an engine failure at that instant, continue on the remaining engine and climb to a height of 50 feet.

Not all manufacturers specify an accelerate-go distance. Even if your POH/AFM does include it, always remember that these figures were determined under ideal flight test circumstances, and not under the kind of real world conditions that you might face.



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Twin Climb Performance

Altitude and Airspeed

After takeoff, altitude gain is more important than achieving an enroute climb airspeed. Accelerate in a shallow climb to V_y , and maintain V_y until you reach a safe single engine maneuvering altitude (typically at least 400 feet AGL).

Follow the specific recommendations in your POH or AFM, but in general, retract the landing gear after you establish a positive rate of climb and you can no longer land safely on the runway remaining.

Single Engine Climb

Climb performance depends on an excess of thrust (power) over what is required for level flight. Losing one engine represents a 50 percent loss of thrust, but it often results in an 80 to 90 percent loss of climb performance - sometimes even more.

As noted, V_{yse} ("blue line") does not guarantee a climb or even level flight with only one engine working, but it is the best performance speed for operation with one engine inoperative (OEI).

Best single engine angle of climb speed (V_{xse}) is used only to clear obstructions during initial OEI climbout. It is invariably a slower speed than V_{yse} , and may be just a very few knots above V_{mc} .

Related Media for this Section



Climb Performance Requirements

[Climb Performance Requirements.pdf](#) (13.2 KB)



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Cruise Performance Considerations

Service Ceiling

Losing an engine in cruise may allow time to establish control and troubleshoot, but one critical cruise consideration is service ceiling.

- ▶ The single engine *absolute* ceiling is where the rate of climb is zero.
- ▶ The single engine *service* ceiling is the altitude at which a twin-engine aircraft with one engine feathered can no longer climb at 50 feet per minute in smooth air.



Service ceiling is important for terrain and obstacle avoidance. If you lose an engine at an altitude above the single engine service ceiling, you can expect to drift down to that altitude. Plan the flight so that you will still be able to maintain minimum IFR or VFR altitudes and

remain clear of terrain/obstacles if you lose an engine. Bear in mind that a 50 fpm climb rate is very small. In some conditions (e.g., turbulence), it may only be enough to maintain level flight.



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Approach and Landing Performance

Make It Count



The most important consideration in a single-engine approach is to execute the approach and landing successfully the first time.

If you have to land a light twin with just one good engine, try to fly the approach and landing as near to normally as possible with respect to key positions, altitudes, and airspeeds.

At best, a single engine go-around will require significant altitude to transition from a descent to a climb with gear and flaps retracted. At worst, your airplane may not have enough power for a successful go-around on just one engine.



Light Twin Training and Proficiency

Safety and Training Tips



Safe operation of light twin aircraft requires three separate, but related, sets of skills: stick-and-rudder (aircraft control), systems knowledge (operation of avionics, hydraulics), and aeronautical decision-making. Good decision-making involves good preparation, including the following actions:

1. Know the key airspeeds for your airplane and when to fly them.
2. Become thoroughly familiar with the AFM/POH recommended procedures and the checklist, particularly the memory items.
3. Know the AFM/POH performance capabilities for your airplane under the proposed flight conditions, and factor in significant margins to adjust for real-world performance. Before every flight, carefully review:
 - *Accelerate-stop distance*
 - *Accelerate-go distance*
 - *Single engine service ceiling*
 - *Expected single engine rate of climb*
 - *Obstacles or terrain in the flight path.*
4. Know the basic OEI emergency procedures common to all conventional light twins:
 - **Control**. Maintain directional control with rudder and aileron. Assume the pitch attitude for Vyse.
 - **Configure**. Execute the memory items from the "Engine Failure After Takeoff" checklist.
 - **Climb**. Assume the bank angle and ball position for zero sideslip and maintain the best climb rate at Vyse.
 - **Checklist**. Review and accomplish any remaining checklist items appropriate to the situation.

Regular training and practice with a qualified instructor is essential for proficiency in any airplane, but it is especially important in light twins. As you train, however, be sure to:

- Thoroughly brief simulated engine failures in advance.
- Maintain a safe altitude when practicing OEI maneuvers.
- Accomplish all simulated engine failures below 3,000 AGL by smoothly retarding the throttle - never with mixture!



Course Review, Notes, Resources

Course Review

Chapter 1 - Critical Concepts

In a light twin, loss of power on one engine results in:

Yaw toward the failed engine (from asymmetric thrust).

Roll toward the failed engine (from loss of airflow over the wing).

Drag on the failed engine side.

Asymmetric thrust is a key consideration in flying light twins, because loss of an engine results in yaw toward the dead engine. In a conventional light twin (both engines turning clockwise), P-factor on the right engine is a major factor. Because the right engine's greatest thrusting moment is to the right of the airplane's center of gravity, it produces significant yaw toward the left if the left engine fails. The left engine is thus considered the *critical engine* because its failure has a greater adverse impact on aircraft control and performance.

Chapter 2 - Control Considerations

The effectiveness of the rudder and ailerons is related to airflow – the greater the airflow, the more effective they are. Airflow depends on airspeed, so it is necessary to establish and maintain an airspeed that will provide enough control authority to counter yaw and roll after engine failure. The published minimum control airspeed – V_{mc} -- is designated by a red radial line near the low speed end on most airspeed indicator.

Chapter 3 - Basic Performance

V_{mc} varies, and many light twins will not maintain level flight near V_{mc} with one engine inoperative. Establish and maintain a higher speed – Vy_{se} ("best rate of climb with a single engine"). Vy_{se} is designated on the airspeed indicator with a blue radial line and generally known as "blueline." Vy_{se} does not guarantee ability to climb with one engine inoperative.

Sideslip significantly increases drag, which is bad for both aircraft control and performance. To achieve zero sideslip with one engine inoperative, the pilot must use rudder and ailerons to bank toward the good engine. The inclinometer will be deflected toward the good engine by about one-half of its diameter.



Chapter 4 - Takeoff Performance

Takeoff planning is essential. *Never* try to fly before reaching V_{mc} , since an engine failure below that speed would leave you without enough rudder effectiveness to control the airplane. Review emergency procedures, so you will be fully prepared to act promptly (and correctly) if you lose an engine on liftoff, or just after takeoff.

Accelerate-Stop Distance is the runway required to accelerate to V_r and bring the aircraft to a complete stop if you experience an engine failure right at V_r .

Accelerate-Go Distance is the runway required to accelerate to either V_r and, assuming an engine failure at that instant, continue the takeoff on the remaining engine and climb to a height of 50 feet. Not all manufacturers specify an accelerate-go distance.

Chapter 5 - Climb Performance

Climb performance depends on an excess of thrust (power) over what is required for level flight. Losing power on one engine represents a 50 percent loss of thrust, but it often results in an 80 to 90 percent loss of climb performance - sometimes even more.

Chapter 6 - Cruise Performance

The *single engine service ceiling* is the altitude at which a twin-engine aircraft can no longer climb at 50 feet per minute in smooth air, with one engine feathered, at maximum certificated takeoff weight.

If you lose an engine at an altitude above single engine service ceiling, you can expect to drift down to the single engine service ceiling. Review the single engine service ceiling before each flight to determine if the airplane can maintain appropriate minimum altitudes and remain clear of terrain and obstacles.

Chapter 7 - Approach and Landing Performance

If you have to land a light twin with just one good engine, fly the approach and landing as near to normally as possible. Execute the approach and landing successfully the first time; your airplane may lack the power to make a successful go-around on just one engine.

Chapter 8 - Light Twin Training and Proficiency

Know key airspeeds and be thoroughly familiar with the AFM/POH recommended procedures. Know the basic one-engine-inoperative (OEI) emergency procedures common to all conventional light twins:

- ▶ **Control**. Maintain directional control with rudder and aileron. Assume the pitch attitude for V_{yse} .
- ▶ **Configure**. Execute the memory items from the "Engine Failure After Takeoff" checklist.
- ▶ **Climb**. Assume the bank angle and ball position for zero sideslip and maintain the best climb rate at V_{yse} .
- ▶ **Checklist**. Review and accomplish any remaining checklist items appropriate to the situation.



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- ▶ **Control**. Maintain directional control with rudder and aileron. Assume the pitch attitude for V_{yse} .
- ▶ **Configure**. Execute the memory items from the "Engine Failure After Takeoff" checklist.
- ▶ **Climb**. Assume the bank angle and ball position for zero sideslip and maintain the best climb rate at V_{yse} .
- ▶ **Checklist**. Review and accomplish any remaining checklist items appropriate to the situation.

Practice with a qualified flight instructor at regular intervals. Thoroughly brief all training activities, especially simulated engine failures, in advance.

Course Notes

For a copy of the course notes, please download the document below.

Related Media for this Section



Course Notes - Multi-Engine Safety Review

[Course Notes - Multi-Engine Safety Review.pdf](#) (897.76 KB)

Resources

For more detailed information, download the document below, which is the multi-engine flying chapter of the FAA's *Airplane Flying Handbook*. You might also find it helpful to visit the Learning Center Library for a copy of the safety pamphlet on *Flying Light Twins Safely* (P-8740-66).

Related Media for this Section



Transition to Multiengine Airplanes (Airplane Flying Handbook Chapter 12)

[FAA-H-8083-3a Chapter 12.pdf](#) (1.03 MB)