

MULTI-ENGINE RATING

ONE ENGINE INOPERATIVE FACTORS



Warning, Cautions, and Notes

- Throughout this course you will find special statements which concern the safety or operation of the airplane



Warnings

Means not observing the corresponding procedure can lead to an immediate and significant reduction in flight safety



Cautions

Means that not observing the corresponding procedure could lead to a short, or long-term reduction in flight safety



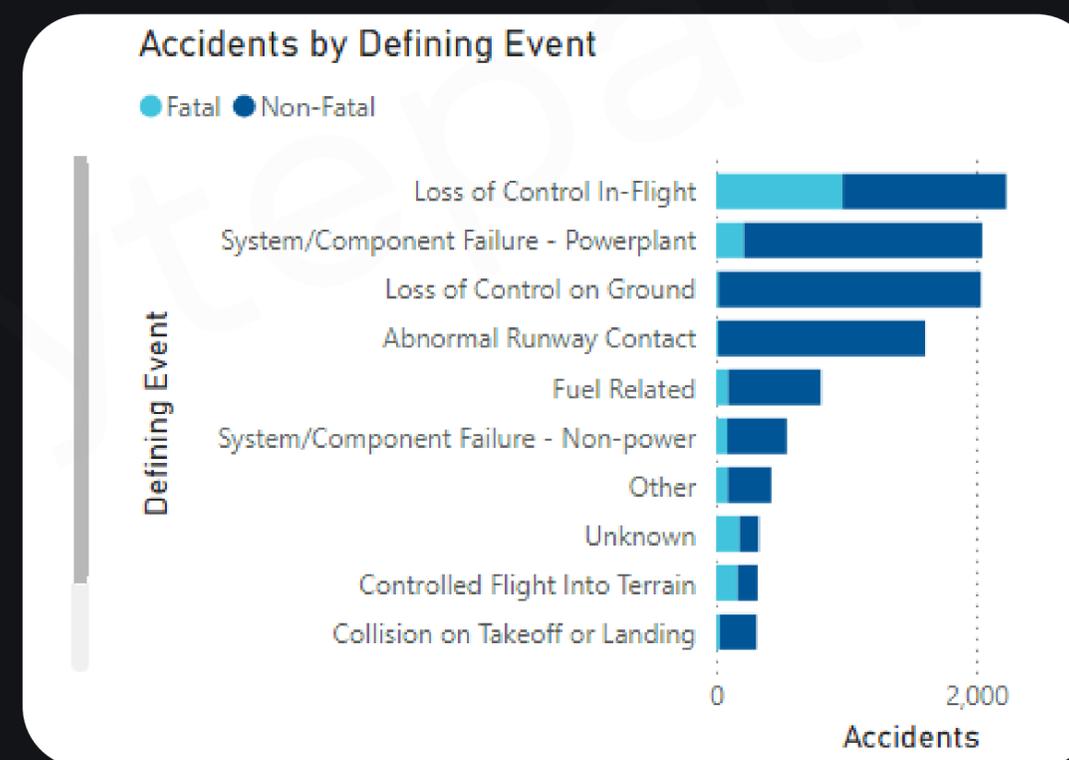
Notes

Signifies an important piece of information that is not necessarily related to safety

Introduction

Why Do We Care?

- Loss of control In-Flight are statistically the most fatal defining event in General Aviation
- Most of these accidents occur as a result of a powerplant failure, which is the second leading cause of fatalities by NTSB reports



When One Engine Fails

- Multi-engine aircraft operate differently in the event of an engine failure
- There are two main considerations when an engine fails:

1 Control

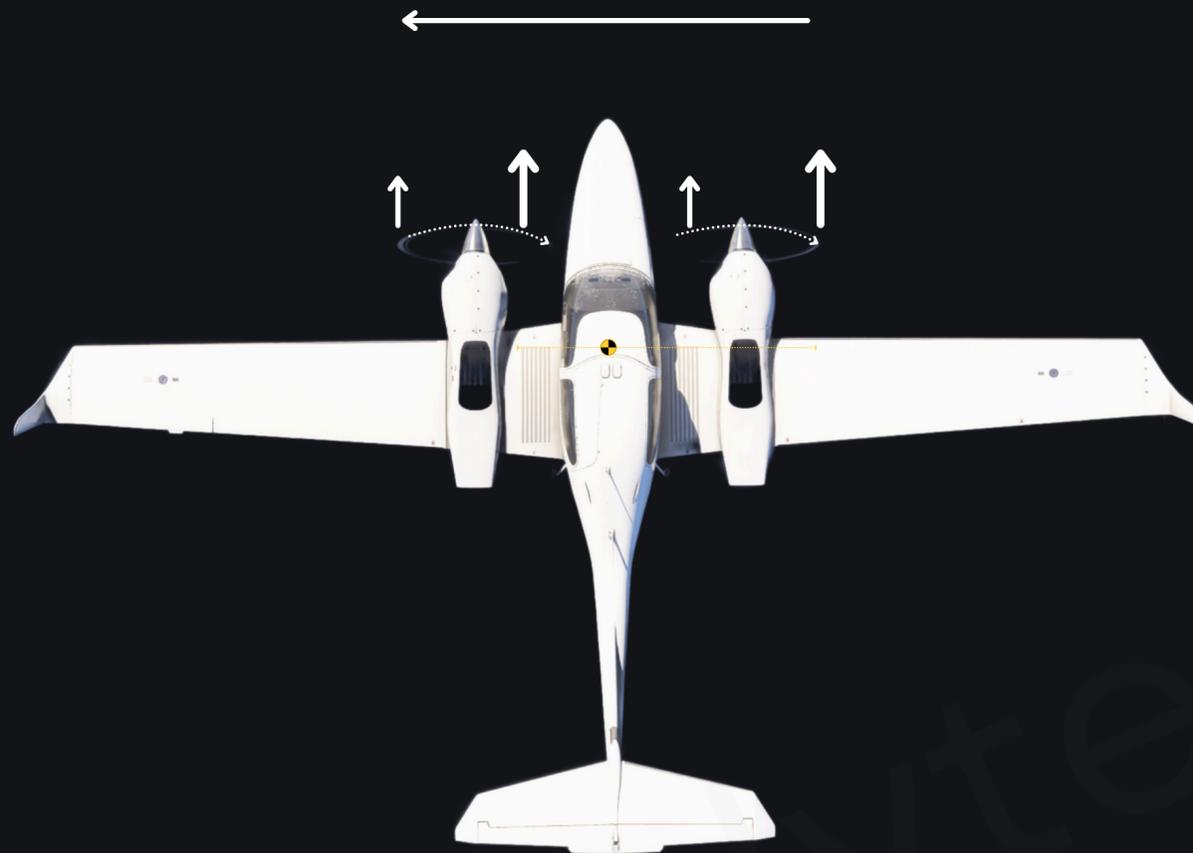
2 Performance

Controllability

- **Critical Engine:** The critical engine is the one whose failure would result in the most adverse effects on the aircraft's handling and performance characteristics
- On conventional, clockwise rotating twins as viewed from the pilot's seat, the critical engine is usually the left engine
- When operating in the single engine environment, the aircraft will have different handling characters than that of normal operations

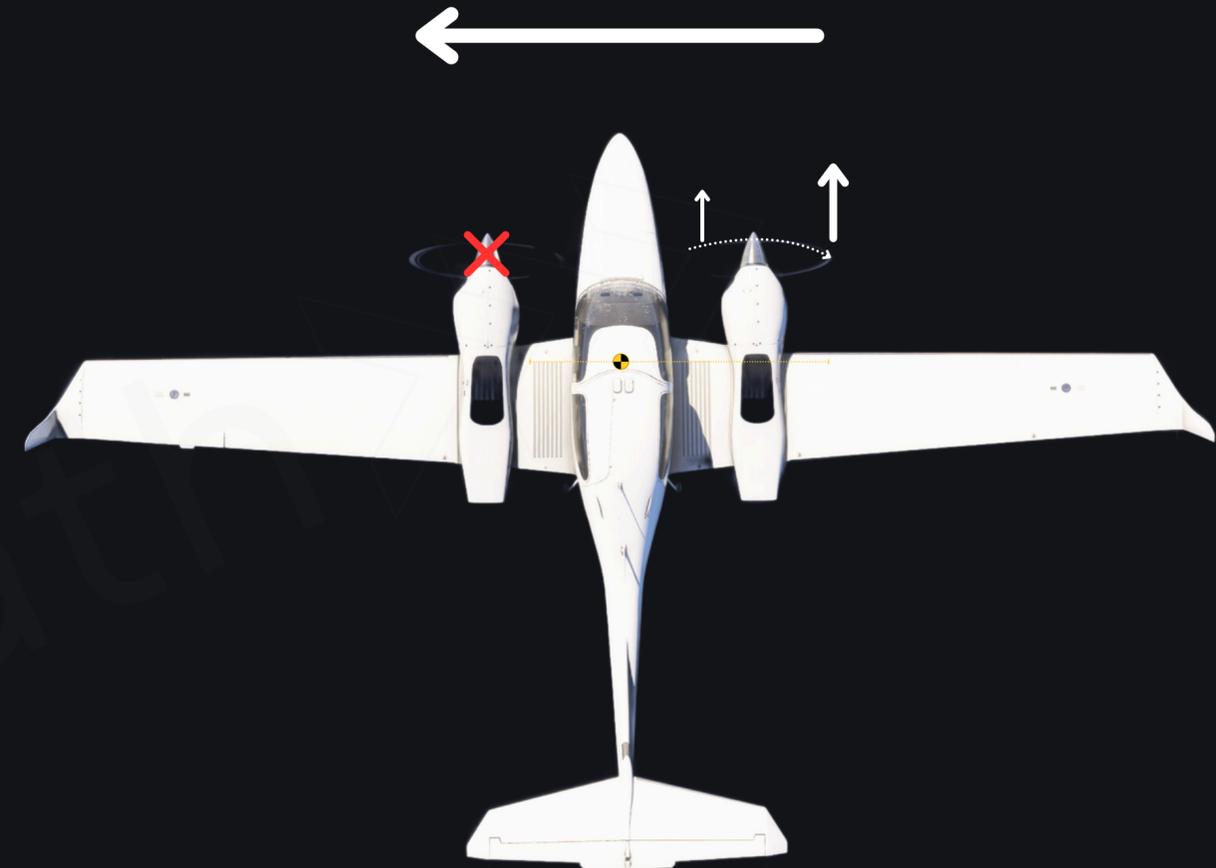
Critical Engine Inoperative Principles

P-Factor - Yaw



Both Engines Operative

- The descending propeller blade of each engine produces greater thrust than the ascending blades
- The descending propeller blade of the right engine is farther from the center of gravity (CG) than that of the left descending propeller



Critical Engine Inoperative

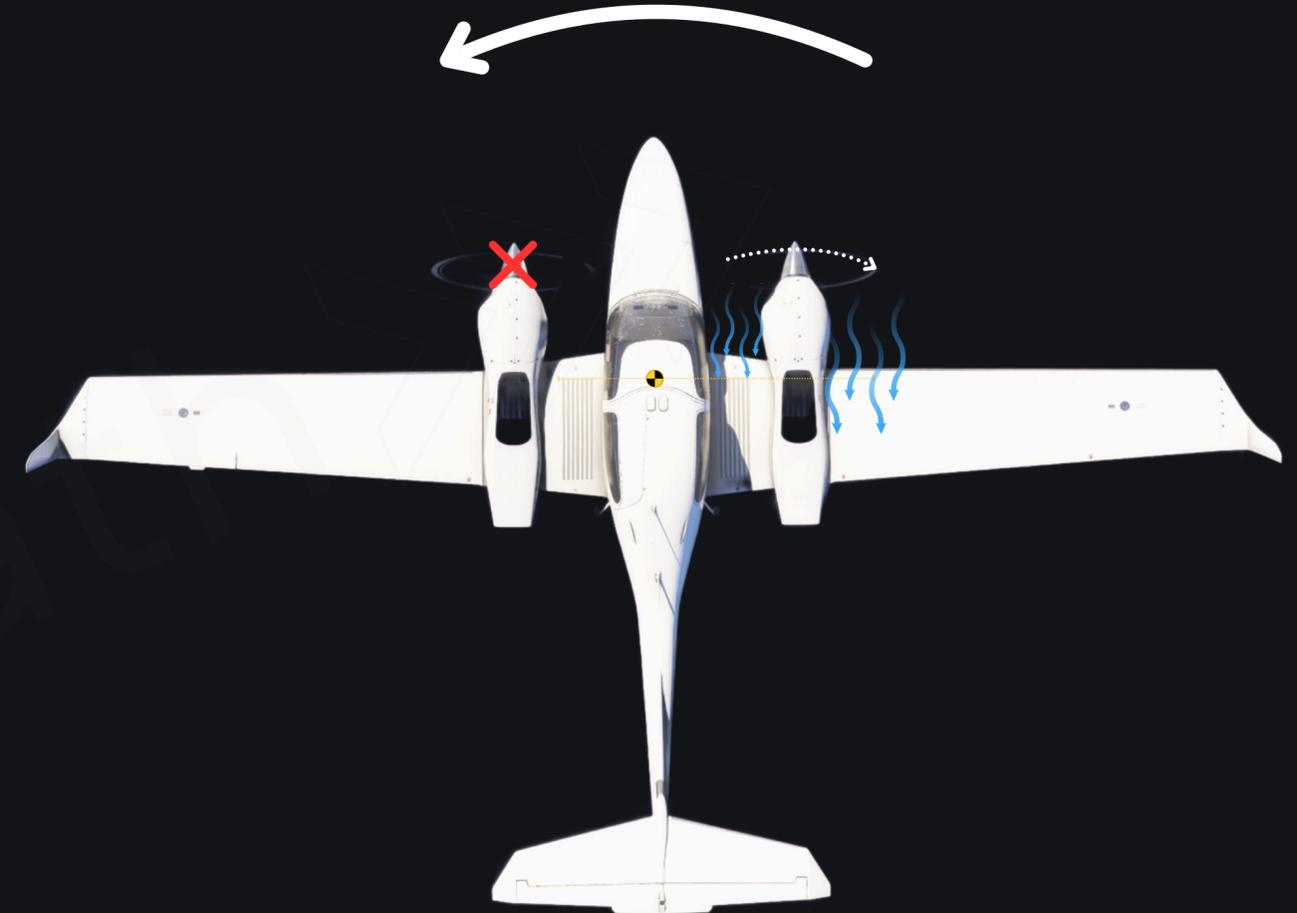
- Failure of the critical (left) engine will result in the most asymmetrical thrust due to the right engines descending propeller having a great arm

Accelerated Slipstream - Roll



Both Engines Operative

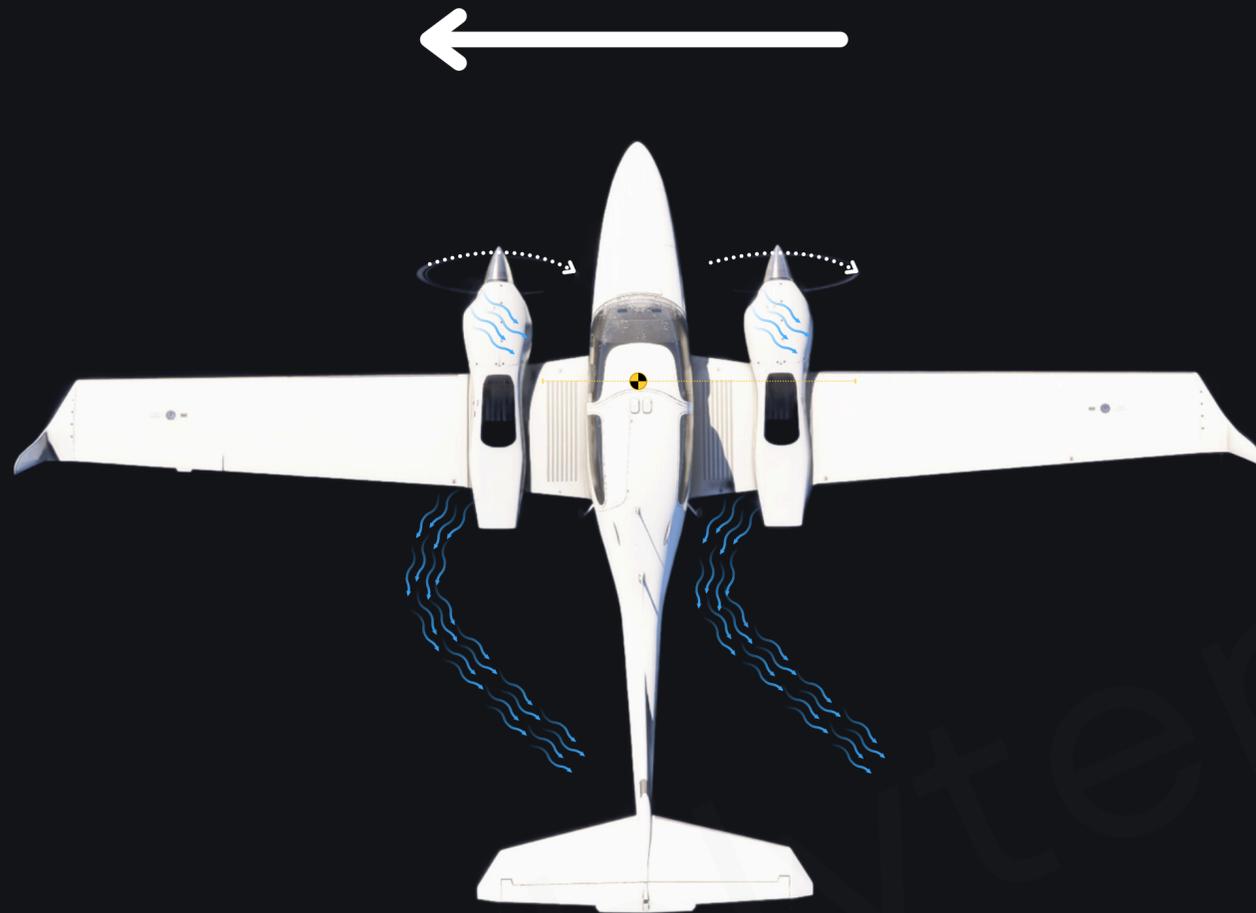
- The descending propeller blades produces more thrust than the ascending blades
- This results in greater airflow over the wings on the right side of each engine
- The right engines descending propeller has a greater distance (arm) than the left descending propeller



Critical Engine Inoperative

- As the critical (left) engine fails, there is more airflow of the right wing which generates more lift
- Resulting in a roll to the left

Spiraling Slipstream - Yaw



Both Engines Operative

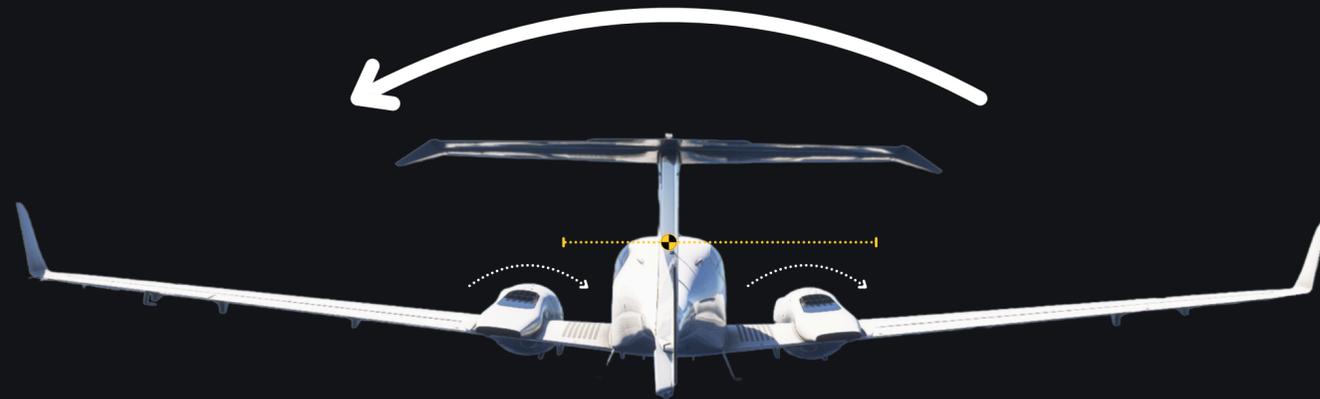
- Each propeller produces a clockwise spinning, three dimensional slipstream of air behind it due to the higher pressures tendency to flow into the lower pressure
- The critical (left) engine's slipstream strikes the vertical stabilizer on the left side creating a left yawing tendency about the vertical axis
- The right engine's slipstream, does not strike the rudder and has no effect on aircraft control



Critical Engine Inoperative

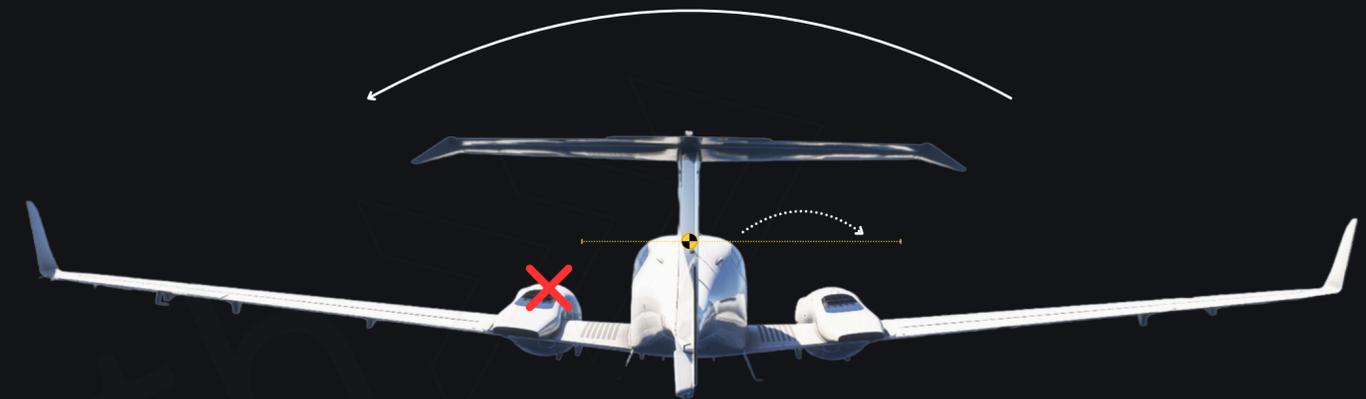
- As the critical (left) engine fails, there is no more slipstream to act on the vertical stabilizer
- Results in an increase in controllability

Torque - Roll



Both Engines Operative

- For every action there is an equal and opposite reaction
- As the propellers spin clockwise (right, from the pilot's perspective), torque is the equal and opposite reaction rolling the aircraft counterclockwise (left)
- If the critical (left) engine were to fail, the aircraft would yaw and roll toward the dead engine on the left, but in this case torque amplifies the left roll, making aircraft control more difficult
- Counter Rotating engines have no critical engine since an engine failure on either engine will affect handling characteristics the same way



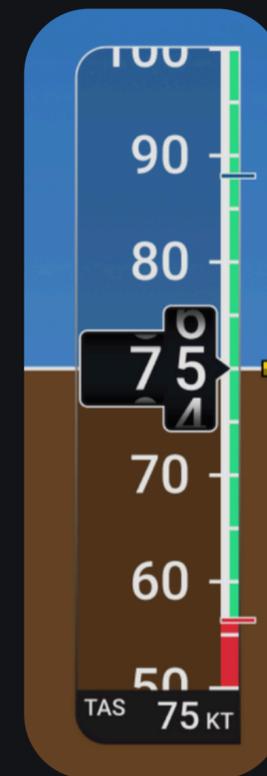
Critical Engine Inoperative

- If the critical (left) engine were to fail, the aircraft would both yaw and roll toward the failed engine
- This would result in the net torque being reduced by 50% and increase directional stability

VMCA

Minimum Controllable Airspeed

- **Vmca:** The calibrated airspeed at which, when the critical engine is suddenly made inoperative, it is possible to maintain control of the airplane with that engine still inoperative and maintain straight flight with an angle of bank of not more than 5 degrees
- Vmca is not a fixed airspeed and changes based on aircraft configuration, atmospheric conditions, and piloting ability
- It is only a fixed airspeed for the specific set of circumstances under which it the speed was determined during aircraft certification

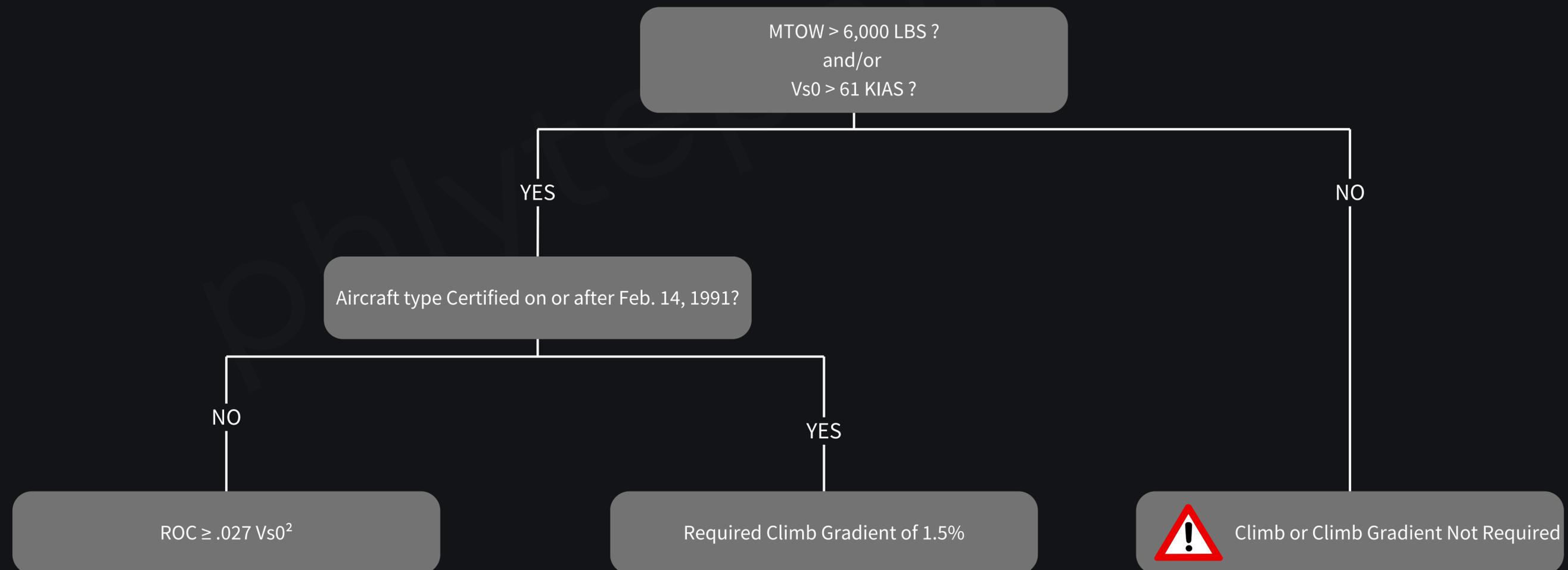


Can be identified as the red radial line on the airspeed indicator

Single-Engine Climb Performance

- Single-engine climb performance requirements for reciprocating engine-powered multiengine airplanes
- Requirements are further broken down into which phase of flight the aircraft is in

Reciprocating Twin Single-Engine Climb Performance



VMCA

Factors Affecting VMCA

Introduction

- Vmca is not a set number and will change based on aircraft configuration, atmospheric conditions, and piloting technique
- *Interactive Factors Affecting Vmc from UND*

Factors Affecting Vmc

- Vmc is not a set number and will change based on aircraft configuration, atmospheric conditions, and piloting technique

Factor	Vmc	Performance	Control	Logic
Maximum Takeoff Power/Thrust				
More Power/Thrust	↑	+	-	More yaw into the dead engine, causing more rudder pressure to be required
Less Power/Thrust	↓	-	+	Less yaw into the dead engine, causing less rudder pressure to be required
Most Unfavorable CG				
Forward CG	↓	-	+	The longer arm the less effective the rudder becomes, resulting in more force output
Aft CG	↑	+	-	The shorter arm the less effective the rudder becomes, resulting in less force output
Most Unfavorable Weight (at sea level)				
More Weight	↓	-	+	More inertia results in less yaw and roll
Less Weight	↑	+	-	Less momentum
Sea Level	↑	+	-	More dense air allows for more power/thrust by the operative engine, resulting in more force into the dead engine for the rudder to overcome
High Altitude	↓	-	+	Less dense air allows for less power/thrust by the operative engine, resulting in less force into the dead engine for the rudder to overcome
Most Critical Takeoff Configuration				
Flaps Up	↓	+	-	Less drag and less lifting force
Flaps Down	↑	-	+	More drag and more lifting force
Cowl Flaps Open	↓	-	→	Forces air into the the cowl flap resulting in increased drag on the operating engine which helps counteract yaw
Cowl Flaps Closed	↑	+	→	Eliminates air from entering the the cowl flap resulting in less drag on the operating engine which does not help counteract yaw
Propeller of the Inoperative Engine				
Windmilling	↑	-	-	More drag, more yaw towards dead engine, more rudder to counteract yaw
Static	↓	+	+	Less drag, less yaw towards dead engine, less rudder to counteract yaw
Feathered	↓	+	+	More drag
Flat	↑	-	-	Less drag
Landing Gear Retracted				
Landing Gear Up	↑	+	-	Less directional stability, more rudder required
Landing. Gear Down	↓	-	+	Acts as a keel (on a boat), providing more directional stability as less force required on the rudder
Out of ground Effect				
Out of Ground Effect	↑	-	-	Aircraft yaws and rolls into the dead engine, resulting in wingtip of the inoperative engine to dip further into ground effect, resulting in less drag, reducing the yaw
In Ground Effect	↓	+	+	Aircraft will not yaw and roll into the dead engine as much
Trimmed for Takeoff				
Trimmed for Takeoff	→	+	→	Trim only alleviates control pressures, making piloting easier
Not In Trim	→	-	→	
< 1.13 x Vsr				
Vmc must below below 1.13 x reference stall speed (Vsr) for the aircraft				
< 20° of Heading Change				
The Pilot should be able to prevent a heading change of not more than 20 degrees during recovery. Assuming no dangerous attitude, exceptional piloting skill, alertness, or strength. Fancy way of saying, anyone should be able to recover within 20 degrees of heading				
< 150 lbs of Rudder Pressure				
The force required on the rudder pressure shouldnt exceed more than 150 lbs. Should not be necessary to reduce power/thrust on the operative engine. Doing so would equalize the asymmetric thrust, making the aircraft easier to control				
< 5° of Bank				
	↓	+	+	It should be possible to maintain control of the airplane in straight flight with an angle of bank not more than 5 degrees

VMC Demonstration

Stall Avoidance

Critical Density Altitude

- Vmca decreases with altitude for normally aspirated engines, stalling speed remains the same
- At some point Vmca and Vs will meet
 - This point is known as the **Critical Density Altitude**
- Twins are not required to demonstrate recoveries from spins
- They tend to have very poor spin handling characteristics
- When a twin stalls under asymmetrical power it will spin in the direction of the idle engine
 - not in the direction of rudder input
- A Vmca demonstration that is allowed to degrade into a single-engine stall with high asymmetrical thrust may result in an unrecoverable loss of control and a fatal accident

