References: FAA-H-8083-3,

Objectives	▪ The student should develop knowledge of the elements related to single engine operations
Key Elements	▪ PAST ▪ Never go below V_{MC} ▪ Maintain directional control (fly the airplane)
Elements	▪ Critical Engine ▪ V_{MC} ▪ Flight Under V_{MC} ▪ V_{MC} and Stall Speed / altitude ▪ V_{YSE} ▪ Engine Failure During / After Lift-Off
Schedule	▪ Discuss Objectives ▪ Review Material ▪ Development ▪ Conclusion
Equipment	▪ White Board / Markers ▪ References
CFI Actions	▪ Present lesson ▪ Use teaching aids ▪ Ask/ answer questions
Student Actions	▪ Participate in discussion ▪ Take notes ▪ Ask / answer questions
Completion Standards	▪ The student will understand what a critical engine is, V_{MC}, and factors that effect V_{MC}

Additional Notes: ____
____
____
____

<u>CE</u> = Common Error

Introduction

Overview

Review objectives / Elements

What

Having two engines is great and all assuming both are operating correctly. Engine failures in a multi engine aircraft are handled very differently than single engine. This lesson will discuss the adverse effects of engine failures in muti engine aircraft

Why

Properly maintaining control with an engine failure is an essential skill of any multi engine rated pilot.

How

Critical Engine

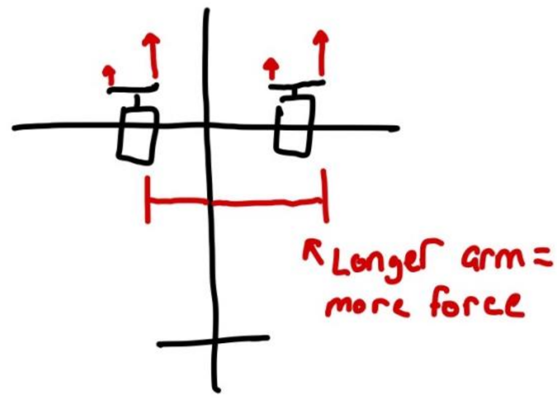
- **The critical engine is the engine whose failure would most adversely affect the performance and controllability of an aircraft**
- **In a conventional twin, both engines turn clockwise, the LEFT engine is critical**
- **Unconventional twins use counter-rotating props to eliminate the critical engine**
- **There are 4 factors responsible for the critical engine (PAST)**
    - P-Factor, Accelerated Slipstream, Spiraling Slipstream, Torque

References: FAA-H-8083-3,

P-Factor - YAW

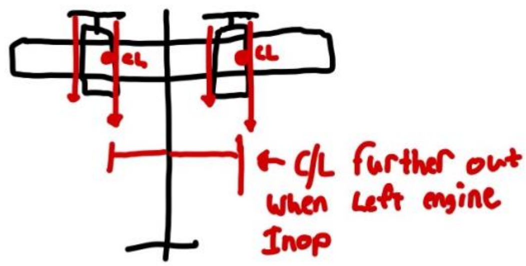
Descending Blade = Bigger Bite = more thrust

This effect is greater when Left engine inop Making Left engine critical



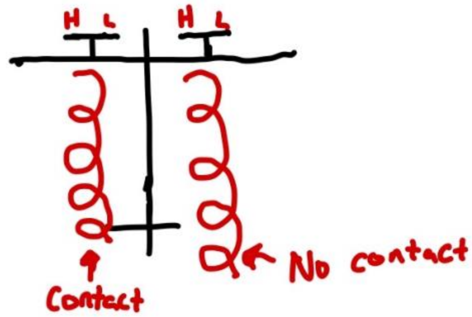
Accelerated Slipstream - Roll

Increased airflow from P-factor makes more Lift on the right side of prop.
This effect is more pronounced when Left engine inop = Left engine is critical



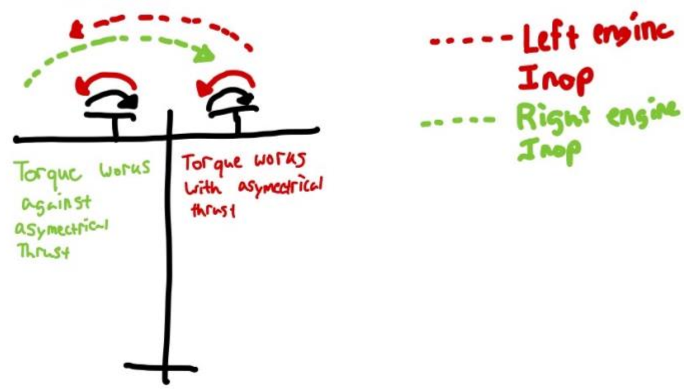
Spiraling Slipstream - YAW

Spiraling slipstream produces a countering force when Right engine is inop But does not when Left inop = Left engine critical



Torque - Roll

Newtons 3rd Law. Left engine inop - Torque works with A.T. making Left engine critical



V_{MC}

- **Minimum controllable airspeed or V_{MC} is the calibrated airspeed at which if the critical engine is suddenly lost, directional control can still be maintained and heading can be maintained with max 5° bank.**

V_{MC} During Aircraft Certification

- **Aircraft V_{MC} is found under a specific set of conditions when certified. FAR 23.149 (SMACFUM).**
    - These represent the most unfavorable conditions (highest V_{MC}).
- **S – Sea level and Standard Day – V_{MC} decreases as altitude increases.**
    - This is primarily due to the fact that the operating engine has the most performance at sea level and on STD days. This increases asymmetrical thrust and increases V_{MC}
- **M – Max power on operating engine – More engine power = higher V_{MC} due to the increased pull towards the dead engine**
- **A – Aft CG. (Legal limit) – Aft CG creates a shorter arm between the rudder and the CG thus making the rudder less effective. This in turn increases V_{MC}**
- **C – Critical Engine Windmilling – Increased drag from a windmilling prop causes the plane to yaw even more towards the dead engine thus, increasing V_{MC}**
- **F – Flaps TO, Gear Up, Trim TO – Flaps create drag on the accelerated slipstream on the operating engine and gear provides a keel effect to stabilize the aircraft (the piper Seminole nose gear moves the CG slightly forward as well).**
    - We don't want these benefits thus we test with flaps TO and gear up
- **U – Up to 5° of bank – Bank significantly lowers V_{MC} due to the horizontal component of lift countering the yaw. We limit this to 5 degrees to prevent unrealistically low VMC numbers. V_{MC} increases at a rate of 3kts per 1° of bank (V_{MC} in the Seminole can be upwards of 71 knots with no bank)**
- **M – Most unfavorable weight (lightest legal) – less weight = less inertia making the aircraft less stable. Less weight also means the aircraft is producing less total lift therefore, the horizontal component of lift from the bank is not as effective**

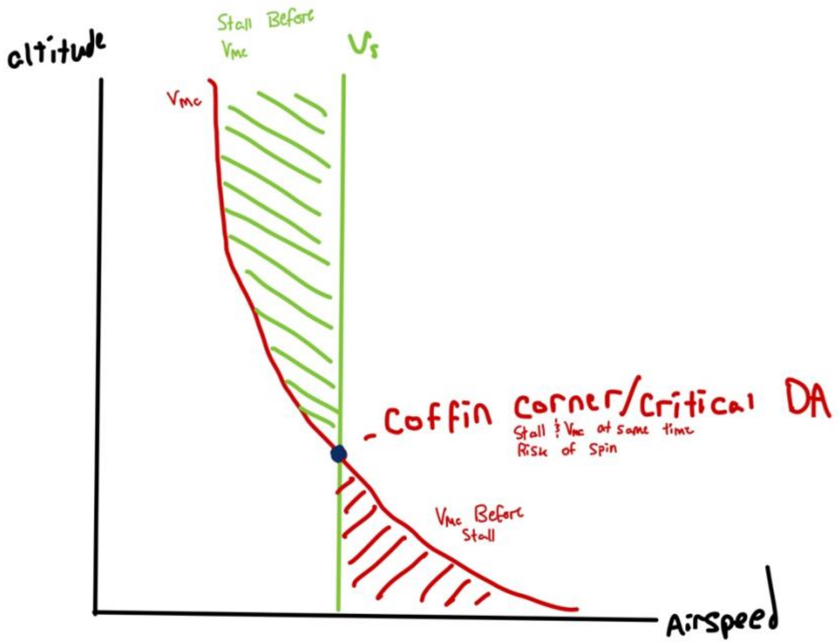
Factor	Control	V_{MC}	Performance
Windmilling Prop	Decreases	Increases (Bad)	Decreases
Max T/O Power	Decreases	Increases (Bad)	Increases
Sea Level (Low DA)	Decreases	Increases (Bad)	Increases
Light Gross Weight	Decreases	Increases (Bad)	Increases
Aft CG	Decreases	Increases (Bad)	Increases
Gear Up	Decreases	Increases (Bad)	Increases
Takeoff Flaps	Decreases	Increases (Bad)	Increases
Takeoff Cowl Flaps	Increases	Decreases (Good)	Decreases
Trimmed for T/O	?	?	?
Airborne / Out of GE	Decreases	Increases (Bad)	Decreases
Bank Angle (Up to 5°)	Increases	Decreases (Good)	Increases

Flight under V_{MC} (recovery)

- **When the aircraft falls below V_{MC}, the aircraft is no longer capable of counteracting the asymmetrical thrust produced and will lose control.**
- **Prompt recovery is key to regaining directional control**
- **The steps for recovery are as follows:**
  - Reduce throttle on operating engine and decrease pitch attitude
    - Reducing throttle on operating engine will reduce the amount of asymmetrical thrust being produce and drastically lower V_{MC} (allowing us to then be above V_{MC} again)
    - Reduce the pitch attitude to one that will allow airspeed to build. This increases rudder effectiveness and allows us to accelerate well above V_{MC}
  - Increase power on the operating engine once airspeed has begun to increase and directional control with full engine power can be maintained
  - Hold V_{YSE} or better

V_{MC} and Stall Speed / Altitude

- **V_{MC} increases with altitude and stall speed remains constant**
  - When performing V_{MC} demo at high altitudes usually the stall horn will come well before max rudder
- **When stall speed and V_{MC} are equal we call this the critical DA or "coffins corner".**
  - A spin is a stall with a yawing moment and that is exactly what we get when we stall at critical DA; a spin



V_{YSE}

- **V_{YSE} is the single engine best rate of climb airspeed**
  - When operating with a single engine airspeed should always be greater than or equal to V_{YSE}
    - V_{XSE} is the only exception for clearing obstacles
  - V_{YSE} will provide the slowest rate of descent to the single engine absolute ceiling in a drift down scenario

Engine Failure During / After Lift-Off

- **Takeoff and go-around are the most critical time to suffer and engine failure**
  - The aircraft will be slow and low to the ground
- **General rules during an engine failure**
  - Number 1 thing is to maintain directional control, flying the airplane is the largest priority
  - Airspeed – if committing to single engine takeoff – hold V_{YSE}
  - Complete the correct procedure for when the engine fails
- **Engine failure on takeoff roll before VR**
  - Immediately maintain directional control, close throttles and stop straight ahead, if you are going to overrun, secure the engines by removing fuel from them (mixture and selector)
- **Engine failure after liftoff with gear down and sufficient runway left**
  - Close throttles and land on the remaining runway
- **Engine failure after liftoff with gear up – this is a big one and it must be treated step by step**
  - Maintain directional control
    - Fly the plane! – V_{YSE} V_{YSE} V_{YSE} V_{YSE} V_{YSE} V_{YSE} V_{YSE} V_{YSE} V_{YSE} V_{YSE} V_{YSE} V_{YSE}!!!!!!!!!!!!!!
  - Get the most out of the operating engine
    - Mixtures fwd, props fwd, throttles fwd
  - Reduce drag
    - Flaps up, gear up
  - Identify the dead engine
    - Use the dead foot, dead engine method
  - Verify dead engine by closing throttle
  - Feather engine – Do not attempt to fix the engine due to the low altitude
  - Secure the engine by cutting off the mixture
  - Declare emergency and divert

Conclusion and Review

Conclusion

Briefly review key points