# Flight Advisor Corner by Hobie Tomlinson

**September 2013** **<u>Flying Multi-Engine Aircraft</u> (Pt. XV)** **AMEL PTS 6**

**<u>Continuing our series</u>** on flying FAR Part 23 (CFR 14, Chapter 1, Subchapter C, and Part 23) certified, small multi-engine airplanes, we are looking at the training issues involved in completing a multi-engine transition course.

**<u>This month</u>** we are continuing the **<u>Multi-Engine Transition Course</u>** series with the discussion of the actual items involved in the ***AMEL & AMES Practical Test*** portion of the **Commercial Pilot – Airplane Practical Test Standards** (**PTS**) ***FAA-S-8081-12C*** (***Commercial Pilot for Airplane Single- and Multi-Engine Land and Sea)*** that became effective on June 1, 2012.

**<u>The Commercial Pilot – Airplane, Multiengine Land and Multiengine Sea</u>** Practical Tests are contained in ***<u>Section 2</u>*** of the <u>Practical Test Standards</u> (PTS). ***<u>Section 1</u>*** of the *<u>Commercial Pilot Practical Test Standards</u>* contains the Practical Tests for Single-Engine Land and Single-Engine Sea Airplanes.

## Pressurized Twins ~ 1979 CE-340A Piston Twin

1,351 Aircraft Produced (1971 – 1984) Continental TSIO-520NB Engines @ 310 HP Ea.

***Wikipedia Image***

**<u>Before we continue</u>** with new material, I wanted to review and elaborate on ***<u>Task H</u>*,** contained in ***<u>Area of Operation I</u>*,** which we discussed last month. In order to contain the length of last month's article, I did not include commentary on these items, but as they are of "*<u>critical core content</u>*" to any Multi-Engine training and/or testing curriculum, I want to devote dedicated commentary to them in this month's article.

- **<u>Principles of Flight – Engine Inoperative (EI)</u> (Task H – AMEL & AMES)** is to validate that the applicant exhibits satisfactory knowledge of the elements related to engine inoperative (EI) principles by explaining the following items:

    - **<u>Meaning of the Term, "Critical Engine</u>."** – ***Critical Engine,*** as defined by 14 CFR, Part 1, Section 1, means the engine whose failure would most adversely affect the performance or handling qualities of an aircraft. For aircraft using U.S. manufactured engines, which turn clockwise when viewed from behind the propeller arc, the left engine becomes the critical engine. The reason for this occurring is the "P-Factor," which is the tendency of the descending propeller blade to have a higher angle of attack than the ascending propeller blade and thus produce greater thrust, especially when the longitudinal axis of the airplane is in a climbing attitude.

      **P-Factor** causes the thrust vector of an engine to shift from the center of the propeller arc toward the side of the descending blade, thus producing a left yawing force. Thus P-Factor causes the thrust vector, from the right engine, to be further away from the aircraft's center of gravity (CG) than the thrust vector, from the left engine; hence, it is operating with the left engine inoperative and using power from only the right engine that produces more yaw, a higher **V**mc, and requires more rudder deflection for any given set of parameters. The drag, associated with this additional rudder defection, lowers the performance available with only the right engine below the performance which can be achieved with only the left engine operational; thus it makes the left engine the critical engine.

      **An interesting side-note** is that on Cessna 337 aircraft, a centerline thrust, multi-engine airplane, the rear engine is the critical engine. This occurs because a boundary-layer airflow separation occurs over the lower-aft "turtle-deck" cowling when the aft engine is inoperative and only the front engine is producing power. This "flow-separation" increases the drag and lowers the front-engine-only performance below that which can be obtained using only the rear engine.

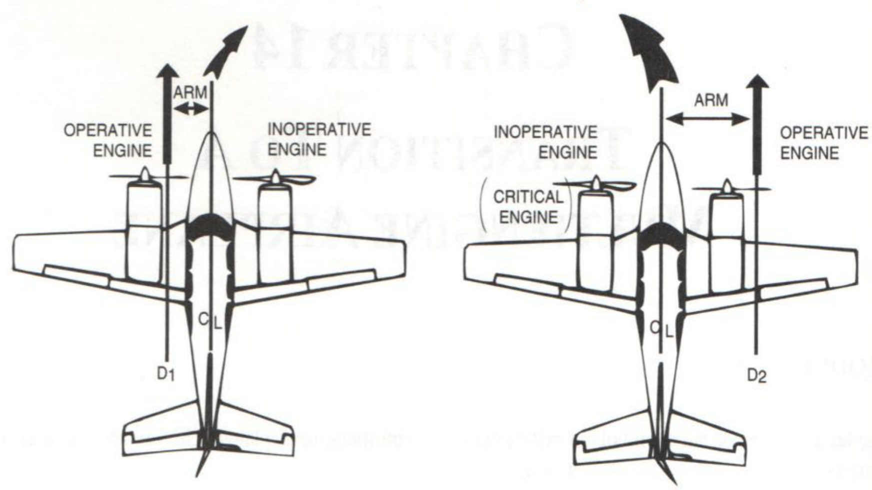


FIGURE 14-2.—Forces created during single-engine operation.

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- **Effects of Density Altitude on a *Vmc* (Velocity, Minimum Control) Demonstration**. ***Density Altitude*** (pressure altitude read from an aircraft altimeter – when set to a barometric pressure setting of 29.92 – and corrected for non-standard temperature) has a direct effect on aircraft performance. Although this is pretty common knowledge, what most people miss is that the lion's share of this performance loss is caused by the decrease in engine horsepower available under high density altitude conditions. Most normally-aspirated engines' maximum available power will drop below 75% of their maximum rated power – during normal cruise flight – in the 6,000 to 8,000 foot density altitude band (depending on the ram air pressure rise and intake duct losses associated with an individual aircraft's cowling and induction system design). Supercharged and/or turbocharged engines will produce rated takeoff power up to the engine's certified "Critical Altitude," which is why they are so popular in the high density altitudes of the western U.S. Turbo-Prop engines will produce rated takeoff torque up to their "Thermal-Limit" altitude. Once the "Critical Altitude" or "Thermal-Limit" altitudes of these respective engines are reached, they begin to lose power with altitude just like normally-aspirated engines. The net result is that any loss of available engine power lowers the aircraft ***Vmc*** due to the lower yawing forces associated with a reduced asymmetric power output.

- **Effects of the Airplane Weight and CG on Controllability. *Controllability* and *Performance*** are the first issues to be discussed as they apply to all airplanes. Both adequate Controllability and Performance are necessary to assure safe flight in any aircraft.

<u>*Controllability* is primary</u> – because without controllability – <u>*Performance* doesn't matter</u>! The minimum controllability airspeeds for any aircraft will always be below the best performance airspeeds. Pilots who have the flight discipline to maintain the required performance airspeeds (regardless of the performance generated – optimum performance airspeeds will produce the best performance possible under the existing circumstances) will never face controllability issues. However, when performance is very marginal, or even negative under adverse engine inoperative conditions, the natural tendency is to bleed energy (airspeed) in a vain attempt to force performance, which is just not available. The end of this process is always tragic because once energy is dissipated, not only does the performance actual decrease below what was being achieved at the proper airspeeds but also when the minimum controllability airspeeds are inevitably violated – control of the airplane will be lost!

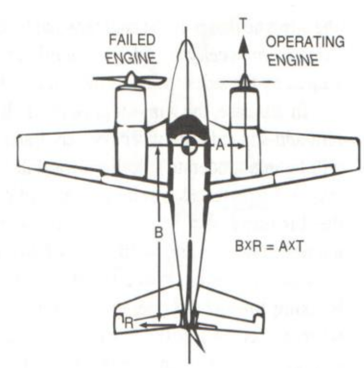

*FIGURE 14-3.—Effect of CG location on yaw.*

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**At Lighter Weights**, <u>*minimum, acceptable controllability is the defining issue*</u>. This is because lighter weights use lower performance airspeeds (that are closer to the minimum controllability airspeeds – thus lessening the airspeed margin); involve higher "deck angles" to maintain these airspeeds (which tends to increase yaw-roll coupling); have less inertia (which allows the airplane to diverge quicker); and provide a lower, sideward, anti-yaw component of lift in a 5 degree bank; thus, it requires more rudder deflection to contain the yawing forces of an inoperative engine (due to the lower lift vectors need to support the lighter weight). ***Thus Vmc speed – when using the prescribed 5 degree bank into the operating engine – is inversely proportional to aircraft weight (i.e. Vmc increases as aircraft weight***

***decreases – and conversely – Vmc decreases as aircraft weight increases)***.

**At Heavier Weights,** *minimum, acceptable performance becomes the defining issue*. (**Note:** One of the most difficult engine inoperative maneuvers in a swept wing airplane (strong yaw-roll coupling), is dealing with an engine failure during a very light weight, second segment climb in Instrument Metrological Conditions (IMC)!

***Center of Gravity (CG)*** is a little more basic and easier to understand. Because an airplane rotates (or pivots) around it CG location, the location of the CG determines the length of the arm that the rudder force is acting through. Since the yawing moment, produced by the rudder, is the product of the rudder force generated (a function of rudder deflection and airspeed) times the arm through which its acts, the maximum rudder yawing moment generated by full rudder defection at any given airspeed becomes a function of the airplane's CG location (i.e. length of arm through which the rudder force acts). Thus the shorter rudder moment arm associated with an aft aircraft CG will produce a lower rudder yawing moment than the longer rudder moment arm associated with a forward aircraft CG. Hence **V**mc increases as the aircraft's CG moves aft and – conversely – **V**mc decreases as the aircraft's CG moves forward.

- **Effects of Bank Angle on Vmc.** **Vmc** is inversely proportional to bank angle and decreases as bank angle is increased. Conversely, **V**mc increases as bank angle decreases. The typical light piston twin will experience a **Vmc** increase of approximately three knots per degree of reduced bank – away from the operating engine. The reason for this that it is the tilting of the wing's lift vector toward the operating engine in a constant-heading bank which produces a sideways lifting force that helps counteract the yawing moment produced by single engine operation. This counteracting force reduces the rudder deflection required to contain the yawing forces produced by single-engine operation (at any given airspeed) and thus lowers the **V**mc airspeed. Manufactures are limited (by regulation – CFR 14, Part 23, Section 149) to the use of a maximum of five degrees of bank into the operating engine when certifying the airplanes official **V**mc speed. (**Interesting Side-Note:** The "old-sage" advice about not banking away from the operating engine probably came from the original short wing Martin B-26 "Marauder" equipped with a small vertical stabilizer and rudder. Remember – "One a day in Tampa Bay?" **Vmc** could increase above single-engine speed when sharply banked away from the operating engine and the concept was probably not well understood during that area. This is obviously not true of current airplanes and was subsequently corrected in later versions of the "Marauder.")



Hobietw@att.net  (802) 363-3411

- **Relationship of Vmc to Stall Speed (V$_{S1}$).** **Aircraft Stall Speed(s)** – **V**$_{S1}$, or stall speed with flaps "UP" in this case – remains at a relatively constant indicated airspeed until reaching an altitude that air compressibility starts to become a factor – usually considered to be above 24,000 feet mean sea level (MSL). (Above this point an aircraft's indicated airspeed at stall starts to increase.) Because **V**mc decreases with altitude (due to the increasing power loss experienced by normally aspirated engines as they climb) and the fact that the aircraft's clean stalling speed (**V**$_{S1}$) remains constant, a convergence of these two speeds starts to occur, with **V**mc eventually even dropping below stalling speed. *There is a high danger in trying to execute a **V**mc demonstration at any altitude where there is insufficient margin between **V**mc and V$_{S1}$*. Should the airplane be inadvertently stalled with high asymmetric power (especially if high aileron deflection is being used in a vain attempt to counter yaw) a violent yawing/rolling departure from controlled flight will result. Because of a light twin's propensity to flat spin, this unrecoverable condition can possibly be entered instantaneously, which has been the initiator of many fatal light twin training accidents. (The Piper PA-30 – Twin Comanche – is particularly susceptible to this issue and requires extra care during multi-engine training.) *The solution to this problem is to preform **V**mc demonstrations in an airplane configuration that produces an artificially high **V**mc and provides a sufficient safety margin above stall* (i.e. using a wings-level, "zero-bank-angle," with only minimal aileron deflection and no rudder trim).

- **Reasons and Indications for Loss of Directional Control.** ***Loss of Directional Control*** occurs – during engine inoperative (EI) flight – when the asymmetrical yawing forces, produced by the operating engine, are no longer able to be overcome by the maximum (opposing) yawing moment produced by full rudder deflection. The ***Indications of Imminent Loss of Directional Control*** are the beginning of a yawing/rolling movement toward the inoperative engine, despite the application of full rudder deflection against the yawing/rolling movement.

- **Importance of Maintaining Proper Pitch, Bank, Attitude, and Coordination of the Flight Controls**. ***It is of critical importance*** to correctly implement Engine Inoperative flight procedures (Especially **Vmc** demonstrations) in order to maintain an acceptable degree of safety during multi-engine training and/or testing scenarios.

  Safety Procedures for multi-engine training and/or testing events include, but are not limited to, the following:
  - Always complete a detailed safety briefing prior to the flight.

- Use safe minimum altitudes – All maneuvers are required to be completed above 3,000 feet AGL (Above Ground Level), or any higher manufacturer's recommended altitude, by the FAA Practical Test Standards.
- Remember, **V**mc is a condition – not a fixed speed – and can vary significantly from the red radial line marked on the airspeed indicator (the **Vmc** airspeed that was demonstrated during aircraft certification).
- Never try to control yaw with the ailerons. Although some aileron deflection is required to balance lift on airplanes in which the operating engine increases the airflow over the wing section directly behind (or in front of) the operating engine (true for airplanes with wing mounted engines driving propellers or tail mounted turbojet engines); the typical aileron deflection required should not normally exceed approximately a one-third deflection of the control yoke. *Using large aileron deflections in lieu of additional rudder produces the potential of stalling the wing section in front of the down aileron – especially when yawing is occurring, thus initiating a violent departure from controlled flight!*
- Always initiate asymmetric thrust conditions with an adequate airspeed margin. When executing **V**mc demonstrations, slowly reduce to **V**mc using a deceleration rate of approximately one knot-per-second in gently climbing flight. Use "Zero-Bank-Angle" flight to artificially increase **V**mc and provide a satisfactory demonstration at a speed which has a sufficient margin over stalling speed.
- Simulate all engine power losses with the engine throttle control when below 3,000 feet AGL. Use the engine mixture control to produce power loss in-flight only when above 3,000 feet AGL.
- Adhere to restrictions contained in the applicable PTS when training/testing engine failures during takeoff.
    - Aborted takeoffs must occur at airspeeds below 50 percent of the calculated **V**mc. Power loss may be induced with the engine mixture control but be prepared to cut the second engine mixture control if the student does not react properly and promptly. Heading divergence occurs very rapidly at this speed. (In a crosswind, failing the downwind engine slows the rate of heading divergence.)
    - Engine power loss after takeoff must be initiated with the engine throttle control and cannot be implemented until after obtaining an appropriate airspeed and an altitude greater than 500 feet AGL.



Hobietw@att.net  (802) 363-3411

- **Recovery Procedures for Loss of Directional Control**. ***Recovery Procedures*** for loss of directional control are two-fold. Airspeed can be increased to provide more rudder authority and/or engine power can be reduced to lessen the asymmetric yawing forces and lower **V**mc. It is important that the appropriate recovery procedure be implemented as soon as uncontained yaw (with full rudder deflection) is identified. When altitude is available, the nose should be lowered to a "target" pitch attitude that will increase airspeed sufficiently to provide adequate rudder authority to contain the asymmetric yawing forces. When existing altitude is insufficient to permit increasing the airspeed enough to provide adequate rudder authority, the power on the operating engine must be reduced (thus lowering the asymmetric yawing forces) to the point where the rudder authority currently available is able to contain the asymmetric yawing forces. In extreme cases, where directional control is being rapidly lost, a large power reduction must be immediately made while simultaneously lowering the nose to increase airspeed and rudder authority.

  **Recovery Procedures** for a "departure" from controlled flight (in case of a "botched" Vmc demonstration or other engine inoperative maneuver) must be immediate and decisive before an unrecoverable situation develops. **Step One** is eliminating all asymmetrical yawing forces by immediately closing both throttles and **Step Two** (which is performed simultaneously) consists of abruptly unloading the wing (to approximately one-half to one-quarter positive "G") by rapid forward pressure on the elevator controls. Rapid, intentional "unloading" of the wing immediately ends the wing's stalled condition and prevents a spin from developing. (The stalling speed of a wing decreases as its positive G-loading decreases, becoming zero airspeed at zero G. As the wing goes into a negative G loads, the negative G stalling speed starts increasing in proportion to the wing's negative G-loading.)

- **Engine Failure during Takeoff – including Planning, Decision Making, and Single Engine Operations (EI). Part 23, *Multi-Engine Airplane Takeoffs*** involve three distinctive phases that are as follows: **1)** Prior to lift-off; **2)** Between Lift-off and 400 feet AGL (the "Area of Decision"); and **3)** Subsequent to 400 feet AGL.

  - **The "Prior to Lift-Off" Phase** of a multi-engine takeoff requires that an aborted takeoff be immediately implemented should an engine failure occur during this phase. The planning for this phase requires that the distance to accelerate to lift-off airspeed and stop (Accelerate-Stop Distance) be calculated and that sufficient runway is available to accommodate this distance.

- **The "Area of Decision" Phase** of a multi-engine takeoff occurs between Lift-off and 400 feet AGL. During this phase of the take-off, *the ability of a Part 23 multi-engine airplane to successfully continue the take-off is contingent on a multitude of factors and is usually an unknown*. (This is in sharp contrast to a Part 25 multi-engine takeoff, during which the aircraft is required to have performance sufficient to successfully continue the takeoff following the failure of the critical engine at a predetermined **V**ef (engine failure) speed and achieve the required height above the takeoff surface within the takeoff distance.)

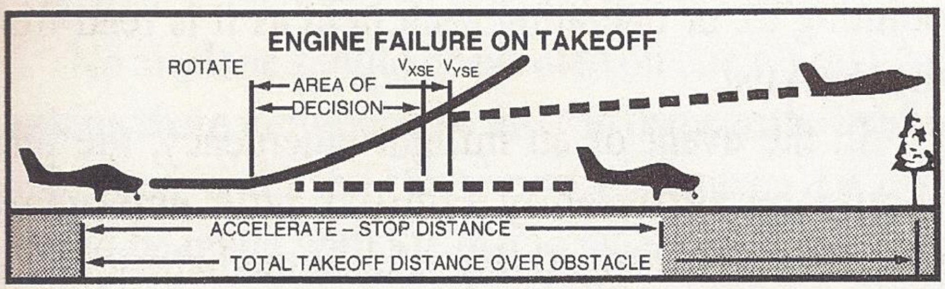

FIGURE 14-7.—Area of decision.

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**Engine Failure during the "Area of Decision"** involves implementing one of the following three strategies:

1) If the landing gear retraction process has not been implemented, close both throttles and land on the remaining runway.
2) If the landing gear retraction process has been implemented, configure the aircraft for single engine climb (inoperative engine's propeller feathered, flaps up & landing gear up) and observe the climb rate. If the aircraft is subsequently climbing and will clear obstacles, continue the takeoff.
3) If the aircraft is subsequently not climbing sufficiently to clear obstacles, or is sinking, make an off-field landing. (If time and the available landing area permit, the landing gear and flaps may be extended.)

- **"Subsequent to 400 Feet AGL",** the aircraft should have sufficient obstacle clearance to circle back to the landing runway, even if it is unable to climb higher. In the event of an engine failure above 400 feet AGL, configure the aircraft for single engine climb and continue the takeoff to a height which allows the aircraft to return for landing. If the density altitude is such that the airplane is incapable of climbing, or even level flight, an off-field landing may still be required, depending upon the airplane's altitude, drift-down rate, and location in relation to a suitable landing runway.

**This appears** to be a good stopping place for this month. Next month we will continue working our way through the actual Practical Test by picking up our discussion with the next ***Area of Operation*** **(Preflight Procedures)** that is contained in the **Commercial Pilot – Airplane Multiengine** Practical Test Standards that became effective on June 1, 2012.

The thought for this month is: ***"It's not what you look at that matters, it's what you see."***
**~ Henry David Thoreau,** ***American Author.***

So until next month, be sure to ***Think Right to FliRite***

## Pressurized Twins ~ CE-340A Turbo-Prop Conversion


Refurbished 1979 CE-340A ~ Powered by (2) Rolls Royce 250-B17F/2 Engines
***Hobie Tomlinson Image***



Hobietw@att.net  (802) 363-3411