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VMC MANEUVERING

by Rick Wheldon

"… (Following takeoff,) several witnesses reported seeing the airplane's right propeller "stopped." One witness reported that as the airplane lifted off the ground, he heard "a loud cracking sound followed by an immediate prop wind down into feather." He continued to watch the airplane, as the gear was retracted and the airplane entered a climb and right turn. Subsequently, the airplane pitched up, entered a "Vmc roll-over," followed by a 360 degree turn, and then impacted the ground."

This, from the factual statement of an NTSB report, was followed by the predictable probable cause of "the pilot's failure to maintain the minimum controllable airspeed following the loss of engine power during the initial takeoff climb … "

Had this engine failure been in a single engine airplane, the resulting 2 fatalities would probably have instead been a slight or undamaged airplane and no injuries. They would have landed back on the same runway since liftoff occurred approximately 3000 feet down an 8502 foot runway with a long grassy field at the departure end. Instead, there was a loss of directional control, followed by a stall/spin type of accident.

When the FAA Flight Standards Board reviewed the MU-2, they noted this accident and determined that Vmc training could improve MU-2 safety. Consequently, a Vmc demonstration maneuver was added to the MU-2 training program and now must be performed on every initial, re-qualification, and recurrent training event, whether it is

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conducted in the airplane or in the simulator. For most of us, the last time we performed the Vmc demonstration maneuver was when we obtained our multi-engine license, so this skill is at best rusty and quite possibly forgotten.

To review the maneuver, we first have to look at Vmc. A common misconception is that Vmc is the speed at which the airplane will lose directional control. Actually, Vmc is one speed at which an airplane will lose directional control under a narrowly defined set of conditions. Some of those conditions are:

1. The airplane is configured for the initial climb, with the gear up and the flaps at the takeoff configuration.
2. The airplane is trimmed for takeoff.
3. The critical engine is assumed to have failed, but the pilot has not yet feathered the engine. For the MU-2, this means that the engine is NTSing, which is the highest drag condition that a failed MU-2 engine will normally develop. Note that the critical engine in 4 bladed MU-2 aircraft is the right engine, but in MU-2s with 3 bladed propellers, the left is the critical engine.
4. The non-critical engine is assumed to be operating at maximum power.
5. The airplane can be banked up to a maximum of five degrees into the operating engine. Since it is in the manufacturer's best interest to demonstrate a low Vmc, and since the speed for loss of directional control will decrease as the bank angle is increased, it is fairly safe to assume that all airplanes are certified with the maximum allowable 5 degrees bank into the operating engine.
6. Finally, the CG is assumed to be at its most aft position.

With all these variables, it is obvious that loss of directional control can occur at a variety of airspeeds, depending on configuration, trim, which engine failed, pilot technique (bank angle and yaw control) and CG. I generally assume that loss of directional control will occur at an airspeed higher than the published Vmc. However, loss of directional control will seldom occur at airspeeds above Vxse, which is the first target airspeed for an MU-2 in the event of an engine failure. Therefore, with proper technique, directional control can almost always be maintained when the proper engine failure after takeoff profile is followed.

Let's look at the Vmc demonstration maneuver in the training manual, referring also to the FAA Practical Test Standards. To begin the maneuver, slow the airplane in level flight to 125 knots on 2 engines and trim. This approximates the takeoff trim setting. Without re-trimming, set the critical engine to zero thrust (between 5% and 17% torque) and advance the simulated operating engine as required to maintain the 125 knot airspeed. Using rudder and spoiler, bank into the operating engine approximately 3 degrees, to the zero sideslip bank angle. The balance ball will displaced about 1⁄2 ball width towards the operating engine. Hold the rudder pressure and stabilize the attitude. Now, raise the nose slightly and advance the operating engine power to takeoff power. This will require the addition of still more rudder. Adjust pitch to slowly reduce the airspeed at a rate of 1 knot per second. Rudder pressure will increase fairly rapidly as you slow. Keep the bank angle and ball displacement constant. At about 10 knots before published Vmc, the instructor will place his foot on the rudder to prevent further deflection. To the student, this will feel as if the rudder has reached its stops, and any further airspeed decay will result in a loss of directional control. Once this is recognized, recover by lowering the nose slightly to increase airspeed, and reducing power on the operating engine. Once airspeed has increased, power may be slowly added. The maneuver is complete when the airplane is again established straight and level at 125 knots airspeed.

A benefit of performing the Vmc demonstration in this manner (maintaining takeoff trim) is that the student gets a realistic feel for what the actual rudder pressure will be in the event of an engine failure right after liftoff. Certification requirements allow up to 150 pounds of rudder pressure at Vmc, which can be a challenge for some smaller pilots. This, of course, brings up another point – the pilot seat placement is critical. I once flew a simulated engine failure with a highly qualified pilot who nearly lost control of the airplane at 130 knots. It turned out that his seat was too far back for him to fully depress the rudder pedal. I shudder to think of the outcome if the engine had actually failed at 110 knots.

Another benefit is to practice flight at optimum bank angle, which results in zero sideslip. In other words, at optimum bank, the fuselage is pointed directly into the wind. This produces minimum drag and the best rate of climb. Optimum bank produces another very real benefit. Since the rudder does not have to be displaced as far as a wings level, ball in the center condition, less rudder pressure is required. It's easier!

Of course, all multi-engine pilots recognize that, when maneuvering on a single engine near Vmc, they are also maneuvering near stall, Vs. How should a pilot respond to an impending single engine stall? It turns out that the recovery procedures for stall are nearly identical to those for Vmc. If a buffet or a stick shaker is noted, immediately lower the nose and reduce power on the operating engine. I would be more aggressive in the stall recovery as compared to the Vmc recovery, because single engine stalls can easily progress into spins, which are commonly fatal near the ground. The difference between a single engine stall and a single engine spin is usually yaw control. If the balance ball is where it is supposed to be, a stall will likely result. However, with poor pitch and yaw control, spins are the common outcome. The yaw creates the spin.

How do the indicated airspeeds for loss of directional control and stall compare to one another? Under any given set of conditions, either could be higher. Vs remains relatively constant at the altitudes that we operate (it increases slightly at the highest altitudes due to compressibility effects.) Directional control, on the other hand, is greatly affected by power changes. Thus, at low altitudes, where we can maintain 100% torque, the speed for loss of directional control is relatively constant during the climb. However, as we climb past the altitude where the engine becomes temperature limited, the torque begins to drop off and the Vmc speed will start to decrease. Directional control may be observed at speeds slower than stall speeds, so the stall becomes the limiting factor. This is illustrated in Fig.1 (below), for the condition where power is decreasing with increasing altitude. Because of a concern about initiating single engine stalls, many instructors shy away from Vmc demonstrations at high density altitudes.

Single engine operations near Vmc require skill and care. Balanced flight is essential. The most important lesson to be learned from the Vmc demonstration, in my mind, is this – don't get slow in the first place. In the understated words of a friend of mine – a truly talented aero engineer – "Always remember, airspeed is your friend." That seems like good advice to me.

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