From: [redacted]
To:
Subject: FW: DC3 accident -- Vmca discussion by FAA flight test pilot
Date: Saturday, June 1, 2019 4:14:06 PM

VMCA information from FAA Flight Test Pilot

From: Roberts, Charlie (FAA) [redacted]
Sent: Wednesday, May 29, 2019 9:32 PM
To: Folkerts Michael [redacted]
Cc: Hempen, Patrick (FAA) [redacted]
Subject: RE: DC3 accident -- Vmca

Mike, Pat –

V_{MCA} : Minimum Control Speed (Air)

V_{MCA} is the minimum airspeed at which a multi engine airplane remains safely controllable and able to maintain basic directional control in the event of a failure of one or more of its engine(s) while in flight with at least one remaining engine operative. Directional control of an airplane with a failed engine is primarily maintained by inputs by the pilot to generate aerodynamic effectiveness of the airplane's flight control surfaces (mostly the rudder) to counteract the yawing moment caused by the asymmetric thrust of the operating engine(s) in addition to the increased drag on the opposite side of the longitudinal centerline of the airplane due to the the engine failure. Aileron input to keep the wings level (and/or up to 5 degrees of bank into the operating engine is an additional component to directional control as it is also important to be able to maintain lateral (bank) control of the airplane in the situation of an engine failure. It has been shown, that, in most multi engine airplanes, banking between 2 to a maximum of 5 degrees into to good engine (depending on some other factors such as speed, aircraft weight, and location of its center of gravity) can have a beneficial effect to V_{MCA} considerations. V_{MCA} is a minimum in-flight airspeed established for an aircraft under a certain defined set of factors, assumptions, and specified aircraft configuration (gear, flap, power, and weight/CG) that of which flying at (or above) has been proven acceptable for maintaining aircraft directional control without running out of flight control deflection or control force limits.

In the specific case of the subject DC-3 accident airplane (N467KS), V_{MCA} was to be re-evaluated by flight test and established as a part of its upcoming aircraft certification project to modify the airplane by installing engines capable of more horsepower than those that were previously approved on the airplane, however this had not yet been conducted for the subject aircraft at the time of the crash. The V_{MCA} for the airplane with its previously approved engines producing was published (in the Airplane Flight Manual) as 75 Knots Calibrated Airspeed (KCAS) / 67 Knots Indicated Airspeed (KIAS). In other similar certification projects of this nature on this type of airplane it has been found that an approximate 1 knot increase for every 33 horsepower of increase to the available engine power (assuming all other factors disused above for establishing V_{MCA} for the airplane remain the same). Using this analytical approach to an estimate of what the new V_{MCA} would be for the increase of horsepower alone, it equates to an additional 5 to 6 knots above the baseline V_{MCA}.

Given that it appears that the left propeller did not feather when the left engine suddenly failed at or shortly after V_1 the amount of drag this would result in it is estimated through drag equations to have raised the V_{MCA} another approximately 20 knots.

Additionally, from photographic evidence of the accident sequence of events, it appears that the aircraft yawed and banked to the left (opposite of into the operating engine) during the accident sequence suggesting that the drag of the apparent unfeathered propeller on the left engine, coupled with the higher horsepower of the operating engine on the right side of the aircraft, was greater than the rudder deflection and aileron inputs to overcome the asymmetric thrust/power condition during the accident sequence after liftoff from the runway. The yaw and bank opposite of the operating engine is estimated to additionally increase the estimated VMCA another 5 to 10 knots.

Overall, considering all the factors shown in the accident sequence (as mentioned above), it is conservatively estimated that the minimum airspeed required to maintain directional control of the aircraft (V_{MCA}) would have been on the order of an additional 30 to 40 knots above the previous V_{MCA} of 75 KCAS / 67 KIAS – which would equate to 105 to 115 KCAS / 97 to 107 KIAS. According to engine ADAS data recordings during the accident sequence the airplane's airspeed varied from approximately 86 knots at engine failure to a maximum of approximately 90 knots briefly before decreasing to approximately 73 knots just prior to impact.

******* "and now … for the rest of the story …" all about V_{MCA} *******

V_{MCA} is not to be mistaken for an airspeed that assures that the aircraft will still be able to either maintain altitude or be able to climb in the event of an engine failure. It is a minimum airspeed established for a particular aircraft at which the ability exists to safely maintain directional control only.

V_{MCA} for any given airplane model is normally established during initial aircraft certification by flight test and is typically re-established as a part of any subsequent aircraft certification projects for modifications made to the aircraft that could have an effect on the airplane's V_{MCA} (ie. engine power modifications and/or propeller changes, aerodynamic changes effecting flight control effectiveness such as vortex generators, changes to the aerodynamic exterior shape of the airplane by external shapes/equipment, etc.). During the initial or subsequent certification flight test efforts, V_{MCA} flight testing is conducted to show compliance to directional control requirements in both a static and dynamic condition when failure occur of the aircraft's defined critical engine. Both conditions have corresponding criteria and methodology for demonstrating satisfactory directional control in the event of a failure of the aircraft's critical engine.

When V_{MCA} is determined for any given airplane model it is predicated upon certain defined factors and assumptions. Typically, the worst case of aircraft weight and balance producing the most conservative (a higher V_{MCA}) is a light weight/aft Center of Gravity (CG) aircraft. Other factors for determining an aircraft's V_{MCA} include that maximum flight control surface deflections and/or any control force limits (ie. rudder force limits) will not be exceeded in the process of maintaining proper directional control. Two assumptions that are generally made for determining V_{MCA} in twin engine propeller driven airplanes is that, A) the propeller of the failed engine is to be feathered (either automatically if so equipped, or manually) following the engine failure, and B) the remaining operating engine is set for maximum permissible thrust/power setting.

Historically, in older generations of aircraft, the certification criteria and methodology for establishing the V_{MCA} for multi engine airplanes was to determine V_{MCA} for the aircraft in the approved normal takeoff configuration after gear retraction (flaps still set for takeoff, if so prescribed), but has since been amended to evaluate V_{MCA} considerations of an aircraft in both a takeoff configuration (commonly still referred to as "V_{MCA}") and in an approach/landing configuration (commonly now referred to as V_{MCL}), with the more conservative (higher) V_{MCA} being published for the aircraft and provided to the pilot(s) in the AFM(S), as well as marked on the airspeed indicator(s). In the case of some aircraft, it has been found during V_{MCA} flight testing that the aircraft will stall before losing directional control. In this case, the published V_{MCA} would not be lower than the clean configuration power off stall speed.

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