

## Accidents after Engine Failure Can Be Prevented

### Improvement of Aviation Regulations, Flight Manuals and Textbooks Required

An engine failure, or a propulsion system malfunction on a multi-engine airplane sometimes leads to a tragic accident. Accidents with big airplanes attract more attention than accidents with small multi-engine airplanes, but around the globe and especially in big countries like the USA and Australia, accidents after engine failure with small multi-engine airplanes happen quite frequently but are not covered by the global news media.

The cause of many of these engine failure related accidents is often determined as propulsion system malfunction and/ or out of control due to inappropriate crew response to propulsion system malfunction (ICR/PSM). However, airplanes are thoroughly flight-tested to determine operational speed limits. One of the limiting speeds for surviving engine failures is the minimum control speed in the air ( $V_{MCA}$ ) that is published in all Airplane Flight Manuals, and that is to be observed by all pilots.

On Part 25 airplanes,  $V_{MCA}$  is used to calculate the takeoff safety speed  $V_2$ . Either  $V_{MCA}$  or  $V_2$  has to be observed by pilots of all multi-engine airplanes to prevent out of control after engine failure, so why do accidents following the failure of an engine on multi-engine airplanes continue to happen? And are they preventable in the first place?

Harry Horlings of AvioConsult, a USAF Test Pilot School graduate flight-test engineer and retired Lt Col - Chief Flight Test - of the Royal Netherlands Air Force and therewith one of the top aircraft experts in the world, researched many engine failure related accidents and included in his research a review of airplane flight manuals, student pilot textbooks and other publications on asymmetrical powered flight, as well as aviation regulations FAR 23 and 25 and the European (EASA) equivalent CS 23 and 25.

His conclusion is that many accidents following the failure of an engine are indeed caused by inappropriate crew response, but the flight crews are not to be blamed. Somehow the test methods and conditions that are used by experimental flight-test crews to determine  $V_{MCA}$  never made it to be incorporated appropriately in many, if not most, regulatory paragraphs and – consequently – not in most airplane flight manuals and textbooks either. As a result, pilots do not get to know (anymore) that the  $V_{MCA}$ , that is listed or charted in the flight manual of their airplane, is not the minimum speed for maneuvering their airplane while an engine is inoperative, but that  $V_{MCA}$  is no more than a safe minimum speed to barely maintain straight flight after engine failure, **provided** a small 2 to 5 degree bank angle (as opted by the manufacturer) is maintained away from the inoperative engine. This very important bank angle precondition for the listed  $V_{MCA}$  to be valid is almost never listed with  $V_{MCA}$  in any emergency procedure, flight manual, textbook, etc. This small bank angle though, can make the difference between life and death if an engine fails during takeoff or go-around, i.e. as the power setting of the remaining engines is high.

Takeoff Safety Speed  $V_2$ , which is used on big (Part 25) airplanes, is calculated during preflight using  $V_{MCA}$  and stall speed  $V_S$ , so  $V_2$  as well is only valid and safe as long as the bank angle precondition is applied. If the small bank angle is not applied by the pilot after an engine failed, the listed  $V_{MCA}$  and/ or the derived takeoff safety speed  $V_2$  are no longer valid; the actual  $V_{MCA}$  can be 10 to 60 knots or more higher and might even increase above preflight calculated  $V_2$ , rendering the airplane uncontrollable at once. In addition to the degraded controllability, the one-engine-inoperative climb performance will be considerably decreased as well, because of the increasing drag due to the sideslip that builds up if the small bank angle is not maintained.

Once pilots start maneuvering while an engine is inoperative – even if the airspeed is at or above the preflight calculated  $V_{MCA}$  or  $V_2$  – the *actual*  $V_{MCA}$  might increase above the flight manual listed  $V_{MCA}$  or above the preflight calculated  $V_2$  and control might be lost immediately and cannot be regained if the altitude is too low; a catastrophe cannot be avoided. If pilots are fortunate enough to succeed in maintaining control immediately following the sudden failure of an engine, they still might crash during the remainder of the flight following the engine failure, while maneuvering at too low an airspeed with high thrust setting on the remaining engines.

The typical flight path of an airplane that suffers from the loss of control while one of the engines is inoperative and the other engine(s) is/ are set to provide a high thrust level is an uncontrollable descending flight path in the direction of the inoperative engine. Then the indicated airspeed is below the *actual*  $V_{MCA}$ .

Something needed to be done to increase the survivability of an engine failure. Therefore AvioConsult published a 31,000-word, 34-page Report: "*Prevention of Airplane Accidents after Engine Failure*" in June 2005. One of the conclusions is that many regulatory sections in FAR and CS 23 and 25, although solely intended for airplane certification, are often copied straight into flight manuals and textbooks. The regulations are not intended for this purpose though. This inappropriate copy-work leads to incorrect definitions and incorrect understanding of the controllability of an airplane when an engine is inoperative. To the opinion of AvioConsult, this is what already caused many engine failure related accidents.

Modern cockpit displays incorporate many cues and alerts of getting too close to all kinds of dangerous airspeeds, altitudes, attitudes, etc., but the perhaps most important cause of engine failure related accidents never made it to be incorporated in the design of cockpit displays and alerting systems.

The report not only explains asymmetrical powered flight, but also comments on engine emergency procedures, on deficient and imperfect text in flight manuals as well as on aviation regulations, on shortfalls in cockpit displays and alerting systems. Besides comments, many recommendations for improvement are presented, including improved text that can be copied straight into flight manuals, aviation regulations, textbooks, etc.

The intended readers of the report are all multi-engine rated pilots as well as members of regulatory committees of FAA and EASA, multi-engine airplane manufacturers, flight manual writers, airplane accident investigators, etc. After reading the report, the behavior of an airplane after engine failure will be understood much better, which – without any doubt – will result in a reduction of the number of accidents following the failure of an airplane engine while in-flight or during flight while an engine is inoperative.

An abbreviated version of the report was presented as paper 'Staying Alive with a Dead Engine' to the European Aviation Safety Seminar of the Flight Safety Foundation in Athens, Greece on 14 March 2006.

AvioConsult also informed aviation authorities like FAA, EASA, NTSB and ATSB, as well as many airplane manufacturers around the world, including Boeing, a few months ago, but most of them believe their regulations and procedures are OK. But this is definitely not the case; the organizations say so because the improvement process will cost millions, but will also save many lives (and cost for law suits).

Maybe the next tragic, though unnecessary accident following the failure of an engine will finally trigger both the authorities and manufacturers to initiate the long awaited and necessary regulations and manual improvement process. AvioConsult is convinced that thereafter most Accidents after Engine Failure Can Be Prevented.

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Not for publication:

Most airline and certification pilots are not familiar with the experimental flight-test methods and conditions used to determine  $V_{MCA}$ . Therefore, this article, the report and the paper can only be verified or confirmed (if required) by formally trained experimental test pilots or flight-test engineers and by either one of the formal Test Pilot School. For addresses, please refer to the links page on [www.avioconsult.com/links.htm](http://www.avioconsult.com/links.htm) or ask AvioConsult for one or more names.

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