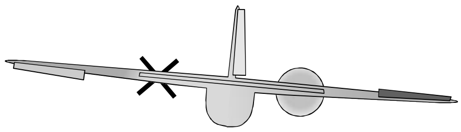

First eight pages of

Airplane Control
and
Analysis of Accidents
after
Engine Failure

Multi-Engine Airplanes

for

Test and engineering pilots and airplane accident investigators

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– *Committed to Improve Aviation Safety* –

Airplane Control and Analysis of Accidents after Engine Failure

This paper is an initiative of and is written by Harry Horlings, Avio*Consult*. An oral presentation to accompany this paper is available as well. The first paper on this subject originates from Nov. 1999; accident analysis was added May 2012.

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1. INTRODUCTION

1.1. Engine failures or, in general, propulsion system malfunctions of multi-engine airplanes continue to result in serious incidents and fatal accidents all around the globe quite frequently, although the airplanes were designed, flight tested and certified to continue to fly safely both immediately following such a malfunction as well as during the remainder of the flight while an engine is inoperative. Since January 1996, more than 300 accidents were reported on the Internet (by only a few Western countries) causing more than 3,100 casualties, ref. 1. After reviewing many accident investigation reports, it was noticed that most flight instructors, (airline) pilots and accident investigators explain the minimum control speed in the air (V_{MCA}) and the remaining performance after engine failure of multi-engine airplanes in a different way than airplane design engineers, experimental test pilots and flight test engineers. This difference in interpretation has, to the opinion of the author of this paper, resulted in many incidents and catastrophic accidents because of the loss of control and/or decreased performance following a propulsion system malfunction or while an engine was inoperative, and in incorrect and incomplete conclusions and recommendations in accident investigation reports. A separate paper (ref. 2) was written for CPL and ATPL instructors, pilots and student pilots on Control and Performance during Asymmetrical Powered Flight.

1.2. The objective of this paper is to bridge the obviously existing knowledge gap on airplane control after engine failure between the design engineers, experimental test pilots and flight-test engineers on one side, and test and engineering pilots as well as airplane accident investigators on the other side. This paper briefly describes almost all that these pilots and accident investigators should know about the controllability of an airplane after engine failure or while an engine is inoperative, on the ground and in the air. Included are brief descriptions of the design methods of the vertical tail and of the experimental flight-tests to determine the minimum control speeds in the air and on the ground of an engine-out multi-engine airplane. Some imperfections in AFMs (AFM) and on required placards in cockpits of Part 23 airplanes, that relate to controllability and performance after engine failure, are discussed as well, as are the real values of rotation speed V_R and takeoff safety speed V_2 of Part 23 Commuter and Part 25 airplanes. In § 8, flight-test knowledge based analyses of six accidents are presented using data of accidents and incidents that really happened, both with and without available data of Flight Data Recorders.

1.3. The author of this paper is a graduate of the USAF Test Pilot School (TPS), Edwards Air Force Base, CA, Class 85A. During the one-year course, all aspects of experimental flight-testing and evaluation of aircraft and its systems are taught to the students (pilots and engineers) for obtaining the qualification/ endorsement to prepare, conduct and report on experimental flight-testing of all types of airplanes (and simulators), military or civil, single or multi-engine during first flights, qualitative evaluations and flight-test programs following alterations or modifications. The TPS entry level in 1985 was a master degree in engineering and for pilots also 1,000 flight hours. About 50% of the time were academic hours, the rest was for actual flight-test training and gaining flight-test experience in over 25 different types of aircraft and simulators.
The training included the theory and actual engine-out flight-testing of propeller and turbojet/ fan airplanes during and following the intentional shut down of one engine on two-engine airplanes (n-1), and of one and two engines on the same wing on four-engine airplanes (n-2). The acquired flight-test data of such flight-tests are used to calculate the dynamic and static minimum control speeds (V_{MCA}) for listing in the limitations section of AFMs.

1.4. This paper was written using Federal Aviation Administration (FAA) and European Aviation Safety Agency (EASA) Flight Test Guides (FTG), ref.'s 3, 4, 5, Federal Aviation Regulations (FAR), ref. 6 and EASA Certification Specifications (CS), ref. 5, aeronautical university series of books by Dr. J. Roskam, University of Kansas, ref. 7, course books of USAF TPS, ref. 8, and Empire TPS, ref. 9, and the paper Procedures and analysis techniques for determining the air minimum control speed, ref. 10.

1.5. AFMs usually present only one – standardized – minimum control speed (V_{MC}), which in fact is the minimum control speed in the Air, or Airborne (V_{MCA}). However, there are many more V_{MC}'s and *actual* V_{MCA}'s, as will be shown in this paper. Data resulting from analysis using the V_{MCA} prediction techniques, taught at the TPS, ref. 11, were used to calculate the figures in this paper that show the *actual* V_{MCA} for different bank angles and weights. This method and the calculations are explained in the paper 'The Effect of Bank Angle and Weight on the Minimum Control Speed V_{MCA} of an Engine-out Airplane', ref. 12.

1.6. This paper does not include the methods for the actual investigation of the wreckage debris, but only uses some of the results of investigations. The data that should be available and used for analyzing propulsion system malfunction related incidents or accidents will be discussed. Although text and figures mainly present propeller airplanes, the theory applies to turbojet/ fan-equipped airplanes as well.

1.7. After reading this paper, pilots will improve airplane control after engine failure and airplane accident investigators will be able to improve the analysis of airplane accidents following a propulsion system malfunction. The engine-out performance and the real value of the V_{MC}'s, that are listed in the AFMs of multi-engine airplanes as well as the conditions for which V_{MCA} is valid, will be understood much better, which is of vital importance for including appropriate conclusions and recommendations in the accident investigation reports. These reports will become much more valuable for preventing propulsion system malfunction related accidents and incidents in the future.

