Supplementary Analysis
of the
Catastrophic Accident involving
Cessna 404, VH-ANV
Jandakot WA Australia, 11 Aug. 2003

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References:

1) ATSB Report 200303579:
http://www.atsb.gov.au/publications/investigation_reports/2003/AAIR/aair200303579.aspx

2) Report *Airplane Control after Engine Failure*, abbreviated version, Avio*Consult*:
http://www.avioconsult.com/downloads/Airplane Control after Engine Failure - Abbreviated.pdf

Author biography

Harry Horlings is a retired pilot and graduate Flight Test Engineer of the USAF Test Pilot School, Edwards Air Force Base, CA, December 1985. Following his Air Force career, which he concluded as Chief Experimental Flight Test, he founded Avio*Consult* and dedicated himself to improve aviation safety using his knowledge of experimental flight-testing. He researched many catastrophic accidents with multi-engine airplanes that occurred after engine failure or while an engine was inoperative. He published several papers and reports on the prevention of this kind of accidents and presented these to the European Aviation Safety Seminar of the Flight Safety Foundation, to the Dutch TSB, the Engine and propeller Directorate of the FAA and to a number of Airlines, Air Force and Navy organizations. He also wrote supplementary analyses of individual catastrophic accidents, of training and airplane flight manuals and of deficiencies in Aviation Regulations FAR, CS 23 and 25 and equivalent, all of which can be downloaded (for free) from the products page of www.avioconsult.com.

1. Introduction

1.1. After reviewing many accident investigation reports, it was noticed that there are huge differences in the interpretation and the use of the air minimum control speed V_{MCA} (and of takeoff safety speed V_2) of a multi-engine airplane between airplane manufacturers and experimental test pilots on one side and airline pilots as well as accident investigators on the other side. These differences in interpretation have lead to catastrophic accidents caused by the loss of control and/ or performance after engine failure and to incorrect conclusions in the accident investigation reports.

1.2. To improve the knowledge of airplane control while an engine is inoperative and to improve accident investigations, the report 'Airplane Control after Engine Failure' was written, using the theory and flight test techniques as taught at the USAF Test Pilot School, as well as using the criteria used for designing the vertical tail of an airplane as taught at the aviation faculties of universities around the globe.

1.3. Accident investigation is always performed to learn from the accidents and to recommend improvements in order to prevent similar accidents from happening again. From the reviewed investigation reports, it became clear that many, if not most accident investigation reports do not analyze the controllability of a multi-engine airplane after engine failure in the same way that was used to design the vertical tail and to flight-test the airplanes to determine V_{MCA}. Therefore, a supplementary analysis to the investigation report of a number of engine failure related accidents was written, including the subject accident. To understand the analysis presented below, it is recommended to read the above mentioned report, that can be downloaded from the products page of website: www.avioconsult.com. An abbreviated version can be downloaded with the link in ref. 2.

2. The accident

2.1. Shortly after liftoff, while still over the runway, the right engine failed. The pilot retracted the landing gear, selected flaps up and feathered the right propeller and then, at very low altitude, turned left, into the operating engine, to return for landing.
One of the conclusions in the report was: The aircraft was maneuvered, including turns and banks, at low altitude resulting in a decrease in airspeed below that required to maximize one-engine inoperative performance.
While on the left hand downwind leg, the airspeed decayed, the altitude could not be maintained and the airplane descended and impacted with the ground. Weight and cg were within limits.

2.2. Two factors played an important role in the post engine-failure phase of flight: climb performance while one engine was inoperative and air minimum control speed V_{MCA}.

2.3. The accident investigation report, ATSB Report 200303579, in § 1.18.3, presents the conditions for determining V_{MCA}, one of which is a 'maximum of 5 degrees of bank toward the operating engine'. This 'maximum' bank angle is indeed a condition for the manufacturer to determine V_{MCA} during flight-testing, but once V_{MCA} is listed in the airplane flight manual (AFM), the bank angle to be applied by the (line) pilot is no longer a 'maximum' bank angle of 5 degrees, but a fixed conditional bank angle to be maintained for the listed V_{MCA} to be valid, because the *actual* V_{MCA} varies considerably with bank angle. Cessna has obviously determined V_{MCA} using a bank angle of 5 degrees toward the operating engine, because Cessna repeatedly presents this bank angle in the engine emergency procedure, in the performance graph (figure 5-19) for one engine inoperative and with V_{YSE} and V_{XSE}. This 5 degree bank angle toward the operating engine is therefore the fixed, conditional bank angle to be applied by C404 pilots after engine failure. Any smaller bank angle, or a bank angle away from the operating engine, will lead to an increase of the *actual* air minimum control speed V_{MCA} and a decrease of the remaining climb performance, because the drag due to thrust asymmetry increases. Maintaining the 5 degree bank angle toward the operating engine is required to prevent an accident after engine failure or while an engine is inoperative, because it keeps the *actual* V_{MCA} safely below the listed value, which is the worst case value, and keeps the drag low. So, for keeping the *actual* V_{MCA} and the drag low, the 5 degree bank angle has to be maintained and, hence, turning should be prohibited (as long as the altitude is low and while the power setting is high). It is important to realize that the solid foundation for the 'software' V_{MCA} limitation is the 'hardware' confinement of the vertical tail of the airplane which is most certainly only designed and sized to be able to maintain straight flight while banking 5 degrees away from the inoperative engine.

2.4. The use of the word 'maximum' in the definition of V_{MCA} in flight manuals (and in accident investigation reports) is a widely spread misunderstanding that is caused by most, if not all, writers of flight manuals, student pilot textbooks and training programs who simply copy definitions out of Aviation Regulations (part 23.149) into their pilot manuals and books that are intended for airplane operations. These Regulations however, are intended for the certification of airplanes and definitely not for their operational use. This has led and will lead again to incorrect understanding of both V_{MCA} and the remaining climb performance after engine failure and hence to catastrophic accidents, unless the misunderstanding is taken away.

3. Cause of the accident

3.1. The pilot did not maintain 5 degrees of bank after engine failure as required in step 6 in the engine failure procedure in the flight manual, but initiated a turn at a too low altitude (100 ft AGL) and a too low airspeed. Control was not lost immediately, because the turn was in the direction of the operating engine, which is the favorable direction for keeping *actual* V_{MCA} low, i.e. below the published V_{MCA}, and/or the airspeed was higher than the *actual* V_{MCA}. Maintaining a wings-level attitude or a bank angle in the direction of the failed engine though, will increase *actual* V_{MCA} to a value much higher than the flight manual listed V_{MCA} and will lead to control problems if the indicated airspeed is low and the power high.

3.2. The performance of a multi-engine airplane while an engine is inoperative decreases considerably if a bank angle of 3 to 5 degrees (to be specified by the manufacturer) away from the failed engine is not maintained, while the airspeed is low.
This small bank angle reduces the sideslip to near zero, therewith reducing the total airplane drag to a minimum and increasing the remaining climb performance.

3.3. The accident was caused by a pilot who did not adhere to notes and procedures in the C404 Flight Manual and who obviously did not understand the consequences of an inoperative engine on the controllability and the performance of his multi-engine airplane.

The accident investigation report did not include the effect of bank angle on V_{MCA} and the necessity for maintaining a 5 degree bank angle into the good engine as a life-saving factor that influences both the controllability and the one engine inoperative climb performance.
Pilot and accident investigators were obviously not familiar with the effect of bank angle on both V_{MCA} and the airplane performance. They might have never heard of this.

It is the objective of the Report '*Airplane Control after Engine Failure*' that Avio*Consult* presents on the products page of its website to improve this, and to improve procedures, engine-out training, aviation regulations, etc. Many recommendations are presented. ■