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LIMITED REVIEW[1]

Airplane Flight Manual DA 42 TDI
Doc. No. 7.01.05-E, Rev. 9 17-Jan-2022
on the Subject Engine Failure

1. Introduction

1.1. Since 1996 more than 500 engine failure-related accidents with multi-engine airplanes were reported on the Internet, causing more than 4,000 casualties, despite the authoritative EASA/ FAA requirements for designing, thoroughly flight-testing and certification of airplanes for engine-out flight. Avio*Consult* started reviewing Accident Investigation Reports, Airplane Flight Manuals and Multi-engine rating courses on this subject using gained knowledge at universities as well as the USAF Test Pilot School in an attempt to contribute to reducing the accident rate. It did not take long to conclude that there is an accident-causing knowledge gap between (airline) pilots of multi-engine airplanes and airplane design engineers of manufacturers, including their experimental test pilots, on the subject of controllability of multi-engine airplanes after failure of one of its engines.
Pilots are neither made aware anymore of the real value of the minimum control speed V_{MCA}, that is already used during the design phase and is published as one of the airspeed limitations in the Airplane Flight Manual (AFM), nor of the manoeuvre limitations that must be observed when the airspeed is as low as or close to V_{MCA} when one engine is inoperative and high thrust is selected on the remaining engine, to avoid losing control. Proper knowledge on this subject got lost, accidents are the consequence.

1.2. The author of this limited review is graduate Flight Test Engineer of the USAF Test Pilot School, Edwards AFB, CA (1985). The very few Test Pilot Schools around the globe provide the highest level of flight training required to conduct experimental flight-tests. The entrance level was an MSc degree in engineering or a BSc and an entrance exam. Test Pilot Schools teach aircraft performance, flying qualities, airborne systems and flight-test management. During the one-year course, students receive academics and flight training on the subjects mentioned and conduct some 120 flight hours of flight-testing in 24 different types of airplanes: gliders, single, twin and 4-engine propeller and turbojet transports, fighter jets, helicopters and simulators. They have to pass 32 exams, write 32 reports, and undergo frequent test rides. Flying qualities testing of multi-engine airplanes while an engine is inoperative and determining the Minimum Control Speed in the Air (V_{MCA}) is part of the curriculum. Flight Test Guides[2] describe and explain the flight-test methods. The courses on Flying Qualities of two Test Pilot Schools can be downloaded from the USArchives via links provided on the Links page of the website of Avio*Consult*[3].

1.3. Manufacturers, except for a very few, do not publish correct definitions of the minimum control speeds and the accompanying manoeuvre limitations for use by pilots anymore in their Airplane Flight, Operating and Training Manuals, but copy the definitions out of the EASA or FAA Certification

[1] This review can also be downloaded from website https://www.avioconsult.com/downloads.htm (#14) for the links to function.
[2] - EASA CS-23 incl. Flight Test Guide, https://www.easa.europa.eu/en/downloads/18858/en; V_{MCA} testing in Book 2, § 48 on page 2-FTG-2-53, pdf page 261.
- FAA Flight Test Guide AC-23-8C: http://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_23-8C.pdf
[3] Website Avio*Consult*, Links page with links to USArchives downloads: https://www.avioconsult.com/links.htm.

Specifications/ Regulations, and equivalent, which are to be used by design engineers and experimental test pilots.
Engine emergency procedures do not include the most important limitation anymore that pilots should observe to prevent the loss of control, especially during take-off, approach for landing and go-around, and authorities do regrettably not review Airplane Flight Manuals for compliance with their own regulations and Flight Test Guides.
The consequence is that pilots, without realizing, manoeuvre their airplane after engine failure in a way for which it was not designed and flight tested, and subsequently lose control and get killed, taking crew and passengers with them. The loss of knowledge causes aviation to drift into failure.

1.4. In an attempt to increase the level of knowledge on the subject of flight with an inoperative engine, Avio*Consult* published several reviews and accident analyses, wrote several papers and courses and published these on the Downloads and Accidents pages of his website[4]. A video lecture was uploaded on YouTube[5].
Papers were also presented during seminars of the European Chapter of the Flight Safety Foundation[6] , the EuroControl Safety Forum in Brussels[7], Dutch ALPA and other organizations, such as FAA, LBA and universities. Many concerned pilots, who noticed that the explanation of flight with an inoperative engine in their flight and training manuals does not agree with the published papers of *AvioConsult* (and hence, with the formal certification and flight-test regulations), asked Avio*Consult* for help on the subject. Many manufacturers, authorities and Transport Safety Boards were asked to improve their manuals and investigations, but these organizations obviously also suffer from poverty of knowledge, because they did not change anything and regrettably did not appreciate the competency of a Test Pilot School graduate either. Fatal accidents continue to happen…

1.5. A recent accident is the loss of a DA 42 in Slovakia on 22 Feb. 2023. The airplane was in use by a local private flight school in Trenčín. Markiza TV reported: "*The tragedy should have happened while trying to turn off one of the engines and then start it up. This is usually learned during such flights, but this time it was probably the cause of the plane crash*". Again, the question is why do such fatal accidents happen when airplanes must be designed to continue to fly safely after engine failure and are thoroughly flight tested as well? Although the investigation is on-going, part of the answer might be that the DA 42 Airplane Flight Manual, like the flight manuals of many more types of airplane, does not contain the control and performance limitations as the airplane design engineers used during designing the airplane, and as are required in certification specifications and requirements.

1.6. The DA 42 AFM was reviewed out of curiosity on the subject of engine failure after downloading it from the website of DIAMOND AIRCRAFT INDUSTRIES GMBH[8]. This manual might be a little different from the one that applies to the mishap airplane. The AFM has been verified for EASA by the Austrian Civil Aviation Authority Austro Control (ACG) as Primary Certification Authority (PCA) in accordance with the valid Certification Procedures and approved by EASA with approval no 2004-4703.

1.7. This review is not to apportion blame or liability to anybody, but to alert/make aware/ teach/ learn from, which is necessary because appropriate knowledge obviously just faded away during the past 50 years or so, and fatal accidents with multi-engine airplanes, not only with the DA 42, continue to happen every month. For this reason, explanations are included as well as recommendations for improvement. This review might also apply to the AFM of the other airplane types of the manufacturer, and to AFM's of other airplane manufacturers as well, because most of the errors are commonly made for the reason given in the paragraphs above.
If the review of certain subjects in this report is not adequate, these might not have been described

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[4] Website Avio*Consult*: https://www.avioconsult.com.
[5] Harry Horlings, video lecture: *"The real value of the minimum control speed"*, https://youtu.be/Wbu6X0hSnBY.
[6] Harry Horlings, *"Staying Alive With a Dead Engine"*. Proceedings – European Aviation Safety Seminar (EASS), Athens, Greece, March 13 – 15, 2006.
[7] Harry Horlings, *"Safety Critical Procedure Development requires high level multi-disciplinary knowledge"*, https://skybrary.aero/sites/default/files/bookshelf/4665.pdf. PPT with working animations: https://www.avioconsult.com/downloads/Safety%20Forum%20slides%20AvioConsult%20June%202019%20-%20video%20links.ppsm.
[8] Airplane Flight Manual DA 42 TDI Basic Rev. 9 2022-01-17. http://support.diamond-air.at/fileadmin/uploads/files/after_sales_support/DA42_Twin_Star/Airplane_Flight_Manual/Basic_Manual/70105e-Rev9-complete.pdf

properly (for a not-DA 42 pilot).

1.8. The manufacturer is strongly recommended to improve the AFM.

2. Review of EASA Approved pages

2.1. AFM § 1.5 Definitions and Abbreviations

2.1.1. **V_{mCA}**. "*Minimum Control Speed. Minimum speed necessary to be able to control the airplane in case of one engine inoperative*".

How is V_{MCA} defined in Regulations (CS 23.149) and in Flight Test Guides[2]?

"*V_{MCA} is the calibrated airspeed at which, when the critical engine is suddenly made inoperative, it is possible to maintain control of the aeroplane, with that engine still inoperative, and thereafter maintain straight flight at the same speed with an angle of bank not more than 5°*".

In other words, V_{MCA} is the minimum speed at which the airplane can be recovered safely from the yawing and rolling motions following the sudden failure of the critical engine in-flight, and thereafter maintain straight flight with a bank angle smaller than 5°.

This definition is out of Certification Specification 23.149 (a) that is to be applied by design engineers of airplane manufacturers and by experimental test pilots to determine V_{MCA} in-flight. The design engineer uses V_{MCA} during sizing the vertical tail: a smaller tail (less weight and production cost) results in a higher V_{MCA} (to be able to maintain directional control with the rudder after engine failure). The tail may not be that small that V_{MCA} exceeds 1.2 V_S (CS 23.149 (b))[2].

Regulations require V_{MCA} to be determined in-flight while all of the factors that have influence on V_{MCA} are at their worst-case value, resulting in the highest V_{MCA}, such as critical engine inoperative and maximum available take-off thrust on the opposite engine (largest thrust yawing moment[9]), propeller feathered if the system is automatic (non-feathering increases the thrust yawing moment, hence V_{MCA}), aft cg (shortest rudder moment arm), lowest weight (smallest side force due to weight), etc. A small bank angle away from the inoperative engine decreases both V_{MCA} and the sideslip angle; the latter cannot be avoided when keeping the wings level after engine failure.

During flight-testing in accordance with EASA and FAA Flight Test Guides[2], with the airplane in the configuration just described, the airspeed is slowly decreased during straight flight, while keeping the wings level, until the rudder is maximal deflected and the airplane starts yawing. This airspeed is the V_{MCA} with the wings level. Then, while maintaining straight flight, the bank angle is increased away from the inoperative engine until reaching 5° or less at the option of the manufacturer, while decreasing the airspeed until the rudder (or control force) is again maximal and the airplane starts yawing. The airspeed at which this occurs is the V_{MCA} of the airplane that will be published in the AFM. The small favorable bank angle opted by the manufacturer (max. 5°) is usually the bank angle at which the sideslip, hence drag, is minimal, for maximum remaining climb performance.

These approved tail design and flight-test methods imply that the *actual* V_{MCA}, i.e. the V_{MCA} that the pilots experience in-flight when keeping the wings level, as well as during turns, is higher than the AFM-published V_{MCA}. The increase with level wings is between 6 and 30 kt for small straight-wing and large swept-wing airplanes respectively, and is much larger during turns. The effect of bank angle is an important factor to consider, but is regrettably forgotten during the past 50 years. The effect of bank angle and of most other factors on V_{MCA} are thoroughly explained for pilots in report *Airplane Control and Analysis of Accidents after Engine Failure* by Avio*Consult*[10].

2.1.1.1. V_{MCA} (as to be spelled i.a.w. CS - Definitions[11]) is definitely not the "*minimum speed necessary to be able to control the airplane in case of one engine inoperative*", but is the minimum speed required for being able to counteract the yawing and rolling moments[9] (or motions) with rudder and ailerons after a sudden engine failure and thereafter to maintain straight flight only, provided a small bank angle (max. 5° - as opted by the manufacturer) is being maintained away from the inoperative engine (CS 23.149[2]).
Not maintaining this small bank angle, for instance by keeping the wings level or

[9] A moment is the product of a force and its perpendicular distance to the center of gravity (cg); produces a rotation about the cg.
[10] Harry Horlings, "*Airplane Control and Analysis of Accidents after Engine Failure*", https://www.avioconsult.com/downloads/Airplane Control and Analysis of Accidents after Engine Failure.pdf.
[11] EASA CS - Definitions, https://www.easa.europa.eu/en/downloads/1674/en, Section 2.

during a turn, increases the *actual* V_{MCA} that a pilot will experience in flight above the V_{MCA} that is published in the AFM, and hence above the red radial line on the Airspeed Indicator (ASI). The increase of V_{MCA} with the wings level can be 6 kt or more above the published V_{MCA}. If the – not indicated – *actual* V_{MCA} increases above the indicated airspeed, control of the airplane will be lost – by definition and, to most pilots who don't know all about V_{MCA}, also by surprise.

2.1.1.2. The abbreviation V_{MC} of is often used, also in CS-23, but CS – Definitions[11] defines the Minimum Control Speed, take-off climb, as V_{MCA} (Airborne) to distinguish it from the other V_{MC}'s, such as V_{MCL} (landing) and V_{MCG} (ground – take-off run).
V_{MCA} not only applies during take-off climb though, but also during the remainder of the flight while one of the engines is inoperative.

2.1.1.3. In addition, banking away from the small favourable bank angle to either side not only increases *actual V_{MCA}*, but also the sideslip angle, increasing the drag and reducing the climb performance. Dr. Jan Roskam (Kansas University) wrote in one of his well-known airplane design series of college books[12] for sizing the vertical tail: "*The $V_{MC(A)}$ value ultimately used ties take-off performance to engine-out controllability*".

2.1.1.4. Many accidents happened after engine failure during take-off when the pilot decided to land as soon as possible, and turned the engine-out airplane at low speed and altitude right away to the downwind leg in the traffic pattern, rather than climbing straight ahead first until reaching a safe altitude where the airspeed can be increased (with >20 kt) and turns can be made safely.

2.1.1.5. When the airspeed is as low as or just above the AFM-published V_{MCA}, near full rudder is already required for counteracting the asymmetrical thrust yawing moment, and less or no additional rudder is available for directional control during a turn. As the turn is initiated, control will be lost immediately.
It also happened that pilots did not apply adequate rudder to stop the yaw, to maintain the heading; partial rudder increases the actual V_{MCA}. This often caused the Loss of Control and casualties, because of the low altitude from which recovery is not possible before colliding with the ground. This also occurs during engine-out training. Refer to the YouTube video referenced in footnote 5 on page 2, and the report in footnote 10 in which such an accident with an EMB-120 is reviewed and analysed.

2.1.1.6. CS 23.149 allows the manufacturer to determine V_{MCA} *during straight flight* with either the wings level or with a small favourable bank angle of up to 5°. The difference is the magnitude of V_{MCA}, and the remaining sideslip angle, i.e. drag. Again, when keeping the wings level, the *actual V_{MCA}* is higher than V_{MCA} when maintaining a small bank angle away from the inoperative engine; the drag is also higher decreasing the remaining rate of climb (see the textbox in § 2.1.1 above). Therefore the manufacturer should publish the bank angle that was used to size the vertical tail and/or to determine V_{MCA} together with V_{MCA} and the other bank-angle-affected V-speeds in the AFM, such as V_{YSE} and V_{XSE}.

2.1.1.7. Recommended is to define V_{MCA} for pilots in an AFM as follows:

> V_{MCA} is the minimum speed for maintaining straight flight when an engine fails or is inoperative and the opposite engine is set to provide maximum thrust, provided a bank angle is being

[12] *Airplane Design, 8-part set of books*, Dr Jan Roskam, KU and DAR Corporation. https://shop.darcorp.com/index.php?route=product/product&product_id=59.

maintained of 3° – 5° (exact number to be provided by the manufacturer) away from the inoperative engine.

2.1.1.8. It is strongly recommended to include the following WARNING:

Use up to full rudder to maintain straight flight. Do not initiate a turn away from the small favourable bank angle while the asymmetrical thrust is maximal and the airspeed is, or is close to V_{MCA}. Not only the loss of control is imminent, climb performance might become less than positive as well. The AFM-published V_{MCA} is not a safe minimum airspeed for making turns, only for straight flight.

2.1.2. **V_{SSE}**. "*Minimum Control Speed for Schooling. Minimum speed necessary in case of one engine intentionally inoperative / idle (training purposes)*".

2.1.2.1. EASA CS/FAR 23.149 (d) define V_{SSE} as *"a minimum speed to intentionally render the critical engine inoperative that must be established and designated as the safe, intentional, one engine-inoperative speed"*. V_{SSE} is not a minimum control speed (*"for Schooling"*), but a high enough speed at which an engine should be intentionally made inoperative just prior to a V_{MCA} demo or engine-out flight training. V_{SSE} is the speed from which the airspeed is slowly decreased down to V_{MCA} while maintaining straight flight (see the text box in § 2.1.1 above). If during training the airspeed is not decreased below V_{SSE}, the pilot will not learn to appreciate both V_{MCA} and the manoeuvring restrictions that come with it.

2.1.2.2. Mentioning the critical engine by the rule makers is incorrect. Pilots should be trained to handle (the airplane after) failure of either engine. Just like V_{MCA}, only one V_{SSE} is to be published that applies for either engine that is to be rendered inoperative. V_{SSE} is calculated by the manufacturer and is not determined during flight testing.

2.1.2.3. V_{SSE} not published in the DA 42 AFM, only its inappropriate definition.

2.1.2.4. Rendering an engine inoperative means shutting it down intentionally as would occur during an actual engine failure. The AFM of the DA 42 however, does not allow shutting down an engine using the fuel selector valve (CAUTION in § 3.5.3 on page 3-24).
When the engine is shut down using the ENGINE MASTER switch, the propeller will also feather which results in controllability that is not realistic after a real engine failure; the actual V_{MCA} will be lower than with an unfeathered propeller. When an engine is left running in flight idle, rather than shut down, the actual V_{MCA} might be higher than the published V_{MCA} because of the increased propeller drag and thrust yawing moment. Control might even be lost at an airspeed above the red lined V_{MCA}.

2.1.2.5. Pilots should realize that rendering an engine inoperative at V_{SSE} does not demonstrate the dynamic motions after a sudden failure as would occur at the lower take-off speed or V_{MCA}. The use of V_{SSE} does not provide realistic dynamic V_{MCA} training.

2.1.2.6. When it is not allowed by the manufacturer or owner to shut down an engine for a V_{MCA} demo, a power level or an RPM/load% that equals the drag of an unfeathered propeller should be made available and used during the demo. This RPM/load% is not provided in the DA 42 AFM.

2.1.3. **V_{YSE}.** *"Best Rate of-Climb Speed for one engine inoperative"*

2.1.3.1. For V_{YSE} to be the "*Best Rate of-Climb Speed for one engine inoperative"*, also a small bank angle away from the inoperative engine is required. This bank angle is smaller than for V_{MCA} because V_{YSE} is a little higher than V_{MCA}. See further § 3.14.1 below.

2.1.4. **V_{XSE}, V_{REF} and V_R** are not defined in AFM § 1.5.

2.1.5. Please use upper and lower case letters correctly in abbreviations throughout the AFM. All V's (Velocities) should be capitalized (EASA CS-Definitions[11]).

2.2. AFM § 2.2 Airspeed

2.2.1. **Column IAS**. In the table in this paragraph and throughout the AFM, airspeed is presented as KIAS.

2.2.1.1. Airspeeds are indicated on the display of the Garmin G1000 Integrated Avionics System and on the mechanical back-up Air Speed Indicator.

> What are Indicated and Calibrated Airspeeds (IAS and CAS)[13]?
>
> The airspeed indicator (ASI) in a cockpit indicates the IAS. An ASI is designed and calibrated to display the difference between total pressure P_T and static ambient pressure P_a. But the instrument is and cannot be perfect. The indicated airspeed values have three categories of errors: instrument errors in the ASI, and lag and position errors of the pitot-static system. The IAS displayed on one ASI is not by definition equal to the IAS displayed on a second ASI in the cockpit or on a maintenance-replaced ASI, when connected to the same pitot-static system.
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> The stall, takeoff, minimum control, cruise and landing speeds, and the handling qualities of the airplane were determined with a calibrated test system and were reported as CAS for a given gross weight (mass). These for flight operations important speeds are usually published as numbers or in graphs as KCAS in the AFM of a type of airplane. Temperature and air density do not affect CAS; CAS has the same significance on all days: CAS today, even if hot or high, is CAS during a standard day. CAS is therefore the most important airspeed for pilots. The CAS in one airplane is the same as CAS in another airplane of the same type, with identical pitot-static systems; the limiting and operational speeds in CAS are the same and are published in their common, generic AFM.
>
> The AFM-writer cannot know the instrument errors of each individual ASI installed in production airplanes, which is the reason that CAS is normally used in generic AFM's. In the cockpit of each airplane, correction tables show the relationship between the IAS and CAS of each individual installed ASI, except for a few categories of airplanes.

2.2.1.2. As described in the textbox above, IAS is equal to CAS ± V_{ic} (the instrument correction). Unless the instrument errors of the Garmin 1000 and the backup ASI are zero or exactly the same, the IAS's displayed on both systems are not equal. Therefore, the question can be raised for which system the IAS in the table in AFM § 2.2 applies, for the G1000 or the back-up ASI? CAS data would apply to both systems, but there is more to this.

2.2.2. Airspeed, General

2.2.2.1. CS 23.1581 (d) requires *"All Aeroplane Flight Manual operational airspeeds must, unless otherwise specified, be presented as indicated Airspeeds"*.
CS 23 Flight Test Guide (page 2-FTG-2-17) states in § 18 d for commuter category airplanes: *"(1) Takeoff Speeds. The following speed definitions are given in terms of calibrated airspeed. The AFM presentations are required by 23.1581(d) in indicated airspeed (IAS)"*.
The *"following speed definitions"* are those of: V_{EF}, V_{MC}, V_1, V_R, V_S, V_{LOF} and V_2.
The consequence of requiring IAS in an AFM is that each individual copy of an AFM will be unique, because of unique instrument errors, and as many of these speeds are published on "approved" pages, each AFM-copy requires approval by EASA as well. Imagine a series of 500 airplanes sold of the same type and configuration, then EASA will have to approve the indicated airspeeds in 500 AFM's, rather than in only one, the type-specific AFM when CAS is used. When during maintenance an ASI is removed and replaced, the IAS might also change

[13] For detailed theory and test methods refer to the Fixed Wing Performance Flight Test Manual FTM-108 from § 2.3.5 of the USNaval Test Pilot School, or to the Performance Phase Textbook Vol. I § 5.5 of the USAF Test Pilot School.

when the instrument error differs from the error of the replaced instrument, which would require EASA approval again.
The requirement is not in agreement with CS 23.1587 (d) (10), next paragraph.

2.2.2.2. CS 23.1587 (d) (10) requires *"The relationship between IAS and CAS determined in accordance with CS 23.1323 (b) and (c)"*, but only for commuter category aeroplanes. So the question is whether the airplane is certified and in use in the normal or utility, or in the commuter category. When the airplane is in use for training pilots for a professional career as airline pilots, then commuter category requirements should apply to teach the pilots all aspects of operating a multi-engine airplane, hence CAS should be used in the AFM.

2.2.2.3. As already mentioned in the textbox above, the use of IAS throughout an AFM raises the question how the writer of the AFM knows the instrument error of an ASI in a particular airplane; he can only have airspeed data in CAS. So in a common AFM that applies to a series of airplanes of the same type, IAS should not be used, unless the air data computer allows the entry of correction data of instruments or air data systems, including after maintenance-replacement.
IAS is the same as CAS if there are no instrument errors. The stall speed or V_{MCA} in CAS is the same for all similar types (tail numbers) of airplanes for which the AFM applies, but the stall and V_{MCA} speeds in IAS are not. The backup airspeed indicator might also indicate a different IAS than the G1000 avionics system in the same airplane.
The limiting and operational airspeeds in the AFM are determined in CAS in a test airplane, not in each production airplane. Therefore, in an AFM, CAS should be used, rather than IAS. But CS 23 regrettably prescribes different; this has consequences as shown in an example below.

2.2.2.4. In the DA 42 Maintenance Manual[14], 34-10-00, page 211, pdf page 1450, the following table presents the permissible airspeed indication errors.

"*Table 2: ASI Indication Error*

Airspeed	*Permissible Error*
160 kts	*±4 kts*
100 kts	*±4 kts*
40 kts	*±1.7 kts*"

EASA ETSO-C46a[15], Appendix 1, § 2.3(c)(1) on Calibration states: *"The indicated airspeed pointer must indicate airspeed in accordance with the values contained in Table I"*. In this ETSO Table I, the approved tolerance at 50 kt = ±4.0 kt, from 60 – 120 kt = ±2.0 kt, at 150 kt = ±2.5 kt and at V_{NE} (194 kt) = ± 3.0 kt, which deviate from the table above (kt is the formal symbol for knots).
CS / FAR 23.1323 (b) defines the pitot-static system error, excluding the ASI calibration error, to not exceed the maximum of 3% of CAS or 5 kt. So the total max. approved airspeed system error could be as high as (5+2=) 7 (ETSO) or even (5+4=) 9 kt (DA 42 MM Table 2)! Is Table 2 correct? These are numbers that a pilot needs to be made aware of. An example will be given to show why.

2.2.2.5. The AFM-published V_{MCA} is 68 KIAS. If the flight tests of the DA 42 for certification returned a V_{MCA} of 68 KCAS and the instrument error is the maximum approved 4 kt, then the ASI indicates (68 KCAS + 4 =) 72 KIAS. When the pilot decreases the airspeed to 68 KIAS, he/she is in fact decreasing to 4 kt below V_{MCA}.

[14] DA 42 Series Airplane Maintenance Manual, http://support.diamond-air.at/fileadmin/uploads/files/after_sales_support/DA42_Twin_Star/Airplane_Maintenance_Manual/Basic_Manual/70201-DA42-AMM-r5.pdf.
[15] EASA European Technical Standard Order ETSO-C46a, Maximum Allowable Airspeed Indicator Systems Performance Requirements, https://www.easa.europa.eu/download/etso/ETSO-C46a_CS-ETSO_0.pdf.

And if the wings are kept level, the *actual* V_{MCA} might even be 6 kt higher (72+6=) 78 KIAS (see text box in § 2.1.1 above), which is 10 kt higher than the red-lined 68 KIAS!
The take-off procedure in AFM § 4A.6.7 requires a V_R of 70 KIAS and an initial climb speed of 77 KIAS. Both are indeed higher than the red-lined worst-case V_{MCA} of 68 KCAS, but lower than the *actual* V_{MCA} of 78 KIAS when instrument error and increase of V_{MCA} due to bank angle are taken into account; loss of control is likely after engine failure when a take-off is conducted using these speeds.
A pilot considers to be safe when maintaining an airspeed of 10 kt above V_{MCA}, but this might not be the case because of the airspeed system errors that are within approved tolerance.
To prevent the loss of control, several (indicated) safety speeds (V_S, V_{MCA}, V_R, etc.) as well as their markings (red, blue lines) on the ASI need to be adjusted to account for the (known) instrument errors, don't you agree? Or a little table with the relation between CAS and IAS should be required and provided for Normal and Utility, as for Commuter Category Airplanes.

2.2.2.6. In AFM § 5.3.1 the airspeed calibration data are presented in three IAS-CAS graphs for three flap settings. In the flaps up case, a V_{MCA} of 68 KIAS (red line speed) = 72 KCAS, 4 kt difference (like in example above). Why are these graphs included if CAS is not used in the AFM? Are the red and blue radial lines on the ASI adjusted for the instrument errors? Not mentioned in the legend is whether the charts are for the Garmin 1000 or for the back-up airspeed indications.

2.2.2.7. The cover sheet of the reviewed AFM does not include a tail number, or the serial numbers of the airspeed indicators for which the published indicated airspeeds in the AFM are valid. The ASI instrument errors have most probably not been added to (or subtracted from) the Indicated Air Speeds that are published in the AFM, and were not used either to change the position of the radial lines and markings on the dials of the (individual) displays and instruments they are presented on (G1000 and backup ASI). In the example of the previous paragraph, the red line for indicating V_{MCA} should be at 72 kt. Then the Airspeed Indicator complies with CS 23.1545 (b)(6) and with CS 23.1581 (d) (§ 2.2.2.1 above). Since the regulations tolerate instrument errors, it might also be approvable to publish the approved tolerances in the airspeed table head for pilots to be made aware.

2.2.3. Garmin 1000 Airspeed indication

2.2.3.1. The Garmin Air Data Computer (GDC 74A) receives P_T and P_a from the pitot tube and converts this to IAS. This conversion process might also have errors, but these are not presented. On page 488 (pdf page 502) of the G1000 Pilot's Guide[16] for the DA 42, a comment to a message advisory is: *"GDC1 is reporting that the airspeed error correction is unavailable"*. This suggests that an airspeed correction is indeed possible. This is mentioned only once in the Pilot's Guide, but not in the G1000 Cockpit Reference Guide[17]. The Maintenance Manual (34-40-00 page 216) only requires a leak test, not the entry of airspeed error correction data. The same remarks apply as for the standard (backup) ASI.

[16] Garmin G1000 Integrated Avionics System, Pilot's Guide. http://static.garmin.com/pumac/190-00649-03_0B_web.pdf.
[17] Garmin G1000 Integrated Flight Deck, Cockpit Reference Guide. https://static.garmincdn.com/pumac/G1000:Diamond_CockpitReferenceGuide_DA42version0370.17orlater_.pdf.

2.2.4. **The remark with V_{MCA}** in the table in AFM § 2.2 is: "*With one engine inoperative keep airspeed above this limit*".

2.2.4.1. V_{MCA} is not only the minimum control speed with one engine already inoperative, but also the minimum speed to be observed in anticipation of an engine failure, especially during take-off and go-around.

2.2.4.2. Just keeping *"the airspeed above this limit"* will result in the loss of control during turns. As explained in § 2.1.1 above, V_{MCA} is only valid for straight flight while banking a few degrees away from the inoperative engine, and is definitely higher during turns. It is recommended to remind pilots of this flight restriction by repeating this here as additional lifesaving remark.

2.3. AFM § 2.3 Airspeed Indicator Markings

2.3.1. **Red radial, 68 KIAS, Minimum Control Speed, single engine**.

2.3.1.1. The red radial (and other markings) might have to be positioned at a different airspeed number to adjust for instrument errors, see § 2.2.1.2 above.

2.3.1.2. *"Minimum Control Speed"* is not only intended for flight with an inoperative, with a *"single engine"*, but also in anticipation of an engine failure, as also mentioned in § 2.2.4.1 above; see also the WARNING in AFM § 3.5.6 (a), page 3-36, that is copied in § 3.7.1 below.

2.3.1.3. Recommended is to replace *"single engine"* with: 'for straight flight while banking x° away from the failed engine'; x° is to be determined by the manufacturer.

2.4. AFM § 2.8 Center of Gravity

2.4.1. No lateral cg limitations are specified in this paragraph as required in CS 23.23, although a placard, to be positioned next to fuel quantity indicator with the text *"Max. difference LH/RH tank 5 US gal"* (AFM page 2-29) suggests that a lateral cg limit does exist.

3. Review of Non-Approved pages

3.1. AFM § 3.1.2 Certain airspeeds in emergencies

Event	Airspeed
One engine inoperative minimum control speed (air) V_{mCA}	68 KIAS
One engine inoperative speed for best rate of climb V_{YSE}	82 KIAS

3.1.1.1. V_{MCA} and V_{YSE} are again listed in this paragraph. Repeating these airspeeds here is not required, not necessary, because the limiting and operational airspeeds in an AFM are to be presented in the Operating Limitations chapter, to be easily and quickly found.

3.1.1.2. If not deleted here, it is recommended to repeat the definition and warning as already presented in § 2.1 above, including straight flight and the small bank angle for which the published V_{MCA} is valid only.

3.1.1.3. V_{YSE} most probably also requires a small bank angle for minimum drag and hence maximum or *"best"* single engine rate of climb. The same applies to V_{XSE}, the airspeed for maximum single engine range, which is not published here.

3.2. AFM § 3.5 One Engine Inoperative Procedures

3.2.1. **WARNING 1**. "*In certain combinations of airplane weight, configuration, ambient conditions, speed and pilot skill, negative climb performance may result*".

3.2.1.1. Not mentioned here is bank angle. A bank angle away from the small favourable bank angle increases the sideslip considerably, and hence the drag, reducing climb performance. A small bank angle away from the failed engine should be applied as soon as possible after engine failure, and be maintained during straight flight until a safe altitude is reached (see § 2.1.1 above).

3.2.1.2. It is strongly recommended to add as first WARNING (or combine with the current first): 'At airspeeds at or close to V_{MCA}, maintain straight flight using rudder, and bank 5° away from the inoperative engine to avoid the loss of control and a negative rate of climb'. Accidents learn that pilots forgot, or didn't know about the large influence of bank angle on the controllability and performance of airplanes after engine failure.

3.3. AFM § 3.5.2. Engine trouble shooting

3.3.1. This paragraph begins with **a NOTE**: "*With respect to handling and performance, the left-hand engine (pilots view) is considered the "critical" engine*". This note is repeated in AFM § 5.3.9.

3.3.1.1. The AFM does not explain why critical engine is mentioned, and what the criticality is. The critical engine is the engine which, after failure, leads to a V_{MCA} that is a few knots higher than after failure of the other engine (because of the shift of the thrust vector in the propeller discs at higher angles of attack (P-vector), which is of importance for airplane design engineers for sizing the vertical tail and for test pilots to determine the highest, the worst case V_{MCA}. Hence, the effect of the failure of the critical engine is included in the tail design and in the AFM-published V_{MCA}.
For pilots, the failure of the non-critical engine results in a V_{MCA} that is a few knots lower than the V_{MCA} published in the AFM. The published V_{MCA} is the highest, worst case, most unsafe V_{MCA} after failure of either engine and ensures controllability, but only during straight flight while maintaining a small bank angle away from the inoperative engine.
So, pilots don't need to know which of the engines is the critical engine, unless only one of the engines drives a generator or a hydraulics pump whose failure affects controllability. The published V_{MCA} is safe after either engine failure, provided the manoeuvre limitations are observed. See the text box in § 2.1.1 above for the V_{MCA} definition.

3.3.1.2. Furthermore, there is only one V_{MCA}, and only one engine emergency procedure that apply whichever engine fails. A pilot does not have to analyse whether the failing engine is the critical engine or not. Hence, *"critical engine"* does not have to be mentioned in an AFM, it's for design engineers and test pilots only, to ensure they publish the worst-case V_{MCA} (which is why it is defined in the Certification Specification CS 23.149 and equivalent). Refer to the Flight Test Guide in CS-23, Book 2, paragraph 48 (page 2-FTG-2-53 – footnote 5 on page 1 above).

3.3.1.3. The effect of weight and bank angle on V_{MCA} is much larger than the effect of failure of the critical engine versus the non-critical engine (refer to the report in footnote 10 on page 3). So, bank angle should be mentioned in this note (as described above), rather than the critical engine.

3.4. AFM § 3.5.3. Engine Securing (Feathering) Procedure

3.4.1. **Step 2. ENGINE MASTER inoperative engine . . . . OFF**

3.4.1.1. Switching the ENGINE MASTER of the failed engine to OFF is obviously the only way to feather its propeller. But the propeller will only feather if its speed is above 1300 RPM. A NOTE and a CAUTION to this effect explain this:

NOTE on AFM page 3-27: *"To feather the propeller, the propeller RPM must be above 1300 RPM. Below 1300 RPM the start locks will not disengage and the propeller will keep wind-milling.*

To avoid unsuccessful attempts, the procedure instructs to feather the propeller at 1800 RPM".

CAUTION on AFM page 7-30: *"If the engine is shut down below an RPM of 1300 the propeller pitch remains below the start lock position. In this case the speed must be increased to increase the propeller RPM"*.

3.4.1.2. So it seems that the propeller of an engine that failed just prior to or after lift-off, and its speed quickly decreased below 1300 RPM, can only be feathered after climbing to a safe altitude for the propeller speed to be increased above 1300 RPM by increasing airspeed (80 – 120 KIAS), most probably during a descent. Is this feathering procedure interpreted correctly? Is the AFM correct on this? OEI climb performance data with an unfeathered propeller are not published, isn't it?

3.4.2. **NOTEs on page 3-27 and 3-31**. "*To feather the propeller, the propeller RPM must be above 1300 RPM. Below 1300 RPM the start locks will not disengage and the propeller will keep wind-milling. To avoid unsuccessful attempts, the procedure instructs to ' feather the propeller at 1800 RPM*".

3.4.2.1. On page 3-26, a CAUTION states that *"the propeller starts windmilling at airspeeds of 80 KIAS and above"*. The resulting RPM is not mentioned. Does this also mean that when the propeller produces high thrust during take-off (at lower speed) and the engine suddenly fails, after which the RPM of the propeller rapidly decreases below 1300 RPM, or even stops rotating, the propeller will not feather when the ENGINE MASTER is switched OFF? This also raises the question whether V_{MCA} (68 KIAS) was indeed determined with the propeller in the position it assumed by itself, windmilling or stopped rotating, as required by CS-23.149 and the Flight Test Guide.

3.4.2.2. If this is not the case, please rephrase the NOTE. The same remarks apply for the NOTE on AFM page 3-31.

3.4.3. CS 23.1189 (a)(3) requires "*Operation of any shut-off means may not interfere with the later emergency operation of other equipment such as propeller feathering devices*".

3.4.3.1. "*Operation of any shutoff means*" includes switching the ENGINE MASTER of the failed engine to OFF. The DA 42 AFM describes that that feathering and unfeathering requires a propeller speed of 1300 RPM or above. If the propeller speed quickly decreases below 1300 RPM after engine failure, there seems to be no way to feather the propeller in an emergency operation and hence, get rid of propeller drag as soon as possible, unless the speed is increased first above 1300 RPM.

3.4.3.2. Don't you agree that switching off an engine and requiring an increase of the propeller speed to 1300 RPM or above *"interferes with the later emergency operation"* of feathering the propeller for achieving both lower drag and a lower actual V_{MCA} as soon as possible?
Or are the description of the feathering and unfeathering system and the operating procedures not interpreted correctly? These differ from feathering system and procedures of other airplanes.

3.4.4. CS 23, Flight Test Guide on page 2-FTG-4-1 on pdf page 298 requires:
"(i) Tests should be conducted to determine the time required for the propeller to change from windmilling (with the propeller controls set for takeoff) to the feathered position at

the takeoff speed determined in § 23.51.
(ii) The propeller feathering system should be tested at one engine inoperative climb airspeed ….
(iv) In order to demonstrate that the feathering system operates satisfactorily, propeller feather should be demonstrated throughout both the airspeed and the altitude envelope since engine failure may occur at any time".

3.4.4.1. CS 23 obviously requires a propeller feathering system to achieve the feathered position throughout the airspeed and altitude envelope, whether the propeller is windmilling or not. This makes sense, because a pilot wants to reduce the propeller drag as soon as possible after engine failure to avoid a negative ROC.

3.5. AFM § 3.5.4 Unfeathering & Restarting the Engine in flight

3.5.1. **The 2nd WARNING on page 3-25.** "*An unfeathered propeller causes increased drag and reduces/increases climb/sink rate up to 200 ft/min*".

3.5.1.1. An unfeathered propeller not only reduces performance, but also increases the sum of the thrust yawing moments after engine failure, and requires a larger rudder deflection or a higher airspeed to maintain control. Since the feathering is not automatic, V_{MCA} will have been determined with a windmilling propeller, hence at higher drag. The AFM does not provide the information that the *actual V_{MCA}* is lower than the published V_{MCA} when the propeller is feathered (which is nice to know for the remainder of the flight and during the approach for landing).
The slashes (/) in the warning are not placed with care; meant is that *"An unfeathered propeller causes increased drag and reduces climb rate (or increases sink rate) with up to 200 ft/min".*

3.5.1.2. When the wings are kept level, the sideslip is not minimal, the rate of climb not maximal (or the rate of descent not minimal). As explained before, sideslip, hence drag, can be reduced by maintaining straight flight and attaining a small bank angle away from the failed engine/ propeller. The WARNING should include a statement to this effect.

3.6. AFM § 3.5.5 Engine Failure During Take-off

3.6.1. AFM § 3.5.5 (a) Engine Failure During Ground Roll

3.6.1.1. CS 23.149 (f) requires a V_{MCG} to be determined. This speed is not published in the AFM, neither are accelerate—stop distances. The latter are only required for commuter category airplanes, i.a.w. CS 23.1587 (d)(1). Refer to the remark in § 2.2.2.1 above on commuter category for pilot training.

3.6.2. AFM § 3.5.5 (b) Engine Failure After Lift Off

Continued take-off:

WARNING on page 3-34. *"…Under certain combinations of ambient conditions, such as turbulence, crosswinds and wind shear as well as pilot skill the resulting climb performance may nevertheless be insufficient to continue the take-off successfully…"*.

3.6.2.1. A few conditions are mentioned, but a very important condition is regrettably not included: maintain straight flight while also maintaining a small bank angle (to be determined by the manufacturer) away from the inoperative engine, which keeps both actual V_{MCA} and the sideslip/drag as low as possible, hence the rate of climb maximal.

"1. Power lever . . . . MAX
2. Rudder . . . . maintain directional control
3. Airspeed . . . . V_{YSE} = 82 KIAS / as required,

4. Landing gear . . . . UP to achieve a positive ROC
5. FLAPS . . . . check UP
6. Inoperative engine . . . . secure according to 3.5.3 - ENGINE SECURING (FEATHERING) PROCEDURE"

3.6.2.2. A few remarks on these steps:

1. Power lever or levers? In the NOTE in AFM § 3.5.3 Engine Securing (Feathering) Procedure, the power lever of the secured engine must be set forward as required to mute the warning horn.

2. Rudder to maintain straight flight (initially to regain directional control).

2a. Add a very important step: 'bank 5° into good engine (to the same side as foot pressure)'.

3. Airspeed as required, by what? (V_{XSE}, V_{YSE}, > V_{MCA}?).

4. Landing gear UP. Delete "*to achieve a positive ROC*" or add reasons in other steps too. It is not certain that ROC will be positive, depends on more factors.

6. Inoperative engine … identify & verify.

7. Can a step be added here: 'Affected engine: ENGINE MASTER … OFF', to get rid of propeller drag as soon as possible, and thereafter (at or above 500 ft) secure the engine according to AFM § 3.5.3?

3.7. AFM § 3.5.6. Engine Failures in Flight

3.7.1. AFM § 3.5.6 <u>(a) Engine Failure … at Airspeeds below V_{mCA} = 68 KIAS</u>

"***WARNING***. *As the climb is a flight condition which is associated with high power settings, airspeeds lower than v_{mCA} = 68 KIAS should be avoided as a sudden engine failure can lead to loss of control. In this case it is very important to reduce the asymmetry in thrust to regain directional control*".

3.7.1.1. Missing here is to avoid the loss of control by maintaining straight flight and a small bank angle away from the failed engine for the actual V_{MCA} not to be higher than 68 KIAS. A wings-level attitude might increase V_{MCA} by 6 kt or more.

3.7.1.2. Reduction of thrust (temporarily) is indeed the only way out to save airplane and souls on-board if the airplane does not respond to (max.) rudder deflection at low altitude. Good point! As soon as control is re-established, bank 5° into good engine and apply full thrust, while maintaining straight flight, climbing to a safe altitude (which might take a long time).

3.7.2. Procedure steps:

"1. Rudder . . . . apply for directional control
2. Power levers . . . . retard as required to maintain directional control
3. Airspeed . . . . v_{YSE} = 82 KIAS / above v_{mCA} = 68 KIAS as required
4. Operative engine . . . . increase power as required if directional control has been re-established

Establish minimum / zero sideslip condition (approx. half ball towards good engine; 3° to 5° bank).

5. Inoperative engine . . . Secure according to 3.5.3 – ENGINE SECURING (FEATHERING) PROCEDURE"

3.7.2.1. A few remarks on these steps:

1. Rudder to maintain straight flight.

2. Power levers, see § 3.7.1.2 above.

3. Airspeed, the correct abbreviations are V_{YSE} and V_{MCA}.

4. Recommend to merge this step in step 2, see § 3.7.1.2 above

"Establish …". Good step, but why was this not included in the procedures above? Adequate rudder and banking as soon as possible, while maintaining straight flight is recommended, since it decreases both sideslip and actual V_{MCA}, and increases the safety margin above V_{MCA}, and might avoid the loss of control.

5. Feathering, to decrease the thrust yawing moment and the drag, should be accomplished as soon as possible. Refer to § 3.6.2.2 step 7 above.

3.7.3. AFM § 3.5.6. (b) Engine Failure during Initial Climb above V_{MCA}

3.7.3.1. Same remarks as in § 0 above.

3.7.4. AFM § 3.5.6. (c) Engine Failure during Flight

3.7.4.1. Same remarks however it is not recommended to maintain V_{MCA} when max. thrust is selected and turns have to be made.

3.7.4.2. In addition, the airplane might be drifting down to the single engine ceiling. In order to achieve maximum range, maintaining V_{XSE} is recommended while maintaining a small bank angle into the good engine to reduce the drag. The bank angle should have been presented by the manufacturer in the max. range charts.

3.7.5. The procedures in § 3.5.6 (a) – (c) are identical and therefore could be merged into one procedure for Engine Failures In-flight.

3.8. AFM § 3.5.7. Landing with One Engine Inoperative

3.8.1. Preparation: **WARNING** on backrests.

3.8.1.1. It is recommended to add another WARNING:
'Do not increase thrust to max. during turns at airspeed V_{REF}; the combination bank angle and high thrust increases the actual V_{MCA} and might lead to the loss of control at low altitude from which recovery is not possible. Plan the approach and landing ahead; a long straight-in approach is much safer'.

3.8.1.2. V_{REF} should be listed in § 2.2. That is where readers are looking for airspeeds.

3.8.2. Just prior to *"step 7: Not before being certain of "making the field“"*:

3.8.2.1. Replace by 'When certain of making the field:'.

3.8.3. "Step 14. Trim . . . . as required / directional trim to neutral"

3.8.3.1. Choice? Neutral trims is recommended to 'feel' the rudder, which is not maximal during final approach and landing. It might also prevent vacating the runway after touchdown when the rudder has to be reversed when the propeller of the idling operating engine produces higher drag for a while.

3.8.4. Does the DA 42 have no additives to V_{REF} for safe approach speeds in windy conditions?

3.9. AFM § 3.5.8. Go Around.

3.9.1. **CAUTION**
"*The go-around / balked landing is not recommended to be initiated below a minimum of 800 ft above ground*".

3.9.1.1. Delete *"a minimum of"* , is superfluous.

3.9.1.2. Write 'A go-around', rather than *"The go-around"*.

3.9.2. Procedure Steps 1 – 5.

3.9.2.1. The same remarks apply here as presented in § 3.7.2 above

3.9.3. ***"Establish minimum sideslip*** *and manoeuvre for a new attempt to land. Repeat from Section 3.5.9 - FLIGHT WITH ONE ENGINE INOPERATIVE"*.

3.9.3.1. Minimum sideslip can only be established by banking a small bank angle into the good engine during straight flight. Therefore it is safer to remind pilots in this procedure to maintain straight flight while banking a few degrees (mention the number) when the asymmetrical thrust is increased, rather than the current text.

3.9.3.2. To manoeuvre while one engine is inoperative, a higher airspeed than V_{YSE} might be required. Some twins require V_{MCA} + 20 kt for maintaining control during shallow turns.

3.10. AFM § 3.5.9 Flight with One Engine Inoperative

3.10.1. ***"CAUTION****. Even if a positive flight performance can be established with one engine inoperative, land as soon as practicable at the next suitable airfield / airport."*

3.10.1.1. Here "*land as soon as practicable*" is used (only once in the AFM), while elsewhere in the AFM, and even on the same page, "*land as soon as possible*" is used. Most Flight Manuals define what the difference is. This should be done here too. Land at destination, on the nearest airport or immediately?

3.10.2. Procedure steps:

" 1. Airspeed . . . . above vmCA = 68 KIAS to maintain directional control

3. Fuel Quantity . . . . monitor continuously.

4. FUEL SELECTOR . . . . remaining engine / set CROSSFEED or ON etc."

3.10.2.1. A few remarks:

1. Recommendation on airspeed as presented above (maintain straight flight).

3. Monitoring continuously distracts attention from aviating, being the first priority (when OEI). Probably meant: 'frequently'.

4. Intended might be:
FUEL SELECTOR remaining engine . . . . Alternate CROSSFEED and ON frequently during the remainder of the flight so as to keep fuel laterally balanced within 5 US gal (or a EU measure).
See AFM § 2.15 Limitation Placards (not § 2.14 as in the NOTE this page).

3.10.3. No advice is given here to bank a few degrees into the good engine to reduce the drag and increase the range.

3.11. AFM § 4A.2 Airspeeds for Normal Operating Procedures

3.11.1. Table with airspeeds.

3.11.1.1. Several airspeeds are accompanied by their abbreviation, some not. Please include all.

3.11.2. *"V_R is min. 70 KIAS"*.

3.11.2.1. CS 23.51 requires *"V_R must not be less than the greater of 1.05 V_{MCA} or 1.10 V_S"*. The V_{MCA} of the airplane is 68 KIAS (AFM § 2.2), so V_R must not be less than

71.4 KIAS. This V_{MCA} is measured while maintaining a small 5° bank angle away from the inoperative engine. Keeping the wings level increases the *actual* V_{MCA}, in this case to a value higher than V_R. Loss of Control is imminent. V_R is too low! (also on AFM § 5.3.6 page 5-10).

3.11.2.2. Several lower speeds require a small bank angle to stay above *actual* V_{MCA}.

3.11.3. **NOTE** on page 4A-4: *"vx is always less than vy. For the DA 42 however, the actual value of vx would be below the minimum safe speed. The minimum airspeed for best angle of climb was therefore raised to the value of vy"*.

3.11.3.1. What is meant by *"minimum safe speed"*? This is not defined in AFM § 2.2. Is it the stall speed, or V_{MCA}?

3.11.3.2. V_X is found where the tangent intersects with the polar curve[18] and is larger than V_S. V_Y is the highest vertical speed of the polar curve, in both cases when the top of the curve is above zero. When the remaining engine power is not sufficient to maintain altitude, or during a glide, V_Y is lower than V_X.

3.12. AFM § 5.3.6 Take-off Distance

3.12.1. Same remarks as in § 3.11.2 above.

3.13. AFM § 5.3.9 Page 5-23 One Engine Inoperative Climb Performance

3.13.1. **Condition** - Remaining engine (RH) . . . . MAX @ 2300 RPM

3.13.1.1. Why is *"(RH)"* added? RH might mean Right Hand engine, but doesn't this step also apply when the other engine is inoperative? Of course. Therefore delete (RH).

3.13.1.2. Why *"MAX @ 2300 RPM"* here, and elsewhere in the AFM just *"MAX"*?

3.13.2. **Dead engine …. feathered and secured**

3.13.2.1. Elsewhere in the AFM the dead engine is called *"inoperative engine"*.

3.13.3. **NOTE.** *"With respect to handling and performance, the left-hand engine (pilots view) is considered the "critical" engine"*.

3.13.3.1. This note is already discussed in § 3.3.1 above.

3.13.4. "Zero sideslip . . . . . . established"

3.13.4.1. How does a pilot do that? By banking a few degrees into the good engine while maintaining straight flight.

3.13.5. **NOTE** about the critical engine.

3.13.5.1. Refer to remarks in § 3.3.1 above.

3.14. AFM § 5.3.9 Page 5-24. One Engine Inoperative Climb / Descent

3.14.1. **Chart on page 5-24.** Legend is: *"Conditions: Flaps: UP, Power: remaining engine MAX @ 2300 RPM / Dead engine: feathered + secured, Airspeed: 82 KIAS"*.

3.14.1.1. Performance depends very much on the drag. The drag, when an engine is inoperative, is minimal when a small bank angle is being maintained into the good engine during straight flight. This bank angle is smaller than the bank angle used for V_{MCA} because V_{YSE} is higher than V_{MCA}. Most small twins have to use 3° at V_{YSE}. It is recommended to add the bank angle requirement to the legend, and to use V_{YSE} or (blue radial) V_{YSE} rather than 82 KIAS. See also § 2.1.3.1 above.

[18] Harry Horlings, "*Airplane Control and Analysis of Accidents after Engine Failure*", https://www.avioconsult.com/downloads/Airplane Control and Analysis of Accidents after Engine Failure.pdf, § 3.1.4.

3.14.2. **Chart on page 5-25** (> 1700 kg):

3.14.2.1. There is no legend on this page, recommend to copy from page 5-24.

3.15. AFM § 5.3.10 Cruising (TAS)

3.15.1. **Conditions**: "*POWER lever . . . . as required to adjust selected displayed LOAD [%]*".

3.15.1.1. *"POWER lever"* must be POWER levers (plural, because all engines operating).

3.15.1.2. *"… as required to adjust selected displayed LOAD [%]"*. What is meant with selected and displayed?

3.15.1.3. Is *"Load"* similar to Torque as used in other airplanes?

3.16. AFM § 7.9.2 Propeller

3.16.1. Propeller Control

3.16.1.1. Scales of the chart in this paragraph are not readable.

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