Pilot Operating Handbook and Aircraft Flight Manual
Viking DHC-6 Series 400 (Twin Otter) and Variants,
PSM 1-64-1A, Revision 3,
dated 8 Feb. 2017

Limited Review[1]

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1. Introduction

1.1. On 25 April 2025, a DHC-6-400 Twin Otter of the Royal Thai Police crashed into the sea shortly after takeoff from Hua Hin Airport, Thailand. Initial reports mention the failure of the right engine. Although conclusions can only be drawn following the accident investigation, which usually takes more than a year, Avio*Consult* reviewed the Airplane Flight manual (AFM) of this type of airplane that could be retrieved from the Internet, because of the experience with inappropriate content of AFMs of many multi-engine airplanes on the subjects of engine failure and flight with one engine inoperative. It is very rare that transportation safety boards also review the AFM of the crashed airplane as part of accident investigations, while the cause of many accidents often is a shortfall in such manuals, and in derived training manuals.

1.2. Since 1996 more than 500 engine failure-related accidents with multi-engine airplanes were reported on the Internet alone, causing more than 4,100 casualties, despite the FAA/EASA and equivalent regulations for designing, thoroughly flight-testing and certification of airplanes for flight while an engine is inoperative. Avio*Consult* started reviewing accident investigation reports, Airplane Flight Manuals (AFM) and multi-engine-rating courses on this subject 20 years ago using knowledge gained at universities as well as at 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 on the subject of controllability and performance of multi-engine airplanes while an engine is inoperative between (airline) pilots and their instructors, certification authorities and accident investigators on one side, and airplane design engineers and graduates of a test pilot school on the other side.
Multi-engine rated pilots learn about the minimum control speed (V_{MC} or V_{MCA}) of their airplane, but are regrettably neither made aware anymore of the real value of the $V_{MC(A)}$ that is already used during the design phase of the airplane and is published as one of the airspeed limitations in the Airplane Flight Manual, nor of the associated maneuver limitations that must be observed to avoid losing control when one engine is indeed inoperative and high thrust is selected on the remaining engine(s). Proper knowledge on this subject got lost or forgotten during the past 50 years; too many fatal accidents are the consequence.

1.3. The author of this limited review is graduate Flight Test Engineer of the USAF Test Pilot School, Edwards AFB, CA (1985). This Test Pilot School (TPS) and the very few other TPSs around the globe provide the highest level of flight-test training required to conduct experimental flight-testing, including flight-testing while one or two engines are made inoperative. The entrance level was an MSc degree in engineering or a BSc and an entrance exam. TPSs teach aircraft performance, flying qualities, airborne systems and flight-test management. During the one-year course, students receive academics and flight-test training on these subjects and conduct some 120 flight hours of flight-testing in 24 different types of curriculum aircraft: fighter jets, single-, twin- and 4-engine propeller and turbojet airplanes, helicopters,

[1] This Review, with working links, can also be downloaded from: https://www.avioconsult.com/downloads.htm#DHC-6.
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gliders, and simulators. They have to pass 32 exams, write 32 reports, and undergo frequent test rides. Calibrating pitot-static systems, and flying qualities testing of multi-engine airplanes while half of the number of engines are made inoperative, and determining the Minimum Control Speed in the Air (V_{MC} or V_{MCA}) is part of the curriculum. The FAA Flight Test Guide[3] also describes and explains the flight-test techniques used by test pilots to determine V_{MC} (V_{MCA}) in-flight. The Flying Qualities course of the USAF Test Pilot School, which includes the explanation of the controllability of multi-engine airplanes when an engine is inoperative, can be downloaded in two parts from the USArchives[4].

1.4. To again 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 its website[5]. A video lecture *"The real Value of V_{MCA}"* with the subtitle *"How to prevent a dead engine from turning into a killing engine"* was uploaded on YouTube[6]. A similar paper *"Staying Alive with a Dead Engine"* was also presented to the 18th Annual European Aviation Safety Seminar[7] (EASS), Athens, Greece, March 2006. These papers discuss V_{MCA} and the often-inappropriate V_{MCA} definition in Airplane Flight Manuals. The papers are still actual, despite many organizations being informed and alerted.
"Safety Critical Procedure Development requires high level multi-disciplinary knowledge" [8] is the title of a paper presented by Avio*Consult* in 2019 to the EuroControl Safety Forum in Brussels. Papers were also presented to the FAA Engine and Propeller Directorate, Luftfahrt Bundes Amt, Delft University, Dutch ALPA, and other organizations.

1.5. Many concerned pilots and flight instructors, 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 Avio*Consult* (and hence, with the official certification and flight-test regulations of FAA, EASA and equivalent), asked Avio*Consult* for advice on the subject.
Many manufacturers, authorities and Transportation Safety Boards were asked to improve their manuals and investigations, but these organizations obviously suffer from poverty of knowledge, because they did not respond, change anything, and obviously did not appreciate the competency of a Test Pilot School graduate either. Fatal accidents after engine failure continue to happen; pilots and their passengers continue to lose their lives during unnecessary and avoidable accidents, as is frequently reported on the Internet.

1.6. This review is limited to AFM Sections 0 to 5, with the exception of a few paragraphs of the POH sections. The review presents engineering and flight-tests based facts, not opinions, and is not to apportion blame or liability to anybody, but is written to alert, make aware, teach, and learn from, which is necessary because appropriate knowledge obviously just faded away during the past five decades or so, and fatal accidents with multi-engine airplanes, not only with the Twin Otter, continue to occur every month. For this reason, explanations are included as well as some suggestions and recommendations for improvement. Further information can be found in the books, regulations, and papers that are referenced to in footnotes. Although presented for the DHC-6 Twin Otter AFM, the remarks made below not only

[3] FAA Flight Test Guide, Advisory Circular AC 23-8C: http://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_23-8C.pdf.
[4] Flying Qualities Textbook, USAF Test Pilot School. Volume II, Part 1, 1986, https://ia800107.us.archive.org/32/items/DTIC_ADA170959/DTIC_ADA170959.pdf.
Flying Qualities Textbook, USAF Test Pilot School. Volume II, Part 2, 1986 (Chapter 11, Asymmetrical power), https://ia801001.us.archive.org/17/items/DTIC_ADA170960/DTIC_ADA170960.pdf.
[5] Website Avio*Consult*: https://www.avioconsult.com.
[6] Harry Horlings, video lecture: *"The real value of the minimum control speed"*, https://youtu.be/Wbu6X0hSnBY.
[7] Harry Horlings, *"Staying Alive with a Dead Engine"*. 18th Annual European Aviation Safety Seminar (EASS), Athens, Greece, March 2006, https://www.avioconsult.com/downloads/Staying alive with a dead engine - AvioConsult.pps.
[8] 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 Forum slides AvioConsult June 2019 - video links.ppsm.

apply to this AFM, but to AFMs of most multi-engine airplanes as well. The most recent version of this review can be downloaded from the website of Avio*Consult*[1] or other websites, for the links to work.

1.7. On the title page is declared that the document *Pilot Operating Handbook and Airplane Flight Manual* (POH/AFM) meets the General Aviation Manufacturers Association (GAMA) Specification No. 1[9]. This Specification is regrettably not prepared with a high level of aeronautical competence and puts the POH/AFM-writers of the member companies on the wrong foot, on several subjects. Specification No. 1 will be reviewed separately.
POHs and AFMs must be nothing less than perfect because pilots have the right to know and understand how to prevent a dead engine from turning into a killing engine. They have the right to be provided with required and available high-level knowledge in excellent POHs, AFMs and training manuals.

2. General Remarks on Airspeeds Used in an POH/AFM

2.1. During reviewing this and other POH/AFMs, the use of Calibrated Air Speeds (CAS) and Indicated Air Speeds (IAS) was found to be neither in compliance with the way these airspeeds are defined and used in 14 CFR FAR 23[10] – Airworthiness Standards: Normal and Commuter Category Airplanes, nor as used during airplane design, calibration flight testing, and nor as taught at Test Pilot Schools[11]. AFM-writers, authorities, and pilots seem to struggle with understanding why these airspeeds exist and what their function is. Therefore, a few general remarks are presented prior to reviewing the AFM. Reference is made to the applicable aviation and other regulations.

2.2. Calibrated Air Speed and Indicated Air Speed of an Airplane

2.2.1. Two speeds in aviation give information about the distance travelled in a period. These are the True Air Speed (TAS), being the speed of an airplane through the air mass with an ambient pressure and temperature which is not (yet) disturbed by the airplane, and the Ground Speed (GS), which is the speed of the airplane relative to the ground, which is TAS plus or minus a tail-, or headwind component. Both are used by pilots for navigation, to calculate the time at which the destination is reached.
TAS however, is not useful for the piloting task, i.e. for control and performance, because TAS is influenced by ambient temperature and altitude (density). The use of TAS would require computing different speeds for each combination of weight, ambient temperature, and altitude (density). In addition, it is quite complicated to build an accurate mechanical TAS indicator to account for temperature and altitude effects, which was the reason to introduce the Calibrated Air Speed (CAS), which makes the flying task and the use of performance data easier. At sea level *in a standard atmosphere*, TAS is equal to CAS. TAS is, besides for navigation, also used for propeller thrust, turn calculations, etc., i.e. mainly for engineering (design) purposes and flight-test.

2.2.2. CAS is *'the mother'* of all airspeeds and is measured by a calibrated pitot-static system. CAS has the same significance on all days; CAS on one day is CAS on another day, CAS does not depend on temperature and altitude (density). Therefore, the takeoff, stall, cruise, minimum control, and landing speeds are proportional to the CAS for a given gross weight. CAS is of direct use to the pilot, which is the reason why these important piloting speeds are (to be) published as CAS in the POH/AFM.

[9] GAMA Specification No. 1, Specification for Pilot's Operating Handbook, Rev. No. 2, 1996, https://gama.aero/facts-and-statistics/consensus-standards/publications/gama-and-industry-technical-publications-and-specifications/.
[10] Code of Federal Regulations, Title 14, Chapter I, FAR 23, 1−1−10 Edition was used in this review. Link to 2017 version: https://www.ecfr.gov/on/2017-01-03/title-14/chapter-I/subchapter-C/part-23/subpart-B.
[11] *Pitot-Statics and the Standard Atmosphere*, 4th edition (July 2020), Russell E. Erb, USAF Test Pilot School, https://apps.dtic.mil/sti/pdfs/AD1115005.pdf.

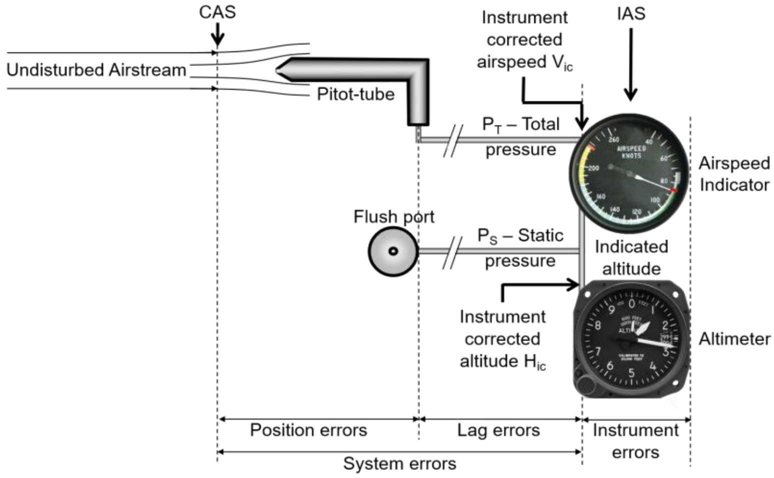


Figure 1. A common Pitot-static system and its errors; from Calibrated Airspeed (CAS) in undisturbed airstream to Indicated Airspeed (IAS) on the Airspeed Indicator (ASI).

2.2.3. P_T and P_S are measured with a pitot-static system and their difference $P_T - P_S$ is indicated by an Air Speed Indicator (ASI), which is simple in design and construction, accurate and easy to calibrate. However, neither a pitot-static system, nor an ASI is regrettably without errors due to the positioning of the sensors on the airplane (in disturbed air), and due to manufacturing of the ASI. Hence, the airspeed that the pilot reads on the ASI is not the CAS anymore, but is called the Indicated Air Speed (IAS), which is the CAS minus the pitot-static *system errors* and minus the *instrument errors* of the Air Speed Indicator (ASI). The airspeed measuring system is illustrated in Figure 1. The airspeed ahead of the tip of the pitot-tube in the undisturbed airstream is the CAS of the airplane; the ASI indicates the IAS to the pilot. The errors will be discussed further below.

2.2.4. ***Position Error*.** The position error is the error caused by locating the pitot-tube and flush ports on the fuselage, rather than in the undisturbed airstream in front of the airplane. The pitot-static system is calibrated during flight-testing during which its airspeed *position error* is determined over a range of airspeeds, for several flap and landing gear configurations, and weights. 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*". The position error does not cause difference between the IAS indicated on separate ASIs in the same cockpit that are connected to the same pitot-static system; then a single position error chart applies to any of the ASIs.

2.2.5. ***Lag errors.*** The pressure lag errors for airspeed and altitude are caused by the length of the tubing causing a small delay and are considered not to have influence except when changing airspeed or altitude. These errors will not be used below.

2.2.6. ***Instrument Errors***. The expansion of the aneroid (diaphragm or bellows) within a mechanical ASI due to the difference between P_T and P_S is transferred by mechanical parts such as levers, pinion, and springs to the pointer of the ASI which rotates above an airspeed scale indicating the IAS. The ASI is mechanically designed and constructed to indicate the airspeed with respect to the standard atmospheric pressure and temperature at sea level.
The errors between the air pressures P_T and P_S at the entrance of the ASI and the eyes of the pilot(s), caused by the mechanical parts within the ASI, such as manufacturing discrepancies, magnetic fields, hysteresis or friction, altitude, temperature changes, vibration, inertia of moving parts, and the parallax, contribute to the instrument error. The instrument error of each individual ASI over a range of airspeeds is determined in an instrument laboratory during calibration, as required by FAR 23.1323(a).

2.2.7. Hence, each individual ASI has its own (total) *instrument error*. In a cockpit with two or three different ASIs for pilot, copilot and a backup, the airspeed indication of each IAS usually differs because the instrument errors of each of the ASIs differ, while the CASs, calculated after adding the known instrument correction of each ASI and the (common) position error correction of the pitot-static system, are equal.

2.2.8. SAE AS 8019 presents detailed ASI specifications, but this document is not available for free. The free FAA Standard ETSO-C46a[12] is for maximum allowable airspeed indicator systems which indicate continuously both indicated airspeed and maximum allowable airspeed (FAR 23.1303(g)(1)). Although this standard may not apply to regular ASIs, the tolerance numbers will not differ very much, and are partly presented for low airspeeds in Figure 2.

2.2.9. ETSO-C46a Appendix 1, § 2.3(c)(1) states: "*The indicated airspeed pointer must indicate airspeed in accordance with the values contained in Table I*". In this ETSO Table I (Figure 2), the approved tolerance at a range of airspeeds is defined.

TABLE I

Speed knots	Impact pressure (qc) inches Hg at 25° C	Tolerance knots
50	0.1198	±4.0
*60	.1727	2.0
80	.3075	2.0
*100	.4814	2.0
120	.6950	2.0
*150	1.091	2.5
180	1.580	3.0
*200	1.959	3.0
230	2.610	3.0
*250	3.100	3.0
280	3.924	3.5
*300	4.534	[illegible]
320	[illegible]	[illegible]
*[illegible]		

Figure 2. ETSO-C46a, Part of Table I. Minimum performance standards for pitot-static type airspeed indicator systems.

Another error source is friction on the pointer: *"The friction on the pointer must not produce an error exceeding 3 kt"* at each point indicated by an asterix in Table I.

Hence, the instrument error of an ASI indicating V_S, V_{MCA}, V_{REF}, or takeoff speeds in the range 60 – 120 kt is allowed to be ±2 kt (Figure 2). The approved tolerance at 50 kt (≈V_{MCG}) is ±4 kt. During increasing or decreasing airspeeds, the instrument error might increase with 3 kt (*friction). In a worst-case situation, the difference between the IAS indicated on two ASIs in the same cockpit is allowed to be up to 4 kt (if one error happens to be −2 kt and the other +2 kt).

2.2.10. The pressure difference P_T minus P_S at the entrance of the ASI is a measure of the IAS corrected for the instrument error (Vic − Figure 1), which should be the airspeed to enter the position error chart that is published in the AFM.

2.2.11. Modern air data systems don't have a mechanical ASI anymore (except for a backup/ alternate); pressure transducers in the air data system convert the air pressures into digital numbers for further processing and display. Such a system however, still has the errors as shown in Figure 1. In some cases, an air data system allows entry of calibration correction to compensate for position and lag errors, and possibly also for (its own) instrument errors so that CAS can be displayed on the speed tape in the cockpit. In most cases, the pilot still must deal with both the position and instrument errors though, and hence with both CAS and IAS.

2.2.12. ***Total airspeed error***. The maximum regulations-approved airspeed error, being the sum of the approved instrument and position errors, is in a worst case allowed to be as high as (2 + 5 =) 7 kt (ETSO-C46a and FAR 23.1323(b)). This number could be increased by the allowed 3 kt friction error during acceleration or deceleration. These are numbers that a pilot needs to be made aware of for being able to plan and conduct the takeoff, approach and landing safely, and for handling the airplane in case an engine fails.

2.2.13. Test Pilot Schools also teach Equivalent Airspeed, but the difference with Calibrated Airspeed is small and within acceptable tolerances, and will not be discussed here. Refer to the (free) book *Pitot-Statics and the Standard Atmosphere* in footnote 11 for a complete course on pitot-statics, airspeeds, and altitudes.

[12] 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.

2.2.14. ***Summary***. The three most used airspeeds in the AFM will be briefly summarized.

A proper definition of Calibrated Airspeed (CAS) would be:

CAS is the airspeed in undisturbed air with respect to the standard atmospheric pressure and temperature at sea level

CAS is the airspeed of the airplane in undisturbed air, i.e. in the free airstream in front of the bow wave of the airplane. The errors caused by the disturbed air, the placement of the pitot-tube in disturbed air, and the pitot-static system are determined during **calibration** over a range of airspeeds (and altitudes) and furnished as position error in the POH/AFM. CAS is important for the piloting task; the AFM-published speed limitations such as V_S, V_{MCA}, and V_{MO}, and operational speeds such as V_1, V_R, V_2 and V_{REF}, and handling characteristics, are proportional to CAS for a given gross weight. CAS is also used to present performance data in an AFM. CAS has the same significance on all days, whatever the pressure and temperature are. CAS cannot be displayed in the cockpit by a simple mechanical instrument, but must be calculated by the pilot by adding the instrument error correction and the position error correction to the airspeed indicated by the Airspeed Indicator (ASI). The errors can be positive, zero or negative. The CAS of two airplanes flying in formation should be equal, while their IAS are most probably not.

The use of CAS allows the manufacturer or operator to use (copies of) the same POH/AFM for a series of airplanes of the same type. CAS is often inappropriately explained as being the abbreviation of Computed Air Speed, even by accident investigators.

2.2.15. A proper definition of Indicated Airspeed (IAS) would be:

IAS is the airspeed indicated by an Airspeed Indicator

IAS is equal to the CAS plus both the pitot-static system position error and airspeed indicator instrument error. The position error of the pitot-static system over a range of airspeeds is presented in the AFM; the instrument error of each individual ASI must be furnished to the pilot separately.

The errors can be positive or negative. The pilot must calculate limiting speeds provided in the POH/AFM from CAS to IAS for use in the cockpit, and calculate CAS from IAS for using appropriate performance data in the POH/AFM.

2.2.16. A proper definition of True Airspeed (TAS) would be:

TAS is the airspeed of an airplane with respect to the ambient pressure and temperature

TAS is the airspeed to be used for the navigation task, for calculating the time enroute. TAS is calculated from CAS using the ambient pressure altitude and OAT, with an E6-B flight computer or by on-board computers. At sea level and in standard temperature, TAS = CAS.

2.3. Calibrated Air Speed and Indicated Air Speed in Regulations

2.3.1. FAR 23.1581(d) requires: *"All Airplane Flight Manual operational airspeeds, unless otherwise specified, must be presented as indicated airspeeds"*. All operational airspeeds in a type-generic AFM (V_S, V_{MCA}, takeoff speeds, etc.) are determined, calculated, and usually specified to be presented as CAS for reasons described in the paragraphs above and in § 2.4 below. CAS cannot be presented on an instrument in a cockpit because of the pitot-static system and instrument errors that vary with airspeed. Such an instrument would be too complicated to make, and would have many errors (§ 2.2.3 above). In the future, computers might be able to calculate and compensate for the position and "instrument" errors and display the important CAS rather than IAS. Until then, pilots must calculate all AFM operational airspeeds from CAS by adding instrument and position errors to the IAS, and vice-versa, even if small (§ 2.4.5 below).

This FAR requirement can only be met if, besides the position error, also the instrument errors of each individual ASI in all of the DHC-6 Series 400 airplanes are known to the AFM-writer, including the errors of a second or third ASI in the same cockpit. This would lead to a large data table, the use of which would be prone to errors. A maintenance replacement of a defective ASI would lead to an amendment of the AFM, and approval by authorities taking quite some time during which the airplane is grounded, unless the instrument error of the new ASI is exactly the same as of the replaced ASI.
In addition to the amendment of the AFM of the specific tail number, the required placard in the cockpit (FAR 23.1563) with airspeed limitations also needs to be amended and replaced. This cannot be the intention of this FAR requirement; it is obviously unworkable, and must be in error (or is misunderstood). The quoted FAR 23.1581(d) could also mean that all operational airspeeds must be presented by an ASI which is accompanied by an instrument correction table for a range of airspeeds on the instrument panel, for the pilot to be able to calculate the real indicated airspeed. When the author of this review started flying Part 23 airplanes in the early seventies, such a table could still be found on the instrument panel.

2.3.2. Pt. 23, SFAR No. 23, § 13(a) and FAR 23.1323(a) require: *"Each airspeed indicating instrument must be calibrated to indicate true airspeed (at sea level with a standard atmosphere) with a minimum practicable instrument calibration error when the corresponding pitot and static pressures are applied".* TAS in these conditions is indeed equal to CAS, but not in other conditions. TAS is not useful for the piloting task at higher altitudes and at ambient temperatures and pressures that deviate from the standard atmosphere for observing airspeed limitations and for performance, hence this requirement might be an error in this regulation as well. TAS is for navigation, as was also mentioned in § 2.2.1 above.

2.3.3. FAR 23.1581 (d) (§ 2.3.1 above) requires operational airspeeds to be presented as indicated airspeeds, while FAR 23.1323(a) requires that each airspeed indicating instrument must be calibrated to indicate True Air Speed. FAR 23 seems to need a review by real experts as well.

2.3.4. *FAR 23.1323 (b) requires: "Each airspeed system must be calibrated in flight to determine the system error. The system error, including position error, but excluding the airspeed indicator instrument calibration error, may not exceed three percent of the calibrated airspeed or five knots, whichever is greater, throughout the following speed ranges:"*
A similar requirement is in Part 23, SFAR No. 23, § 13: "*The airspeed indicating system must be calibrated to determine the system error, i.e., the relation between IAS and CAS, in flight and during the accelerate takeoff ground run*", and in § 13(d): "*information showing the relationship between IAS and CAS must be shown in the Airplane Flight Manual*".
The system error is the position error plus the lag error (Figure 1 above), but not including the instrument error. The relationship between IAS and CAS is the sum of the instrument error of the ASI and the position error of the pitot-static system: CAS = IAS + instrument error + position error. The instrument error cannot be presented in an AFM, as explained above, only the position error is provided in a chart or table. In this SFAR paragraph, the instrument error is obviously assumed to be zero, which in reality cannot be the case due to the manufacturing process of ASIs. The pilot must read the airspeed instrument correction from an instrument error correction table and add this to the IAS to calculate the instrument corrected airspeed (Vic) which is then used to enter the position error chart to read the position error or CAS. An IAS to Vic conversion table is to be made for each individual ASI (for each serial number).

2.3.5. FAR 23.1323 requires both the pitot-static system and the airspeed indicator instrument to be calibrated separately. The calibration data of both should be made available to the pilot to be able to calculate the CAS from the IAS during flight, and to calculate pre-flight determined performance data and takeoff speeds from CAS in the AFM to IAS for use in the cockpit. The GAMA Specification No. 1 seems not to mention the instrument calibration error and therefore does not comply with FAR 23. It should not have been approved by the aviation

authority.
The DHC-6 POH/AFM does not adequately show the relationship in compliance with Part 23.

2.3.6. In FAR 23.1587(d): *"In addition to paragraph (a) of this section, for commuter category airplanes, the following information must be furnished— (10): The relationship between IAS and CAS determined in accordance with §23.1323 (b) and (c)"*.
The relationship between IAS and CAS is the sum of the position error (≤ 5 kt) and the instrument error (≤ 4 kt), i.e. between 0 and 9 kt, depending on the airspeed, and can be 3 kt higher due to the approved friction error when the airspeed decreases or increases. This FAR paragraph requires both the position error and the instrument error to be furnished. The position error is usually published in a chart in the AFM, but the instrument error seems forgotten, while it can be larger than the position error. Not furnishing instrument errors is not in compliance with this FAR paragraph.

2.4. Calibrated Air Speed and Indicated Air Speed in the AFM

2.4.1. Throughout the DHC-6 AFM, speed limitations and operational speeds are presented both as Calibrated Air Speed (CAS) and/or as Indicated Air Speed (IAS) in tables and charts, but a good definition of either airspeed (as in § 2.2.14 above) is not presented in § 0.6.
The apparent predetermined difference between CAS and IAS is obviously chosen to be between −1 and +3 kt (as in AFM Table 2-1) and seems to be only the position error (AFM § 5.7 and § 5.9). The instrument error is obviously considered zero, which is not in compliance with FAR 23, as already mentioned above.
Some graphs are using CAS only (Fig. 5-6 (V_S), Fig. 5-7 (Takeoff power setting), Fig. 5-8 Continuous Power Setting, etc.), others are in IAS only (Fig. 4-1, Fig. 5-17, etc.).
This mix of CAS and IAS may lead to misinterpretations and is prone to errors, because the sum of the errors in a pitot-static system varies with the installed instruments. Therefore, IAS cannot be used in a type-generic AFM, because IAS will differ from airplane to airplane as a consequence of a different instrument error of the installed ASIs, which are a consequence of their design and production.

2.4.2. The takeoff, stall, minimum control, cruise, approach and landing speeds, and the handling qualities of the airplane were determined during experimental test flights 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 CAS in tables and charts in the AFM and are valid for airplanes of the same type, with a similar pitot-static system. As also mentioned above, another reason for publishing airspeeds as CAS is that the AFM-writer cannot know the instrument error of each individual ASI installed in production airplanes (at any one time), which is also a reason that CAS is normally used in generic AFMs. In the cockpit of each individual airplane, correction tables should show the relationship between the IAS and CAS of each individual installed ASI, except for a few categories of airplanes, unless the errors are compensated for in the air data system (§ 2.2.11 above).

2.4.3. The DHC-6 AFM presents many airspeeds as IAS, but not all. This might cause confusion, and certainly also errors. Limiting airspeeds presented as IAS might be higher than intended/determined as CAS + position error + instrument error, which might lead to controllability problems, while the pilot believes to be safe when reading the ASI.

2.4.4. *An example*: The minimum control speed, determined during flight-tests is 66 KCAS (AFM Table 2-1, flaps 10°). The position error CAS to IAS = −2 kt (Δ V, AFM Figure 5-5), and suppose the instrument error is the maximum approved −2 kt, which is not provided. Then the minimum control speed is indicated as 66 KCAS − 2 + 2 = 66 KIAS. The placard in the cockpit (AFM § 2.18 A) tells the pilot that V_{MCA} is 64 KIAS. So, if maintaining 64 KIAS, the pilot believes to be safe, but this airspeed is 2 kt below the worst-case V_{MCA} (in IAS), and he will lose control when an engine fails. The takeoff speeds (in IAS), which are calculated using V_{MCA}, will also be too low on this ASI. This also affects the takeoff speeds.

2.4.5. Readers might believe 1 or 2 kt is not that big of an (instrument) error, so why all of the fuzz. But it is not about the few knots, it's all about physics, about the forces and moments generated by the aerodynamic control surfaces that are required to maintain the equilibrium of forces and moments, i.e. to maintain control, which are proportional to V^2 (lift equation: Lift = C_L ½ρV^2 S). A few knots have a very large influence on the generated control forces, and can make the difference between life and death. For instance, a difference of 2 kt on the generated aerodynamic force at an airspeed V = 80 kt is $82^2 - 80^2 = 324$ units of force, and not just 2^2. Rule makers require airspeeds to be provided accurately; rules were made many years ago with competence and should not be amended or neglected by ignorance, because physics has no mercy.
Pilots have the right to be made aware of the errors in the pitot-static systems for them to be able to apply the correct speed corrections and hence, correct limitations (in CAS), and to conduct a flight and return home safely.

2.4.6. A statement on the title page states that the DHC-6 AFM meets the General Aviation Manufacturers Association (GAMA) Specification No. 1, but the GAMA specification does not comply with FAR 23 and FAA Flight Test Guides. For instance, it states in the Preface: *"Calibrated Airspeed (CAS) is to be used only as necessary to comply with any applicable requirements of the certificating authority as the pilot works exclusively with Indicated Airspeed (IAS)"* and on Page 1-2: *"IAS values published in this Handbook assume zero instrument error"*, while FAR 23 requires instrument errors to be determined during calibration (FAR 23.1323(a)), and the relationship between IAS and CAS to be determined (FAR 23.1587(d)(10)) and be made available to the crewmembers (FAR 23.1501(b)). A pilot can only read IAS from the ASI, but should work with operating limitations and performance data that should be furnished in CAS in the AFM (independent from ASI instrument error and pitot-static position error). Hence, GAMA forces its members (including DHC) to break both the law as well as the FAR requirements for the contents of an POH/AFM. The AFM is designated by number (PSM -64-1A) in the Type Certificate Data Sheet (No. A9EA for the DHC-6), and is required for the airplane to be operated airworthy. In the Specification many more statements are found that are not in agreement with FAR 23 and FAA Flight Test Guides. The writers of GAMA Specification No. 1 obviously had a disappointing understanding of airplane speeds, performance, and control, and of FAR 23, and do not contribute to preventing accidents. A review of GAMA Specification No. 1 will be published soon on the Downloads Page of the website of Avio*Consult*.

3. AFM Section 0 – § 0.6 General Airspeed Terminology and Symbols

3.1. Some of the errors in this Section will be briefly discussed below, and suggestions for improvement given.

3.2. **Airspeeds CAS, IAS, and TAS** are not at all properly defined, only the meaning of the abbreviations KIAS, KCAS and KTAS are described. Refer to § 2.2 above for explanation, and to § 2.2.14 to § 2.2.16 for proper definitions of these airspeeds.

3.3. **GS** (not defined) is the Ground Speed of the airplane. GS = TAS minus the headwind or plus the tailwind component.

3.4. **V_1 Decision Speed**. "*V_1 is the highest airspeed on the ground at which, as a result of engine failure or other reasons, the pilot is assumed to have made a decision to either continue or reject the take-off*".

3.4.1. The word *"reject"* is often used, but is not correct in this case. Rejecting a takeoff is to be used when the takeoff did not yet begin, for instance when during takeoff planning a runway is found to be too short, or when ATC has a runway change request during taxying. When a takeoff has begun, but cannot be continued, *"abort"* is the correct English word to use (refer to an English dictionary, like the Webster).

3.5. **V_2 Take-off Safety Speed**. "*Take-off Safety Speed is the actual speed at 35 feet above the runway surface as demonstrated in flight during single engine take-off*".

3.5.1. The airplane must reach V_2 before it is 35 feet above the takeoff surface, and must continue at a speed as close as practical to, but not less than V_2, until it is 400 feet above the takeoff surface (FAR 23.57(c)(2)).

3.5.2. The last words *"during single engine take-off"* will not be meant as permission to conduct a takeoff on one engine. Meant will be 'after continuing the takeoff following an engine failure'.

3.6. **V_{EF} Engine Failure Speed** *"is the speed at which the engine was presumed to have failed during the take-off roll*".

3.6.1. V_{EF} is included in this list, but is intended for use by test pilots during takeoff testing only. Included to impress? It is not used in, and should be deleted from the AFM.

3.6.2. FAR 23.51[13] (which is for the certification of airplanes, not for their operational use) defines V_{EF}: "*V_{EF} is the calibrated airspeed at which the critical engine is assumed to fail. V_{EF} must be selected by the applicant but must not be less than 1.05 V_{MC} determined under §23.149(b) or, at the option of the applicant, not less than V_{MCG} determined under §23.149(f)*".

3.6.3. The applicant is the manufacturer who applies for the type certificate of his airplane. V_{EF} is not a speed to be used by airline pilots; they use decision speed V_1 that has to be provided by the manufacturer in tables or charts in the AFM for use by pilots. V_1 must not be less than 1.05 $V_{MC(A)}$ or less than V_{MCG} (is V_{EF}) plus the speed gained during the recognition and reaction time after engine failure. Note that FAR 23.51 uses Calibrated Airspeed, not Indicated Airspeed.

3.6.4. The calculation of V_1 includes V_{MCA}, V_{MCG} and the reaction time. Engine failure speed V_{EF} should therefore be removed from this list and replaced by decision speed V_1 in the DHC-6 Series 400 AFM § 0.9, § 5.21, and § 5.22, and elsewhere, such as in the Amphibian supplement.

3.7. **V_{LOF} Liftoff speed** "is used in certain performance graphs found in Section 5. It is the speed at which the aircraft actually leaves the runway surface".

3.7.1. The same applies as for V_{EF}. V_{LOF} is not of any use for airline pilots, only for test pilots during takeoff performance testing. If a pilot rotates the airplane slowly, then V_{LOF} is higher. Delete V_{LOF} from this list and out of the DHC-6 AFM, including in the performance section.

3.8. **V_{MCA} Minimum Control Speed** "*is the lowest speed at which the aircraft is controllable in flight in the take-off configuration (flaps 10° for a landplane) with one engine operating at maximum power (50 PSI torque, 96% NP) and the propeller of the other engine feathered. Below this speed, it is not possible to maintain control of the aircraft if maximum continuous power or maximum take-off power is set on the operating engine*".

3.8.1. Throughout the POH/AFM, both V_{MC} and V_{MCA} (V_{MC} in the Air) are used as abbreviation for minimum control speed; they denote the same speed, though. V_{MC} is used in FAR 23 while other publications use V_{MCA}. The use of both V_{MC} and V_{MCA} in the same DHC publication might be found confusing; better would be to choose one.

3.8.2. V_{MC} is defined in FAR 23.149(a) as follows: "*V_{MC} is the calibrated airspeed at which, when the critical engine is suddenly made inoperative, it is possible to maintain control of the airplane with that engine still inoperative, and thereafter maintain straight flight at the same speed with an angle of bank of not more than 5 degrees*".

[13] Although the certification basis of the DHC-6 airplane is Part 23 Normal Category, the TCDS (A9EA) includes a number of Commuter Category paragraphs as additional requirements.

3.8.3. FAR 23 is for the certification of airplanes. $V_{MC(A)}$ is already used by the tail design engineer for sizing the vertical tail and ailerons, because these control surfaces are essential for generating the control forces and moments to act against the asymmetrical thrust yawing and rolling moments during a sudden engine failure, and to be able to *"thereafter maintain straight flight"* when the asymmetrical thrust is maximum. $V_{MC(A)}$ is the lowest airspeed at which the forces and moments generated by the aerodynamic control surfaces are just large enough to counteract the asymmetrical forces and moments after an engine failure and maintain an equilibrium of forces and moments. V_{MCA} is measured during flight-testing in accordance with the FAA Flight Test Guide (FTG) in Advisory Circular AC 23-8C[3], page 83. Not only a *dynamic* V_{MCA} is determined, being the V_{MCA} at which it is possible to *maintain control* when an engine *suddenly* fails, but also a *static* V_{MCA} is measured at which it is possible to *maintain straight flight thereafter* while the thrust is maximum asymmetric. During flight-testing, the critical engine is made inoperative because then the thrust yawing moment is a bit larger and hence V_{MCA} a few knots higher than when the other engine is made inoperative. V_{MCA} applies in anticipation of and following either engine failure, though.

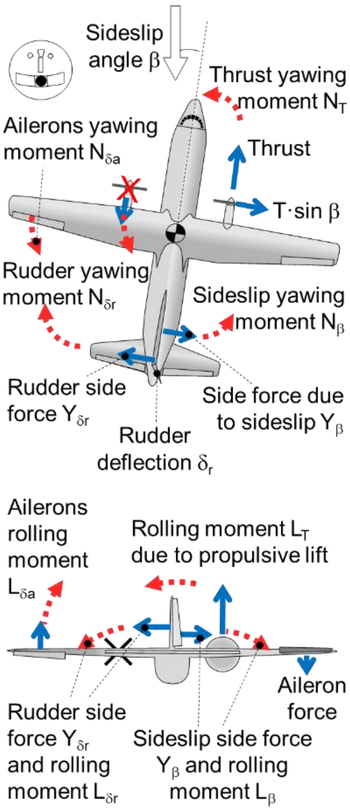


Figure 3. Lat-Dir forces and moments in body axis coordinate system, OEI, wings level, straight flight. Forces are not to scale.

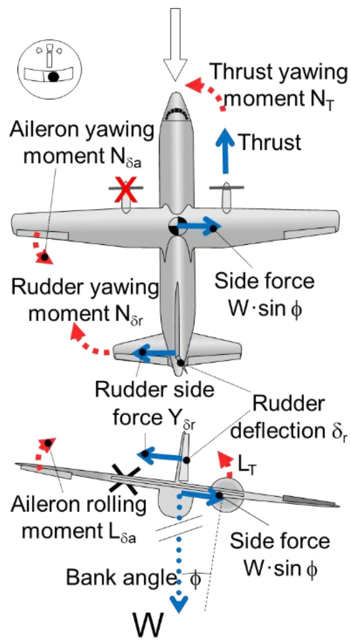


Figure 4. Lat-Dir forces and moments in body axis coordinate system, OEI, bank angle 5° into good engine, straight flight.

NOTE. In the analysis of Lateral-Directional forces and moments, the body axis coordinate system is used. Lift has no lateral component in this system, but Weight (gravity) has, even at large bank angles.

3.8.4. The static V_{MCA} is first determined with the wings level, by slowly reducing the airspeed until the heading can no longer be maintained with full rudder at maximum asymmetrical thrust (Figure 3), and then again while maintaining a small bank angle (smaller than or equal to 5°) away from the inoperative engine (Figure 4). When the wings are kept level, the rudder deflection to counteract the asymmetrical thrust also causes a sideslip, which generates an opposite side force and yawing moment and hence, also drag. A small bank angle into the good engine reduces this drag; it does not initiate a turn, because the thrust is asymmetrical and hence, the flight not coordinated. The manufacturer determines the magnitude of the small bank angle away from the inoperative engine which must not exceed 5° (FAR 23.149). This small bank angle generates a small side force in the center of gravity (cg) opposite of the sideslip side force, reducing the sideslip angle and hence, reducing the rudder deflection to only the level required to counteract the asymmetrical thrust after engine failure. Hence, the small bank angle reduces the drag to a minimum for a maximum remaining rate of climb. Because the small bank angle also decreases the required rudder deflection, it allows decreasing the airspeed further until the rudder is again maximum, resulting in a lower V_{MCA}, but only as long as the bank angle is less than 5°. This small bank angle is therefore quite relevant for the safety of flight with an inoperative engine; read more in the referenced paper[14].

3.8.5. V_{MCA} with this small bank angle is used by the manufacturer to reduce the size of the vertical tail with rudder and still comply with the regulation. The fin with rudder (and the ailerons) then generates just large enough forces and moments to counteract the (maximum) asymmetrical thrust yawing moment and other moments.
The vertical tail with rudder may not be sized that small though, that V_{MCA} increases above 1.2 V_{S1} (FAR 23.149(b)). Many pilots misinterpret this limit as 'V_{MCA} will always be lower than 1.2 V_S'. This is correct for straight flight while maintaining the small bank angle into the good engine, but certainly not during turns when the actual V_{MCA} will increase to a (much) higher value than 1.2 V_S. Refer to the paper *Airplane Control and Analysis of Accidents after Engine Failure*[14] for a thorough explanation of control after engine failure and V_{MCA} flight testing.
The highest of dynamic or static V_{MCA} during straight flight, which usually is the static V_{MCA}, will be published as the V_{MCA} of the airplane in the AFM. Determining a V_{MCA} during turns while One Engine is Inoperative (OEI) is not required by FAR 23, but this V_{MCA} is much higher than the AFM-published V_{MCA} for straight flight.

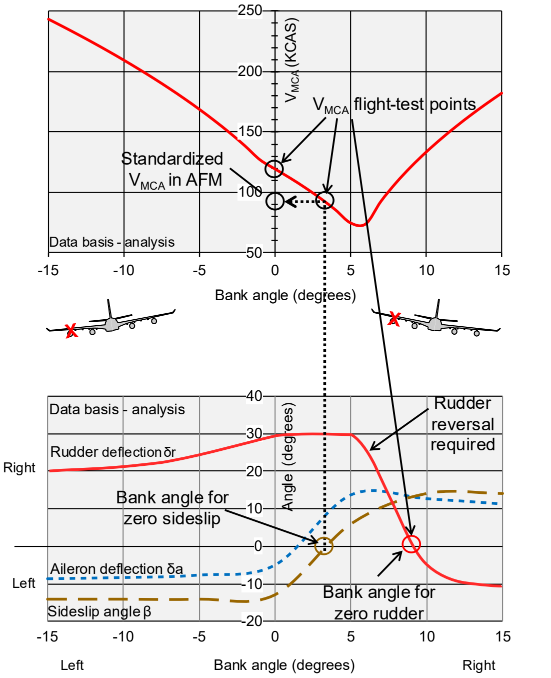


Figure 5. Effect of bank angle on V_{MCA} and on rudder, aileron, and sideslip angles during equilibrium flight at maximum thrust, for a sample airplane.

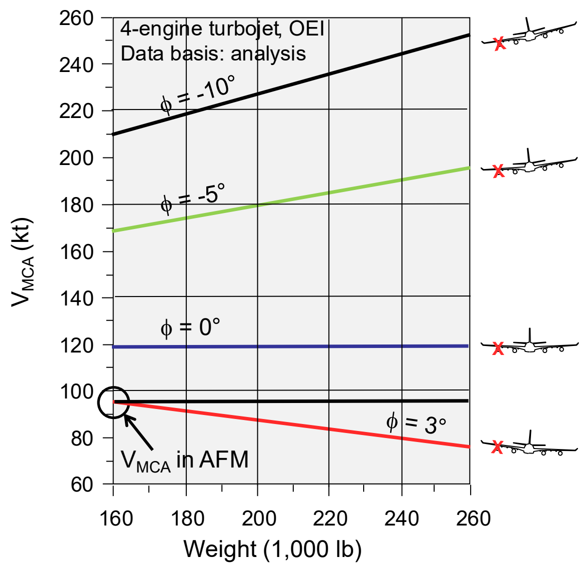


Figure 6. Effect of Weight and Bank Angle on V_{MCA}.

NOTE. C-130 pilots know this figure, because it is like the Weight and Bank Angle figure in the C-130 Performance Manual SMP-777.

[14] 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*.

3.8.6. As mentioned above, V_{MCA} while maintaining a small up to 5° bank angle into the good engine decreases V_{MCA}. For a DHC-6-100, the V_{MCA} while maintaining the small bank angle is approximately 6 kt lower than when keeping the wings level[15]. This means that when the wings are kept level, the actual V_{MCA} of the DHC-6, i.e. the V_{MCA} that the pilot will experience in-flight, is approximately 6 kt higher than the AFM-published V_{MCA}. When banking away from the small favorable bank angle to either side, the side force due to banking will increase the sideslip which affects the side force due to rudder deflection. A higher airspeed will be required to maintain the balance of lateral and directional forces and moments, i.e. to maintain control, hence, the actual V_{MCA}, i.e. the V_{MCA} which the pilot will experience in-flight, will increase considerable during turns while an engine is inoperative. Refer to paper *The Effect of Bank Angle and Weight on V_{MCA}*[16]. Figure 5 and Figure 6 are copied out of this paper, and were calculated for a Boeing 707 type airplane for which the stability derivative data were available. V_{MCA} for this airplane is determined at a bank angle when the sideslip angle in minimal, ≈3°. When banking more than 3° into the good engine, the sideslip increases. To contain the sideslip, and reduce the drag, the rudder needs to be reversed to compensate for the increased sideslip side force and prevent the vertical fin from stalling. The increase of actual V_{MCA} when banking to either side is also obvious.
For a DHC-6, a 20 to 30 kt (or more) higher airspeed will be required to maintain control when maximum asymmetrical thrust is maintained or attained during a shallow turn.
The actual V_{MCA} decreases also when reducing the asymmetrical thrust a little. This can be used temporarily to turn, following a straight climb to a safe altitude. This asymmetrical thrust reduction reduces the thrust yawing moment and therewith the required counteracting rudder deflection, leaving room for increased deflection during turns when the sideslip increases. Engine-out flight is never a coordinated flight. Pilots need to be made aware of all of this.

3.8.7. A conclusion of the above is that V_{MCA} varies with bank angle and thrust level. Manufacturers are regrettably not required to publish the bank angle that was used to determine V_{MCA}, neither in the V_{MCA} definition, nor with V_{MCA} data in the AFM, while some manufacturers do publish the bank angle for minimum drag/maximum performance in the legend of OEI performance charts (Piper in the PA-44 POH, and Lockheed in C-130 manuals). The AFM should remind pilots with: '**Published V_{MCA} is valid for straight flight only; V_{MCA} increases during turns**', and: **'The pilot controls the actual V_{MCA} with bank angle and (asymmetrical) thrust'**.

3.8.8. V_{MCA} is also used for calculating the takeoff speeds V_R and V_2, and is often considered to be applicable during takeoff only, and to be always as low as the red (radial) line on the ASI or as placarded. But a V_{MCA} applies during the whole flight, which might be the reason that V_{MCA} (V_{MC} in the Air) is used in most publications, including in the subject AFM. V_{MCA} is defined in AFM § 0.6, while in the manual also the undefined V_{MC} is used. So, it is recommended to add to this definition that these minimum control speeds mean the same, and that an actual V_{MCA} always applies in anticipation of, and following an engine failure during the remainder of the flight, that V_{MCA} increases during turns to an undetermined actual value, and that V_{MCA} can be 'managed' by the throttle of the operating engine. In the above-mentioned paper[14] Avio*Consult* explains almost all about V_{MCA}, and analyzes a few accidents after engine failure.

3.8.9. In the DHC-6-400 AFM, the required small 5° bank angle required for the AFM-published V_{MCA} to be valid is not included with V_{MCA} data. Its effect on controllability is only briefly mentioned in the Missed Approach procedure § 3.9.2: *"Maintain heading by applying rudder and, if necessary, lowering the wing on the side of the operating engine up to 5°"*.
The effect of the small bank angle on the sideslip angle, i.e. on the drag and therewith on the OEI climb and go-around performance, is mentioned in AFM § 9-50.3.1.1 where is stated: *"AP*

[15] Experience of the author from V_{MCA} testing a UV-18 (DHC-6-100) during curriculum flight test training at the USAF Test Pilot School (with less powerful engines).
[16] Avio*Consult* - Harry Horlings, *The Effect of Bank Angle and Weight on V_{MCA}*, https://www.avioconsult.com/downloads/Effect of Bank Angle and Weight on Vmca.pdf

will not maintain the optimum single engine climb technique (3 to 5° bank towards live engine, 1/2 ball slip indication))". In § 9-50.3.1.4 a similar note is included. In AFM § 10.6.9 on Single Engine Operations is stated: *"Although optimum single engine performance will be achieved with 5° of bank towards the live engine …".* The writer of this part of the AFM obviously knows about some of the characteristics of V_{MCA} and engine-out performance. These notes should not only have been provided for autopilot operation.

The significant effects of bank angle on control and performance when an engine is inoperative are not adequately explained and presented in the DHC-6 AFM, as required by FAR 23.1585 Operating procedures: (a) "*For all airplanes, information concerning normal, abnormal (if applicable), and emergency procedures and other pertinent information necessary for safe operation and the achievement of the scheduled performance must be furnished, including— (1) An explanation of significant or unusual flight or ground handling characteristics;*". Pilots have the right to be made aware of the bank angle for which the AFM-published V_{MCA} is valid, and of the large increase of V_{MCA} when the bank angle and straight flight are not being maintained for *safe operation* of an engine-out airplane.

3.8.10. An improved V_{MCA} definition in § 0.6 for pilots would be: Minimum Control speed V_{MC} or V_{MCA} is the lowest airspeed which can be obtained during straight flight while maintaining 5° bank towards the good engine, with full directional and/or lateral control inputs when one engine fails or is inoperative, and the opposite engine is set at maximum thrust. V_{MCA} increases with bank angle (during turns) and thrust of the good engine and hence, is controlled by the pilot.

3.8.11. Copies of the applicable regulations, flight test guide and course books are compiled in one Background Info pdf file[17] for the reader to verify the above.

3.9. V_{MCG} Minimum Control speed on the Ground

3.9.1. The AFM, in § 0.6, does not present a definition of V_{MCG}, while a V_{MCG} is published in AFM Table 2-1 (§ 4.1 below) and used in AFM § 10-1.7 (§ 9.2 below).

3.9.2. V_{MCG} is defined 14 CFR Part 23.149(f) as follows: "*V_{MCG} is the minimum control speed on the ground, and is the calibrated airspeed during the takeoff run at which, when the critical engine is suddenly made inoperative, it is possible to maintain control of the airplane using the rudder control alone (without the use of nosewheel steering), as limited by 150 pounds of force, and using the lateral control to the extent of keeping the wings level to enable the takeoff to be safely continued. In the determination of V_{MCG}, assuming that the path of the airplane accelerating with all engines operating is along the centerline of the runway, its path from the point at which the critical engine is made inoperative to the point at which recovery to a direction parallel to the centerline is completed may not deviate more than 30 feet laterally from the centerline at any point*".

3.9.3. An AFM-definition could be: 'V_{MCG} is the minimum speed at which the deviation from the takeoff path on the runway after a sudden engine failure is 30 ft or less. Full rudder does not provide a large enough side force to counteract the thrust yawing moment at takeoff run speeds lower than V_{MCG}. When an engine fails at speeds lower than V_{MCG}, the deviation will be larger, reason why the takeoff should be aborted immediately to avoid vacating the runway. V_{MCG} is one of the factors used to calculate V_1'.

3.10. V_S Stalling Speed (or minimum steady flight speed) "*is the lowest speed at which the aircraft is controllable*".

3.10.1. There is no pilot who makes a yaw or roll control input when the stall horn sounds, i.e. when a stall is imminent, because the trailing wing, or the wing with the down going aileron

[17] AvioConsult, *Background information for the definition, theory, flight test and use of V_{MCA}*, https://www.aviocon-sult.com/downloads/Background VMC(A) Regulations and Flight Test.pdf

will (partially) stall, and control might be lost. So, at V_S, the aircraft is not controllable, but can only maintain straight flight, just like is the case for V_{MCA}. A better definition of V_S would be: 'The stall speed is the minimum steady flight speed attainable (during steady straight flight)'.

3.11. **V_{YSE} Best Rate of Climb Speed – One Engine Inoperative "***is the speed which results in the greatest gain of altitude within a given period of time, while flying one engine feathered and the other engine at MTOP or Maximum Continuous Power***".**

3.11.1. The greatest gain of altitude is only achieved when the sideslip, hence the drag, is minimal which will only be the case when maintaining straight flight with a small bank angle, usually 3° at V_{YSE}, but 5° as mentioned in AFM § 10.6.9, into the good engine. This straight flight requirement as well as the small bank angle should therefore not only be included in the V_{YSE} definition, because these are essential *"for greatest gain of altitude"*, but also in the legend of the One Engine Inoperative climb performance charts (§ 5.16, § 5.17, § 5.25 – § 5.30), for the presented data to be valid as, for instance, Piper did in the PA-44-180 POH on page 5-23.

4. AFM Section 2 – Limitations

4.1. AFM Table 2.1 presents Airspeed limitations.

Table 2-1 Airspeed Limitations

			KCAS	KIAS
a.	Minimum Control Speed – Air (V_{MCA})	Flaps 10°	66	64
	Minimum Control Speed – Ground (V_{MCG})	Flaps 10°	49	50
b.	Climb Speed – Best Angle (V_X)	Flaps 0°	89	87
	Climb Speed – Best Rate (V_Y)	Flaps 0°	103	100
	Climb Speed – Single Engine (V_{YSE})	Flaps 10°	82	80

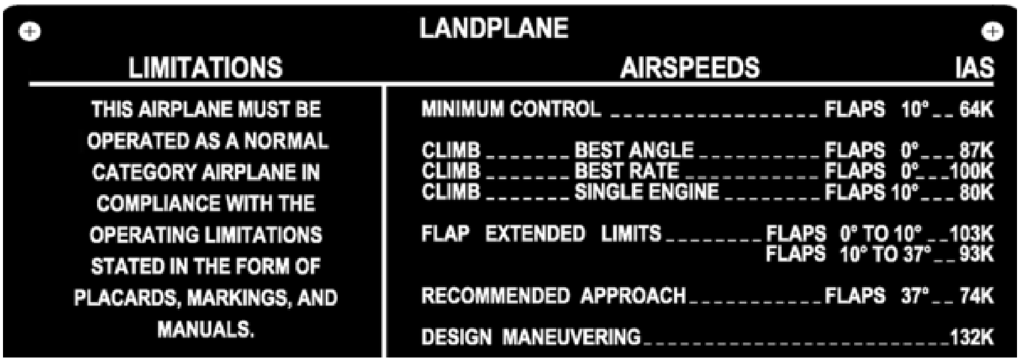
4.1.1. The use of IAS and CAS is discussed § 2.1 above. The airspeed limitations in this table are in both IAS and CAS, while other tables and graphs present data as either IAS or as CAS, which is confusing. The airspeed position error correction (called Δ V) for V_{MCA} is presented in the chart in AFM § 5.9, and is +2 kt for 10° flaps (CAS = IAS + Δ V). Hence, the difference between V_{MCA} in KIAS and KCAS in Table 2-1 is only the position error, and is not including the instrument error of the ASI, or the errors in the ADAHRS or in the ESIS. Therefore, the instrument error might have been considered zero by the AFM-writers, for all DHC-6 airplanes for which this AFM applies. But this can never be the case, is not in compliance with FAR 23.1587(d). No statement is presented in the AFM that the instrument errors are neglected. When the allowed instrument errors (§ 2.2.8 above) are not taken into account, the requirement in FAR 23.1587(d)(10) to furnish the relationship (and not part of the relationship) between IAS and CAS in accordance with FAR 23.1323 (b) and (c), is not complied with, rendering the IAS values presented in the AFM invalid. Refer to the example in § 2.4.4 above. This table also makes it obvious that pitot-static data is not compensated with the system errors in the pitot - static system, in the ADAHRS, and in the airspeed indicating system. Such a compensation would be easy to achieve in an electronic air data system/computer.
Pilots have the right to know whether the indicated airspeeds are correct, and what instrument error corrections must be added to make them accurate.

4.1.2. With a windmilling, rather than a feathered propeller, the thrust yawing moment increases and a higher airspeed is required. The actual V_{MCA} is even another 4 kt higher (warning in AFM § 5.27), and with the wings level, V_{MCA} is approximately 6 kt higher[15]. When banking away from the favorable bank angle to either side, the actual V_{MCA} increases even more, and when the rudder is not maximum deflected to maintain the heading, V_{MCA} increases as well (a higher airspeed is required for the less than maximum deflected rudder to generate the force required to act against the unchanged thrust and sideslip yawing moments). These associated conditions for the published airspeed limitation V_{MCA} to be valid should be included in its definition for the pilots to be made aware. The AFM-published V_{MCA} is valid only for straight flight while maintaining a small 5° bank angle away from the inoperative engine. For V_{YSE}, the same limitations apply, but with a smaller bank angle of ≈3°, because the higher airspeed decreases the rudder requirement (≡ V^2) to counteract the asymmetrical thrust, and a smaller bank angle is required to counteract the rudder side force for the sum of the side forces to be zero and the resulting sideslip to be minimal[16] and the remaining rate of climb maximal.

4.1.3. These associated conditions, and the variation of V_{MCA} with many variables, should also be mentioned in the legend of Table 2-1 for the pilots to be able to prevent accidents after engine failure.

4.2. AFM § 2.18 Placards

4.2.1. 4A. Operating Instructions Placard. The top part of this placard is:


LANDPLANE

LIMITATIONS	AIRSPEEDS			IAS
THIS AIRPLANE MUST BE OPERATED AS A NORMAL CATEGORY AIRPLANE IN COMPLIANCE WITH THE OPERATING LIMITATIONS STATED IN THE FORM OF PLACARDS, MARKINGS, AND MANUALS.	MINIMUM CONTROL		FLAPS 10°	64K
	CLIMB	BEST ANGLE	FLAPS 0°	87K
	CLIMB	BEST RATE	FLAPS 0°	100K
	CLIMB	SINGLE ENGINE	FLAPS 10°	80K
	FLAP EXTENDED LIMITS		FLAPS 0° TO 10°	103K
			FLAPS 10° TO 37°	93K
	RECOMMENDED APPROACH		FLAPS 37°	74K
	DESIGN MANEUVERING			132K

4.2.2. V_{MCA} is listed as *"Minimum Control … Flaps 10° …64K"*. This V_{MCA} is, in accordance with FAR 23.149 (a), determined during straight flight while a small, but max. 5°, bank angle away from the inoperative engine is being maintained. V_{MCA} at other moderate bank angles, such as during turns, is 20 – 30 kt, higher. Pilots should be reminded by adding '(bank 5°)' in the 'minimum control' line.

4.2.3. All limitations are IAS, which in fact suggests that the placard was made using the instrument correction of the installed ASI. If that is the case, the placard has to be removed and replaced when the ASI is (maintenance-) replaced by an ASI which does not have exactly the same instrument error. In addition, the AFM of this airplane (tail number) then also has to be amended, and approved by the authorities. See also § 2.3.1 above.

4.2.4. On the left side is stated that the airplane must be operated as a normal category airplane, while the Type Certificate Data Sheet (TCDS A9EA) requires including a few additional commuter category performance requirements, and the use of a specific manual, the TC approved AFM, PSM-1-64-1A.

4.2.5. There is obviously no requirement in the AFM to provide a placard or table with the instrument error of the installed ASI (or ADAHRS and ESIS) over a range of speeds for the pilot to be able to convert IAS to an accurate CAS.

5. AFM Section 3 – Emergency and Abnormal Procedures

5.1. AFM § 3.2 Airspeeds for Emergency Operations

5.1.1. This paragraph presents a table with airspeeds for emergency operations:

3.2 Airspeeds for Emergency Operations

All speeds are given for the maximum permitted weight in the phase of flight described.

V_{YSE}	Single Engine Best Rate of Climb Speed (Flaps 10°):	80 KIAS (all weights)
V_{MCA}	Minimum Control Speed – Air, One Engine Inoperative:	64 KIAS
V_{S0}	Stall speed, landing configuration (Flaps 37°):	56 KIAS
V_{S1}	Stall speed, take-off configuration (Flaps 10°):	66 KIAS
V_S	Stall speed, flaps up:	73 KIAS

5.1.2. Here V_{MCA} is used, rather than V_{MC}, which not defined in AFM § 0.6. The associated conditions for V_{YSE} and V_{MCA} to be valid are not included either (§ 4.1.2 above), although the most important condition is suggested, though buried, in OEI Missed Approach AFM § 3.9.2 step 3 (§ 5.7 below): *"Maintain heading by applying rudder and, if necessary, lowering the wing on the side of the operating engine up to 5°* ". Not is made clear what is meant by "*if necessary*". When full rudder and still yawing? No, to keep V_{MCA} low.

5.1.3. Flaps for the published V_{MCA} to be valid are not mentioned. In Table 2.1, V_{MCA} for flaps 10° is also 64 KIAS. Does this V_{MCA} apply as V_{MCA} for other configurations than takeoff as well? To answer this question, it is required to know whether the published V_{MCA} is the V_{MCA} with 5° of bank into the good engine, or the actual V_{MCA} with the wings level, in which case this actual V_{MCA} will be 64 + 6 kt = 70 KIAS (§ 4.1.2 above). V_{S1} flaps 10° is 66 KIAS, so is the airplane controllable down to the stall when flaps are up or 10° during straight flight?

5.1.4. The speeds are in KIAS only, while other tables present airspeed data in both KIAS and KCAS. Only V_{MCA} as CAS is valid, is reliable, because V_{MCA} is determined as CAS and the manual is not amended for the instrument error of a specific ASI serial number (§ 2.4.1 above).

5.2. AFM § 3.4 Engine Failure Prior to Rotation

5.2.1. Rotation is normally at higher speed than decision speed V_1. Are you sure the airplane can stop on the remaining runway? Should this paragraph not be called '… Prior to V_1?'

5.3. AFM § 3.4.2. Engine Failure Airborne, Prior to V_{MCA}

5.3.1. The following warning is included:

⚠ WARNING

UNDER NO CIRCUMSTANCE SHOULD ROTATION BE INITIATED PRIOR TO REACHING V_{MC}.

5.3.2. Of course, rotation should never be initiated at too low a speed. V_{MCA} though, is not a takeoff procedure speed, V_1 and V_R are. V_1 is greater than V_{MCG} or 1.05 V_{MCA}, plus the speed gained during recognition of and reaction to an engine failure. V_R must be greater than both V_1 and 1.10 V_{S1}, or greater than the speed that allows V_2 to be reached at 35 ft above runway level. So why use V_{MCA} here? The Warning is not correct either, because the actual V_{MCA} with wings level is 6 kt or more higher than the AFM-published V_{MCA} (§ 4.1.2 above).
When an engine fails prior to reaching V_1, the only action should be to abort the takeoff. If an engine fails while just airborne, and the airspeed is below the actual V_{MCA} (which can be much higher than published V_{MCA}), the probability of losing control at once and at low altitude is very large, and will lead to a catastrophe. This procedure title is not correct.

5.3.3. The ACTION and a NOTE in this emergency procedure are

ACTION

1 **Power levers – Retard as needed to maintain aircraft control.**

2 **Land straight ahead, turn only to avoid obstacles using minimal bank angle.**

NOTE

Be aware that after encountering an engine failure when airborne at a speed below V_{MC}, 'straight ahead' is unlikely to be the same as the runway heading.

5.3.4. In case an engine fails while airborne, and the airspeed is below actual V_{MCA}, Step 1 is correct, is in fact the only action to maintain control, besides exchanging altitude for airspeed. Reducing the asymmetrical thrust reduces the actual V_{MCA} to below the published V_{MCA} for maintaining control.
The writer of this paragraph obviously knows about the effect of power on the directional controllability. Better would be 'Retard as needed to maintain aircraft heading' (i.e. straight flight). Why don't we see this step in other places in the AFM?

5.3.5. Reducing thrust is not the only option. FDR data of many engine-failure related accidents show that pilots did not input up to maximum rudder to maintain the heading, and did not attain the small 5° bank angle away from the failed engine, in which case the actual V_{MCA} is higher than the AFM-published V_{MCA}. Then, a higher airspeed is required for the fin with rudder to generate a large enough side force/yawing moment to counteract the asymmetrical thrust. If the rudder is (and/or the ailerons are) maximum deflected and heading cannot be maintained, then the only option for preventing the loss of control is to retard the power levers a bit (temporarily). This reduces the thrust yawing moment to a level that the rudder can counteract at the current speed.

5.3.6. The NOTE is basically correct. When the wings are kept level, a sideslip up to ≈14° will develop away from the runway heading. Straight ahead is the priority for being able to maintain control, but if the current heading (with the sideslip) cannot be maintained with full rudder, then attaining the small bank angle into the good engine might already be adequate to reduce the sideslip angle and maintain the (runway) heading and therewith maintain control, because it also reduces the actual V_{MCA} of a DHC-6 with ≈6 kt. The uncommanded yaw rate after engine failure is initially not very large if the airspeed is near actual V_{MCA}, and might not even be noticed as an imminent controllability problem.

5.4. **AFM § 3.4.3 Engine Failure Airborne, After V_{MCA}**

5.4.1. The Action in Step 1 is *"Power levers – Set Maximum Power"*. In this procedure also a few errors.
The published V_{MCA} is for straight flight only, while maintaining a small 5° favorable bank angle into the good engine. When keeping the wings level, V_{MCA} is already 6 kt higher than the AFM-published V_{MCA}. When the propeller is not feathered, actual V_{MCA} is also higher (4 kt).
When turning at or little above V_{MCA} (such as at V_2) at maximum asymmetrical thrust, even when the bank angle is limited to 15°, the actual V_{MCA} will increase considerable, rendering the airplane out of control. Before turning, the airspeed has to be increased with at least 20 – 30 kt, or the asymmetrical thrust has to be reduced a little, temporarily (§ 3.8.5 and § 5.3.5 above).
These engine failure procedures in § 3.4 show that the manual writer does not exactly know how to control an airplane after engine failure, and what the real value is of V_{MCA}. V_{MCA} is not a constant. It seems unknown how V_{MCA} is determined, and/or the FAR 23 definition is not exactly known or understood.
Step 1 should also include: **'Maintain straight flight and increase bank to 5° into the good**

engine if the power is maximum, or while increasing the power to maximum' because this is urgent, and change Step 3 accordingly.

5.5. AFM § 3.4.4 Engine Failure During Flight

5.5.1. In several paragraphs a warning is issued that V_{MCA} rises to a higher value (AFM § 5.17, § 5.27, § 5.28, § 9-19). It is recommended to include a Warning in this Engine Failure Procedure as well:
'V_{MCA} rises 20 - 30 knots during shallow turns at high asymmetrical thrust. To prevent the loss of control, reduce the power temporarily a bit during turns to reduce V_{MCA}'. The exact number to be determined by the manufacturer.
Such a warning should also be included in AFM § 3.4.4 Engine Failure During Flight. The Warnings will (hopefully) remind pilots of the increase of V_{MCA} when banking way from the favorable 5° bank angle.

5.5.2. Not mentioned either is that when an engine is inoperative in-flight, the OEI range of the airplane can be increased by maintaining a small (≈3°) bank angle away from the inoperative engine (because it reduces the sideslip, hence drag).

5.5.3. Pilots have the right to be reminded in emergency procedures what the to be observed limitations exactly are to prevent a dead engine from turning into a killing engine.

5.6. AFM § 3.9.1 One Engine Inoperative Landing

5.6.1. Step 5 in this procedure is: "*Minimum V_{REF} airspeed – 1.3 times stall speed for selected flap setting or V_{MCA}, whichever is greater. Refer to Table 3-1*".

Table 3-1 Landing (V_{REF}) Speeds

FLAP ANGLE	1.3 V_S KNOTS IAS					
	12,300 lbs (5,580 kg)	11,500 lbs (5,220 kg)	10,500 lbs (4,760 kg)	9,500 lbs (4,310 kg)	8,500 lbs (3,860 kg)	7,500 lbs (3,400 kg)
10°	85	83	79	75	71	67
20°	80	77	73	70	66	64
37°	74	70	67	64	Not Authorized	

5.6.2. FAR 23.73(c) requires for normal category airplanes a V_{REF} of 1.3 V_{SO} or V_{MCA}, whichever is greater. V_{MCA} = 64 KIAS as defined in AFM § 3.2 and is lower than or equal to any value of 1.3 V_{S0} in Table 3-1, hence factor 1.3 V_{SO} is dominant. However, the actual V_{MCA} when keeping the wings level is approximately 6 kt higher than the published V_{MCA}, hence the actual wings-level V_{MCA} = 70 KIAS, which is higher than V_{REF} in Table 3-1 for flaps 37° and other flap settings at lower landing weights. Actual instrument errors other than zero can make things worse.

5.6.3. Of course, V_{MCA} is only of relevance when the asymmetrical thrust is maximum, which is not the case during a normal approach; then actual V_{MCA} will be lower. If the cg is forward, the rudder moment arm is longer, and actual V_{MCA} will be lower than the published V_{MCA} as well, but a pilot may not count on this. The regulations require using both published V_{MCA} and V_S for calculating V_{REF}. The Landing speeds in this table might not be high enough to meet the FAR requirements.

5.6.4. These remarks also apply to AFM § 3.9.6 Flapless Landing and to § 4.16 Go-Around, and other performance data.
If a go-around becomes necessary, the airspeed has to be increased down the glideslope first to above the wings-level V_{MCA}, or above the published V_{MCA} when attaining and maintaining a small bank angle away from the inoperative engine, before the thrust is increased to maximum, to avoid the loss of control. Pilots should be made aware.

5.7. AFM § 3.9.2 OEI Missed Approach

5.7.1. The missed approach procedure in the AFM is:

1. Set Maximum Power on the unaffected engine.
2. Airspeed (flap 10°) – Climb at 80 KIAS
3. Maintain heading by applying rudder and, if necessary, lowering the wing on the side of the operating engine up to 5°.

5.7.2. ***Step 1***. When setting maximum power on the one operating engine, the actual V_{MCA} increases immediately, and a small bank angle away from the inoperative engine should be applied while increasing the power, while also increasing the rudder to counteract the thrust yawing moment, both for keeping V_{MCA} low. This should be added to Step 1.
Step 3. At airspeed 80 kt (V_{YSE}), 3° of bank to the good engine is usually already large enough to keep actual V_{MCA} low and a zero-sideslip angle, for maximum Rate of Climb.
Maintaining heading is important. V_{MCA} increases considerable above the published value (64 KIAS) when banking away from the 3° – 5° favorable bank angle to either side. This small bank angle is not only good for control, but also decreases the sideslip, and hence, the drag and increases the OEI Rate of Climb with 30 feet per minute (AFM § 10.6.9).

5.8. AFM § 3.12.1 Engine Shutdown in Flight

5.8.1. It is recommended to include in this procedure the same warning as discussed in § 5.5.1 (in AFM § 3.4.4) above.

6. AFM Section 4 – Normal procedures

6.1. AFM § 4.10 Take-off

6.1.1. "Sub § 5 Rotation IAS – As indicated in Figure 4-1."

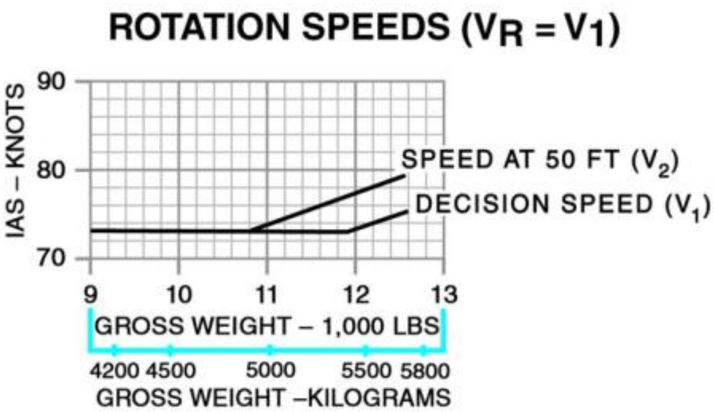


Figure 4-1 Rotation Speeds

6.1.2. FAR 23.51(c)(2) requires V_R to be V_1, 1.05 V_{MCA}, 1.10 V_{S1}, or the speed that allows attaining V_2 before reaching 35 ft above the takeoff surface, whichever is greater.

- At 10.000 lb gross weight, V_S = 61 KCAS = 63 KIAS (The difference between V_S as CAS and IAS at maximum weight is 2 kt – Table 5-3 and Figure 5-6, with instrument error zero).
  V_R = highest of 1.05 × 64 (= 67) and 1.10 × 63 (= 69) = 69 KIAS.
  However, if the wings are kept level, actual V_{MCA} is 6 kt higher. Then V_R = highest of 1.05 × 70 (= 74) and 1.10 × 63 (= 69) = 74 KIAS.
- At maximum weight, V_S = 68 KCAS = 70 KIAS (with zero instrument error), then V_R = highest of 1.05 × 64 (= 67) and 1.10 × 70 (= 77) = 77 KIAS.

However, if the wings are kept level, actual V_{MCA} is 6 kt higher. Then V_R = highest of 1.05 × 70 (= 74) and 1.10 × 70 (= 77) = 77 KIAS.

In both cases, the V_R in the graph is too low. As mentioned before, the difference between IAS and CAS might not be (only) 2 kt if the ASI-instrument error is included.

6.1.3. The line in the chart above, *"Speed at 50 ft (V_2)"* is not clear. FAR 23.51(c)(2)(iv) requires *"attaining V_2 before reaching a height of 35 feet above the takeoff surface"*. FAR 23.51(c)(4) requires Takeoff Safety Speed V_2 >1.1 V_{MCA} or >1.2 V_{S1}. Then:

- at 10,000 lb, V_2 = highest of 1.10 × 64 (= 70) and 1.2 × 63 (= 76) = 76 KIAS,
- at max. weight V_2 = highest of 1.1 × 64 (= 70) and 1.2 × 70 (= 84) = 84 KIAS.

In both cases, V_2 in the chart is too low as well, because V_2 does not have the FAR-required margin above the stall speed. Keeping the wings level will not affect the controllability (during straight flight), but result in less climb performance than could be achieved when maintaining a small bank angle into the good engine, because the sideslip is not minimal and hence, the Rate of Climb not maximum. Are pilots made aware of this?

6.2. AFM § 4.15 Landing

6.2.1. Refer to § 5.6.2 above for remarks on V_{REF}. Landing speed is mentioned in the Landing Distance paragraph in Terminology § 0.9: *"… a speed of 1.3 x V_S or 1.05 x V_{MCA}, whichever is higher"*. However, 1.05 V_{MCA} applies to commuter category airplanes. According to the Additional Requirements in the DHC-6 TCDS, FAR 23.73(c) does not apply, hence the normal category requirement applies: V_{REF} must be higher than 1.3 V_S and 1.00 V_{MCA}. The question that remains is whether the V_{MCA} for calculating V_{REF} needs to be the standardized V_{MCA}, which is measured with 5° of bank away from the inoperative engine, or the V_{MCA} with the wings level (yet unknown, but probably 6 kt higher). In Table 4-1, V_{MCA} is not included.

6.3. AFM § 4.16 Go-around (Balked Landing)

6.3.1. *"Sub § 3. Minimum Airspeed – 1.3 times stall speed with flaps 10°."*

Table 4-2 Go-around Speeds

FLAP ANGLE	1.3 V_S KNOTS IAS					
	12,300 lbs (5,580 kg)	11,500 lbs (5,220 kg)	10,500 lbs (4,760 kg)	9,500 lbs (4,310 kg)	8,500 lbs (3,860 kg)	7,500 lbs (3,400 kg)
10°	85	83	79	75	71	67

6.3.2. These data are the same as in the first line of V_{REF} data in Table 3.1, copied in § 5.6.1 above. V_{MCA} is not included here as well. If an engine fails during (initiating) a go-around, and the other engine is set at maximum power, V_{MCA} increases with ≈6 kt (see § 5.7 above). The go-around speed is too low at low weights when keeping the wings level. These speeds are also only valid while maintaining straight flight, definitely not during turns when an engine is inoperative and go-around power is set. This should be mentioned in the legend of this Table.

7. AFM Section 5 – Performance

7.1. AFM § 5.3.5 Stalling speeds

7.1.1. AFM Table 5-3 presents a few stall speeds for maximum gross weight, forward cg, level flight, idle power, propellers feathered, in KIAS, as follows:

Table 5-3 Stalling Speeds

Phase of Flight	Flap Setting	Stalling Speed (KIAS)
Enroute	0°	73
Enroute	10°	66
Take-off	10°	66
Landing	37°	56

7.1.2. The full stalling speed chart in Figure 5-6 on page 5-31 presents V_S (power off) in KCAS, not in KIAS. The V_S values in the table above suggest a constant position error plus instrument error of 2 kt (CAS = IAS + 2 kt). As explained above, this cannot be right; the position error is 2 kt (AFM Figure 5-5), while the instrument error is obviously assumed to be zero. If a pilot maintains 66 KIAS with 10° flaps, the position error is 2 kt and suppose the instrument error is − 2 kt, then his airspeed is 66 KCAS, which is below the stall speed of 68 KCAS (Figure 5-6). The mixed use of CAS and IAS is also prone to errors.

7.2. AFM § 5.7 Airspeed Position Error Correction – Ground

7.2.1. The position error correction on the ground is presented in AFM Section 5 in Figure 5-3 on page 5-25 (between −1 kt at 60 KIAS and +1.2 kt at 93 KIAS). In the interpretive guidance of the charts, on AFM page 5-24, is stated: *"This chart enables correction of the airspeed displayed on the airspeed indicator due to errors caused by the location of the sources of pitot and static air pressure used by the airspeed indicators"*. This in itself is correct, but there is another error that affects the airspeed displayed on the ASI, and that also affects the magnitude of the position error, which is the instrument error of the ASI. At lower speeds, the instrument error is allowed to be ± 4 kt at 50 kt; refer to the ETSO-C46a Table I in Figure 2 above. Since the graph is initially a near horizontal line, the effect of an approved 4 kt instrument error at 50 kt on position error Δ V is not very large, but increases with increasing airspeed.

7.2.2. To include the instrument error in position error Δ V, the chart should be entered with the IAS corrected for instrument error (Vic). *"Indicated airspeed"* on the x-axis must be renamed to 'Instrument corrected airspeed − (Vic)' because this airspeed was also used during pitot-static system calibration. The effect of small airspeed errors on the forces and moments generated by the aerodynamic control surfaces at higher airspeeds was explained in § 2.4.5 above. Δ V should be called 'Position Correction (Δ Vpc)'.

7.3. AFM § 5.8 Altimeter Position Error Correction – Flight

7.3.1. Besides position error, each altimeter also has an instrument error that influences the altimeter position error correction. FAR 23.1325(e): *"Each static pressure system must be calibrated in flight to determine the system error. The system error, in indicated pressure altitude, at sea-level, with a standard atmosphere, excluding instrument calibration error, may not exceed ±30 feet per 100 knot speed for the appropriate configuration in the speed range between 1.3 VS0 with flaps extended, and 1.8 VS1 with flaps retracted. However, the error need not be less than 30 feet"*.

7.3.2. The altimeter position correction depends on airspeed and altitude. In the NOTE, it should also be mentioned that the chart should be entered with the instrument corrected airspeed (Vic). *"Indicated airspeed"* on the horizontal axis must also be renamed to 'Instrument corrected airspeed − Vic'. Given the data in Figure 5-4, the system error seems to exceed 30 feet per 100 kt speed at sea level at low speed. Both the altimeter instrument and the position corrections must be added to the altimeter reading to yield the corrected altitude. The altimeter instrument calibration data are not mentioned.

7.4. **AFM § 5.9 Airspeed Position Error Correction – Flight**

7.4.1. In the interpretive Guidance on AFM page 5-28, the following sentence is included: "*The vertical axis of the chart, marked Δ Velocity (knots), represents the difference between calibrated airspeed (CAS) and indicated airspeed (IAS)*". This is, as explained above, not correct. The difference between CAS and IAS is not only the position error, which varies with (instrument corrected) indicated airspeed, but includes the instrument error as well (Figure 1). The instrument error is normally not presented in an AFM, because it is not known to the AFM-writer (refer to § 2.4.2 above) but is determined for each individual ASI, apart from the position error, as per FAR 23.1323(a) and (b), and is published separately. This chart obviously considers the *instrument error* to be zero, which will most probably never be the case, and is not in compliance with FAR 23.

7.4.2. As also mentioned for the Ground position error in § 7.2.1 above, the entry variable of the *position error* charts in the AFM is IAS, while the chart is for all DHC-6 Series 400 airplanes and Variants. As also explained above, the instrument error varies with each individual ASI, so this chart cannot be valid for all DHC-6 Series 400 airplanes, and should not have been approved by the aviation authority. The *instrument error* is allowed to be between ±2 and ±4 kt at speeds below 120 kt as mentioned in § 2.2.8 above. So, the sum of the position and instrument errors, i.e. the difference between IAS and CAS of this airplane can be up to 4.5 + 4 = 8.5 kt.
By using IAS as entry variable of the chart, the instrument correction is neglected. The instrument corrected indicated airspeed (Vic = IAS plus or minus the instrument error) should be used as entry variable for the position error correction chart.

7.4.3. In the NOTE: "*In flight, indicated airspeed will always be lower than calibrated airspeed. In other words, the airspeed indicator will always indicate less than the actual airspeed*". Given the allowed total of position and instrument errors which both can be positive or negative (§ 2.2.8 above), this statement is incorrect as well. And what is meant with "actual airspeed"?

7.5. **AFM § 5.16 MTOW OEI Propeller Feathered**

7.5.1. The bank angle that was used to calculate the charts is not included in the text and legend as associated condition. Was this 3° away from the inoperative engine, or with wings level? According to AFM § 9−50.3.11, *"the autopilot will not maintain the optimum single engine climb technique (3 to 5° bank towards live engine, 1/2 ball slip indication)"*.
Is this optimum used for presenting the data in the charts of this and the next paragraphs? Pilots should be made aware because of the differences.

7.5.2. In AFM § 10.6.9 Single Engine Operations, is stated: *"For all other single engine operation conditions, the aircraft should be trimmed for wings level flight with the ball in the middle. This will result in a decrease of about 30 feet per minute from the single engine rate of climb figures published in the performance charts, however, pilot workload will be substantially reduced, particularly so during instrument flight conditions"*.

7.5.3. This answers the question, but this should be in the legend of the charts, not only in Chapter 10 Safety and Operational Tips far back in the POH/AFM. A pilot has the right to know this, especially in the case of the example calculation in this paragraph. If the Rate of Climb is only 77 – 30 = 47 feet per minute, it will take much time to climb to a safe altitude, where a turn can be made safely (at temporarily reduced thrust) while an engine is inoperative. Pilots usually don't trust the remaining engine and want to turn back to the runway and land as soon as possible, and lose control during a turn (because of the increasing V_{MCA}).

7.6. AFM § 5.17 MTOW OEI Propeller Windmilling

7.6.1. Refer to the remarks in § 7.5.1 above.

7.6.2. In § 5.17, and in following paragraphs (5.27, 5.28, 9-19), a Warning is included:

⚠ WARNING

V_{MC} RISES TO 68 KNOTS IAS WHEN THE PROPELLER IS NOT FEATHERED.

V_{MC} (elsewhere in the AFM called V_{MCA}) is listed in the legend of the chart in Figure 5-13, and is obviously 4 kt higher than the standardized V_{MCA} when the propeller is feathered. No mention is made of the associated condition that V_{MCA} (for straight flight) rises with approximately 6 kt (§ 3.8.6 above), 2 kt more, when the wings are kept level, and even more at larger bank angle to either side.

7.6.3. In the Summary is stated: *"Rate of climb speed is 75 knots"*; this should be 'the speed for maximum Rate of Climb is 75 KIAS'. This speed seems a bit low, because V_{YSE} = 80 KIAS (§ 5.1.1 above).
The actual V_{MCA} is 64 KIAS + 4 kt (not feathered) or + 6 kt (wings-level, § 4.1.2 above) = 70 KIAS. The 75 kt climb speed is lower than 1.1 x the actual V_{MCA} (= 77 KIAS) for takeoff (10% safety margin FAR 23.51(c)(4)), and also lower than V_{YSE}. Hence it is important for maintaining control (for lowest actual V_{MCA}), and also for achieving minimum sideslip angle, i.e. minimum drag and hence for maximum climb performance, to attain and maintain the small favorable bank angle of 3°− 5° (as determined by the manufacturer) away from the inoperative engine during climb, and maintain straight flight until reaching a safe altitude. This should be mentioned as associated condition in § 5.17 and in the legend of Figure 5-13 (refer to § 3.8.9 above). No warning is included either, for the large increase of V_{MCA} when banking away from the favorable 5° to either side[16]. These associated conditions should also be included in this same Warning, to remind pilots.

7.6.4. Ambient temperature is used in the chart. Elsewhere in the manual also OAT (Section 10) and in this paragraph also *"free air temperature"*. Also seen is *"Airfield Temperature"* in the Amphibian Supplement in Figures 16 and 18, but not in Figure 17 *("Ambient temperature"*). Why different nomenclature if all mean the same?

8. Section 9 – Supplement 19 Operation with Inoperative Autofeather System

8.1. POH/AFM § 9-19.2 Limitations

8.1.1. **§ 9-19.2.2 Airspeed Limitations.** The increase of V_{MCA} with a not-autofeathered propeller seems to be 4 kt; the increase while maintaining the wings level (≈6 kt) is not mentioned here, nor is the further increase during turns. In the note is written *"The minimum control speed (red horizontal line) at the bottom of the airspeed tape is not appropriate for operations with an inoperative autofeather system"*. Added should be that the minimum control speed neither is appropriate for operations other than maintaining straight flight while maintain a small 5° bank angle away from the inoperative engine (refer to § 3.8.5 above). Why is the V_{MCA} not increased when the propeller autofeather circuit breaker (C7) is pulled?

8.1.2. **§ 9-19.2.4 Placards**. This paragraph requires Placards in case the autofeather is inoperative. Since V_{MCA} is increased with 4 knots above the 'regular' V_{MCA} with an inoperative autofeather system (warning above), *"A placard is required reading "V_{MCA} 68 KIAS""*, but it is recommended to add on the placard 'for straight flight only, while banking 5° into good engine', or shorter, to remind pilots not to turn at too low a speed.

8.2. **AFM § 9-19.3 Emergency and Abnormal Procedures**

8.2.1. **§ 9-19.3.2. Engine Failure During Take-Off.** *"If an engine failure occurs at or above V_{MCA} and a decision is made to continue the take-off, the propeller of the failed engine must be feathered manually as follows"*.
This paragraph is for operation with an inoperative autofeather system, and suggests to be applicable for an engine failure after liftoff, so the airspeed is > 1.1 V_{MCA}. Then the pilot has no option but to continue the takeoff, unless the remaining runway is long enough to abort and land.
If an engine failure occurs during the takeoff run, then V_{MCG} would apply or, as FAR 23.107 determines, that V_1 is the decision speed, not V_{MCG} or V_{MCA}.

8.2.2. **Step 1a** should be to attain a small bank angle of 5° away from the inoperative engine as soon as possible after becoming airborne, to keep both actual V_{MCA} and the sideslip (drag) low, because the asymmetrical thrust during takeoff is maximum.

8.2.3. **Step 3 is to "Climb at 80 KIAS", and Step 4** is: *"Propeller lever of affected engine – FEATHER. Climb to a safe altitude, if turns are required, bank angles of 15° or less will ensure maximum climb rate"*. Turning at 80 kt is still considered marginal (only 10 kt above actual V_{MCA} when flying straight), but the manufacturer might have determined this during specific flight-testing. Bank angles of 15° will certainly not ensure maximum climb rate, on the contrary, during wings level, the sideslip angle is at least 14 degrees[15] causing drag and a decrease of ROC; an increased bank angle to either side will increase the sideslip even more. When turns are required, after climbing to a safe altitude, reduce the asymmetrical thrust a little which will reduce the rudder requirement, making room for a turn. Some altitude will have to be sacrificed, but control will be maintained. The manufacturer should be able to provide some good advice on the effect of bank angle on V_{MCA}. See also the report in footnote 16 on page 13.

8.2.4. **§ 9-19.3.3 Go-Around with Engine Inoperative.** The only words in this paragraph are *"V_{MCA} is 68 KIAS"*. It is recommended to add: 'for straight flight with 5° of bank away from the inoperative engine', to remind pilots of the limitations and associated conditions of the AFM-published V_{MCA}.

8.3. **AFM § 9-19.5 Performance**

8.3.1. § 9-19.5.2 Amending Performance Calculations. When the autofeather system is inoperative, takeoff data must be amended using the steps in this procedure. V_1 and V_2 need to be increased by 4 kt and the takeoff distances must be increased with 15%. A warning alerts the reader that *"V_{MCA} rises to 68 knots IAS with autofeather inoperative"*. This increase of V_{MCA} due to the increased asymmetrical yawing moment by the windmilling propeller, obviously needs to be included in the V_1 and V_2 calculation, while keeping the wings level also increases V_{MCA}, even with ≈6 kt, which seems unknown, and hence is not used similarly. These is no warning in the AFM either that V_{MCA} rises to 64 + 6 = 70 KIAS when the wings are kept level. The effect of bank angle on V_{MCA}[16] is obviously unknown to the AFM-writers and reviewers, but is life threatening to pilots. Every graduate of a test pilot school knows about and has experienced the difference between V_{MCA} with wings level and V_{MCA} with a small favorable bank angle of 5°.

8.3.2. **§ 9-19.5.4 Take-Off Rate of Climb – One Engine Inoperative, Propeller Windmilling.** Same remark as in previous paragraph. In addition, the climb speed is 75 KIAS (inset). However, when the propeller of the failed engine is windmilling, and the wings are kept level, the *actual* V_{MCA} during straight flight will be 68 + highest of 4 kt for windmilling or 6 kt for wings level = ≈74 KIAS, only one knot below the required climb speed of 75 KIAS at weights less than 11,400 lb. Regulations require the climb speed to be ≥1.10 V_{MCA}, hence the climb speed needs to be at least 82 KIAS. It is obvious that the wings-level V_{MCA}, which is also determined during flight-testing, should be published in an AFM, along with the standardized V_{MCA} which is determined while maintaining a small (5°) bank angle. Both V_{MCA}'s are valid for straight flight only. The wings-level V_{MCA} should be used to calculate takeoff safety and performance speeds.

8.3.3. In the example calculation is stated: *"the takeoff rate of climb will be 30 feet per minute at 75 knots"*. In AFM § 10.6.9 it is stated that keeping wings level decreases the OEI rate of climb with 30 feet per minute; hence, at the given conditions, the airplane will not climb. So, it would be advisable to mention in the legend of Figure 9-16-2 that the data is valid only during straight flight while a small bank angle is being maintained into the live engine.

9. Section 10 – Safety and Operational Tips

9.1. AFM § 10 Safety and Operational Tips

9.1.1. A few paragraphs are already reviewed above. With the other remarks and suggestions presented above, it should be possible to improve this paragraph. If assistance is required, contact Avio*Consult*. Two paragraphs will be reviewed though.

9.2. § 10-1.7. Series 400 Limitations – Elaboration

9.2.1. The fourth paragraph: *"The V_{MCG} has been published to enable use of lower V_1 speeds on contaminated runways, in accordance with data provided in Flight Manual Supplement 37"*. V_{MCG} is not defined in § 0.6, nevertheless, V_{MCG} is published to be 50 KIAS in AFM Table 2-1, in compliance with FAR 23.51(c). Supplement 37 was not available for review, so this statement cannot be commented on. However, a remark can be made on a lower V_1 on contaminated runways.
V_{MCG} is the minimum, the lowest airspeed at which, when an engine suddenly fails during the takeoff run, the deviation from the takeoff path on the runway is 30 ft. At lower airspeeds, the airplane will vacate a (60 ft wide) runway, unless the throttles are closed immediately following the failure of an engine. On a contaminated runway, this deviation might be larger if the nose wheel steering is less effective (it was not allowed to be engaged for determining V_{MCG}), hence V_{MCG} would be higher. Takeoff decision speed V_1 for commuter class airplanes must not be less than V_{MCG} or not be less than 1.05 V_{MCA} plus the speed gained with the critical engine inoperative during the failure recognition time (FAR 23.51(c)). Hence, a higher V_{MCG} only has effect on V_1 if it increases above 1.05 V_{MCA}. Rotation speed V_R must not be less than the greatest of V_1, 1.05 V_{MCA}, etc. A lower V_1 has no effect on V_R because 1.05 V_{MCA} is greater, isn't it? V_{MCA} doesn't change due to runway contamination. So why this statement?

9.3. § 10.6.9 Single Engine Operations

9.3.1. Optimum single engine climb performance *("3° to 5° bank towards live engine")* is mentioned in the Go-around OEI procedure in AFM § 9-50.3.14, but is regrettably not repeated in the OEI missed approach procedure AFM § 3.9.2.
AFM § 10.6.9 on Single Engine Operations also confirms: "*Although optimum single engine performance will be achieved with 5° of bank towards the live engine and the slip-skid ball displaced half a ball width from center, it should not be necessary to do this except during the most demanding single engine climb scenario when the greatest possible rate of climb is required for obstacle clearance*". The small bank angle is considered to be related to performance only, but is also required to keep V_{MCA} low, at or close to the published value. Is the required small bank angle for the presented OEI performance data in AFM Section 5 to be valid stated in the legend of the charts? Is the loss of 30 fpm when keeping the wings level mentioned in the legend of the charts? No, but pilots have the right to be made aware.

9.3.2. Pilots, and also this AFM, consider V_{MCA} to be constant, to be always as low as the AFM-published V_{MCA}, or below 1.2 V_S (§ 3.8.5 above) and not affected by a bank angle. But the physical truth is that the gravity (the weight (mg) of the airplane) always acts in the center of gravity, whatever the airplane attitude in the sky is and hence, affects the equilibrium of lateral-directional forces and moments during banking due to a side force component (mgϕ)[16].

Banking has a large effect on V_{MCA}. Pilots, by controlling this side force with bank angle ϕ, also control V_{MCA} and are able to maintain control of the airplane as long as the airspeed is high enough.

9.3.3. It is recommended to add to this paragraph: 'Do not initiate a turn when rudder and or ailerons are near maximum deflected, or control will be lost if the asymmetrical thrust is, or is increased to maximum. Plan a long straight-in approach for landing to avoid making turns at the low approach speed'.
Pilots have the right to be made aware of such pertinent information that will save their lives, and that of their passengers if an engine fails or is inoperative, or if another event happens that disturbs the lateral and directional equilibrium of forces and moments, such as open cargo hatches or engine cowlings.

10. Conclusions of this limited POH/AFM review

10.1. This manual regrettably has many deficiencies on the use of the different airspeeds, on airspeed measurement and indication, and on flight with an inoperative engine, including engine emergency procedures. The manual is neither in compliance with the certification requirements as directed in FAR 23 or equivalent, nor with the flight-test techniques prescribed in Flight Test Guide (FAA Advisory Circular 23-8C) that are to be used to determine the airspeed limitations and engine-out flying qualities. In this POH/AFM, pilots cannot read and learn, and are not reminded of, how to prevent the loss of control after engine failure. Learning manuals and flying syllabi developed using the POH/AFM will be deficient as well.

10.2. The AFM presents limiting and operational airspeeds as either Indicated Airspeed (IAS), Calibrated Airspeed (CAS), or both, which is confusing and their mixed use is prone to errors. The IAS data are invalid, because the airspeed (and altitude) instrument errors were not used.
FAR 23 requires all limiting airspeeds to be determined as CAS, because CAS is the airspeed measured by a calibrated pitot-static system, and CAS on one day is CAS on another day. CAS is related to the standard pressure and temperature at sea level which makes CAS the best speed for piloting. CAS however cannot be displayed in the cockpit because of the unavoidable position and lag errors in the pitot-static system, and of manufacturing and other instrument errors in the Airspeed Indicator (ASI). FAR 23.1587(d)(10) requires for commuter category airplanes the relationship between IAS and CAS to be furnished in accordance with FAR 23.1323. FAR 23.1323(b) requires calibration of each pitot-static system of a type of airplane to determine its position error, and the separate calibration of each Airspeed Indicator (ASI), to determine its instrument error. The sum of the two errors is the relationship between IAS and CAS. The position error of the pitot-static system is presented in AFM Performance Section 5, while the airspeed (and also the altimeter) instrument error is usually not presented in an AFM, but provided separately with each individual ASI.
The AFM does not mention the airspeed instrument error, which seems to be considered zero, while the error is allowed to be up to ±4 kt (§ 2.2.8 above). Instrument errors vary per individual ASI, position errors per airplane type having identical pitot-static systems. The CAS in one DHC-6-400 is the CAS in another DHC-6-400, while IAS between two DHC-6 airplanes will differ, because the position errors will be equal, but each individual ASI has its own instrument error, both over a range of speeds. Limiting and procedural airspeeds in an AFM that applies for a series of DHC-6-400 airplanes, should therefore always be presented as CAS. The use of IAS would require a separate AFM for every Airspeed Indicator, which also would have to be approved by the authorities (§ 2.3.1); this of course cannot be achieved. Besides a correction chart for position error correction (−2 to +4 kt) in the AFM, also a table is required in the cockpit for the instrument error correction (±2 to ±4 kt) of each individual ASI or for the air data computer, if applicable, to be able to calculate the CAS from the actual IAS, and vice-versa. A small airspeed error has a huge influence on the control forces generated by the aerodynamic control surfaces at flight speeds (§ 2.4.5), and therewith on the equilibrium of

forces and moments that is required to maintain control of the airplane when an engine fails. The DHC-6 AFM does not adequately show the relationship between IAS and CAS as required in FAR 23.

10.3. The entry variable for the position error charts in the AFM is IAS, while this should be the instrument corrected velocity (Vic), which is the IAS + the instrument error. The instrument error/correction, or a reference to the correction was not found, was not even mentioned in the AFM, as already mentioned above, and is not even included in the legend of the charts, may be because GAMA Specification No. 1 recommends to use a zero instrument error, which is not in compliance with FAR 23 (§ 7.4.2), and may cause fatal airplane controllability problems. The DHC AFM writer and the reviewing authority were obviously not aware of the potential catastrophic consequences of a few knots difference on the forces and moments generated by the aerodynamic control surfaces (§ 2.4.5).

10.4. The AFM does not make clear whether the known position and instrument errors are compensated by and in the ADAHRS and/ or ESIS systems. These systems obviously display IAS to the pilots, rather than CAS, and hence, pilots need both errors as well to be able to calculate CAS, and use limiting speeds and performance data properly, for the safe conduct of flight (§ 4.1.1).

10.5. Several airspeed definitions in § 0.6 are not appropriate or are incorrect. Some of them are only for the certification of the airplane and not for operational use, and hence do not belong in a POH/AFM for pilots. Others are incomplete or missing (§ 3).
The V_{MCA} definition, for instance, is neither correct, nor complete (to ensure safety after engine failure). The used definition of V_{MCA} out of FAR 23 is for the design and certification of multi-engine airplanes, not for their operational use. An airplane is not controllable at V_{MCA}, but only certificated to recover from a sudden failure, and thereafter *maintain straight flight* while maintaining a small 5° bank angle away from the inoperative engine (§ 3.8). This associated condition should also be included in engine emergency procedures to remind pilots. The actual V_{MCA} that a pilot will experience in-flight is not a constant value, but varies with bank angle, asymmetrical thrust level and many more variables. A flight while an engine is inoperative is not a coordinated flight. It appears that the manual writer was not aware of the controllability of an airplane when one of the engines is inoperative and of the real value of the minimum control speed V_{MCA} and of the associated conditions that come with it (§ 3.8).

10.6. The AFM-published V_{MCA}, which is measured while maintaining a small bank angle away from the inoperative engine, is used for calculating operational speeds V_R, V_2, V_{REF}. Some of the presented operational speeds in the AFM seem to be too low, because the increase of V_{MCA} when keeping the wings level is not included in the calculation of the V-speeds (§ 8.3.1).

10.7. FAR 23.1581(a)(2) requires an AFM to contain: *"Other information that is necessary for safe operation because of design, operating, or handling characteristics"*. The AFM indeed publishes V_{MCA} as operating limitation, but its significance for operating the airplane is not adequately explained in the AFM, as also required in FAR § 23.1583(a)(2). V_{MCA} is for regaining control after a sudden failure, and for maintaining *straight flight* thereafter only (FAR 23.149). V_{MCA} increases considerably to a much higher actual value during banking away from the favorable bank angle of 5° to either side, which bank angle is allowed by FAR 23.149 to reduce the sideslip angle to zero, and increase the climb performance. Only in AFM § 3.9.3 (Missed approach), the requirement to *"maintain heading by applying rudder and, if necessary, lowering the wing on the side of the operating engine up to 5°"* is included (§ 5.1.2 above).
The AFM does not adequately emphasize that any banking away from this small bank angle, to either side, and even when the wings are kept level, increases the *actual* V_{MCA}, being the V_{MCA} that a pilot will experience in-flight, considerable. This is very significant for pilots to be made aware of, for them to prevent the loss of control of their airplane, whether just after takeoff or during the remainder of the flight. Pilots have the right to be made aware of this significant associated condition for the *actual* V_{MCA}.

A V_{MCA} applies during the whole flight, V_{MCA} is not the constant small number but varies with bank angle and asymmetrical thrust level. Following the failure of an engine, the pilot controls V_{MCA} with bank angle and remaining thrust (§ 3.8.7).
Pilots have the right to know and understand how to prevent a dead engine from turning into a killing engine. They have the right to be provided with excellent information and procedures in AFMs. They want to get home safely, as do their passengers.

10.8. The first five sections and supplements of this POH/AFM were approved by Transport Canada Civil Aviation. The reviewers did regrettably not notice the errors and deficiencies, which is incomprehensible; safety is at stake, especially when the airspeed is low, such as during take-off when an engine fails. It is likely that AFM-writers and -approvers were not knowledgeable on pitot-static systems, airspeed limitations, and engine-out flying qualities at a level that pilots and public would expect. This should be of great concern (§ 2.4).

10.9. A statement on the title page states that the manual meets GAMA Specification No. 1, but the GAMA specification does not comply with FAR 23 and the Flight Test Guide either, although it is approved by the authorities (§ 2.4.6).
A critical review of GAMA Specification No. 1 is required and will follow soon (on the Downloads page of www.avioconsult.com).

10.10. This review of the DHC-6 Airplane Flight Manual proves that it indeed takes well educated engineers and pilots to write faultless manuals and verify the content; it is worth the cost and effort, because it will prevent accidents and save lives, of both pilots and their passengers. Flight Manuals of many more, if not all multi-engine airplanes require review and improvement; this reviewed AFM is not the only one with errors. During the research for the written papers and this review, it was regrettably noticed that also very many inappropriate papers and videos on engine-out flight are published on the Internet, and on YouTube.
Poverty of knowledge leads to disinclination and incompetence, causing aviation to drift into failure, which is a process that is ongoing at an increasing pace. Philosopher Arthur Schopenhauer wrote *"Every man takes the limits of his own field of vision for the limits of the world"*. For the sake of aviation safety, the self-assumed high levels of training, competence, and experience, i.e. the own field of vision of many men and women in aviation, is not sufficiently wide to prevent fatalities; the limits of the world of aviation are much wider. Universities and Test Pilot Schools widen the field of vision of aviators; opinions of the incompetent don't.
Douglas Adams once said: *"Human beings, who are almost unique in having ability to learn from the experience of others, are also remarkable for their apparent disinclination to do so"*. NTSB Board member Dr. Earl F. Weener used this expression in an NTSB Most Wanted List presentation *"Loss of Control During Takeoff and Landing"* (April 13, 2013)[18]. He did not mention V_{MCA}, because V_{MCA} is always considered a constant quite low speed limit, which is definitely not true; investigators often conclude a stall, rather than loss of control due to increase of V_{MCA}. Dr. Weener regrettably did not respond to a letter from Avio*Consult*, nor did the FAA, ATSB, and many more organizations and manufacturers. Douglas Adams obviously hit the right note. *"The Truth Is Not Always Welcome"* as Schopenhauer also wrote.
Pilots have the right to be well trained and informed. Developing airplane flight and operating manuals and pilot training programs requires high level multi-disciplinary knowledge.

11. Recommendations

11.1. This review was only limited. The manufacturer is strongly recommended to improve the AFM to be in compliance with FAR 23 and Flight Test Guide AC 23-8C, and with their intention, and with the suggestions presented in this review. It is strongly recommended to have the full manual reviewed by competent multi-disciplinary team, consisting in any case of a graduate

[18] NTSB Most Wanted List, Presentation by Board Member Dr. Earl F. Weener
https://www.youtube.com/watch?v=f78kS4Xzbis

of one of the (formal) Test Pilot Schools with a strong engineering background, an aeronautical engineer, an airline pilot, and an aviation human factors expert.

11.2. The IAS data in the AFM should be removed if the AFM is for a series of DHC-6 airplanes. Suggestions are also presented in § 7 of paper *Airplane Control and Analysis of Accidents after Engine Failure*[14]. Pilots should be furnished with instrument error data (airspeed and altitude).

11.3. Information necessary for the safe operation after engine failure must be improved. Pilots have the right to be made aware of controllability limitations to be able to save their souls. They want to get home safely, as do their passengers. Manufacturers have the duty to provide pilots with pertinent information necessary for safe operation, resulting from the design, operating, or handling characteristics, as required in FAR 23.1585 Operating procedures: *"(a) For all airplanes, information concerning normal, abnormal (if applicable), and emergency procedures and other pertinent information necessary for safe operation and the achievement of the scheduled performance must be furnished, including— (1) An explanation of significant or unusual flight or ground handling characteristics"* (§ 3.8.9 above).

11.4. Preparing an amendment for an AFM takes much time. For the time being, and to prevent accidents after engine failure, it is strongly recommended to issue a temporary revision as soon as possible letting pilots know that the AFM-published V_{MCA} and the therewith derived takeoff speeds (V_R and V_2) are valid only during straight flight while maintaining a small specified bank angle away from the inoperative engine, and that V_{MCA} increases with banking to either side and with increasing asymmetrical thrust level, requiring a much higher airspeed to prevent the loss of control.

11.5. It is also recommended that the manufacturer reviews the POH/AFM for the use of the appropriate airspeeds, reviews the need to use V_{MCA} with the wings level for increasing takeoff speeds, and to recommend operators to use airspeed indicator calibration correction, besides position error correction. More recommendations are presented in the review above. ■