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Limited Analysis of Airplane and Training Documents following a catastrophic accident with a PA-44-180 Seminole of Martinair Flight School in the Netherlands, 14 Aug. 2002

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Reference

Report: Prevention of Airplane Accidents after Engine Failure, by Avio*Consult*, June 2005, downloadable from the Products page of website www.avioconsult.com.

Introduction

On 14 August 2002, a Piper PA-44-180 Seminole, owned and operated by Martinair Flight School in The Netherlands, crashed in a lake, killing an instructor and two students during a demonstration of flight with an inoperative engine. The Dutch Transport Safety Board thoroughly investigated the accident and concluded that following the intentional shut down of the left engine, the fuel valve of the right engine was inadvertently closed instead of the valve of the left engine, after which the right engine quit as well and an emergency landing became unavoidable, according to the report. The report also concludes that the airspeed decreased below the stall speed, after which control of the airplane was lost at an altitude from which recovery was not possible.

To the opinion of Avio*Consult*, the report of this accident did not reveal the real cause of this accident. The minimum control speed in the air (V_{MCA}), which is very important for maintaining

control while an engine is inoperative, was not addressed properly. Furthermore, the airplane and training course documentation used by the flight school were not reviewed/ investigated by the accident investigators.
At the request of Avio*Consult*, the Director of the Martinair Flight School gave permission to review the documentation. After the review, both the comments to the investigation report as well as the results of the documentation review were presented to Martinair Flight School as well as the Dutch Transportation Safety Board. The analysis is written in the English language, except for the last paragraph, and is presented in this document as a limited analysis.

Every year, all around the world, a number of small and big airplanes crash due to the loss of control following the failure of an engine. After reviewing many accident investigation reports, Avio*Consult*, having a strong experimental flight-test background, could not understand why these accidents happen, because all multi-engine airplanes are flight-tested and certified, after which operating limitations, using the flight-test data, are calculated and published in airplane manuals for pilots to be able to continue to operate safely following the failure of an engine. The real cause of most engine failure related accidents is, to the opinion of Avio*Consult*, the inappropriate understanding of the minimum control speed V_{MCA} by most pilots, instructors, airplane accident investigators and also by aviation regulation authorities. This was the reason for Avio*Consult* to perform additional research and write a report on the subject that was first published in June 2005 (see reference). This report was used to comment on the accident investigation report of this PA-44-180 accident (not included here) and on the documentation used during training by the Martinair Flight School (this analysis).

This limited analysis, as well as the report presented above as reference, were written by Harry Horlings – Avio*Consult*, graduate Flight-Test Engineer of the USAF Test Pilot School, Edwards Air Force Base, CA, USA, 1985. Avio*Consult* made this analysis available to the Dutch Transportation Safety Board and requested to forward the recommendations to the responsible organizations, like authors of course books and to the manufacturer of the PA-44 airplanes, the New Piper Aircraft company. But the Safety Board is only reactive to accidents, not preventive, as was made clear to Avio*Consult*. Therefore, in the interest of flight safety, Avio*Consult* presents this analysis to whom it may concern, to learn from it and eventually save lives.

In the paragraphs below, remarks (•) and recommendations for improvement (➢) are presented per referenced document, and not in a separate conclusion and recommendation section. The original text, if applicable and where needed, is included in *Italics*. The remarks and recommendations are thoroughly explained in the referenced report.

1. Pilot's Information Manual Seminole, PA-44-180

1.1. Page 1-8. *Definition Air Minimum Control Speed V_{MCA}:*

V_{MCA} is the minimum flight speed at which the airplane is directionally controllable as determined in accordance with FARs. Airplane certification conditions include one engine becoming inoperative and wind milling, not more than 5 degrees bank towards the operative engine, takeoff power on operative engine, landing gear up, flaps in takeoff position, and most rearward cg.

- V_{MCA} is not really the speed at which the airplane is directionally controllable. V_{MCA} is a minimum speed at which it is possible to maintain straight flight only; any bank angle other than the bank angle used to determine V_{MCA} changes the minimum control speed to some *actual* V_{MCA} and might lead to control problems at once. The flight test technique for determining V_{MCA} requires the speed to be reduced until the heading can no longer be maintained while maintaining wings level or with a bank angle of up to 5° toward the operating engine at the option of the applicant (the manufacturer). At V_{MCA}, no maneuvering whatsoever should be attempted. Other configuration items apply as well; refer to the referenced report or to the Flight Test Guides of FAR 23 or EASA CS 23.

- The manufacturer selects the bank angle used to determine V_{MCA}. V_{MCA} however changes considerable if the bank angle is changed (ref.). Therefore, the manufacturer should specify this bank angle with the V_{MCA} that is listed in the Pilot Information Manual (PIM) as an operational limitation. The improved V_{MCA} definition would be:
  - ➢ V_{MCA} is the lowest speed at which <u>straight flight</u> can be maintained while any one of the engines is inoperative, given the specified configuration and bank angle. The listed V_{MCA} is not valid without maintaining the specified bank angle away from the inoperative engine (mostly 2° – 5°). A wings level attitude or a bank angle into the inoperative engine increases *actual* V_{MCA} 10 knots or more!

1.2. Page 2-8. *PLACARDS*

One engine Inoperative Air Minimum Control Speed 56 KIAS.

- This is the V_{MCA} determined by the manufacturer using a certain configuration, maximum continuous power on the operating engine(s), aft cg, flaps takeoff, gear up and a bank angle away from the inoperative engine. If the power is less than maximum, then the actual V_{MCA} is lower, is safer. If the bank angle however is different (plus or minus) from the bank angle used to determine V_{MCA}, the *actual* V_{MCA} is almost always higher, is less safe and might lead to an uncontrollable airplane. Therefore it is strongly recommended to add this bank angle requirement to the placard. By the way, on the OEI climb performance plot on page 5-24, this bank angle requirement is included for the performance data to be valid.
  - ➢ Change the placard to read:
    'One engine Inoperative Air Minimum Control Speed is 56 KIAS, provided the bank angle is 2° – 3° toward the operating engine. Other bank angles increase V_{MCA}.'

1.3. Page 3-2, *Airspeed for safe operations*

- For the three listed one engine inoperative speeds (V_{MCA}, V_{YSE} and V_{XSE}) the same comment applies as in § 1.2 above for the placarded V_{MCA}. Refer to page 5-24 where a bank angle restriction is made for the OEI climb performance to be valid.
  - ➢ Add to the three speeds: 'these airspeeds are valid only as long as the bank angle is 2° – 3° toward the operating engine'.

1.4. Pages 3-4 through 3-8. Several engine failure and engine inoperative procedures.

These procedures contain a step each: *Trim … Adjust to 2° to 3° bank toward operating engine, etc.*

- This step in itself is of course perfect; it supports the other recommendations in this document as well. However, the step comes a little late. The requirement for bank angle (besides rudder input) exists at the moment that, and as long as, high asymmetrical power is set by moving the throttles forward. If this bank angle is not attained as soon as possible after an engine fails, or while an engine is inoperative, the controllability of the airplane is marginal to impossible, depending on the actual value of the other variables that affect V_{MCA}.
  - ➢ Recommended is to move this step up to just below the power setting steps.
  - ➢ It is also recommended to add the bank angle requirement to procedure 3a on page 3-2. This ensures a timely bank angle input together with the rudder and prevents out of control due to engine failure in the earliest stage.

1.5. Page 3-33. *Fuel management during OEI operation.*

- No fuel asymmetry limit is presented in the PIM although the lateral displacement due to fuel asymmetry affects the *actual* V_{MCA}, which might become relevant during an approach or go-around with an inoperative engine. The PIM only presents guidance for achieving increased range by cross-feeding fuel, not an advisory for maintaining a certain fuel balance.
  - ➢ Add the maximum approved fuel imbalance in the appropriate chapters of the PIM.

1.6. Page 4-40. V_{MCA} – Air Minimum Control Speed demonstration.

- According to the definition presented here, *V_{MCA} is the minimum flight speed at which the airplane is directionally and/or laterally controllable … with not more than 5° toward the operative engine*.
  - ➢ Refer to § 1.1 above for comments and recommendation.
- *V_{MCA} for the PA-44-180 has been determined to be 56 KIAS and is a stalled condition.* So this airplane is controllable down to the stall? Then why is there a red radial line on the airspeed indicator indicating V_{MCA} if the airplane stalls prior to decelerating to V_{MCA}? The stall speed plot on page 5-13 shows that V_S at maximum takeoff weight, flaps up and wings level is 57 KIAS. Stall speed data with flaps in takeoff are not presented, but might be a little lower. V_{MCA} however, is to be determined at the lowest weight possible. At this lowest weight, V_S is below 50 KIAS, according to the plot, so at weights lower than maximum weight, V_{MCA} is higher than V_S and is not '*a stalled condition*'. In addition, actual V_{MCA} is higher if the bank angle differs from the bank angle used to determine V_{MCA}, as was explained in § 1.2 above. The *Caution* on page 4-41 suggests too that V_{MCA} is not a stalled condition.
  - ➢ Delete this line because it is incorrect, provided the other information in the PIM is correct.

2. Book Multi-Engine Piston, David Robson, Air Pilot Publishing.

2.1. Page 76, 77. *Minimum Control Airspeed.*

- The author makes a difference between minimum control speed and V_{MCA}, the latter being for sudden and complete engine failure – mostly called the 'dynamic' V_{MCA}. This might lead to the interpretation by the readers of the book that V_{MCA} does not apply during cruising or during the flight following the engine failure while turning back to the runway for landing. This is definitely not correct. Many accident investigation reports show evidence that if pilots succeed in surviving the dynamics of a sudden engine failure, they still crash on the way back to the runway. They are not made aware of a minimum control speed that applies as long as a power asymmetry exists. This speed is a V_{MCA} too; it is called the 'static' V_{MCA}. The highest of static and dynamic V_{MCA} should be shown on the airspeed indicator with a red radial line. The liftoff speed should be always above this line.

2.2. In the specific list of factors for determining V_{MCA}, the following 'classic' errors are made as well:

- *critical engine suddenly failed*… In addition to a dynamic V_{MCA}, determined after the sudden failure of the critical engine, the static V_{MCA} is always determined too (while decelerating slowly). The higher of dynamic and static minimum control speed should be listed as V_{MCA} in flight manuals as an operational limitation. Most often, static V_{MCA} is the highest.
- *no more than 5° bank towards the live engine* . This suggests that the pilot should keep the wings level (to within ± 5°) and also that a max. 5° bank into the <u>dead</u> engine is not a problem. Most applicants (manufacturers) however use a small 2 – 5° bank angle towards the live engine to determine V_{MCA}. This reduces V_{MCA} as well as the

sideslip angle (drag). Banking away from this small 2 – 5° bank angle leads to catastrophes because actual V_{MCA} increases considerably (instantaneously). A larger angle than 5° might lead to fin stall. This line is copied out of FAR 23.149, which is for certification, not for operational use. During certification, no more than 5° should be used, but during operational use by line pilots, the bank angle should be the same as the bank angle used to determine V_{MCA} (as long as the power setting is high and the airspeed is low).

- *maximum takeoff weight* should be 'lowest weight'. This provides the worst case, a higher, more unsafe V_{MCA} than when using maximum takeoff weight, provided a small bank angle is maintained. Normally the maximum takeoff weight is used to calculate V_S for takeoff.

2.3. Page 77 *Factors affecting V_{MCA} – Effect of bank*.

- Second sentence: *But only a small amount of bank (less than 5° – typically 3°), because larger angles cause a significant reduction in the vertical component of lift and so require a higher angle of attack to maintain altitude.* This in itself is correct, but is more aimed at performance than at controllability. For the analysis of the factors that influence the controllability after engine failure, it is better to use Weight, rather than the vertical component of lift. Weight and bank angle ϕ generate a side force $W \cdot \sin \phi$ that reduces the rudder deflection after which the speed can be reduced until the rudder is again maximum and the heading can no longer be maintained. This leads to a lower V_{MCA}, which is favorable to takeoff runway length for the takeoff weight. The worst-case – highest – V_{MCA} is obtained at the lowest weight possible given a certain small bank angle. Greater bank angles lead to higher sideslip angle and to higher drag as well as a higher risk of the vertical fin to stall. Refer to referenced report for additional information and plots showing the huge influence of bank angle and weight on V_{MCA}.

2.4. Page 78. *Effect of CG position.*

- The effect of a forward cg is not only that it increases control power and stability, but also that it decreases actual V_{MCA} to a value lower than the listed V_{MCA} (ref.). V_{MCA} is determined with an aft cg, which is the worst case.

2.5. Page 79. *Conclusion V_{MCA}*.

Having examined V_{MCA} in detail, it must now be said that it is a practically meaningless speed. We only need to know it so we can stay well away from it and to minimize our exposure – just like stalling speed. In many ways, the greatest risk with V_{MCA} as with V_S, is practicing it.

- This understatement of V_{MCA} is very disappointing; the author has probably never studied accidents that occurred after engine failure, or accidents that happened while returning to the airport to land while an engine was inoperative. V_{MCA} is definitely determined for a reason; it should be listed in each and every multi-engine airplane flight manual, also for that reason. V_{MCA} looks like a single constant number, but it is not, as might have become clear after reading these comments so far. V_{MCA} is also used to calculate takeoff safety speed V_2 on Part 25 airplanes.
  The greatest risk is thinking that V_{MCA} is a practically meaningless speed. *They who forget about V_{MCA} are deemed to loose control some day and cause a catastrophe*.

- *The minimum speed at any time during practice should be V_{SSE} …*
  While maintaining this speed, the pilot will not experience the characteristics of flight as he would experience at an airspeed near V_{MCA} and will not recognize the impending loss of controllability. The airspeed is near actual V_{MCA} if either the rudder or the ailerons are at or near full deflection or if the rudder pedal force is 150 lb. At V_{SSE}, the deflections will be far away from full.

This practice limitation makes no sense and leads to pilots who will not be able to handle engine emergencies. The stall characteristics of an airplane cannot be demonstrated at an airspeed some 20 kt above V_S either.

2.6. Page 68. *Options for control after engine failure*.

- While describing three options for equilibrium following the failure of an engine, no reference is made to the magnitude of the three different V_{MCA}'s of these options. Bank angle would be necessary only for best climb performance. But the vertical component of the lift ($L \cdot \cos \phi$) hardly changes when using small bank angles (because of the cosine). Controllability is however affected by a side force component of the weight: $W \cdot \sin \phi$. Side force $W \cdot \sin \phi$ changes a lot more with small bank angles (because of the sine), so V_{MCA} changes considerably with bank angle. However, actual V_{MCA} is lowest, is safest, provided the airplane is banked 2°– 5° towards the operating engine. *Actual* V_{MCA} can easily become 10 kt higher if the wings are only kept level. In fact, the listed V_{MCA} is only valid as long as the same bank angle is applied that was used to determine V_{MCA}. There is regrettably no requirement for manufacturers to list this bank angle as an operational limitation with V_{MCA} (yet). This omission and the consequently misunderstood V_{MCA} led already to many accidents following the failure of an engine. Refer to the referenced report (ref.) for a more thorough explanation.

3. Flying Light Twins Safely

3.1. Page 2, *Roll*, third sentence.

- *These roll forces may be balanced by banking into the operating engine*. It is not the banking that takes care of the banking, but the aileron deflection. The banking generates a lateral force that replaces the side force due to sideslip and therewith keeps V_{MCA} low.
  - ➢ These roll forces may be balanced by applying <u>aileron</u> into the operating engine. The remaining sideslip is balanced by banking just a few degrees into the operating engine. This reduces actual V_{MCA} and the drag, which is favorable during engine failure (during takeoff).

3.2. Page 3, *KEY AIRSPEED FOR SINGLE ENGINE OPERATIONS*.

- *V_{MCA} – Airspeed below which directional control cannot be maintained*. *'Directional control'* is quite correct in this definition. In addition, a life saving condition is missing. Refer to the improved definition in § 1.1.

3.3. Page 4, *Minimum Control Speed Airborne (V_{MCA})*, second sentence, *determination of V_{MCA}*.

- There are two types of V_{MCA} determined during experimental flight-testing: dynamic and static V_{MCA}. Dynamic V_{MCA} is determined by suddenly shutting down the critical engine at test points at decreased speeds. Static V_{MCA} is determined by slowly decreasing the airspeed until the heading can no longer be maintained while the bank angle is a few degrees away from the inoperative engine, as opted by the manufacturer, mostly 2 – 5°. The higher of these two will be listed in the AFM and will be used to position the red radial line on the airspeed indicator. Although the definition suggests V_{MCA} only to be valid for sudden engine failures, V_{MCA} definitely applies also during the flight following the engine failure. Many accidents happen during this flight phase, for instance if turns are made to return to the runway for landing while the power setting on the remaining engine is high.
- So, the last part of the second sentence is incorrect. The OEI performance diagram in the Pilot Information Manual on page 5-24 contains the following note:

NOTE
2° TO 3° BANK TOWARD
OPERATING ENGINE

This means that the data in the diagram are only valid while maintaining this bank angle at a speed of 88 KIAS, etc. Therefore the last part of the second sentence should not be: *'with not more than 5 degrees of bank'*, but:

- "with the same bank angle that was used by the manufacturer to determine V_{MCA}: 2° to 3° away from the inoperative engine ". (Appl ies to the PA-44-180. A 5° bank angle is always safe for all multi-engine airplanes).
- Because the higher of static and dynamic V_{MCA} is listed in the AFM, it is irrelevant to a pilot whether V_{MCA} is for a sudden failure during takeoff, or for continuing the (straight) flight with an inoperative engine. The given V_{MCA} applies anyhow.

- Conditions not mentioned in the list are:
  - lowest weight,
  - maximum allowed fuel imbalance into the inoperative engine (unfavorable).
- If an airplane does *not maintain level flight* at speeds at or near V_{MCA}, then the airplane is either too heavy or the small bank angle is not being maintained if the power setting on the operating engine is high.

3.4. Page 4, V_{SSE}.

- Add to the first paragraph behind *(See figure 7)*:
- This is the *actual* V_{MCA} for wings level. Then, gradually bank away from the inoperative engine to a bank angle of 3° and continue r educing speed until again the heading can no longer be maintained (or until stall). This is as close to the AFM listed V_{MCA} as you can get given the current configuration. Note that V_{MCA} with a small bank angle is lower than V_{MCA} with the wings level. If a yaw string had been attached to the windscreen, the difference in sideslip (and drag) would become clear as well.
- Last sentence on this page: *'Recovery is made by reducing power to idle'*. By reducing to idle, the drag of the idling propeller might be higher than the drag of the windmilling of feathered propeller. This in turn might lead to controllability problems. (See also § 5).
- Reducing as much as required to regain control is already good enough, or reducing propeller RPM to the zero thrust setting (AFM page 4-41). Be careful with the rudder; a sudden release can lead to a fin stall!

3.5. Page 5, V_{YSE}. Second paragraph. *Drag caused by a windmilling propeller, extended landing gear, or flaps in the landing position will severely destroy SE Climb performance*.

- One considerable source of drag is missing here. Keeping wings level will cause a sideslip angle of some 15 degrees. This causes a lot of drag as well.
  - Add behind *propeller*: ', not maintaining the required bank angle (= 2° to 3°) away from the inoperative engine,'

3.6. Page 5, V_{XSE}.

- The required bank angle is not listed here either. Add:
  - 'A small bank angle (2° to 3°) away from the inope rative engine is required to reduce the drag and keep V_{MCA} low'.

3.7. Page 5, *BASIC SINGLE ENGINE PROCEDURES*.

- Second bullet. *Usually, apply maximum power to the operating engine.* Another basic fundamental for applying asymmetrical power should be added to this sentence:
  - … 'and simultaneously apply rudder and a 2 – 5° bank angle into the operating engine to maintain heading and reduce sideslip and drag. The slip ball will be approximately half width to the operating engine side'.
  - The last sentence on this page talks about banking, but that is a little late. Rudder and bank angle are needed and are essential for maintaining control at the same moment that high asymmetrical power is set. This is the only way to maintain control.
  - Delete this line since the bank requirement is added to the second bullet.

3.8. Page 6. *WHEN TO FLY V_X, V_Y, V_{XSE} AND V_{YSE}*.

- The last sentence advices *to establish V_{XSE} or V_{YSE}*, but does no recommend a small bank angle to reduce the drag. Add to this sentence:
  - 'and use rudder to maintain heading and a small 2° to 3° bank angle towards the operating engine to reduce drag.'

3.9. Page 6. *Summary*.

- *Know the key airspeeds for your airplane and when to use them.* The first speed listed here is V_{MC}. In a summary the important aspects are summarized, but the life saving bank angle besides rudder input are not included. Add to the V_{MC} line:
  - V_{MCA} is valid only when the rudder is deflected to maintain heading and a small 2 – 3 degrees bank angle is maintained both into the good engine. Maintain straight flight until reaching a safe altitude; do not turn into either engine unless the speed is well above V_{MCA}. If directional control cannot be maintained, reduce thrust a little and accelerate exchanging altitude for airspeed, if feasible, until control is regained.

3.10. Page 7. *Know the basic single engine emergency procedures:*

- Again, no reference is made to the bank angle that keeps actual V_{MCA} low. Add to *Apply maximum power, if appropriate* in the second bullet:
  - 'and use rudder to maintain straight flight and a small 2–3 degree bank angle away from the inoperative engine.'

4. Emergency Checklist, May '04, V01

4.1. CL 2. Engine failure during takeoff or climb.

- The step to establish 2° to 3° bank into the operative engine comes a little late. As explained before, this bank angle is essential for maintaining control as soon as and as long as asymmetrical power exists. It is also required for getting the max. climb performance.
  - Recommend moving this step up to be the first step and to be applied with the rudder that is required to balance the yawing moment. This should be a bold face/ memory item.

4.2. CL 2a. Same comment as in § 4.1.

4.3. CL 2c. N-1 landing (also for CL 1b).

- No step is included for trim setting and for rudder and banking in case power has to be added for maintaining glide slope of for initiating a go-around. If the yaw trim is still set for cruise, the pilot looses the feel for thrust asymmetry once the throttles are moved forward.

- It is recommended to add a step for setting the trims to normal (takeoff).
- It is also recommended to add: 'If a high asymmetrical power setting might be required during the approach, simultaneously apply both rudder and 2°– 3° bank angle away from the inoperative engine to maintain heading and ground track.'

5. Training Manual PA 44-180. The recommended changes should also be incorporated in the Training Manual PA 44-180 dated 14/06/2005.

6. Oefenprogramma PA-44-180, 10-02-2005 versie 5 (in the Dutch language)**.**

6.1. Op pagina 3/4 onder V_{MCA} demo staat:

- *L-throttle – idle*. V_{MCA} voor dit vliegtuig is bepaald met o.a. flaps in takeoff stand (PIM pag. 1-8) en windmilling propeller maar ook o.a. met een achterlijk c.g. Het is daarom moeilijk om de in AFM of PIM gegeven V_{MCA} te 'kunnen ervaren'. Meestal is de actuele V_{MCA} lager (veiliger) dan de in het AFM opgegeven V_{MCA}.
- Om toch een zo realistisch mogelijke V_{MCA} te kunnen 'ervaren' verdient het aanbeveling om dezelfde configuratie aan te nemen als voor het bepalen van V_{MCA} werd toegepast en een propeller RPM voor zero thrust in te stellen op de gesimuleerd defecte motor, zie tabel PIM pag. 4-41.

• *Handhaaf richting met voeten en niet meer dan 5° dwarshelling.* De toevoeging *'en niet meer dan 5°*' komt uit de definitie van V_{MCA} in het PIM (pag. 1-8) en uit (incorrecte) boeken en voorschriften (FAR 23). Op zich is dit goed, een te grote bank angle into the good engine kan een fin stall tot gevolg hebben, maar deze toevoeging is niet compleet.

- Het moet zijn "en handhaaf 5° towards the operative engine" (zoals correct staat in het PIM op pag. 4-41). Deze 'favorable' bank angle reduceert de *actuele* V_{MCA} en voegt daardoor veiligheid toe; echter 5° de andere kant op, into the failed engine, verhoogt de actuele V_{MCA} nogal veel en is daarom gevaarlijk (vooral als dit in takeoff tijdens een echte engine failure wordt gedaan).
- Advies voor de demo van V_{MCA} is om eerst langzaam te decelereren (1 kt/sec) met wings level en met rudder uitslag voor het handhaven van de heading. Als de neus van het vliegtuig van de heading 'wegloopt' of als maximum aileron of rudder is bereikt, of de pedal force is 150 lb, dan is de snelheid waarbij dat gebeurt de V_{MCA} voor wings level. De echte V_{MCA} is echter lager. Die wordt pas bereikt door 2 – 3° te banken away from the inoperative engine en verder te decelereren tot opnieuw de heading 'wegloopt' (of tot de stall wordt bereikt). V_{MCA} is de snelheid waarbij de heading nog net kan worden vastgehouden. Manoeuvreren met een snelheid op of nabij de echte V_{MCA} is dus uit den boze en is meestal ook niet mogelijk.

• *Vermogen op werkende motor weer bijschuiven en accelereer naar V_{YSE}.* Of wordt hier bedoeld 'op beide motoren'? Als toch alleen vermogen op werkende motor wordt bijgeschoven, dan adviseer ik ook om tevens toe te voegen dat met het toenemen van het asymmetrisch vermogen zowel de uitslag van het rudder moet toenemen als een kleine bank angle away from the inoperative engine moet worden aangenomen. Zodra het asymmetrisch vermogen toeneemt, neemt namelijk ook de actuele V_{MCA} toe en is zowel rudder input als een kleine 2 – 3° bank angle nodig om bestuurbaarheid te handhaven; dit is dezelfde techniek als toe te passen bij motorstoring in takeoff. Overigens is een 5° bank angle ook acceptabel; de drag is iets hoger dan bij 2 – 3°.

• Als beide motoren uitstaan en de linkerpropeller staat in vaanstand en de rechter niet, dan veroorzaakt laatstgenoemde meer weerstand. Dan is een rudder uitslag en een kleine bank angle in de richting van de propeller-in-vaanstand (nu de 'good engine') nodig om het evenwicht te kunnen bewaren als de vliegsnelheid laag wordt. Gebeurt dit niet dan veroorzaakt de sideslip (wind in linkeroor) een acceleratie naar rechts. Hierdoor glijdt het vliegtuig naar rechts (wind komt nu in rechteroor) waarna door het weerhaaneffect de neus van het vliegtuig naar rechts draait; de linkervleugel levert meer lift waardoor het vliegtuig ook naar rechts rolt. Door de lage snelheid, het ontbreken van motorvermogen en de ingebouwde langstabiliteit gaat ook de neus naar beneden; het vliegtuig raakt in een neergaande spiraal. In tegenstelling tot bij een overtrek is het rudder al bijna volledig uitgeslagen om het gieren te stoppen; het wegvallen van de vleugel kan dus met het richtingsroer niet meer worden voorkomen, zoals bij een wingdip tijdens een normale – symmetrische – overtrek te doen gebruikelijk is. Als de hoogte niet toereikend is dan eindigt de vlucht in een calamiteit.

Asymmetrische weerstand voelt niet aan als overtrek, als je te langzaam vliegt ben je onbestuurbaar geworden. V_{MCA} wordt ook niet voor niets de minimum bestuurbaarheidsnelheid genoemd, het is de laagste snelheid waarbij nog net een rechtlijnige vlucht mogelijk is met als voorwaarde dat een kleine rolhoek wordt toegepast in de richting van de werkende motor. Een kleine bank angle de verkeerde kant op en herstel is niet meer mogelijk (als de hoogte laag is); dit gebeurde met vele meermotorige vliegtuigen. ■

