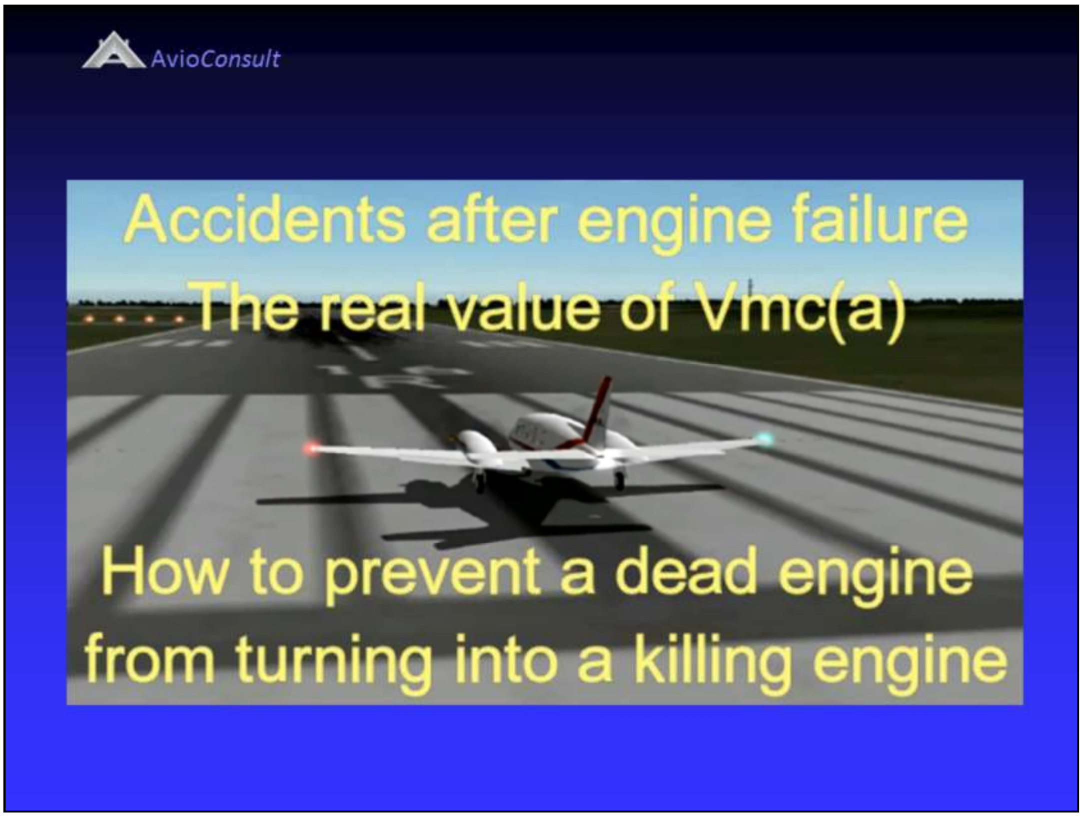

This file contains the full script of the corresponding video, published on the AvioConsult Channel on YouTube, November 2014, updated March 2017: http://youtu.be/Wbu6X0hSnBY

Background papers and links to formal FAA and EASA Aviation Regulations and Flight Test Guides are included on the website of AvioConsult: http://www.avioconsult.com/downloads.htm

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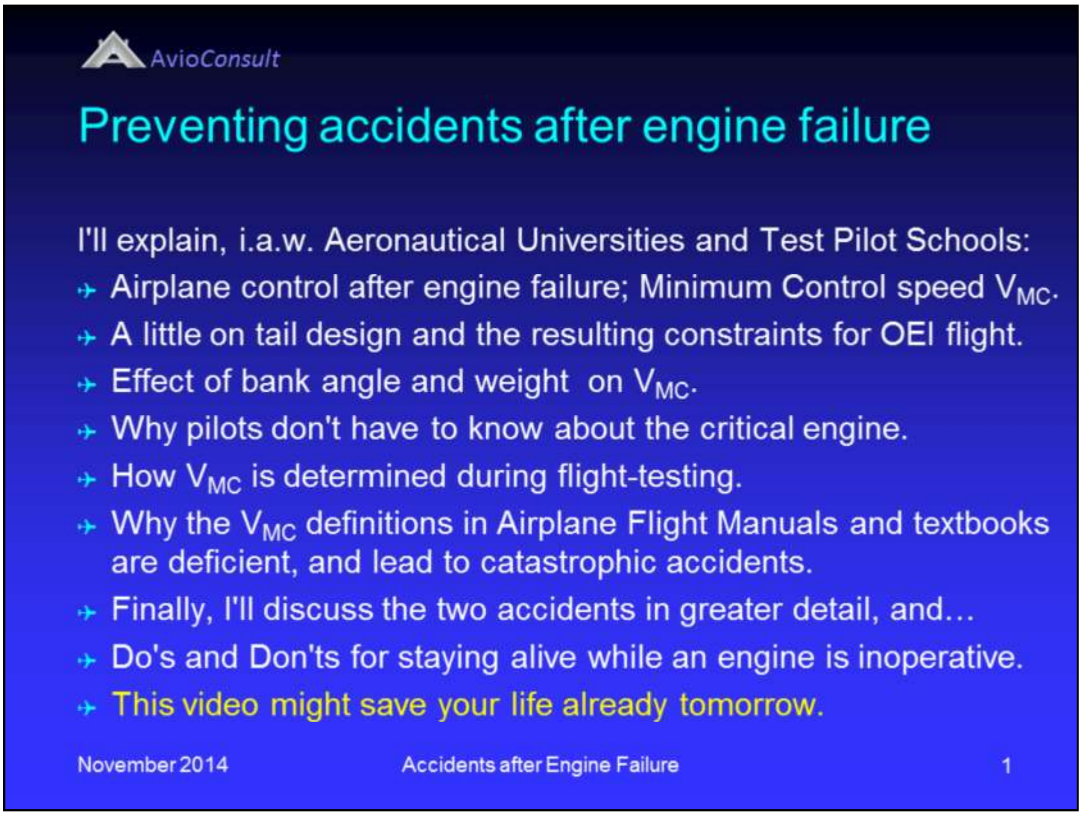


I'll briefly explain a few subjects that all have to do with preventing accidents after engine failure. I'll do that exclusively using books of leading Aeronautical Universities and Experimental Test Pilot Schools and not i.a.w. publications by who-ever, not even including Airplane Flying Handbooks issued by Aviation Authorities…

Then, I'll briefly explain Airplane control after engine failure; and the truth about Minimum Control speed V_{MC}. In order to do that, I'll explain a little on tail design and the resulting constraints for flight with One Engine Inoperative.

Then I'll talk about the effect of bank angle and weight on the minimum control speed.

I'll also explain why pilots don't have to know about the critical engine.

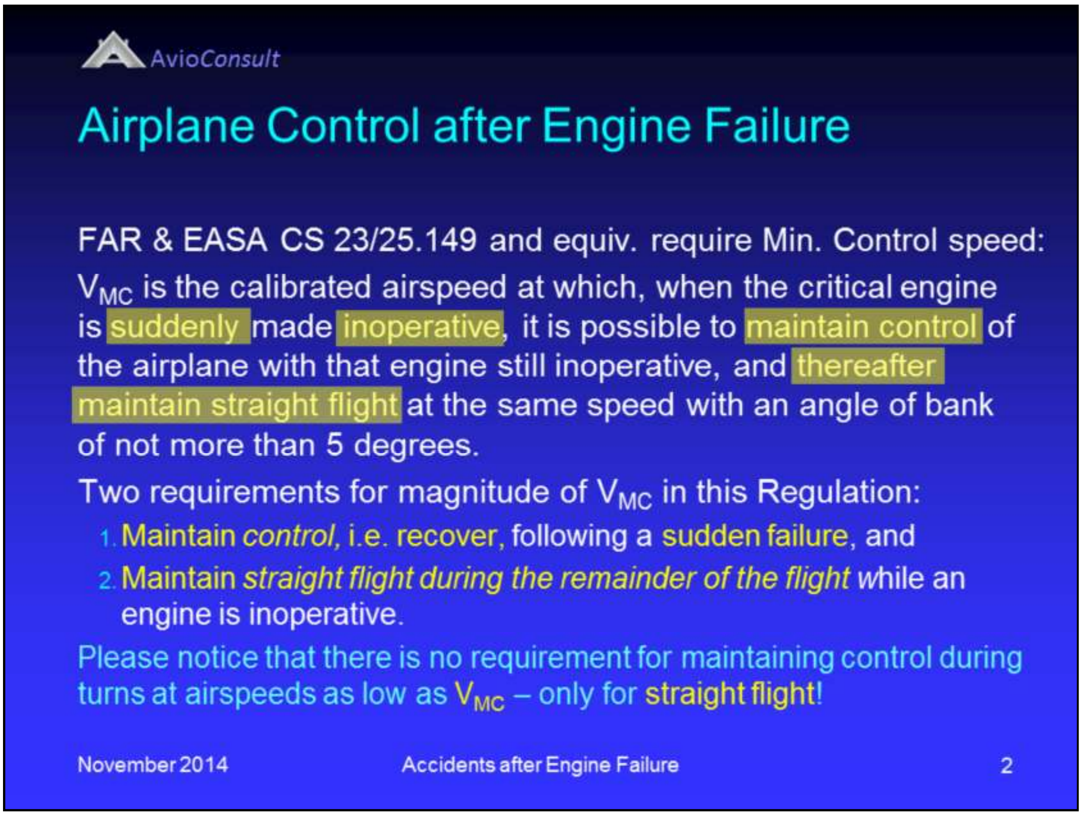
And how V_{MC} is determined during flight-testing.

I'll answer the question why the V_{MC} definitions in Airplane Flight Manuals, flying handbooks and textbooks are deficient, and lead to catastrophic accidents.

Finally, I'll discuss the two accidents you've seen in greater detail, and…

Present some Do's and Don'ts for staying alive while an engine is inoperative.

This video might save your life already tomorrow.



Airplane control after engine failure.

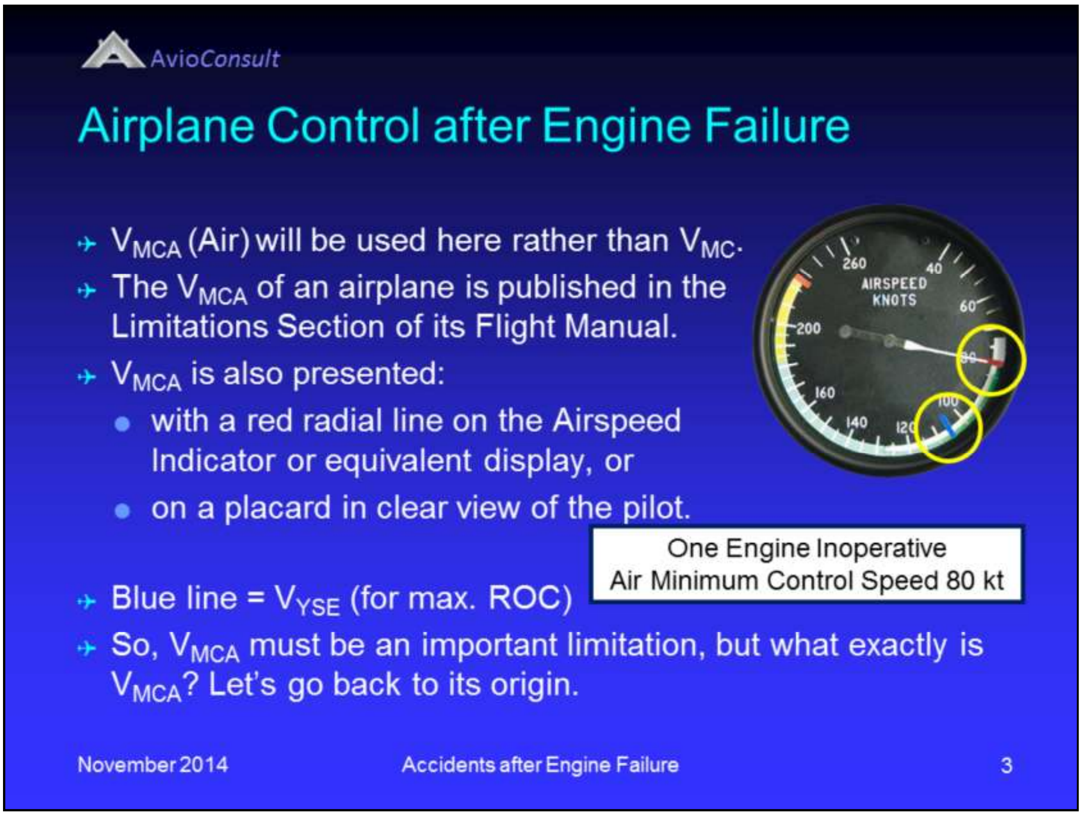
Federal Aviation Regulations & EASA Certification Specifications 23/25 §149 and equivalent require a Minimum Control speed V_{MC}:

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.

There are two requirements for the magnitude of V_{MC} in this Regulation:

1. Maintain control, i.e. recover, following a sudden failure, and
2. Maintain straight flight during the remainder of the flight while an engine is inoperative.

Please notice that there is absolutely no requirement for maintaining control during turns at airspeeds as low as V_{MC} – only for straight flight!



V_{MCA} (for Minimum Control speed in the Air) will be used in this presentation rather than V_{MC}. V_{MCA} is more commonly used today to distinguish between other V_{MC}'s.

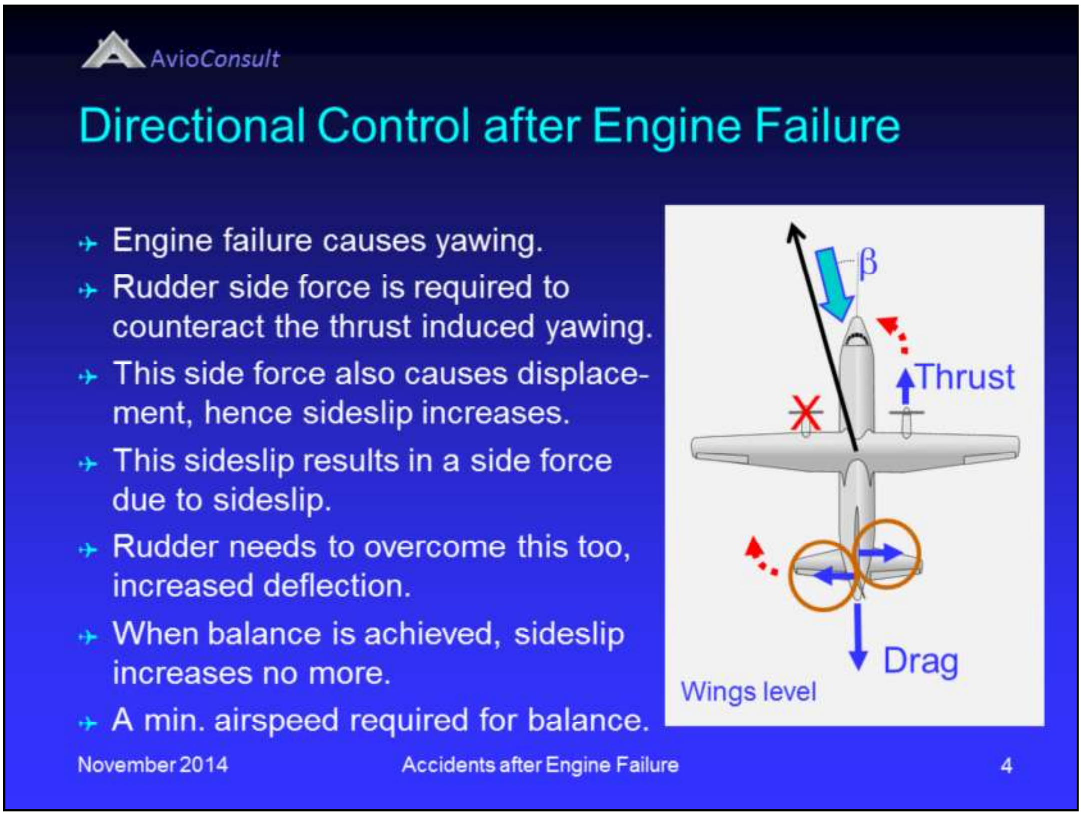
The V_{MCA} of an airplane is published in the Limitations Section of its Flight Manual.

V_{MCA} is also presented:

- with a red radial line on the Airspeed Indicator or on equivalent – electronic – displays, or
- on a placard in clear view of the pilot and as close as possible to the airspeed indicator for heavier and turbine powered Part 23 airplanes.

Blue line speed = V_{YSE}, the airspeed for max. ROC with a single engine.

So, V_{MCA} must be an important limitation, but what exactly is V_{MCA}? Let’s go back to its origin.



Some about directional control after engine failure.

Engine failure causes the airplane to yaw into the failed engine.

A rudder side force is and stays required to counteract the thrust induced yawing moment.

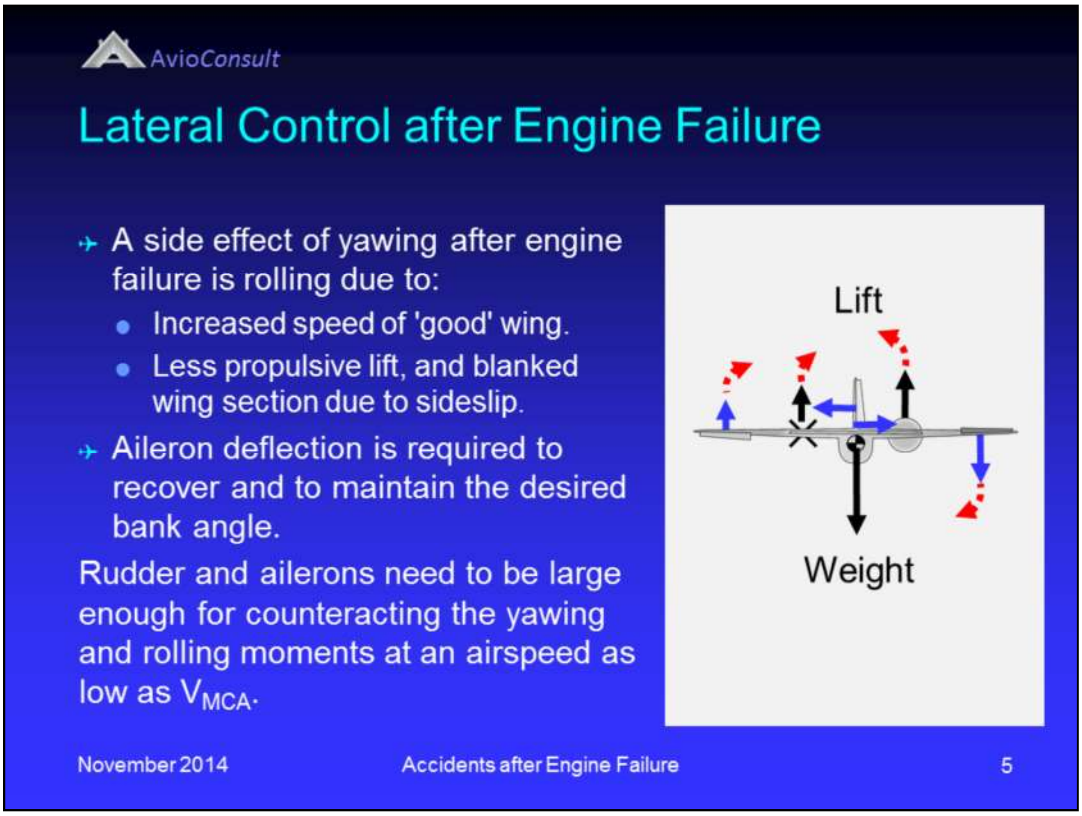
This rudder side force also causes displacement to the dead engine side, hence a sideslip starts to increase.

This increasing sideslip results in an increasing opposite side force due to sideslip caused by the fuselage and vertical tail.

The rudder needs to overcome this increasing side force too, increasing the rudder deflection is required.

When a balance of side forces is achieved, sideslip increases no more.

There is a minimum airspeed required to generate the required side force for balancing the thrust yawing moment and the side force due to sideslip. We'll get to that later.



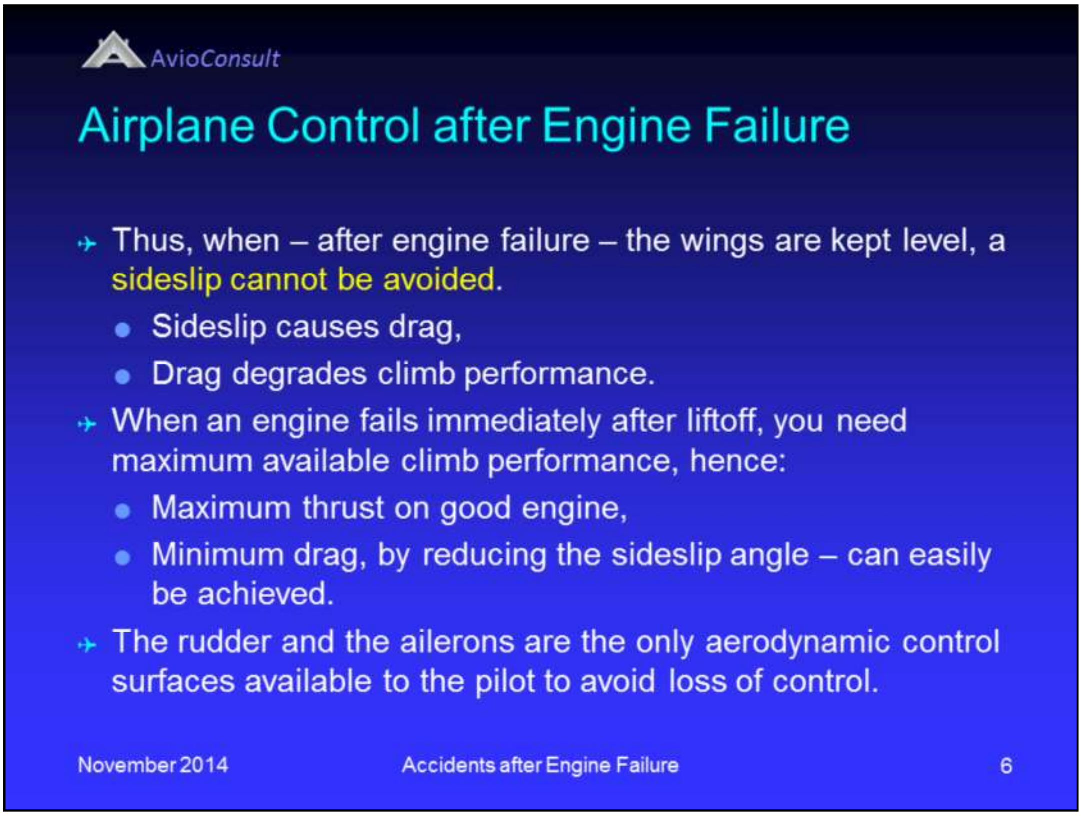
Lateral control after engine failure.

A side effect of yawing after engine failure is rolling due to:

- Increased speed of the 'good' wing.
- Less propulsive lift of the wing section behind the propeller, and less lift of the affected wing, because a section of the wing is blanked from the wind by the fuselage due to the sideslip.

So, aileron deflection is required to recover and to maintain the desired bank angle.

The V_{MC} requirement in the Aviation Regulations require the rudder and ailerons to be large enough for counteracting the yawing and rolling moments at an airspeed as low as V_{MCA}.



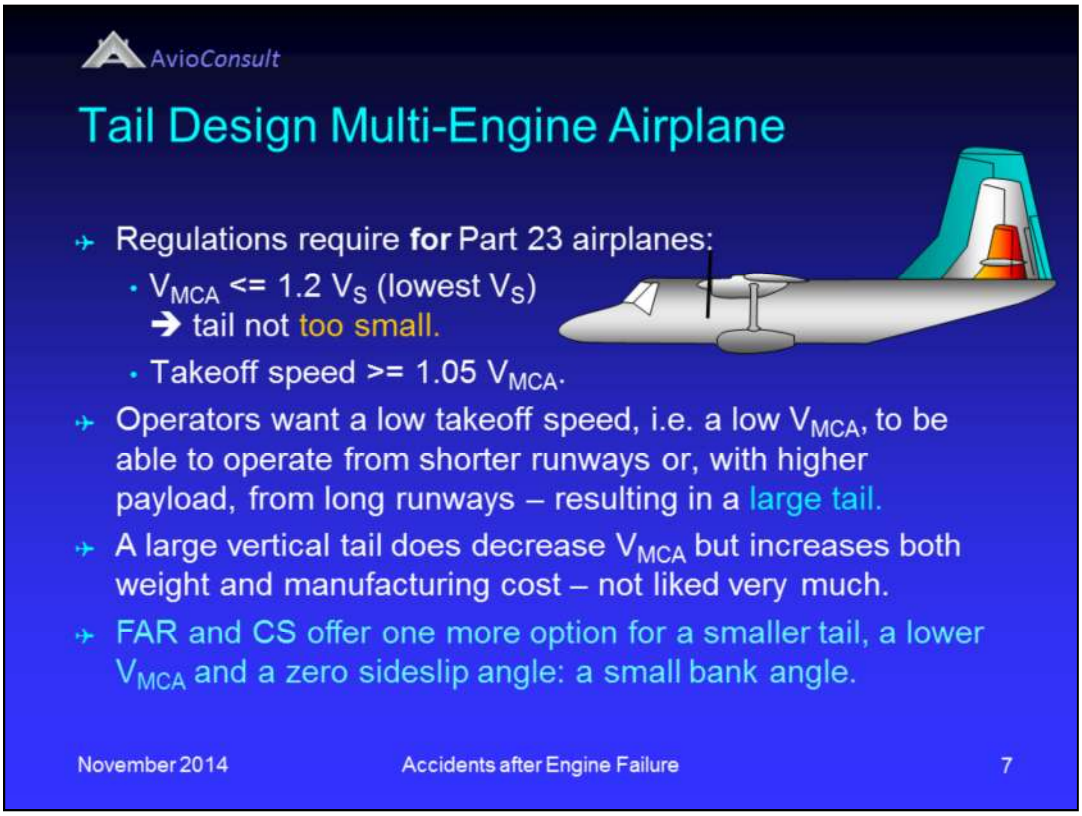
Thus, when – after engine failure – the wings are kept level, a sideslip cannot be avoided. However, …

- Sideslip causes drag,
- Drag degrades the climb performance, especially …

When an engine fails immediately after liftoff, you need maximum available climb performance, hence:

- You would select maximum thrust on the good engine,
- You would like minimum drag, by reducing the sideslip angle – this can easily be achieved as I will show you later.

The rudder and the ailerons are the only aerodynamic control surfaces available to the pilot for maintaining an equilibrium, a balance of forces and moments after engine failure to avoid the loss of control.



A few words on tail design.

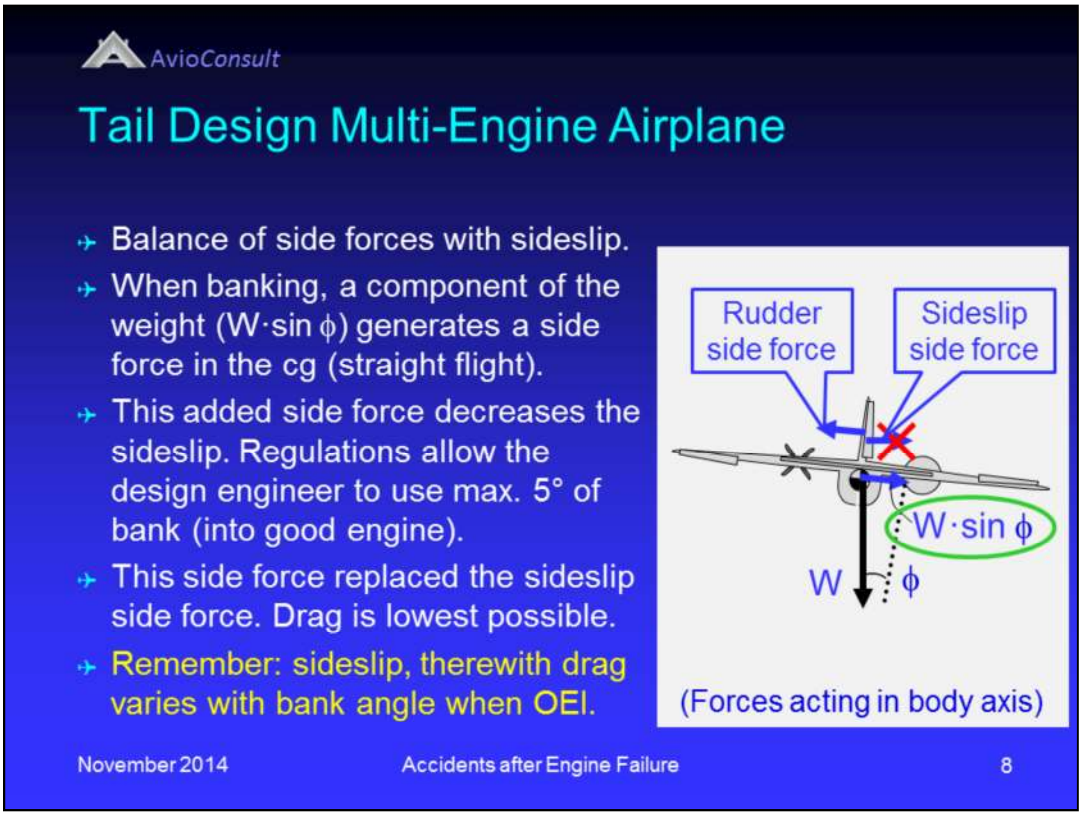
Aviation Regulations require for Part 23 airplanes:

- V_{MCA} to be less than, or equal to 1.2 V_S.
  → so the tail cannot be made too small.
- The takeoff speed must be greater than, or equal to 1.05 V_{MCA}; a 5% safety margin above V_{MCA}.

Operators want a low takeoff speed, i.e. a low V_{MCA}, to be able to operate from shorter runways or, with higher payload, from long runways – resulting in a large tail.

A large vertical tail does decrease V_{MCA} but increases both weight and manufacturing cost – not liked very much.

The Regulations offer one more option for a smaller tail, a lower V_{MCA} and a zero sideslip angle, which is a small bank angle.



The figure shows a balance of side forces of rudder and sideslip as mentioned before. With the wings level, a sideslip cannot be avoided. Of course there are many more forces and moments acting on the airplane, but these are the most important ones.

When banking, a component of the weight (W·sin ϕ – Weight times the sine of bank angle ϕ) generates a side force in the center of gravity (during straight flight).

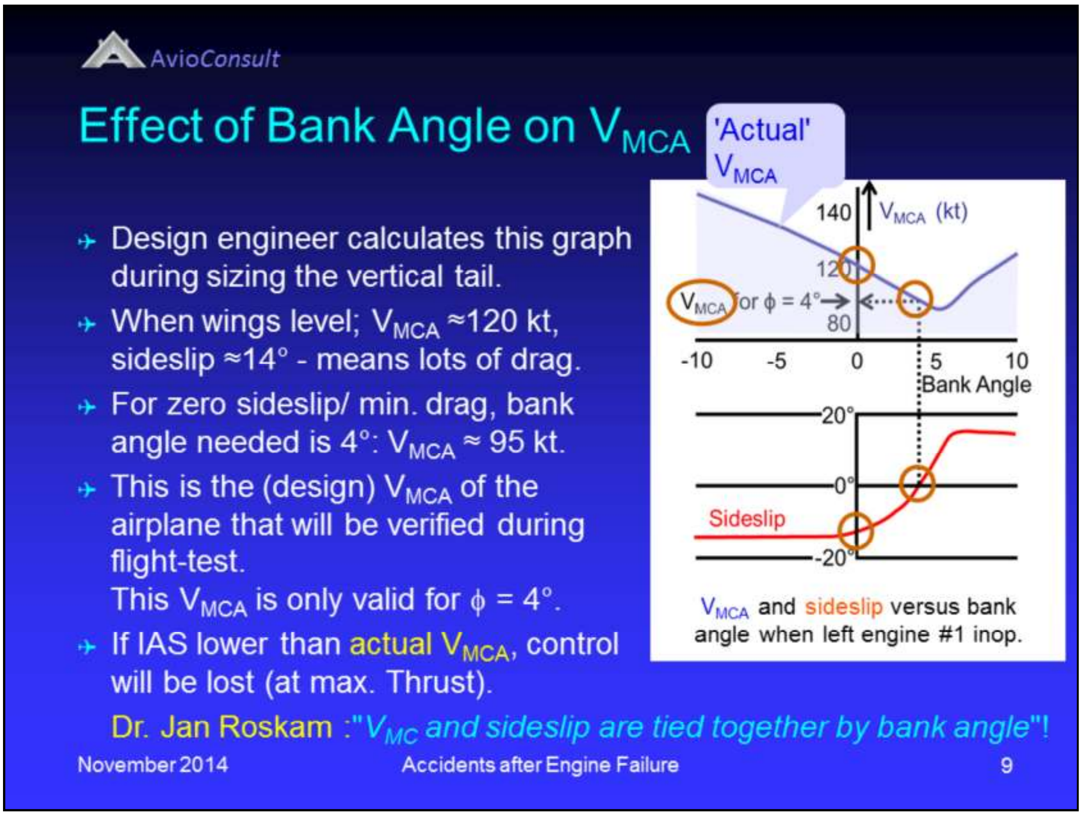
So this small bank angle adds a side force, in this example to the right, decreasing the sideslip. The V_{MC} definition in Aviation Regulations allow the tail design engineer to use max. 5° of bank (which is of course into good engine for the balance of forces). A larger bank angle increases this side force to a value higher than the rudder side force, increasing the sideslip to the same side, which might cause the vertical fin to stall.

This side force due to bank angle replaced the sideslip side force, hence the drag can become the lowest possible.

Remember: sideslip angle, and therewith the drag varies with bank angle when One Engine Inoperative.

Notes: Forces shown are acting in the lateral body or stability axis (Y). Wing lift is not shown, because it has no component in the Y-body axis.

Side force W·sin ϕ is not the often so-called ‘centripetal force’ that turns the airplane. The airplane is shown in straight flight – with asymmetrical thrust.



The previous slide showed the decrease of sideslip, i.e. the decrease of drag with a small bank angle.

The bank angle also has effect on minimum control speed.

The design engineer calculates this graph during sizing the vertical tail of this sample airplane.
The graph shows V_{MCA} and sideslip versus bank angle when the left engine #1 is inoperative.

When the wings are level; V_{MCA} is calculated to be ≈120 kt, the sideslip ≈14° - which means a lot of drag.

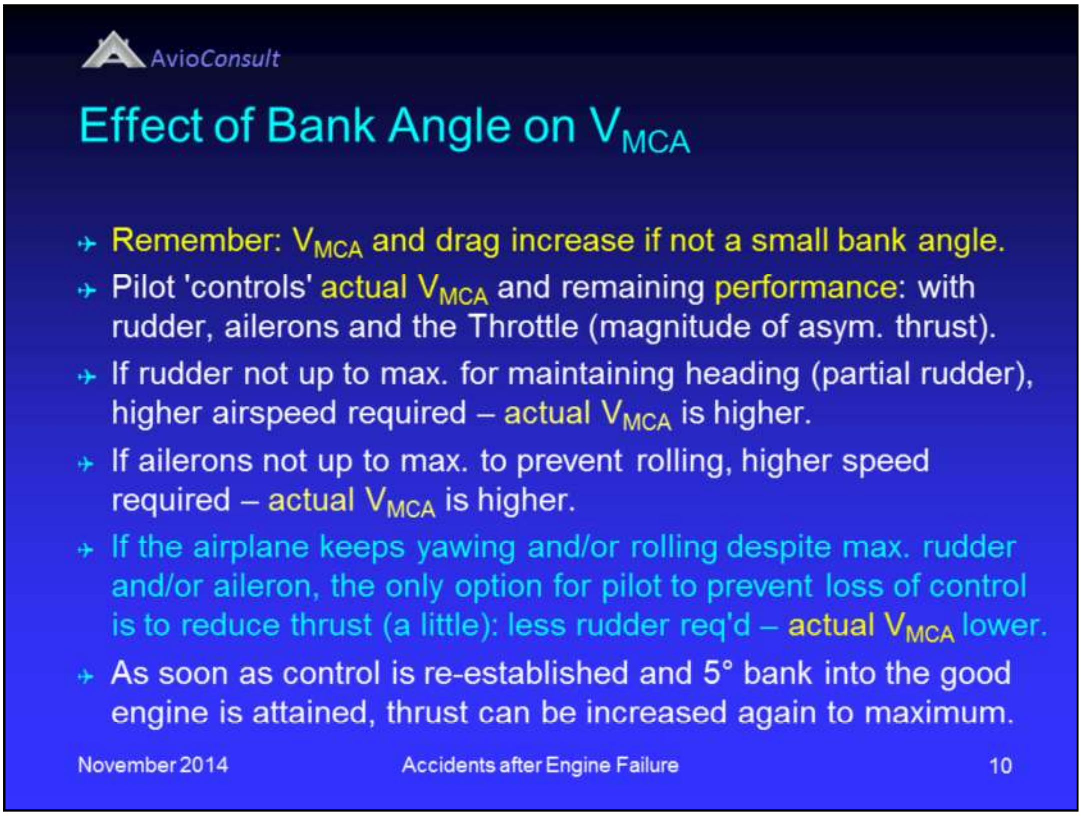
For zero sideslip, i.e. minimum drag, the bank angle needed is 4°: V_{MCA} will then be ≈ 95 kt.

This is the (design) V_{MCA} of the airplane that will be verified during flight-test. This V_{MCA} is only valid for bank angle ϕ = 4°.

This blue line shows the <u>actual</u> V_{MCA}, being the V_{MCA} that the pilot would experience in-flight, for changing bank angles. The actual V_{MCA} increases when the bank angle is smaller or larger than the favorable 4° bank angle for this sample airplane.

If the Indicated Air Speed is lower than the actual V_{MCA}, in this shaded area, control will be lost (at max. Thrust).

Dr. Jan Roskam of the Kansas University wrote in his Airplane Design book on tail design: "V_{MC} and sideslip are tied together by bank angle"!
This graph shows just that.



Remember: Both V_{MCA} and sideslip, i.e. drag, increase if a small bank angle away from the inoperative engine is not maintained. The banking is to the same side as the leg pressure on the rudder pedal.

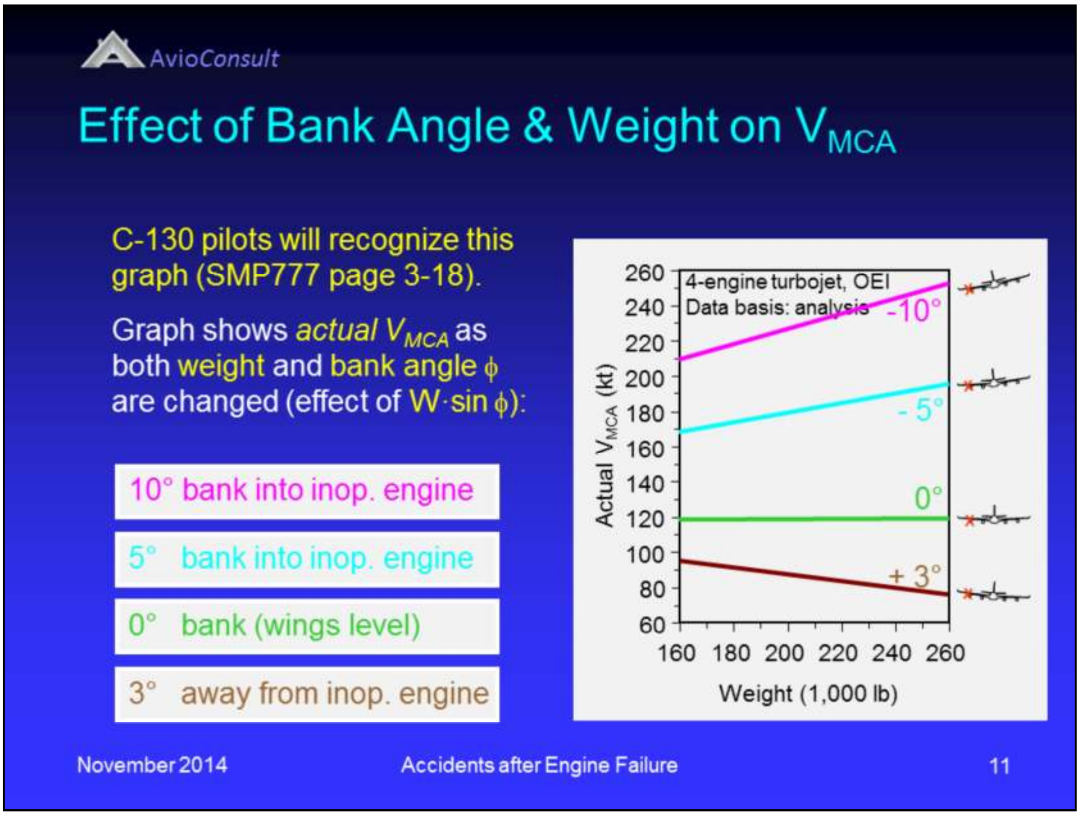
The pilot 'controls' the actual V_{MCA} and the remaining performance with rudder, ailerons and the throttle (magnitude of asymmetrical thrust).

If the rudder not up to maximum for maintaining the heading (we also call that partial rudder), a higher airspeed required – the actual V_{MCA} is higher.

If the ailerons are not up to maximum to prevent rolling, a higher speed is required – actual V_{MCA} is higher.

If the airplane keeps yawing and/or rolling despite maximum rudder and/or aileron, the only option for the pilot to prevent loss of control is to reduce thrust (a little): then the asymmetrical thrust is lower and less rudder is required to counteract – actual V_{MCA} will be lower.

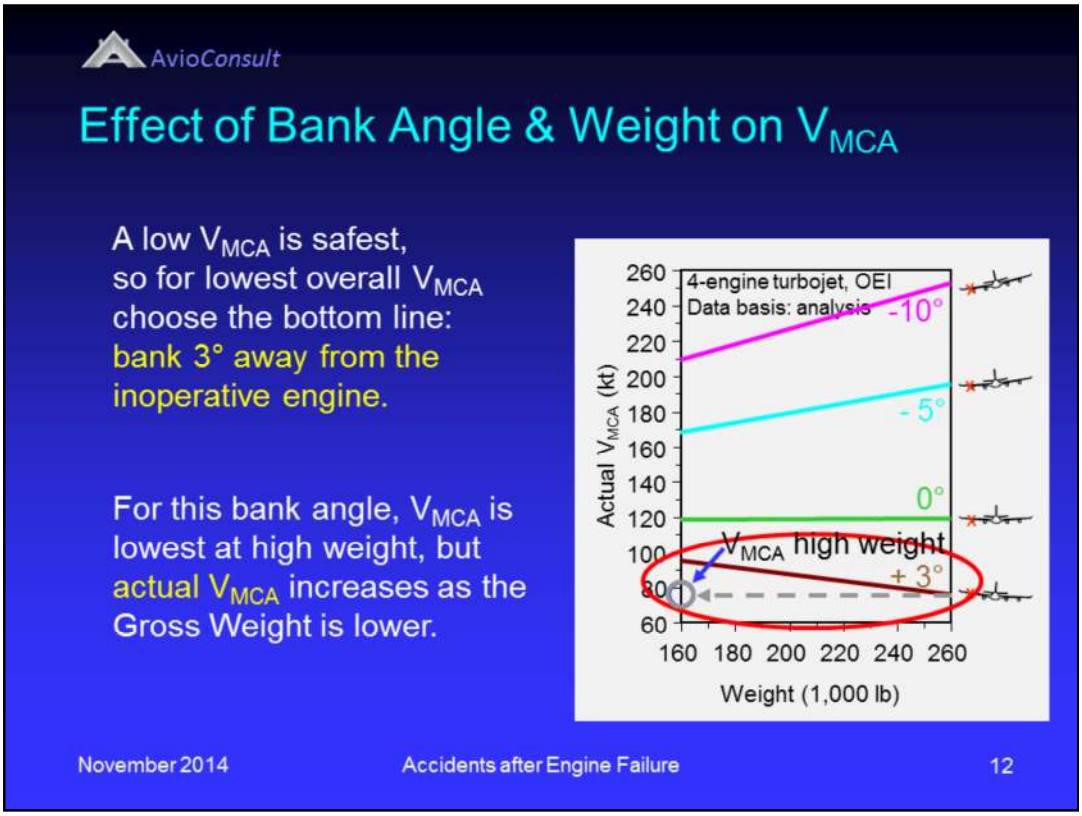
As soon as control is re-established and 5° bank into the good engine is attained, thrust can be increased again to maximum.



The Effect of bank angle & weight on V_{MCA}. Lockheed C-130H pilots will recognize this graph. A similar one is in Performance Manual SMP777 on page 3-18.

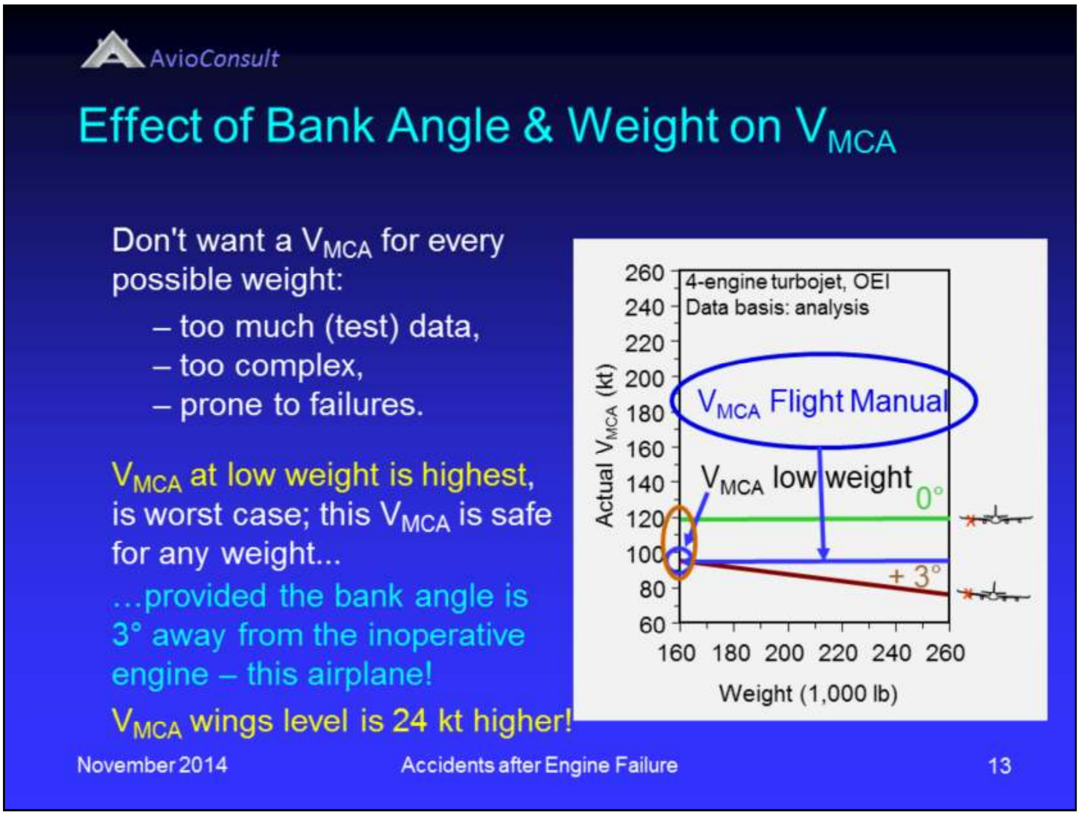
This Graph shows the *actual* V_{MCA} as both weight and bank angle ϕ are changed. This graph shows the effect of side force W·sin ϕ (Weight times the sine of the bank angle ϕ) for several bank angles:

- 3° away from the inoperative engine; I'll discuss this one next.
- 0° bank (wings level). A straight line because sin 0° is zero: weight has no effect on actual V_{MCA}.
- 5° into inoperative engine shown for information, as is
- 10° into inoperative engine.



A low V_{MCA} is safest, so for lowest overall V_{MCA} choose the bottom line: bank 3° away from the inoperative engine for this sample airplane.

For this bank angle, V_{MCA} is lowest at high weight, but actual V_{MCA} increases as the Gross Weight is lower.



We don't want a V_{MCA} for every possible weight:

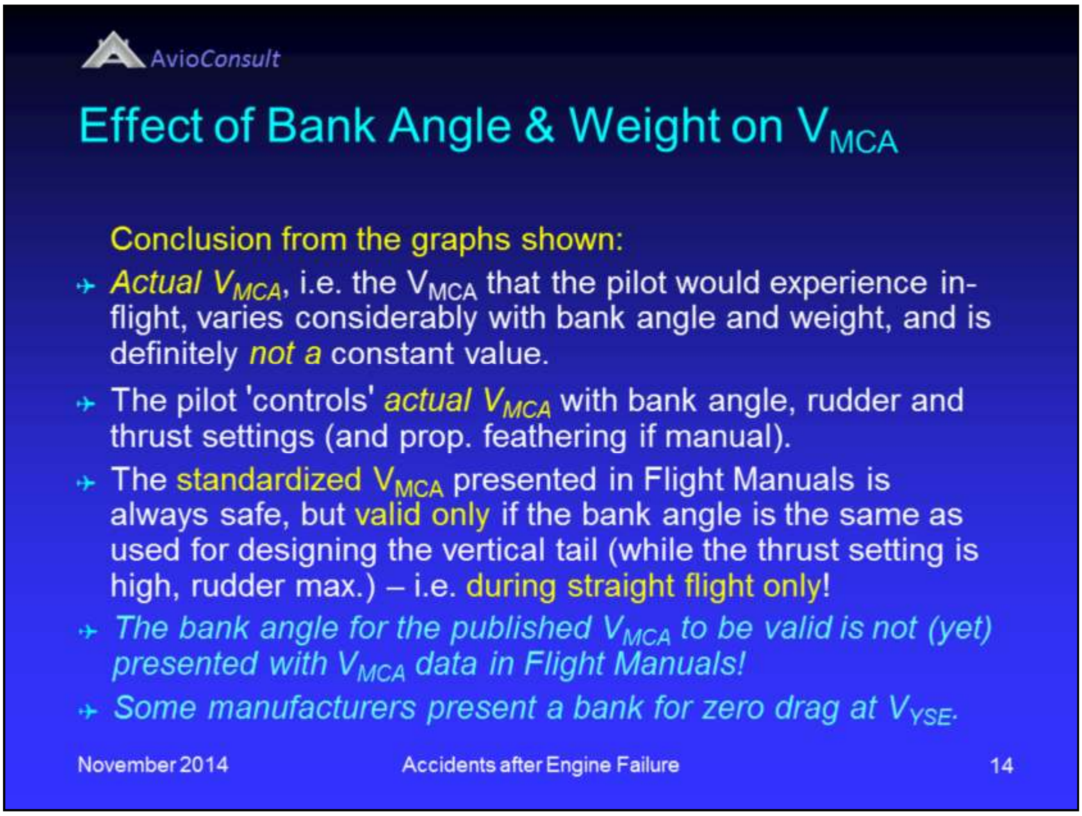
- too much (test) data,
- too complex to look up V_{MCA} for the current gross weight,
- prone to failures.

V_{MCA} at low weight is highest, is worst case; in other words this V_{MCA} is safe for any weight...

…provided the bank angle is 3° away from the inoperative engine – for this airplane!

This is the V_{MCA} that will be published in the Flight Manual and that is valid for all weights.

V_{MCA} wings level is 24 kt higher, which is less safe at low Indicated airspeeds, and in addition, wings level comes with a considerable sideslip as was shown before as well!



Conclusion from the graphs shown:

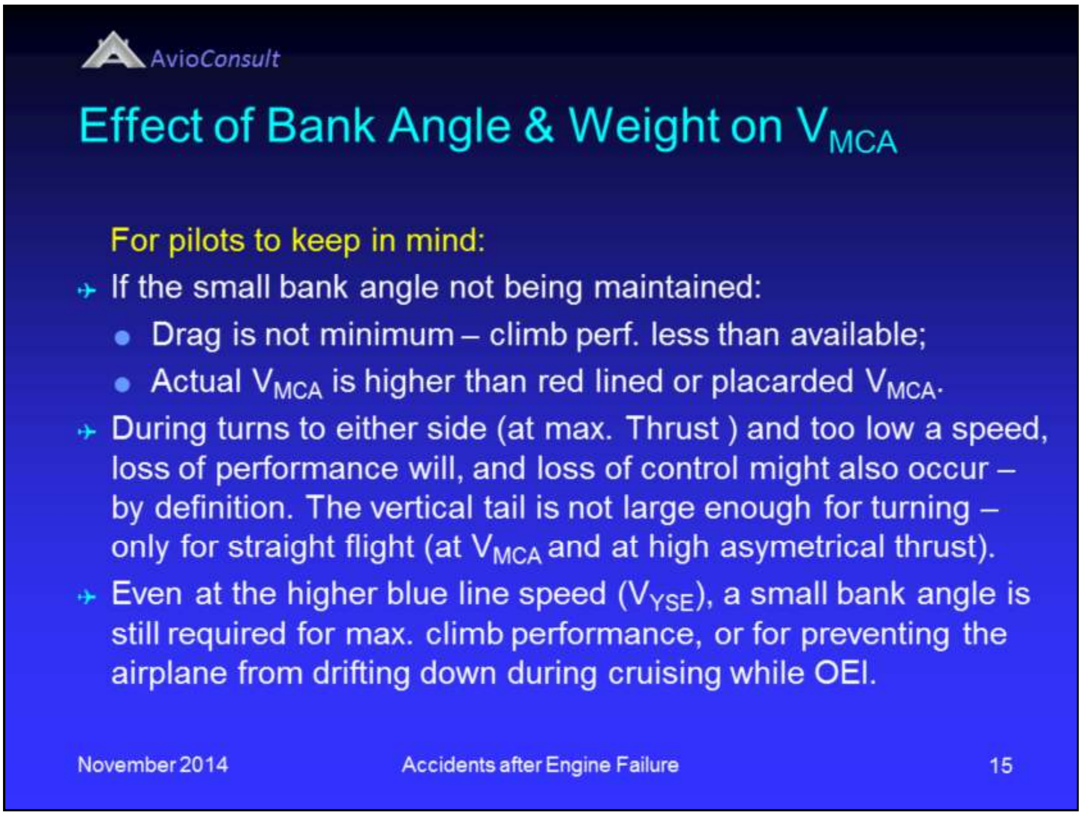
The Actual V_{MCA}, that is the V_{MCA} that the pilot would experience in-flight, varies considerably with bank angle and weight, and is definitely *not a* constant value.

The pilot 'controls' *actual V_{MCA}* with bank angle, rudder and thrust settings (and by propeller feathering if manual – no auto-feather installed).

The standardized V_{MCA} presented in Flight Manuals is always safe, but valid only if the bank angle is the same as used for designing the vertical tail (while the thrust setting is high, rudder max.) – i.e. during straight flight only! Any other bank angle increases the actual V_{MCA}!

The bank angle for the published V_{MCA} to be valid is not (yet) presented with V_{MCA} data in flight manuals, although ...

Some manufacturers do present a bank angle for zero drag at the blue line V_{YSE} in one-engine performance tables or graphs.



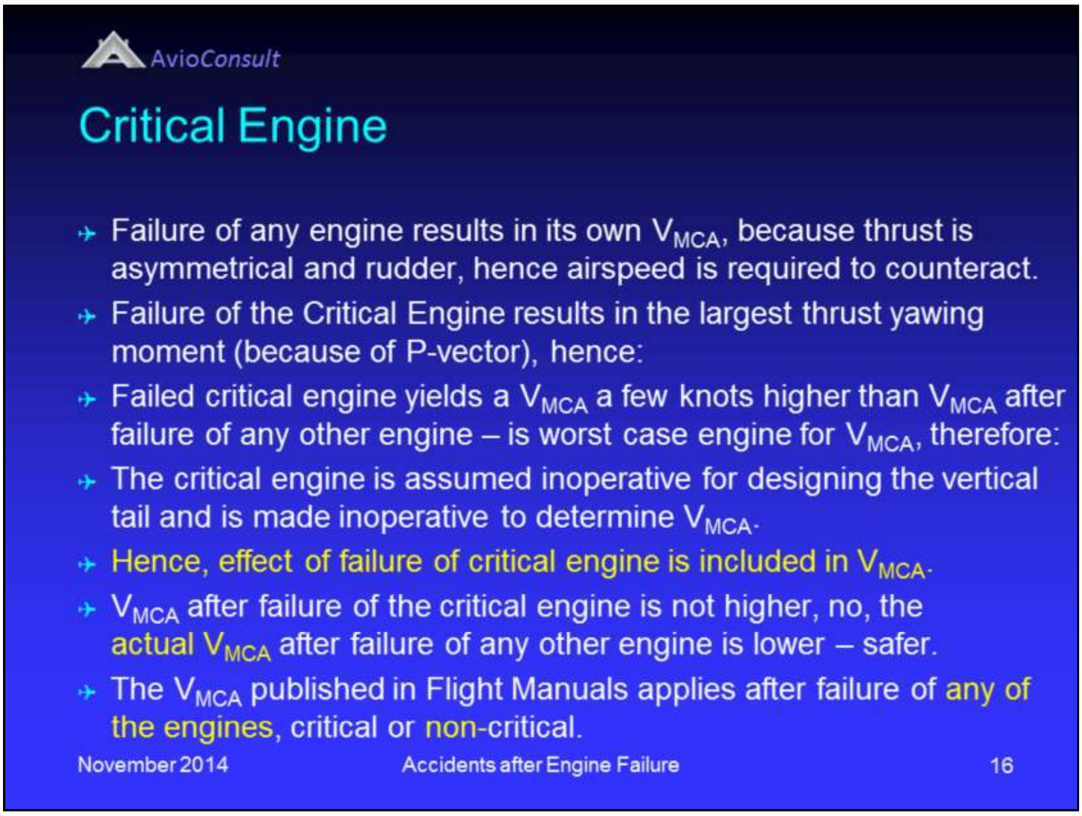
For pilots to keep in mind:

If the small bank angle is not being maintained:

- The drag is not minimum – climb performance is less than would be available;
- The actual V_{MCA} is higher than the red lined or placarded V_{MCA}.

During turns to either side at max. Thrust and too low a speed, loss of performance will, and loss of control might also occur – by definition. The vertical tail is not large enough for turning at airspeeds as low as V_{MCA} and at high asymmetrical thrust – but only for straight flight, which was the requirement in the V_{MC} Regulations as I showed you on one of the first slides.

Even at the higher blue line speed (V_{YSE}), a small bank angle, usually 2 – 3°, is still required for max. climb performance, or for preventing the airplane from drifting down during cruising while One Engine Inoperative.



We now get to the critical engine.

Failure of an engine results in its own V_{MCA}, because while the thrust is the same, the moment arm of the thrust of the remaining opposite engine is not.

Failure of the Critical Engine results in the largest thrust yawing moment (because of P-vector, i.e. the shift of the propulsion vector in the propeller disk when the angle of attack increases due to a decreasing airspeed), hence:

A failed critical engine yields a V_{MCA} that is a few knots higher than the V_{MCA} would be after failure of any other engine – so the critical engine is the worst case engine for the magnitude of V_{MCA}, and therefore:

The critical engine is assumed inoperative for designing, for sizing the vertical tail and is made inoperative during flight-testing to determine V_{MCA}.

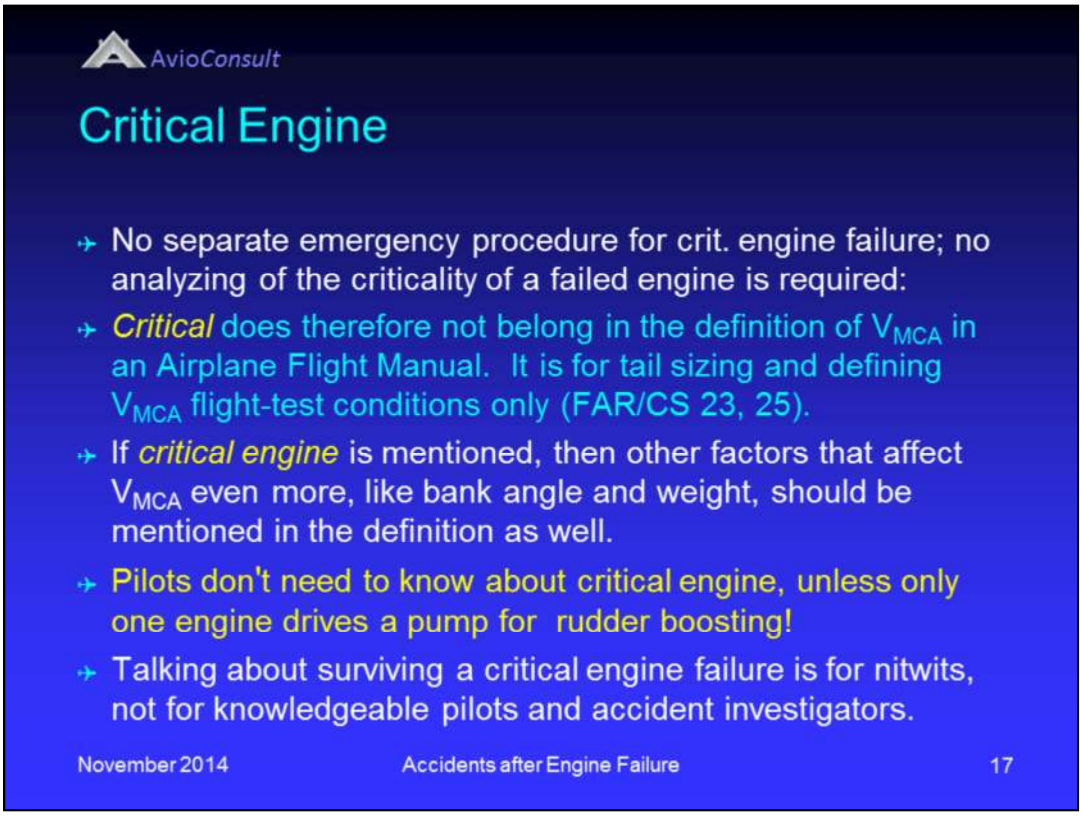
Hence, effect of the failure of the critical engine is <u>included</u> in the published V_{MCA}.

V_{MCA} after failure of the critical engine is not higher, as is written in many publications, no, the actual V_{MCA} after failure of any other engine than the critical engine is lower – which is safer.

The V_{MCA} published in Flight Manuals applies for use by airline pilots after failure of any of the engines though, critical or non-critical. Only one V_{MCA} is published, which is always safe, provided a favorable bank angle – and hence straight flight – is being maintained.

Notes: P-vector (the Propulsion force with a magnitude and direction) is often written as P-factor. Is OK when the P-vector becomes a factor, i.e. when the P-vector shifts in a propeller disc due to increased angle of attack (at lower speeds) and results in a higher V_{MCA} during flight-testing.

The effect of P-factor is included in the AFM-published V_{MCA}.



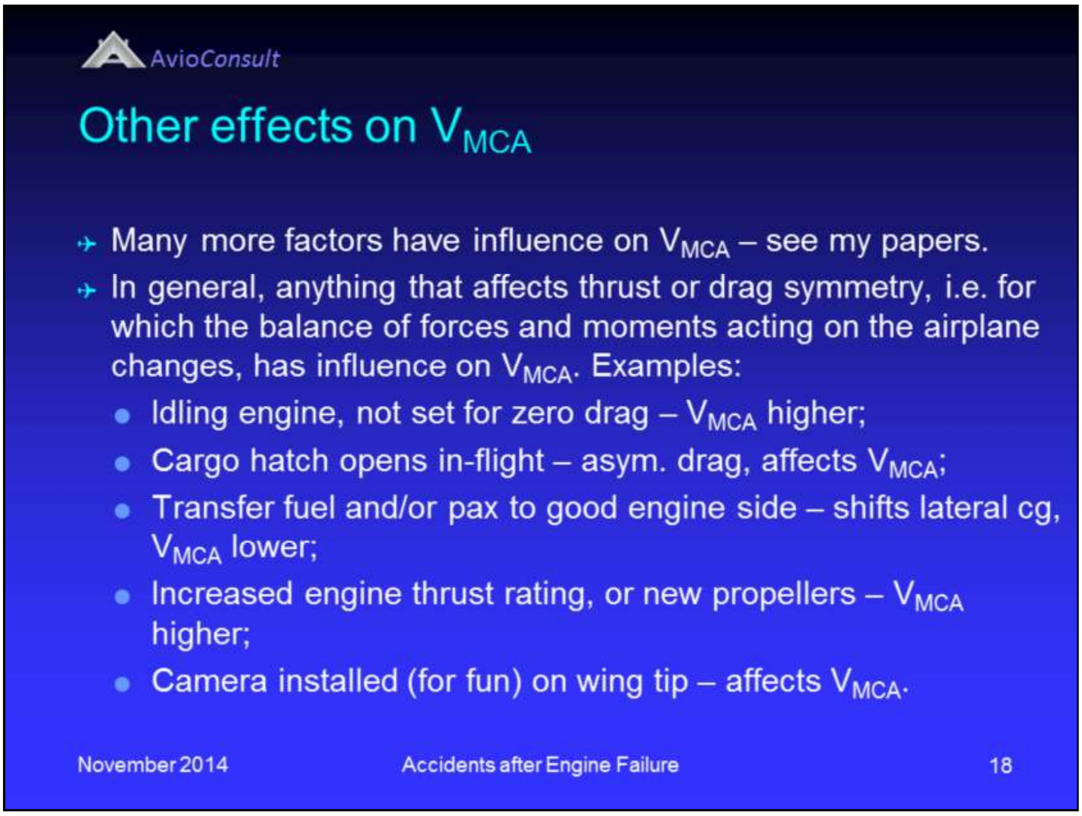
There is no separate emergency procedure for a critical engine failure; no requirement for analyzing the criticality of a failed engine in the cockpit after engine failure:

Critical does therefore not belong in the definition of V_{MCA} in an Airplane Flight Manual, nor in emergency procedures and in textbooks. It is for tail sizing and defining V_{MCA} flight-test conditions only (i.a.w. Aviation Regulations 23 and 25).

If critical engine is mentioned, then the other factors that affect V_{MCA} even more, like bank angle and weight, should be mentioned in the definition as well. But you won't see this, it's of no use.

Pilots don't need to know about the critical engine, unless only one of the engines drives a pump for rudder boosting. This can be the other engine than the engine that would be considered the critical engine.

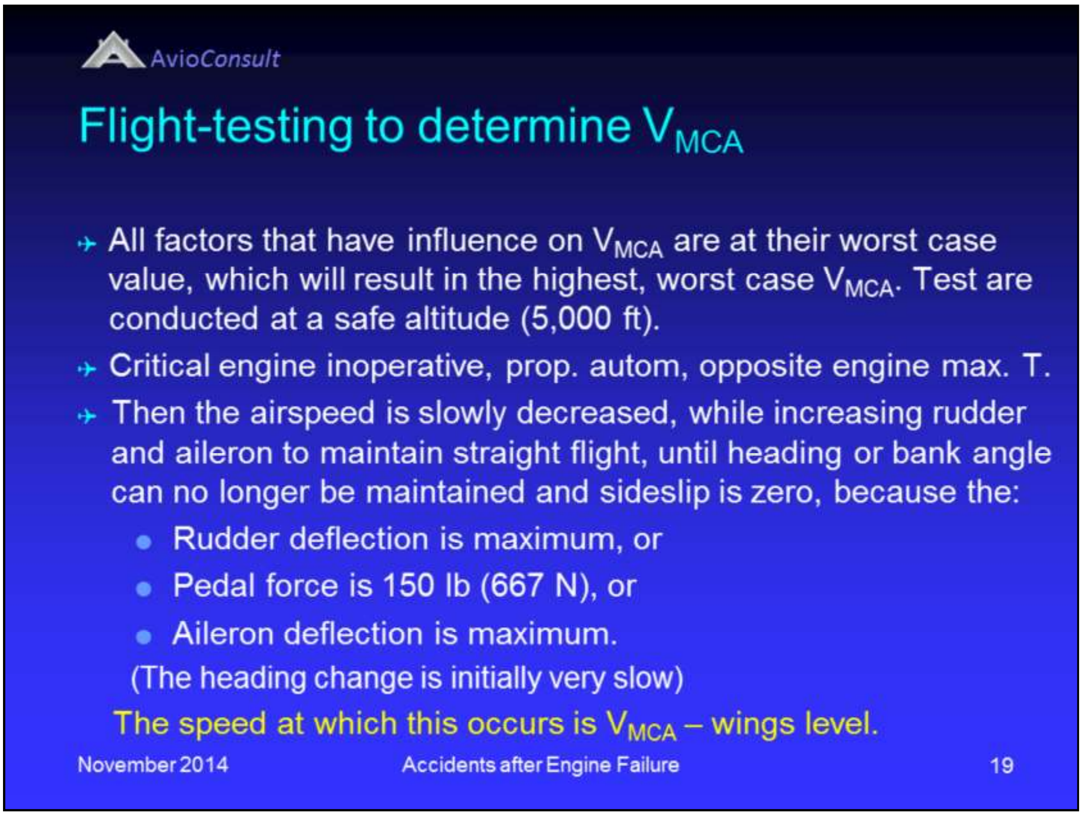
Talking about surviving a critical engine failure is for nitwits, not for knowledgeable pilots and accident investigators – i.e. from now on.



Many more factors have influence on V_{MCA} – see my papers.

In general, anything that affects the thrust or drag symmetry, i.e. for which the balance of forces and moments acting on the airplane changes, has influence on V_{MCA}. Examples:

- An idling engine, not set for zero drag – drag asymmetry is increased, V_{MCA} will be higher;
- Cargo hatch opens in-flight – increases asymmetrical drag, which affects V_{MCA}, this is worst if on the dead engine side;
- The transfer of fuel, and/ or relocating passengers to the good engine side –shifts the center of gravity laterally. The thrust moment arm of the asymmetrical thrust is smaller, and actual V_{MCA} is lower – which is safer;
- Increased engine thrust rating or new, more powerful propellers – will result in a higher V_{MCA}. V_{MCA} should have been determined at the highest possible thrust setting that is possible by the pilot from the cockpit using max. throttles.
- A camera installed just for fun on a wing tip – affects the asymmetrical drag, therewith V_{MCA}.



Flight-testing to determine V_{MCA}

All factors that have influence on V_{MCA} are at their worst case value (low weight, center of gravity aft and into the inoperative engine, etc.), because this results in the highest, worst case V_{MCA} that a pilot would ever experience in-flight, and is therefore safe for publishing in the Airplane Flight Manual. Test are conducted at a safe altitude (5,000 ft) and begin at an airspeed higher than the expected V_{MCA}. For new airplanes, we even have parachutes in the seats.

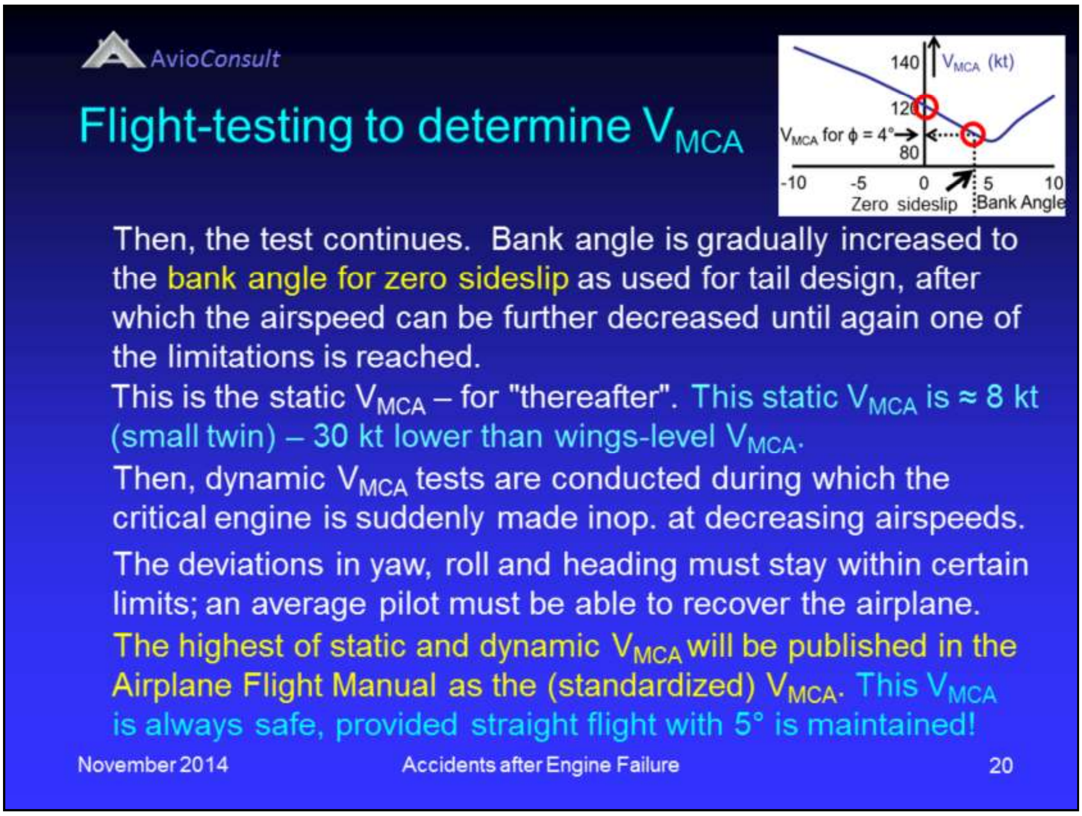
The fuel to the critical engine is cut. The propeller, if applicable, feathers if automatic, otherwise will be wind milling; the opposite engine is set at maximum thrust; both also worst cases.

Then the airspeed is slowly decreased (at a rate of 1 kt/sec), while increasing the rudder and aileron to maintain straight flight, until the heading or bank angle can no longer be maintained, because the:

- Rudder deflection is maximum, or
- Pedal force is 150 lb (667 N), or
- Aileron deflection is maximum or the roll control force is the maximum defined.

(The heading change is initially very slowly).

The airspeed at which this occurs is V_{MCA} – wings level.



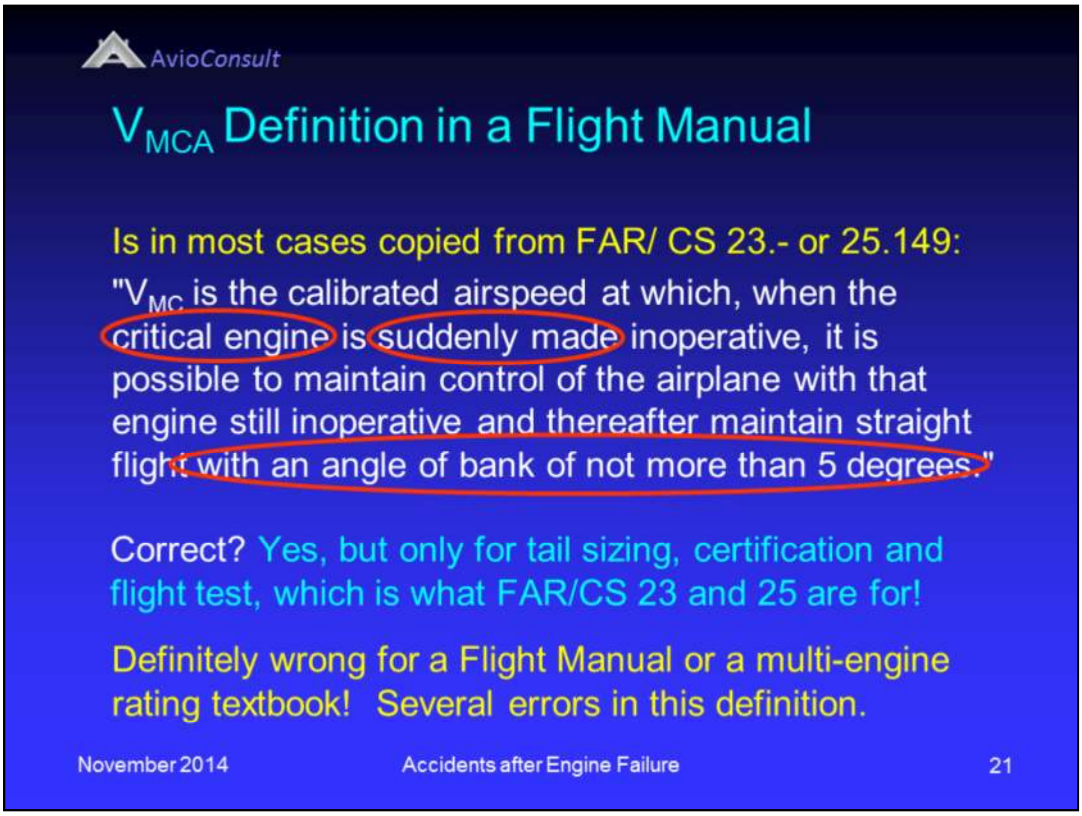
In red, this first test point. Then, the test continues. This graph, made by the tail design engineer, was shown before. The bank angle is gradually increased to the bank angle for zero sideslip as used for tail design after which the airspeed can be further decreased until, with zero sideslip, again one of the rudder and aileron limitations is reached.

This is the static V_{MCA} – for "thereafter" as was defined in the V_{MC} definition in Aviation Regulations. This static V_{MCA} is approximately 8 kt for a small twin, to 30 kt for a 4-engine turbofan lower than wings-level V_{MCA}. These two points are the only two test points during flight-testing to determine the static V_{MCA}.

But the Aviation Regulations require another test to be conducted: the dynamic V_{MCA} test, during which the critical engine is suddenly made inoperative at decreasing airspeed test points.

The Aviation Regulations require that the deviations from the flight path in yaw and roll must stay within certain limits; that an average pilot must be able to recover the airplane.

The highest of static and dynamic V_{MCA} (which is usually the static) will be published in the Airplane Flight Manual as the (standardized) V_{MCA} of the airplane. This V_{MCA} is always safe, even when the thrust is, or is increased to maximum, provided straight flight with 5° of bank into the good engine is maintained!



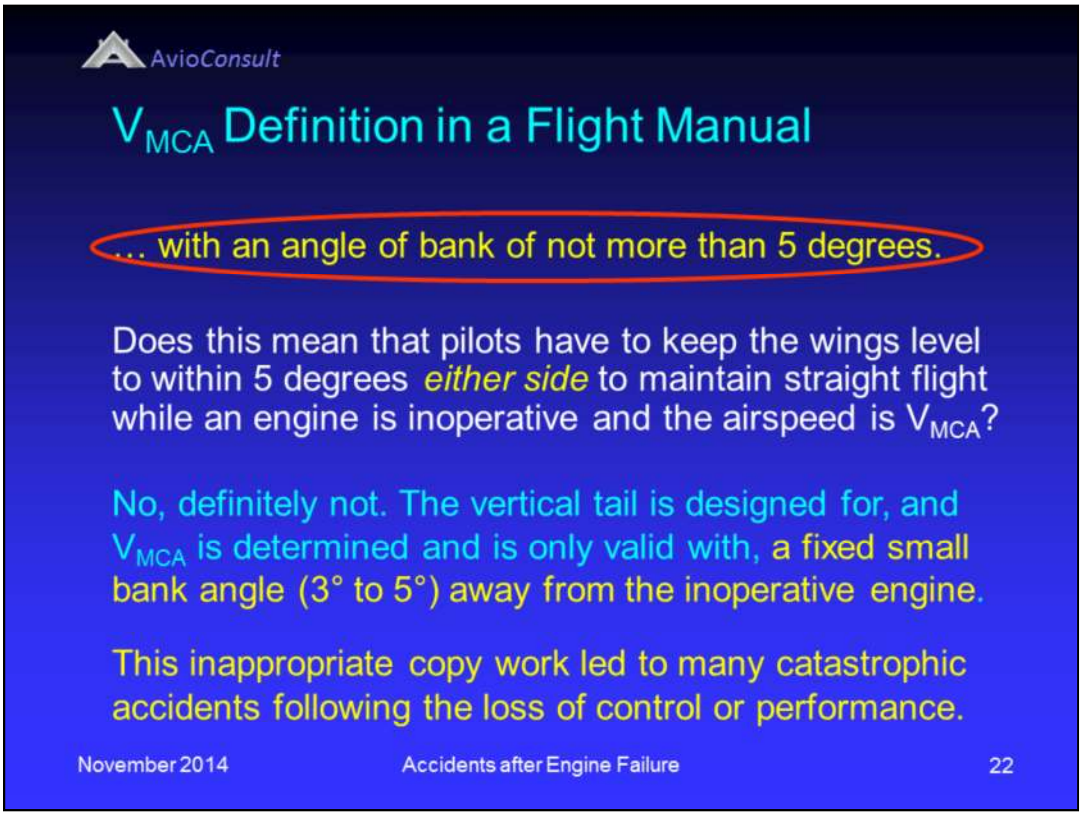
The V_{MCA} definition in flight manuals and flying handbooks.

This definition was already shown before, and is in most cases copied from Design and Certification Regulations 23 or 25 §149.

I will not read it again.

Is this definition correct? Yes, but only for tail sizing, certification and flight test, which is what Aviation Regulations 23 and 25 are for!

This definition is definitely wrong for a Flight Manual, a flying handbook or a multi-engine rating textbook! There are several errors in this definition. I will discuss them with you.

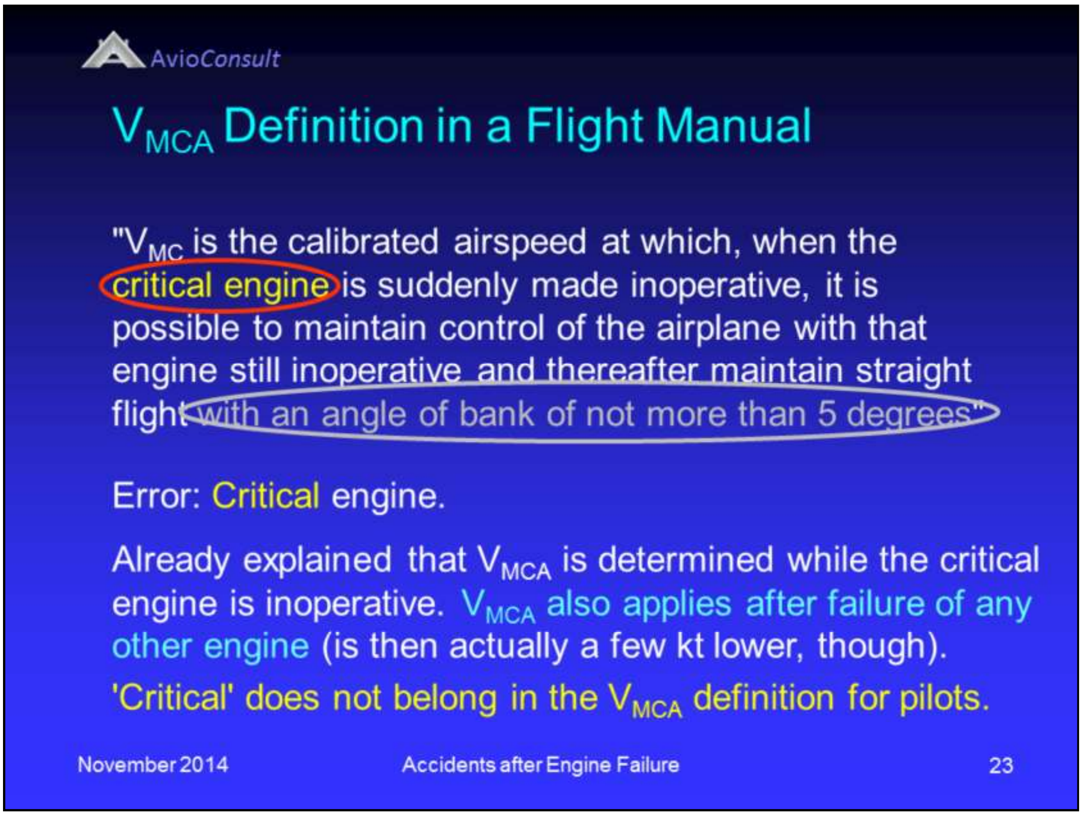


… with an angle of bank of not more than 5 degrees.

Does this mean that pilots have to keep the wings level to within 5 degrees either side to maintain straight flight while an engine is inoperative and the airspeed is V_{MCA}?

No, definitely not. The vertical tail is designed for, and V_{MCA} is determined and is only valid with, a fixed small bank angle of 3 to 5° away from the inoperative engine. The number of degrees depend on the airplane type. The not more than 5° restriction is for the tail design engineer, for sizing the tail large enough to achieve zero sideslip and limit the V_{MCA}.

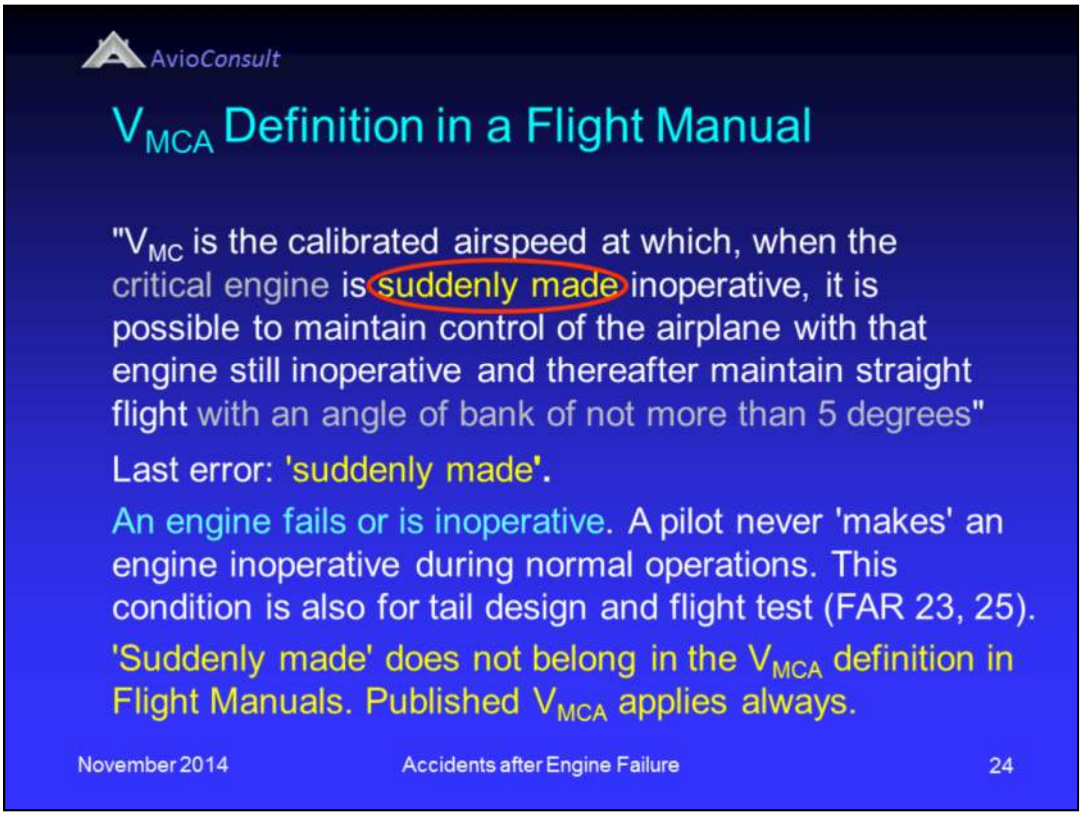
This inappropriate copy work led, to my opinion, to many catastrophic accidents following the loss of control or performance, because the pilots did not maintain straight flight with the favorable bank angle at low speed and high thrust. This inappropriate line is also copied to most, if not all, pilot text books and Airplane Flying Handbooks.



Error: Critical engine.

I already explained that V_{MCA} is determined while the critical engine is inoperative. But V_{MCA} also applies after failure of any other engine; is then actually a few knots lower though, may be even less than the difference between high and low weight.

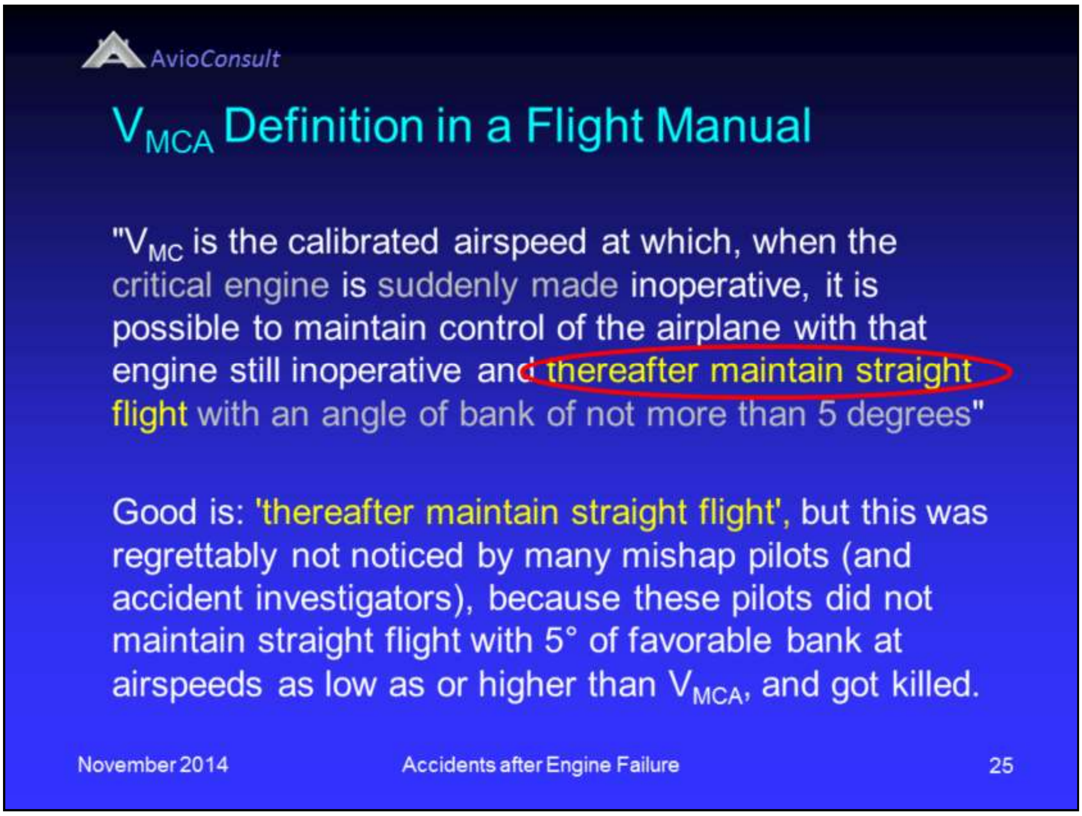
Therefore 'Critical' does <u>not</u> belong in the V_{MCA} definition for pilots. Critical engine <u>never</u> shows up in engine emergency procedures either.



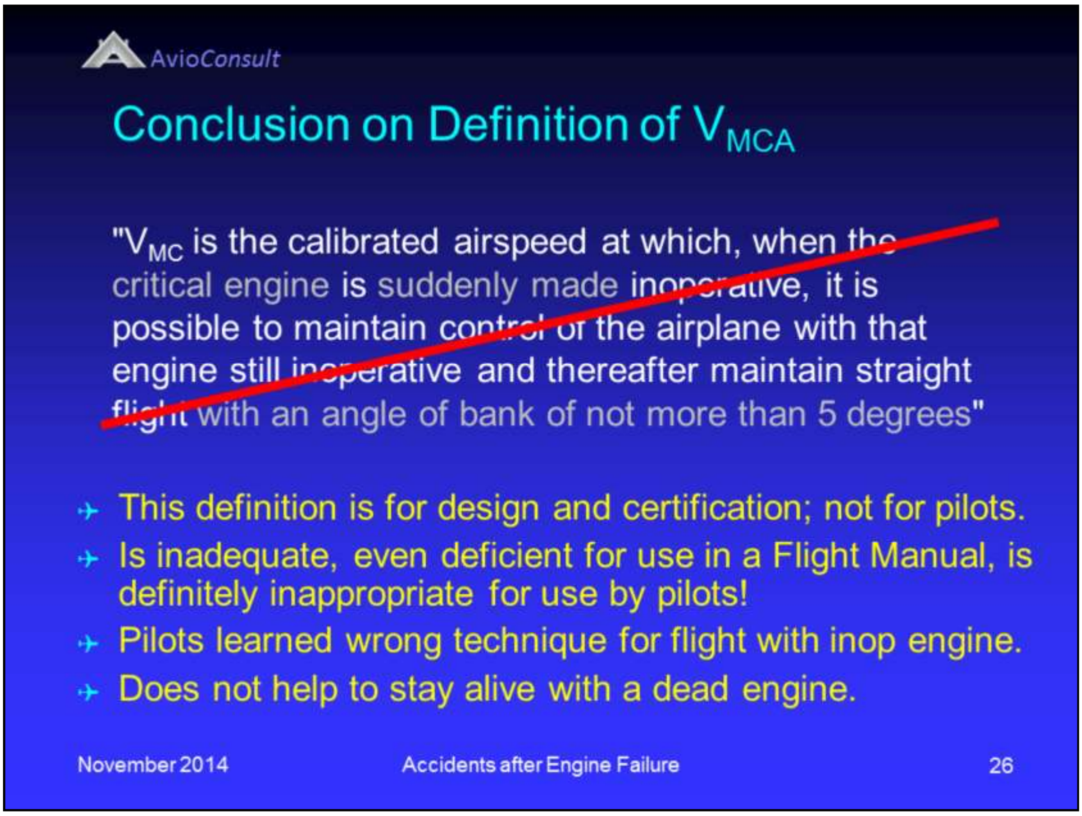
Now the last error: 'suddenly made'.

An engine fails or is inoperative. A pilot never 'makes' an engine inoperative during normal operations. This condition is also for tail design and flight test (Regulations 23 and 25).

'Suddenly made' does not belong in the V_{MCA} definition in Flight Manuals and text books for pilots. The published and indicated V_{MCA} applies always, whether an engine suddenly fails or is inoperative.



Good in this definition is: 'thereafter maintain straight flight', but this was regrettably not noticed by many mishap pilots and accident investigators, because these pilots did <u>not</u> maintain straight flight with 5° of favorable bank away from the inoperative engine at airspeeds as low as or even higher than V_{MCA}, because they turned to downwind for landing too early at too low a speed, or increased the thrust during the final turn for landing, and got killed.

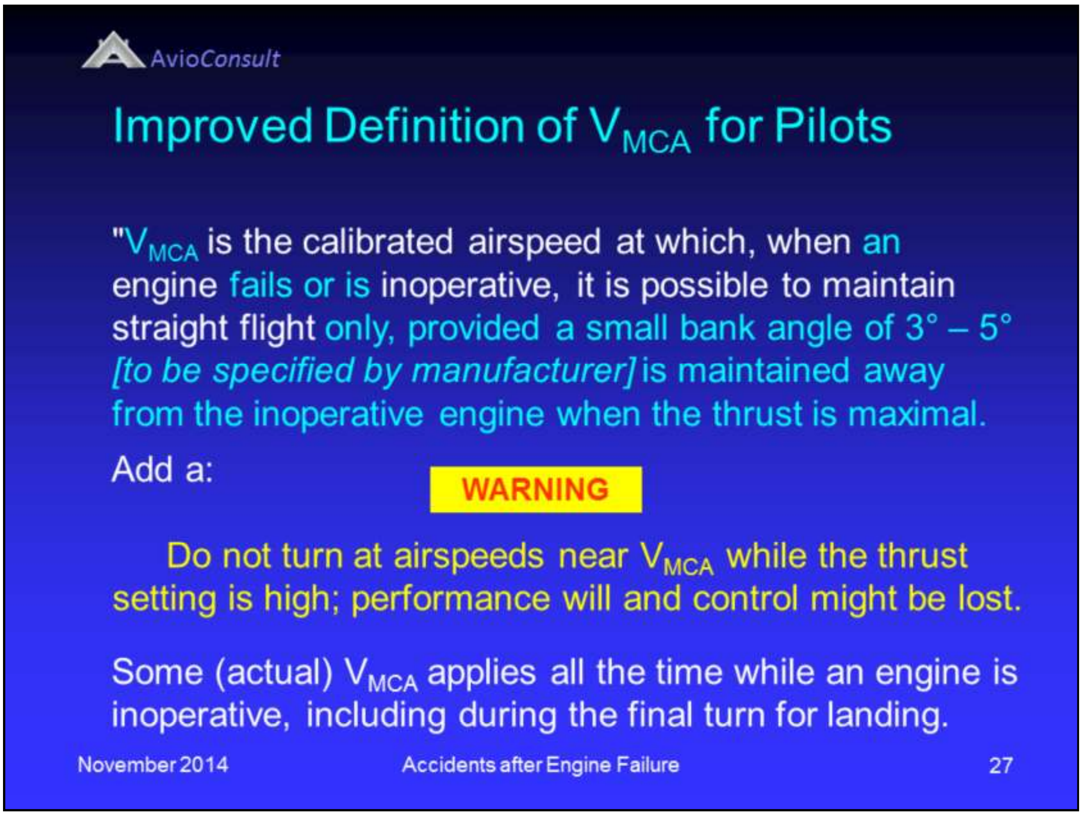


Conclusion on this definition. This definition is for design, certification and flight-test; is not for pilots. It is copied inappropriately from design and certification Aviation Regulations.

This definition is inadequate, even deficient for use in a Flight Manual and in airplane flying handbooks; is definitely inappropriate for use by pilots!

Pilots learned the wrong technique to fly with an inoperative engine at low speed and high thrust setting.

This definition does not help to stay alive with a dead engine.



An improved V_{MCA} definition for pilots would be:

"V_{MCA} is the calibrated airspeed at which, when an engine fails or is inoperative, it is possible to maintain straight flight only, provided a small bank angle of 3° – 5° [to be specified by manufacturer] is maintained away from the inoperative engine when the thrust is maximal".

I would add a warning: Do not turn at airspeeds near V_{MCA} while the thrust setting is high. Performance will, and control might be lost, because some (actual) V_{MCA} applies all the time while an engine is inoperative, including during the final turn for landing when an engine already failed during takeoff.

Takeoff speeds small twins.

I repeat it once more, keeping the wings level increases V_{MCA} to a higher actual value; the increase is approximately 8 kt for a small twin.

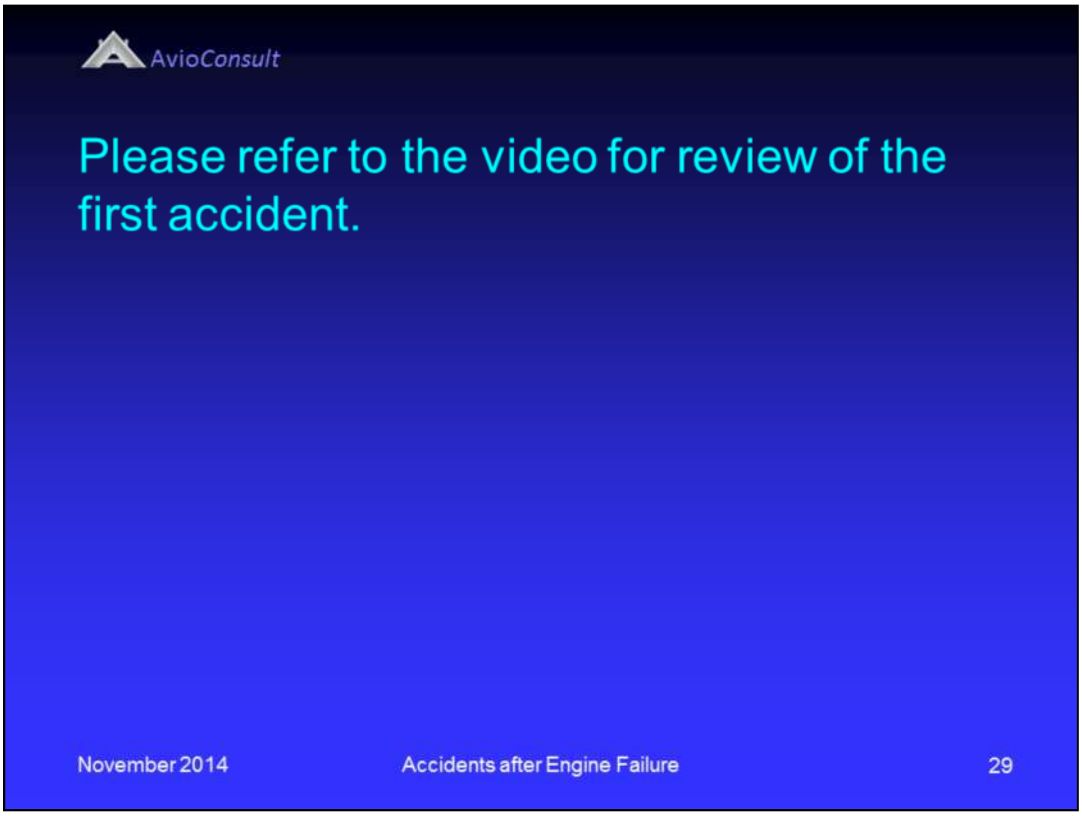
The takeoff speed of small twins is required to be 1.05 times V_{MCA}. This 5% safety margin is however not high enough.

Since the wings are level at liftoff, it is recommended to use at least 1.05 V_{MCA} +10 kt as a safe takeoff speed for a small twin.

Ask the manufacturer of your airplane for the wings-level V_{MCA}, so that you can add a 5% safety margin to that speed.

Following engine failure, attaining 5° away from the inoperative engine should never be delayed, because

Bank angle is required for both performance and control.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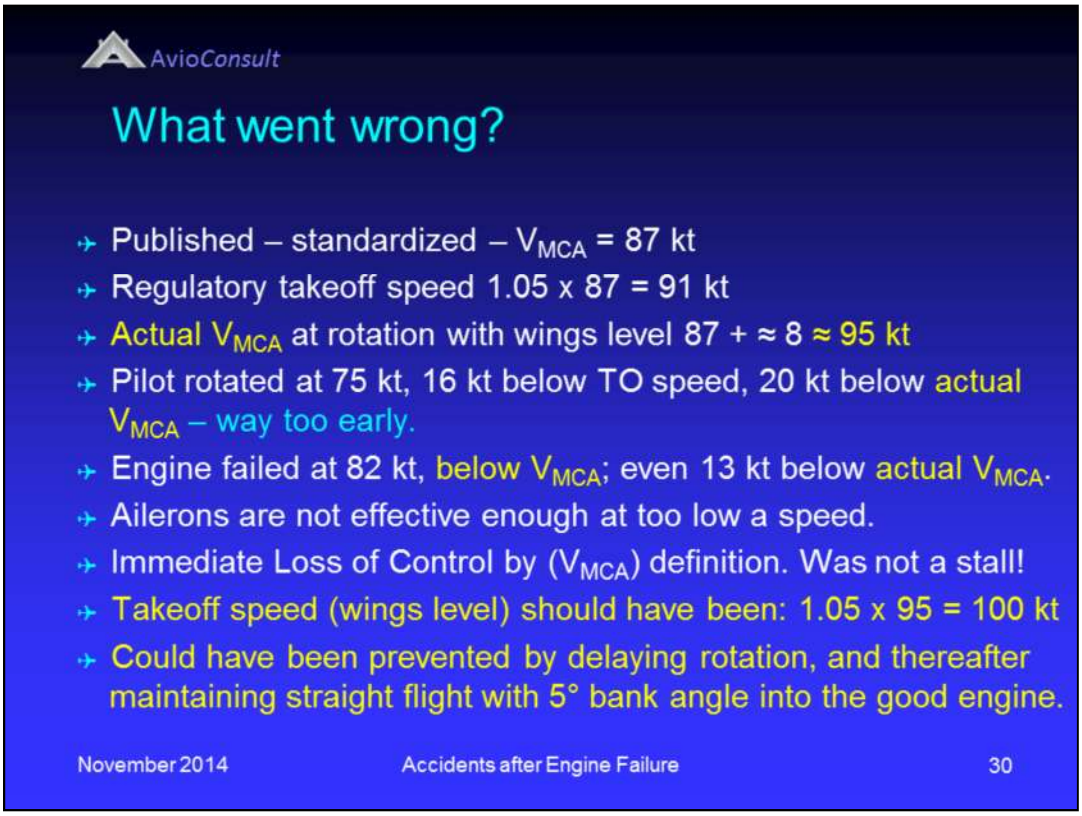


Published – standardized – V_{MCA} in the flight manual = 87 kt.

The regulatory takeoff speed would then be 1.05 x 87 = 91 kt.

The actual V_{MCA} at rotation with the wings level is 87 + approximately 8 kt = 95 kt.

The Pilot rotated at 75 kt, 16 kt below takeoff speed, 20 kt below actual V_{MCA} – way too early.

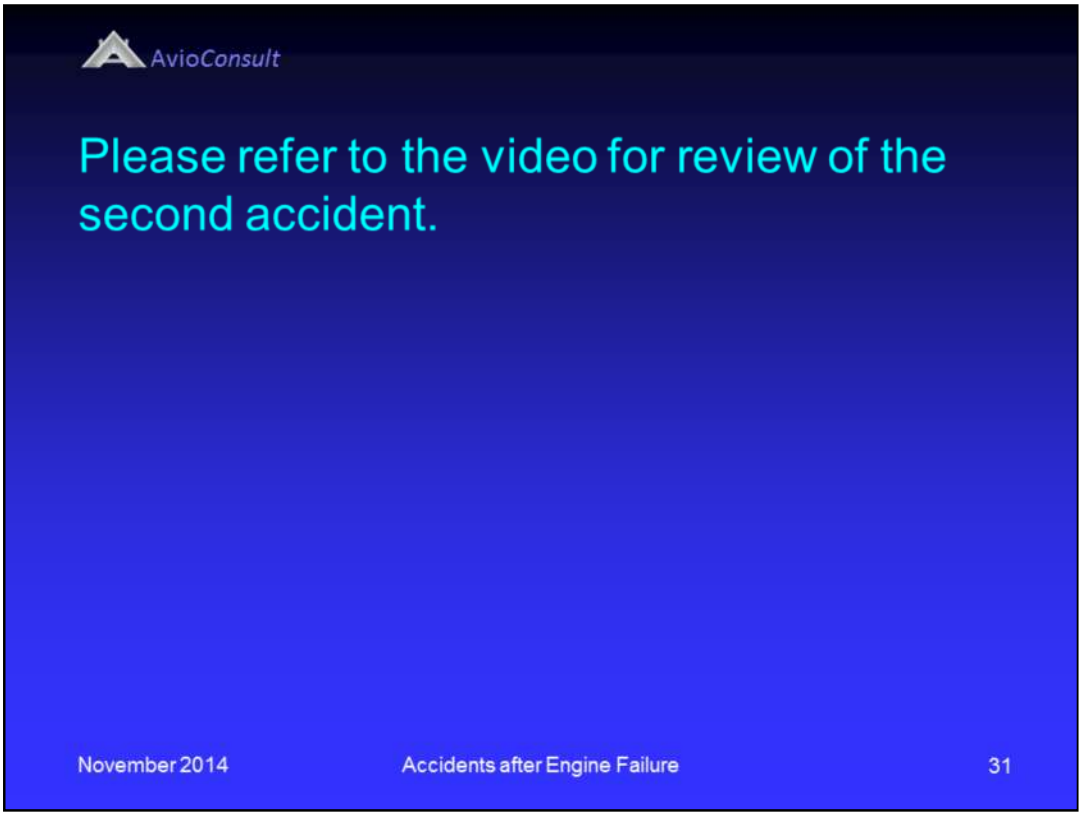
The right (non- critical) engine failed at 82 kt, 5 kt below V_{MCA}; even 13 kt below actual V_{MCA}.

Ailerons were either not max. or not effective enough at too low a speed.

Immediate Loss of Control by (V_{MCA}) definition. This was not a stall!

Takeoff speed (wings level) should have been: 1.05 x wings level V_{MCA}, i.e. 1.05 x 95 = 100 kt.

This accident could have been prevented by delaying rotation until the airspeed was 100 kt, and thereafter by maintaining straight flight with 5° bank angle into the good engine.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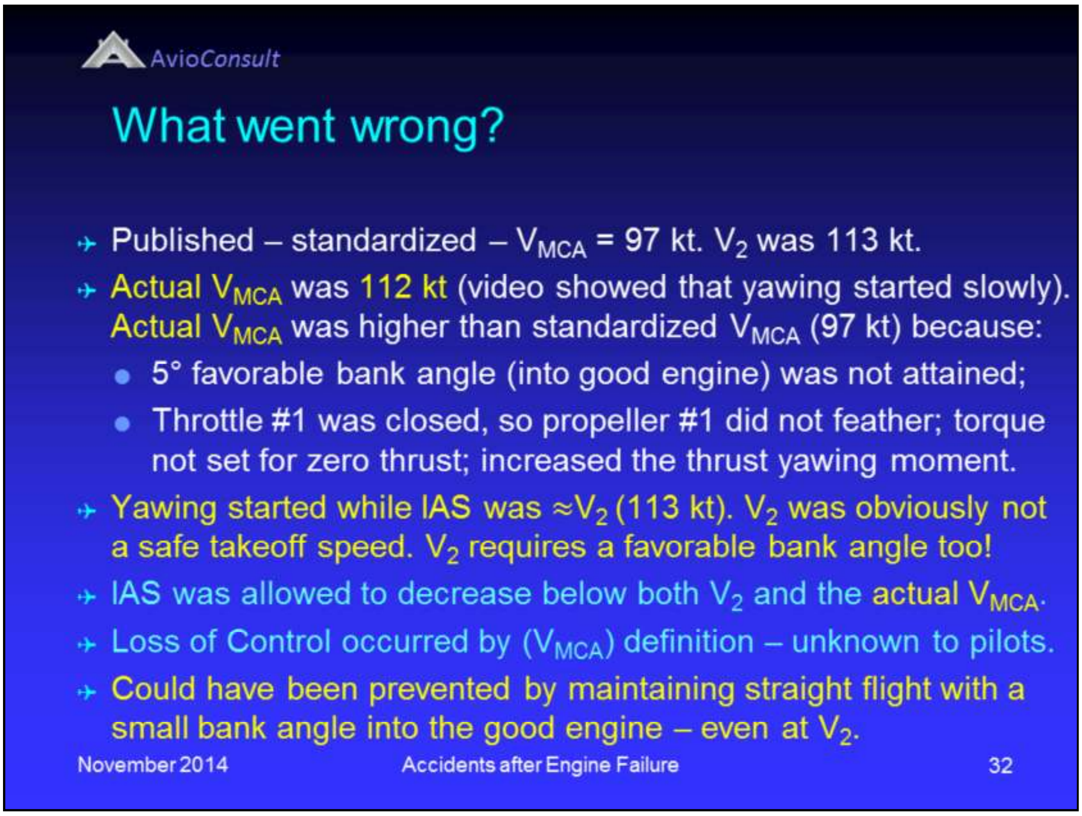


Published – standardized – V_{MCA} = 97 kt. V_2 was 113 kt.

The actual V_{MCA} was 112 kt (because the video showed that the yawing started slowly).
The actual V_{MCA} was higher than the standardized V_{MCA} (97 kt) because:

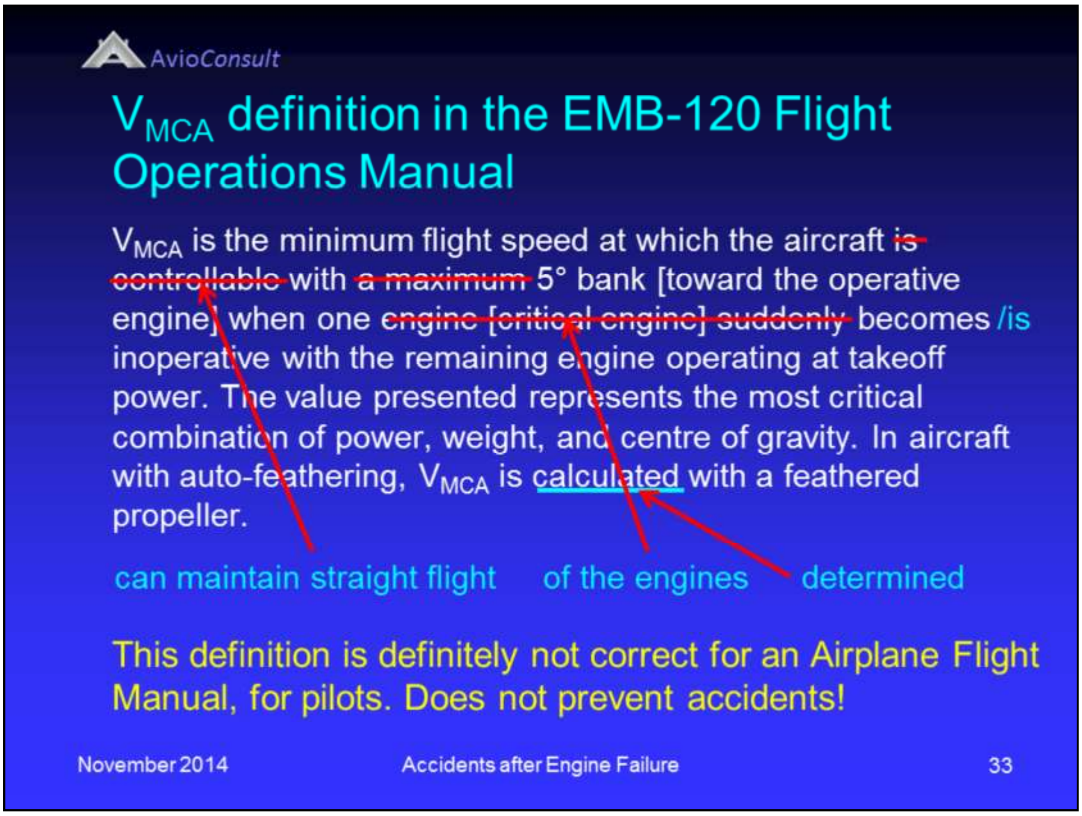
- 5° favorable bank angle (into good engine) was not attained;
- Throttle #1 was closed, so propeller #1 did not auto-feather; in addition, the torque was not set for zero thrust, both of which increased the thrust yawing moment, increasing the rudder requirement, or required a higher airspeed for counteracting the thrust yawing moment.

What the accident investigation report did not mention, is that the yawing started while Indicated Airspeed (IAS) was ≈ V_2 (113 kt). V_2 was obviously not a safe takeoff speed. Takeoff safety speed V_2 obviously requires a favorable bank angle too!

The IAS was allowed to decrease below both V_2 and the actual V_{MCA}.

So the Loss of Control occurred by (V_{MCA}) definition. The pilots and the accident investigators were not familiar with the true value of V_{MCA} and the accompanying constraints.

This accident could have been prevented by maintaining straight flight with a small bank angle into the good engine – even at takeoff safety speed V_2. V_2 on this airplane requires an increment to make it a safer takeoff safety speed.



V_{MCA} definition in the EMB-120 Flight Operations Manual.

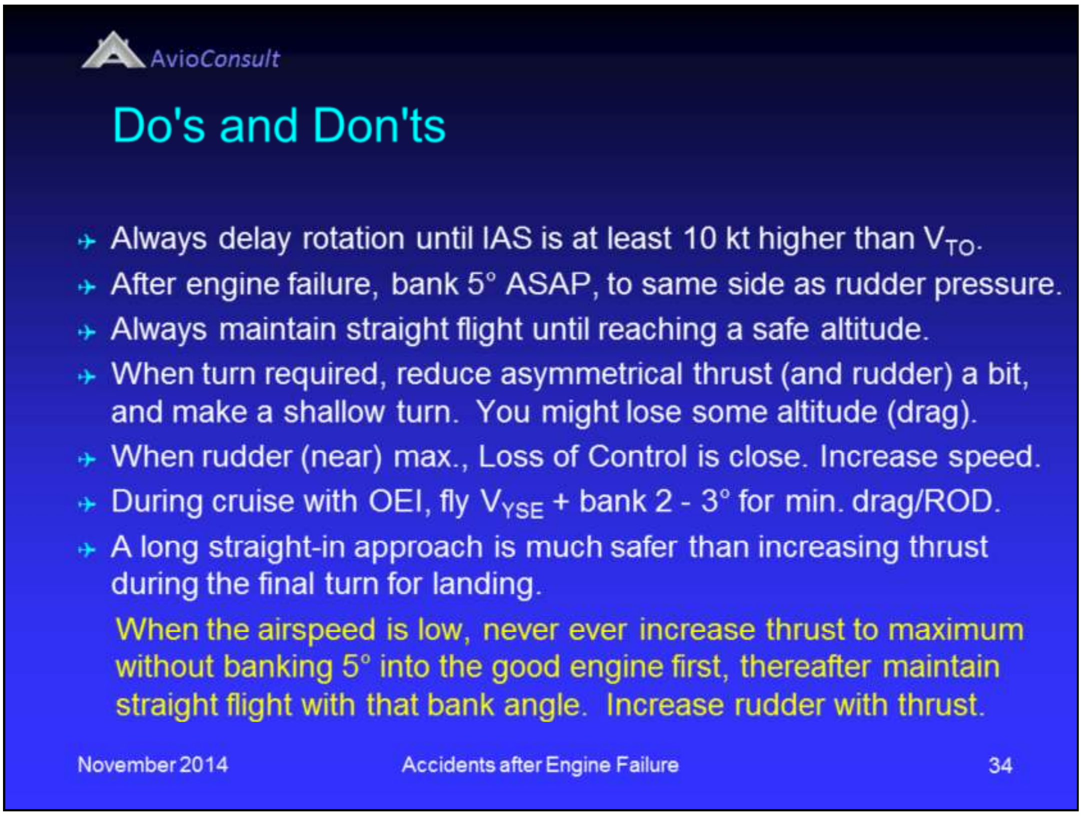
"V_{MCA} is the minimum flight speed at which the aircraft is controllable with a maximum 5° bank [toward the operative engine] when one engine [critical engine] suddenly becomes inoperative with the remaining engine operating at takeoff power. The value presented represents the most critical combination of power, weight, and center of gravity. In aircraft with auto-feathering, V_{MCA} is calculated with a feathered propeller."

The airplane is not controllable with a maximum 5° bank angle, but can only maintain straight flight at V_{MCA} and maximum power setting.

V_{MCA} is not for when one engine, the critical engine suddenly becomes inoperative, but V_{MCA} applies after failure of anyone of the engines, critical or non-critical.

V_{MCA} is not calculated, but determined, i.e. measured during flight test. V_{MCA} is measured with the propeller in the position it assumes after engine failure; if equipped with auto-feather, that system is used, otherwise the propeller is wind milling. It could be added that an inoperative auto feather system increases (actual) V_{MCA}.

This definition, like most V_{MCA} definitions in Flight Manuals, is definitely not correct for an Airplane Flight Manual, for airline pilots. This definition is not in agreement with design and flight-test methods and conditions, and does not contribute to preventing catastrophic accidents, as was again shown here.



A few Do's and Don'ts.

Always delay rotation until the Indicated Airspeed is at least 10 kt higher than the takeoff speed.

After engine failure, bank 5° ASAP, to same side as rudder pressure.

Always maintain straight flight until reaching a safe altitude.

When a turn is required, reduce the asymmetrical thrust and rudder a bit, and make a shallow turn. You might lose some altitude (drag).

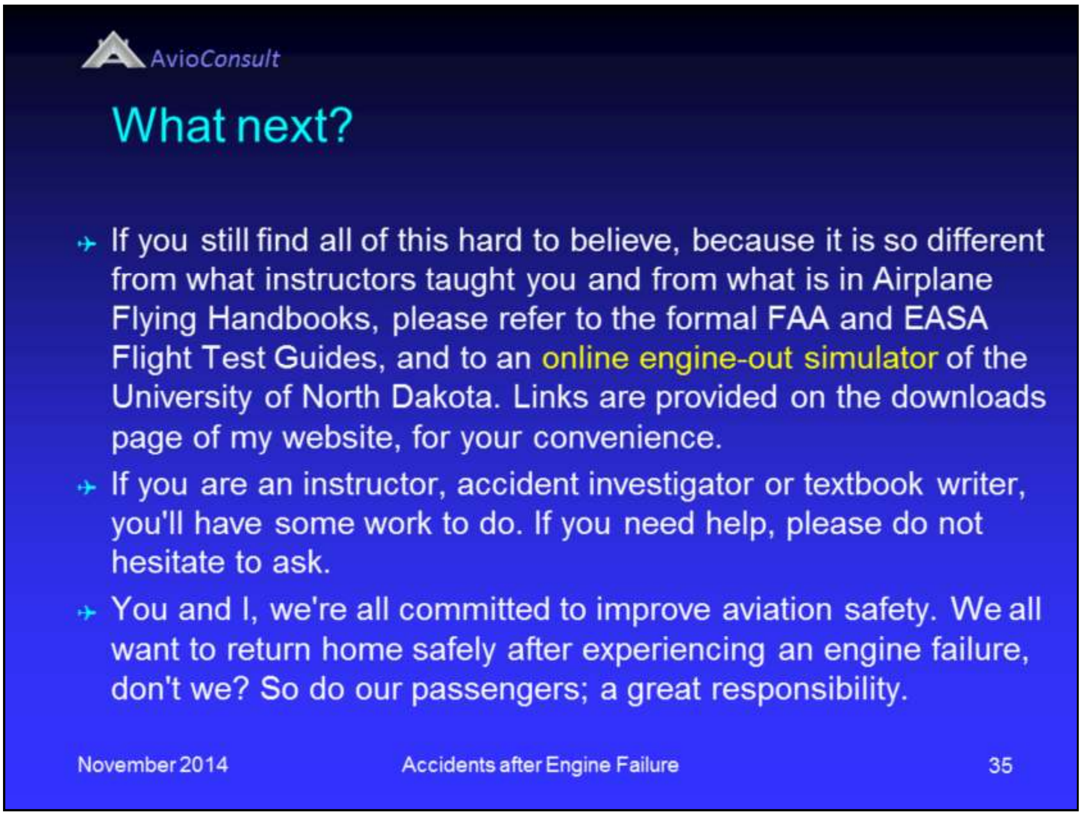
When rudder is (near) maximum, actual V_{MCA} and Loss of Control are close, increase speed.

Before increasing the thrust to max. when airspeed is low, bank 5° again into the good.

During cruise with OEI, fly V_{YSE} + bank 2 - 3° for min. drag/ROD.

A long straight-in approach is much safer than increasing thrust during the final turn for landing for maintaining the approach path.

When the airspeed is low, never ever increase thrust to maximum without banking 5° into the good engine first, and thereafter maintain straight flight with that bank angle. Increase rudder and ailerons with the thrust.

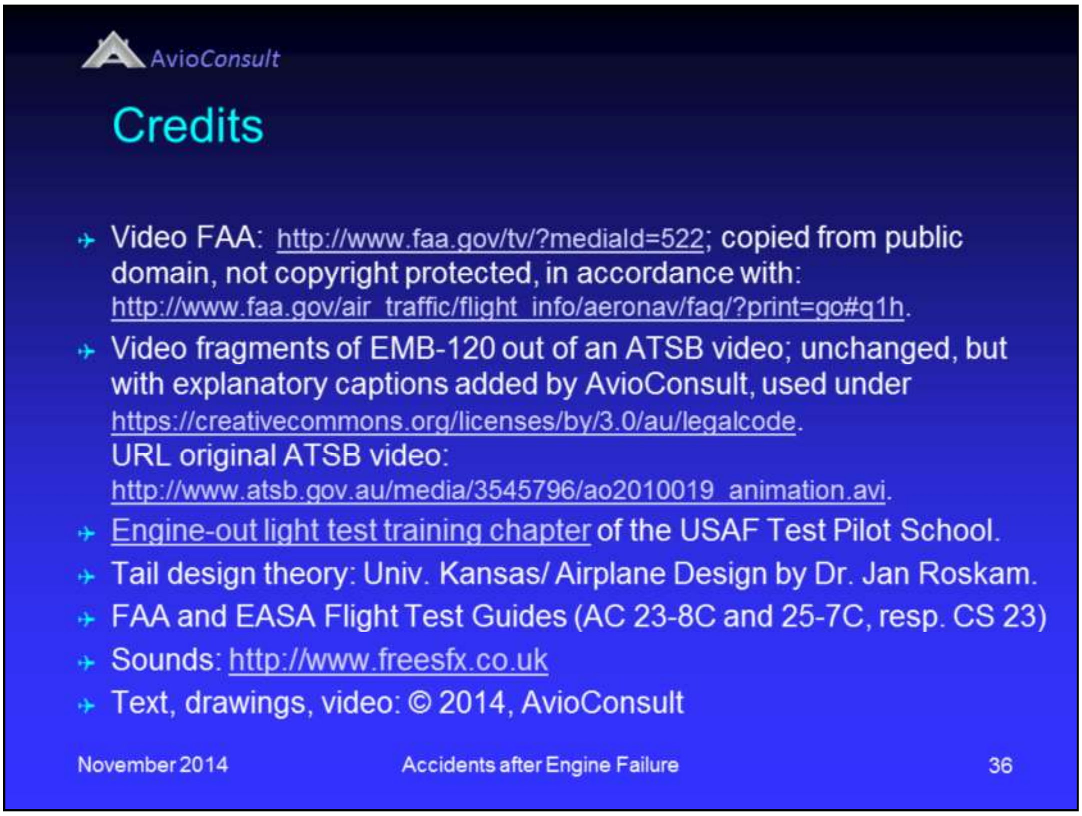


What next?

If you still find all of this hard to believe, because it is so different from what instructors taught you and from what is written in Airplane Flying Handbooks, please refer to the formal FAA and EASA Flight Test Guides, and to an online engine-out simulator of the University of North Dakota. Links are provided on the downloads page of my website, for your convenience, or click here: http://media.avit.und.edu/f4_Inop%20Engine%20Trainer/f1_Inop%20Engine/060302/mainmenu.php

If you are an instructor, accident investigator or textbook writer, I guess you'll have some work to do. If you need help, please do not hesitate to ask.

You and I, we're all committed to improve aviation safety. We all want to return home safely after experiencing an engine failure, don't we? So do our passengers! A great responsibility rests upon our shoulders.



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http://www.freesfx.co.uk.

http://www.avioconsult.com.

The final question:

Can you prevent a dead engine from turning into a killing engine?

Sure you can, but you should know and not forget about the Air Minimum Control Speed and respect it just like you do respect the Stall Speed of your airplane.

Thanks for viewing this video. Please share with all pilots you know.

Fly Safely.

Many more papers on the subject are available on website www.avioconsult.com.