V) CLASS A AEROPLANE

Class A aeroplanes are defined as being any multi engine jet, or any turbo propeller aeroplane with a mass of more than 5,700 kilograms OR has 10 seats or more.

A) Take off

OPERATIONAL REQUIREMENTS

The take-off mass does not exceed the maximum take-off mass as published in the aeroplane flight manual. When calculating the maximum take-off mass:

- the accelerate stop distance must not exceed the accelerate stop distance available,
- the take-off distance must not exceed the take-off distance available
- and lastly that the take-off run must not exceed the take-off run available.

To determine the maximum permissible mass for take-off it is necessary to consider the limits set by:

- The aerodrome distances available (Field Limit Mass)
- The climb requirements (Climb Limit Mass)
- Obstacle clearance (Obstacle Limit Mass)
- Brake energy limitations (V_{MBE})
- Tyre speed limitations (Tyre Speed Limit Mass)
- Runway strength limitation (ACN/PCN)
- Maximum structural mass.

FIELD LENGTH REQUIREMENTS

It is important to find out how the take-off run, take-off distance and accelerate stop distance are calculated and what safety margins the authorities have included. In other words, how are the net distances worked out. These distances are defined in CS-25 and cover the cases of take-off with all engines operating and take-off with engine failure, for both dry and wet runways.

NET TAKE-OFF RUN REQUIRED

If the take-off distance includes a clearway, the take-off run is the greatest of:

- All power units operating (dry and wet runway). The total of the gross distance from the start of the take-off run to the point at which V_{LOF} is reached, plus one half of the gross distance from V_{LOF} to the point at which the aeroplane reaches 35 ft, all factorised by 1.15 to obtain the net TORR.

- One power unit inoperative (dry runway). The horizontal distance from the brakes release point (BRP) to a point equidistant between V_{LOF} and the point at which the aeroplane reaches 35 ft with the critical power unit inoperative

- One power unit inoperative (wet runway). The horizontal distance from the brake release point (BRP) to the point at which the aeroplane is 15ft above the take-off surface, achieved in a manner consistent with the attainment of V_2 by 35ft, assuming the critical power unit inoperative at V_{EF}

NET ACCELERATE STOP DISTANCE REQUIRED

The accelerate-stop distance on a wet runway is the greatest of:

- All engines operating. The sum of the distances required to accelerate from BRP to the highest speed reached during the rejected take-off, assuming the pilot takes the first action to reject the take-off at the V_1 for take-off from a wet runway and to decelerate to a full stop on a wet hard surface, plus a distance equivalent to 2 seconds at the V_1 for take-off from a wet runway.

- One engine inoperative. The sum of the distances required to accelerate from BRP to the highest speed reached during the rejected take-off, assuming the critical engine fails at V_{EF} and the pilot takes the first action to reject the take-off at the V_1 for take-off from a wet runway with all engines operating and to decelerate to a full stop on a wet hard surface with one engine inoperative, plus a distance equivalent to 2 seconds at the V_1 for take-off from a wet runway.

NET TAKE-OFF DISTANCE REQUIRED

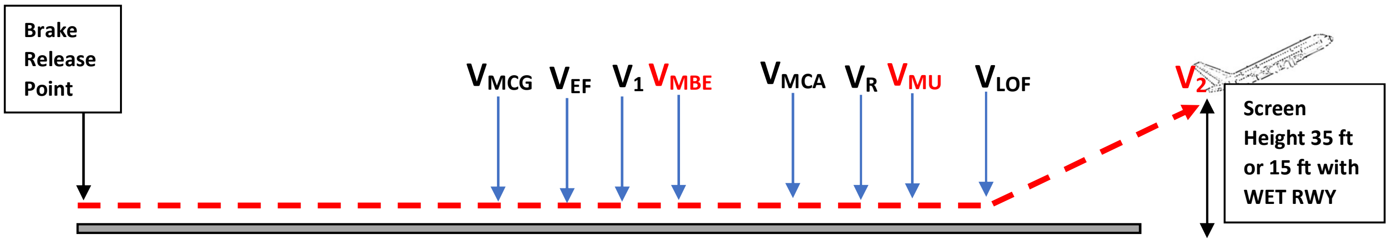
The take-off distance required is the greatest of the following three distances:

- All engines operating. The horizontal distance travelled, with all engines operating, to reach a screen height of 35 ft multiplied by 1.15

- One engine inoperative (dry runway). The horizontal distance from BRP to the point at which the aeroplane attains 35 ft, assuming the critical power unit fails at V_{EF} on a dry, hard surface.

- One engine inoperative (wet runway). The horizontal distance from BRP to the point at which the aeroplane attains 15 ft, assuming the critical power unit fails at V_{EF} on a wet or contaminated hard surface, achieved in a manner consistent with the achievement of V_2 by 35ft.

TAKE OFF SPEEDS



Take-off

From Brake release point to 35ft screen height or 15ft screen height with wet runway

V_{EF}: The speed at which the critical engine is assumed to fail during takeoff.
V_{EF} is selected by the aeroplane manufacture for purposes of certification testing.

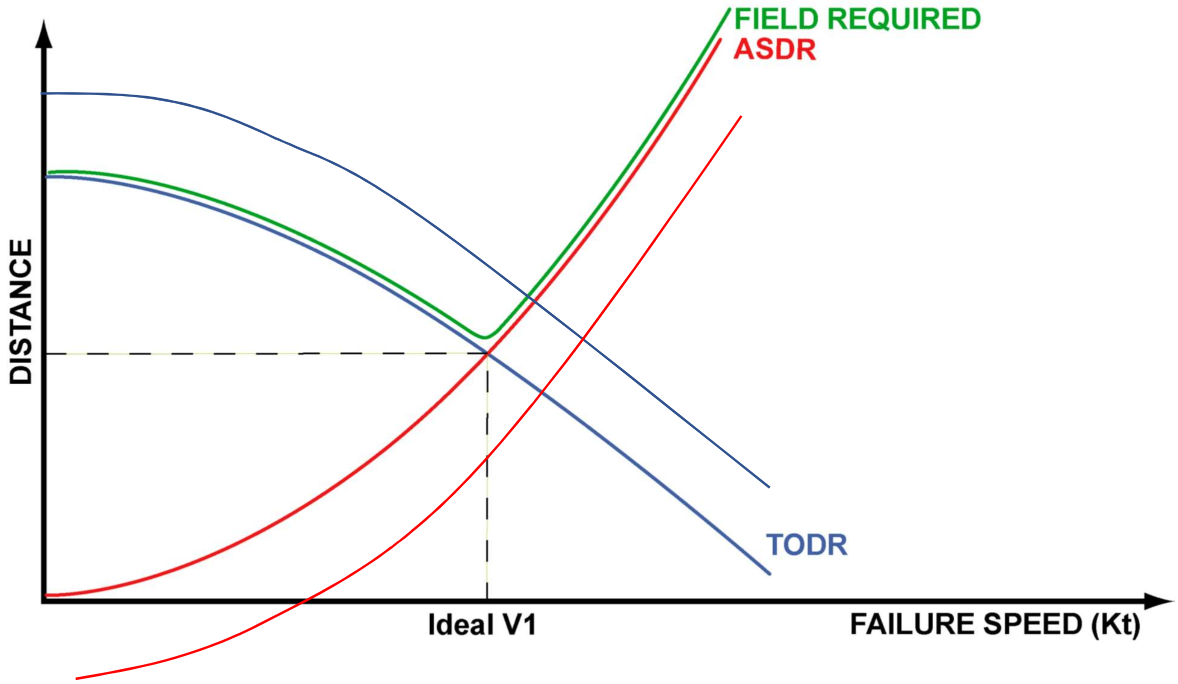
V_1: **The takeoff decision speed** or **the critical engine failure recognition speed**.
It is the speed above which the takeoff will continue even if an engine fails or another problem occurs. Below that speed, the aircraft is able to stop on the the remaining ASDA.

V_{GO} is the lowest decision speed from which a continued take-off is possible within the take-off distance available. V_{STOP} is the highest decision speed from which the aeroplane can stop within the accelerate-stop distance available. These two speeds are the extremes of V1.

The speed V_1:

- may not be less than V_{EF} plus the speed gained with the critical engine inoperative for the time between engine failure and the point at which the pilot applies the first means of retardation.
- ($V_1 \leq V_R$) must not exceed V_R
- ($V_1 \leq V_{MBE}$) must not exceed V_{MBE}
- ($V_1 \geq V_{MCG}$) must not be less than V_{MCG}

If the engine were to fail before V1, then the decision would be to abort the take-off. The reason is because, with only one engine operating, there would be insufficient take-off distance left to accelerate the aeroplane to the screen height. If the engine were to fail after V1, the decision is to continue the take-off. The reason is because the aeroplane is travelling too fast to be able to stop within the remaining accelerate stop distance available.



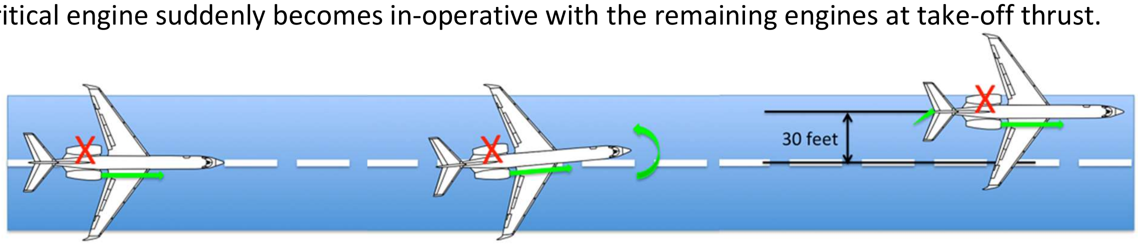
When TODR = ASDR, V_1 is balanced

Affecting factors

Factors	Increase V_1	Decrease V_1
Config (flaps)	Low flap (increase	High flaps set
Density (pressure, temp)	High pressure alt. High temp	Low pressure alt. Low temp
Wind	Headwind	Tailwind
Slope	Upslope	Downslope

V_{MCG}: Ground minimum control speed

It's the minimum speed on the ground at which the take-off can be safely continued, when the critical engine suddenly becomes in-operative with the remaining engines at take-off thrust.



The alive engine will produce more thrust and the failed engine and so the aircraft will yaw. To counteract for this yawing moment, only the opposite rudder can be used. For the rudder to be effective, it must travel at a sufficient air speed. Therefore, if the engine supplies more thrust, the rudder must counteract more and so must travel at a faster airspeed.
Since the thrust is affected by the air density, so V_{MCG} will depend on the air density

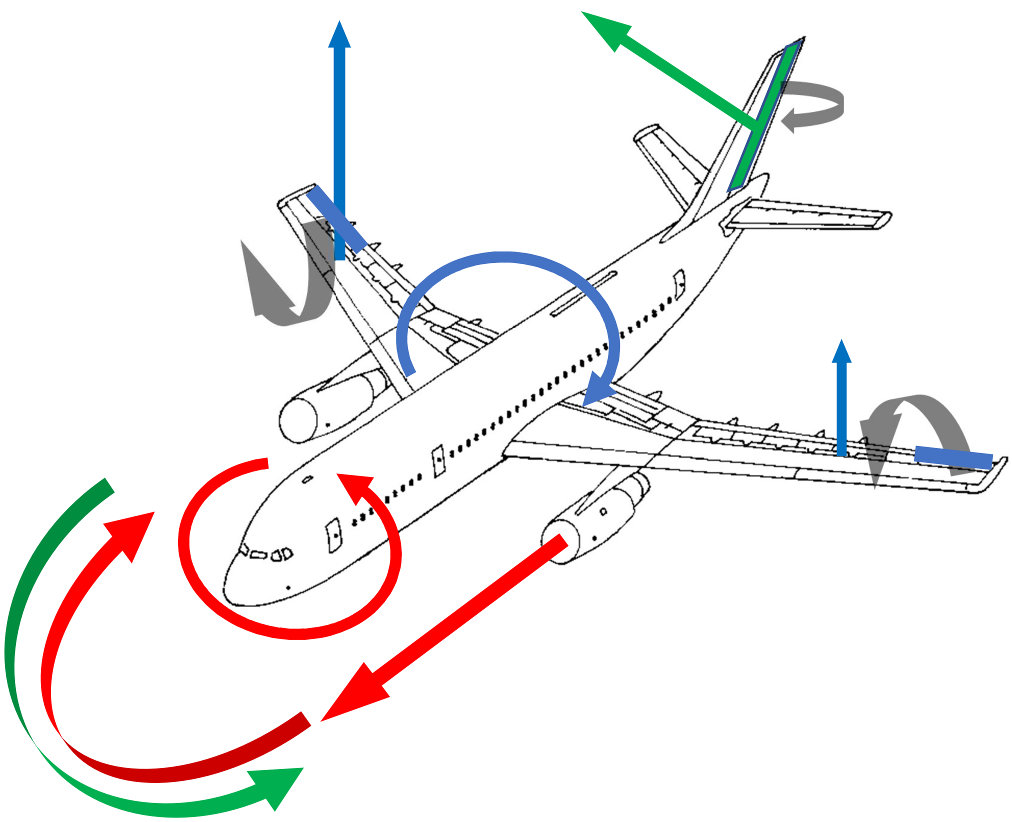
Affecting factors

Factors	Less THURST, decrease V_{MCG}	More THURST, increase V_{MCG}
Density (pressure, temp)	High pressure alt. High temp	Low pressure alt. Low temp
A/C Packs	ON	OFF

During VMCG demonstration:

- the aircraft shouldn't deviate more than 30 ft from the centreline
- The nose wheel steering is disconnected to simulate wet and/or slippery runways conditions

V_{MCA}: The air minimum control speed.
The minimum flight speed at which the aeroplane is controllable, with a maximum of 5° bank, when the critical engine suddenly becomes inoperative with the remaining engines at take-off thrust.



V_{MCL}: Landing Minimum Control Speed

The minimum control speed during landing approach. The minimum speed with a wing engine inoperative where it is possible to decrease thrust to idle or increase thrust to maximum take off without encountering dangerous flight characteristics.

Lateral control must be sufficient to roll the aeroplane, from an initial condition of steady straight flight, through an angle of 20º in the direction necessary to initiate a turn away from the inoperative engine(s), in not more than 5 seconds.

V_{MBE}: Maximum Brake Energy Speed

V_{MBE} is the maximum brake energy speed and it represents the maximum speed on the ground from which an aeroplane can safely stop within the energy capabilities of the brakes. Essentially this means that if the take-off was abandoned at a speed higher than V_{MBE}, and maximum braking force was applied, the brakes would not be able to safely bring the aeroplane to a stop regardless of how much runway was left. The brakes would most probably catch fire, melt and or disintegrate.

For an aircraft of mass M, travelling at a true speed of V, the kinetic energy is ½ MV2. If the aircraft is braked to a stop from this speed, a large proportion of this energy will go into the brakes as heat.

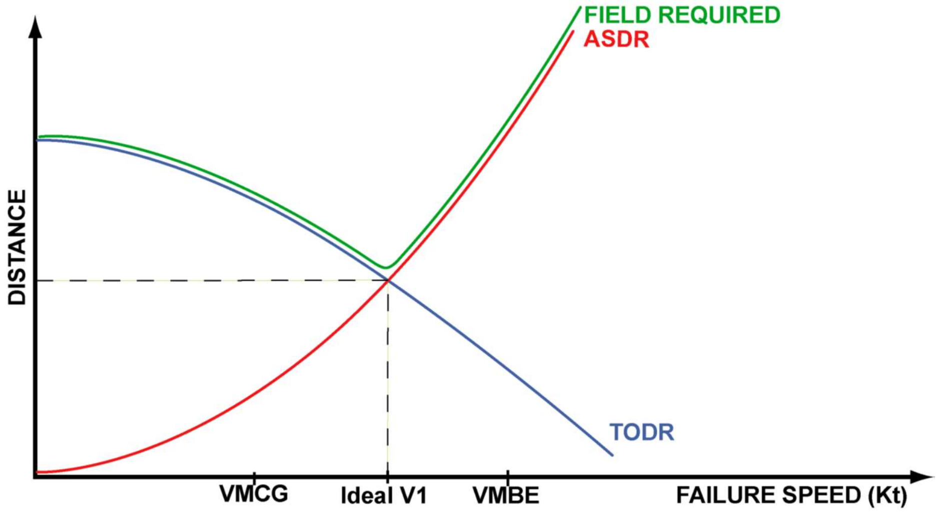
Affecting factors

Factors	Decrease V_{MBE}	Increase V_{MBE}
Weight	Heavy	Light
Density (pressure, temp)	High pressure alt. High temp	Low pressure alt. Low temp
Wind	Tailwind	Headwind
Slope	Downslope	Upslope

V_{MCG} - V_1 –V_{MBE}

V_1 cannot be allowed to be less than V_{MCG} because engine failure below V_{MCG} means the aeroplane is uncontrollable and the definition on V_1 is that the take-off can be continued following engine failure.

V_1 must not be greater than V_{MBE}. Again, this makes sense, because at V_1 the aeroplane must be able to stop or continue the take-off, but above the V_{MBE} it is impossible to bring the aeroplane safely to a stop.



In high density, the value of V_{MCG} is higher than the idealised V_1. In this case, take-off is prohibited. However, this problem is solvable. The chosen V_1 can simply be increased until it is equal to or more than V_{MCG}. However, notice that the accelerate stop distance increases, the take-off distance decreases and more importantly, the total field length required increases. So long as the runway is as long as the total field required, then moving V_1 to this point is not a problem.

V_{MU} - Minimum Un-stick Speed

V_{MU} is slowest calibrated airspeed, at which, the aeroplane can safely lift off the ground, and continue the take-off. However, despite V_{MU} being the lowest speed the aeroplane can safely lift off the runway, in actual operating conditions, the aeroplane does not lift off at this speed. The aeroplane is flown so that it actually lifts-off at a slightly faster speed. The reason is because V_{MU} is very close to the stall speed

V_{LOF}: Lift-off Speed

V_{LOF} means the lift-off speed. V_{LOF} is the calibrated airspeed at which the aeroplane first becomes airborne which is at the moment when the main wheels have left the runway. V_{LOF} should be faster than the minimum unstick speed V_{MU}. The margin above V_{MU} is determined by several factors.

V_{LOF} must:

- not be less than 110% of V_{MU} in the all engines- operating condition **$V_{LOF} \geq 1.10 V_{MU}$**
- not be less than 105% of V_{MU} in the one engine inoperative condition. **$V_{LOF} \geq 1.05 V_{MU}$**

However, if the attitude of aeroplane in obtaining V_{MU} was limited by the geometry of the aeroplane (i.e., tail contact with the runway), V_{LOF} must:

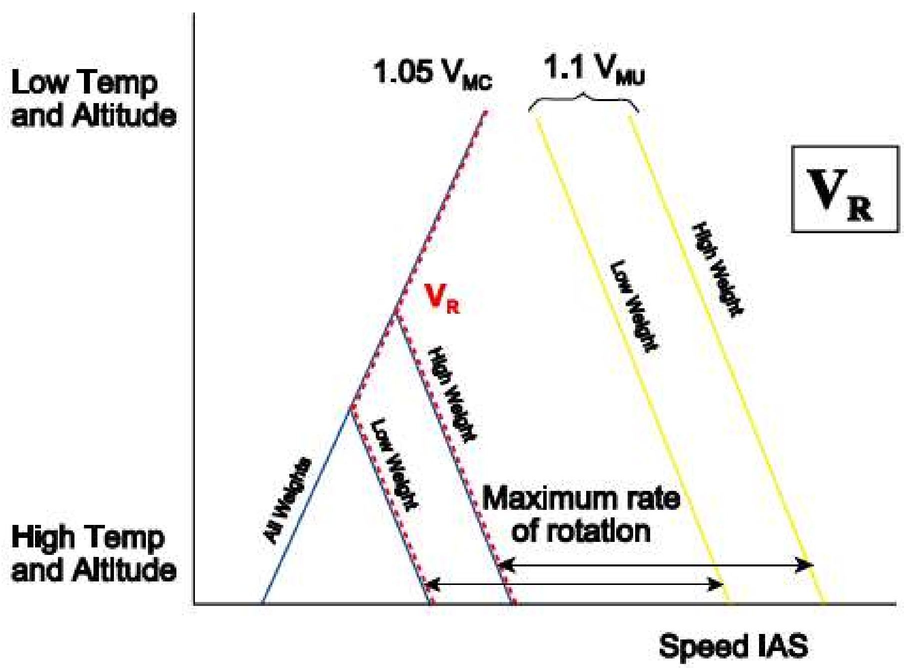
- not be less than 108% of V_{MU} in the all-engines operating condition **$V_{LOF} \geq 1.08 V_{MU}$**
- not be less than 104% of V_{MU} in the one engine inoperative condition. **$V_{LOF} \geq 1.04 V_{MU}$**

V_R: Rotation Speed

Speed at which the pilot initiates action to raise the nose gear off the ground, with the intention of becoming airborne. The pilot action is to pull back on the control column. This action deflects the horizontal stabilizer to create a downward aerodynamic force. This force rotates the aeroplane about its lateral axis and will raise the nose wheel off the ground.

V_R may not be less than

- V_1
- 1.05 V_{MC}
- a speed such that V_2 may be attained before 35ft.
- a speed such that if the aeroplane is rotated at its maximum practicable rate will result in a V_{LOF} of not less than 1.1 V_{MU} (all engines operating) or 1.05V_{MU} (engine inoperative) [if the aeroplane is geometry limited or elevator power limited these margins are 1.08 V_{MU} (all engines) and 1.04 V_{MU} (engine inoperative)]



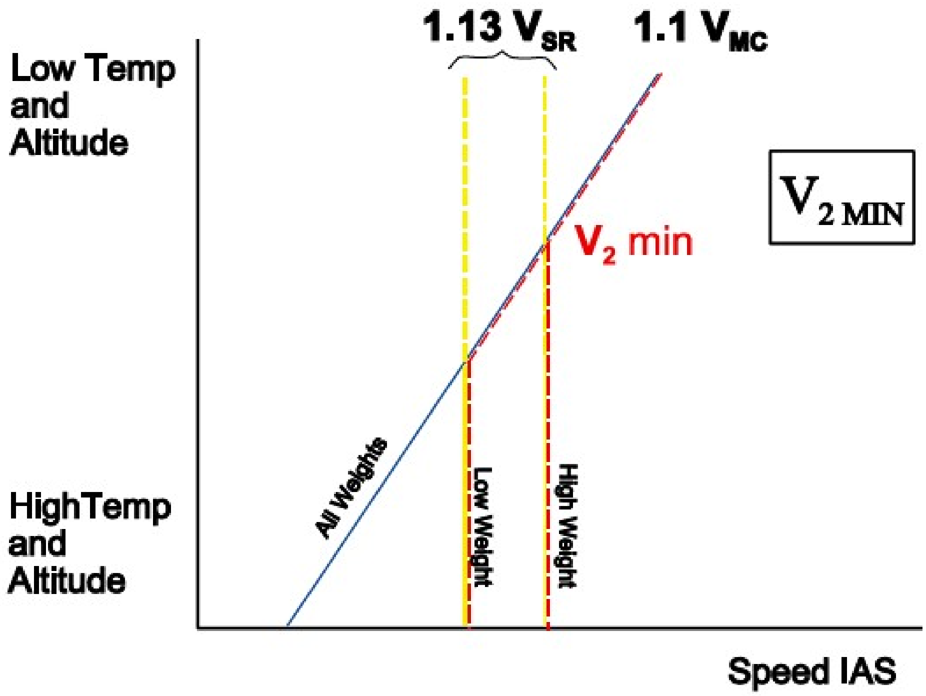
Effects of early and over-rotation

If the aircraft is rotated to the correct attitude but at too low a speed, lift off will not occur until the normal V_{LOF}, but there will be higher drag during the increased time in the rotated attitude, giving increased distance to lift off. Rotation to an attitude greater than the normal lift off attitude could bring the wing close to its ground stalling angle.

V_{2MIN}: The minimum take-off safety speed, with the critical engine inoperative.

V_{2MIN} May not be less than:

- 1.13V_{SR} for 2 and 3 engine turboprops and all turbojets without provision for obtaining a significant reduction in the one engine inoperative power-on stalling speed
  OR 1.08V_{SR} for turboprops with more than 3 engines and turbojets with provision for obtaining a significant reduction in the one engine inoperative power-on stalling speed.
- 1.1 V_{MC}



V_2: Take-Off Safety Speed

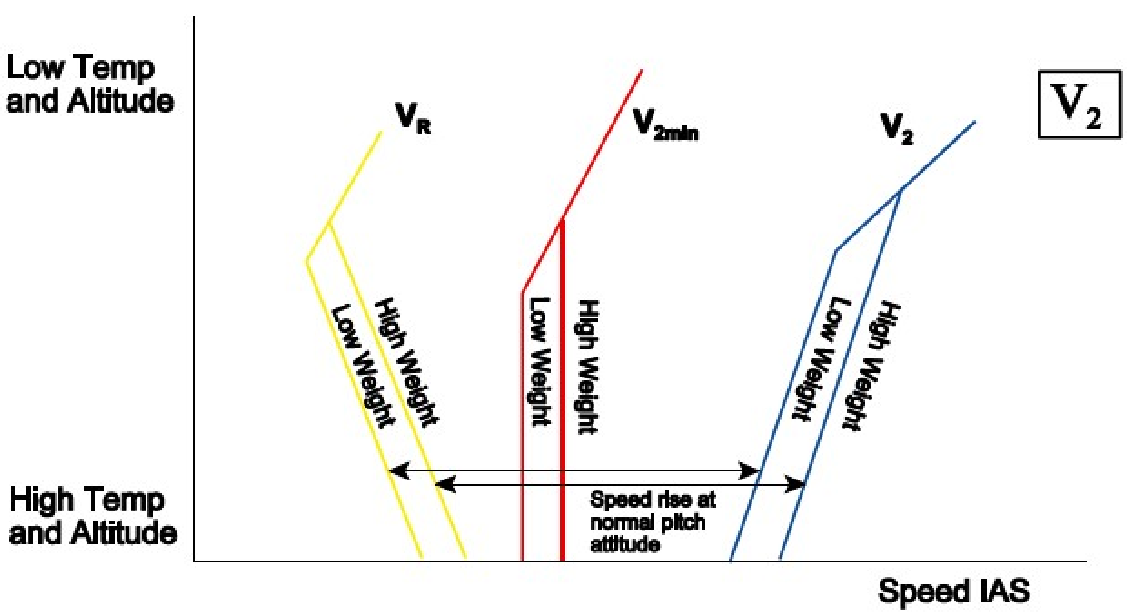
The speed V2 is called the take-off safety speed. V2 is the target speed to be attained with one engine inoperative must be reached at or prior to the screen height.

V_2 is called the take-off safety speed, because it certifies:

- a flight above the stall speed and the second is the minimum control speed.
- in the event of engine failure, V2 allows the aeroplane to be flown until it reaches 400ft.
- a positive climb. In fact, V2 is the slowest speed which will enable the aeroplane to have sufficient excess thrust to climb above the minimum acceptable climb gradients.

V2 may not be less than:

- V_{2MIN}
- V_R plus the speed increment attained up to 35 ft.



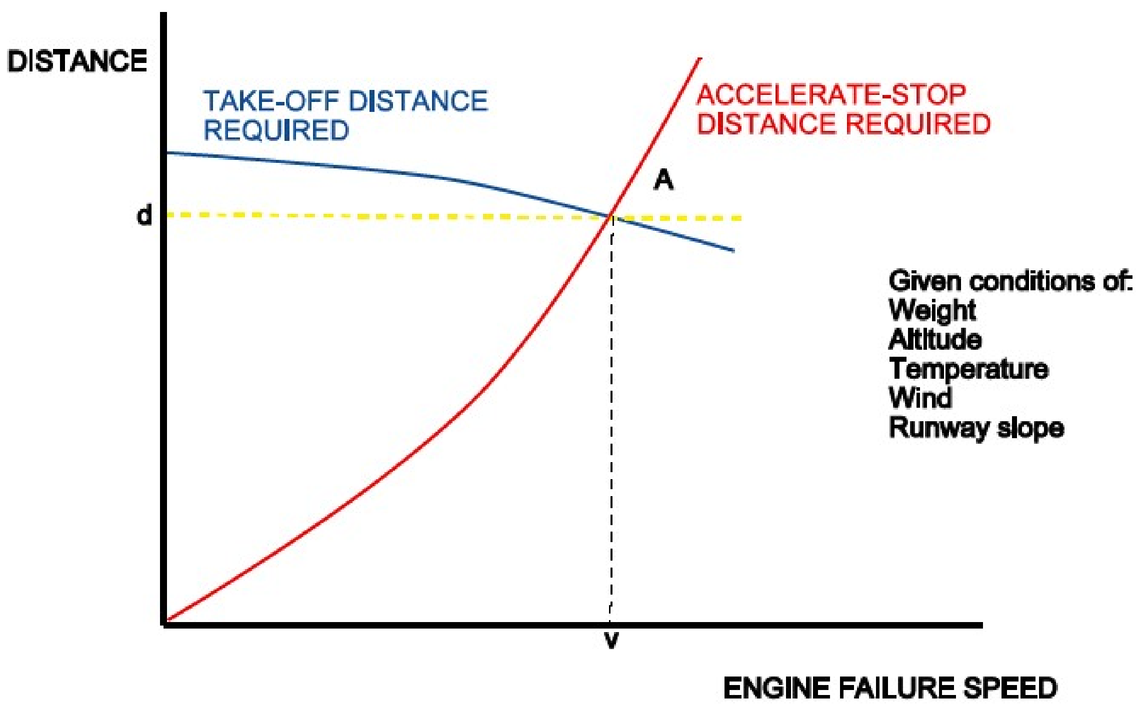
Once V_2 is calculated by the pilots it can be entered into the flight management computer just like V_1 and V_R were. Having done this V_2 will be displayed to the pilots in the speed scale on the left-hand side of the Primary Flight Display or Electronic Attitude Director Indicator.

V_3: The steady initial climb speed with all engines operating (V_2+n)

SELECTING V_1

BALANCED FIELD

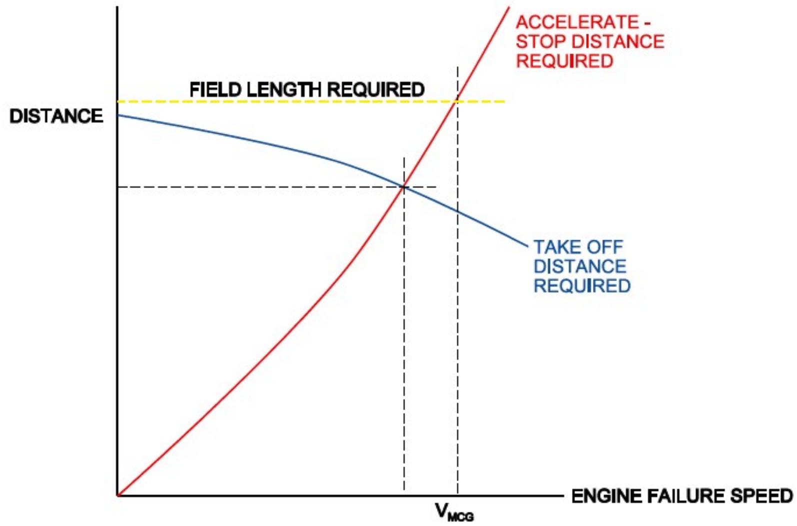
A balanced field exists if the Take-off Distance is equal to the Accelerate-stop Distance. An aerodrome which has no stopway or clearway has a balanced field. For an aeroplane taking off, if an engine failure occurs, the later the engine fails, the greater will be the accelerate-stop distance required but the less will be the take-off distance required. At some speed the two distances will be equal



acceptable, as V_1 must lie within the limits of V_{MCG}, V_R and V_{MBE}. The following situations will give an unbalanced field:

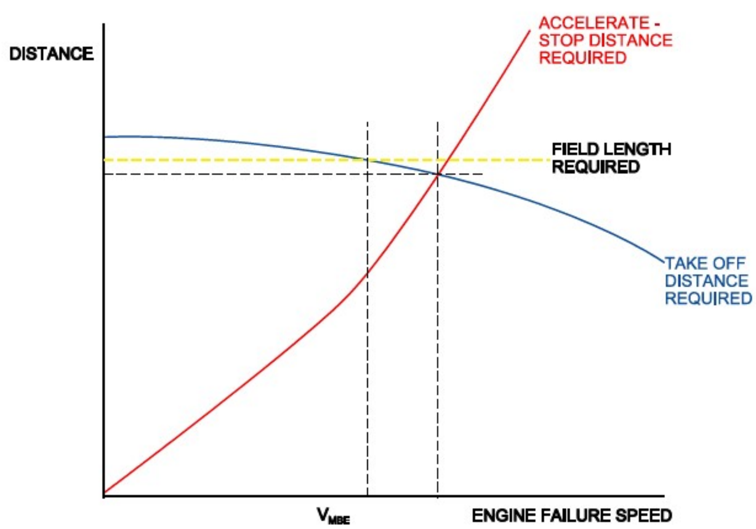
1) **If V_1 less than V_{MCG}**

At low weights and altitudes V_1 for the balanced field may be less than V_{MCG}. In this case V_1 would have to be increased to V_{MCG} and so the TODR would be less, and the ASDR would be greater than the balanced field length. The field length required would be equal to the ASDR at V_{MCG}



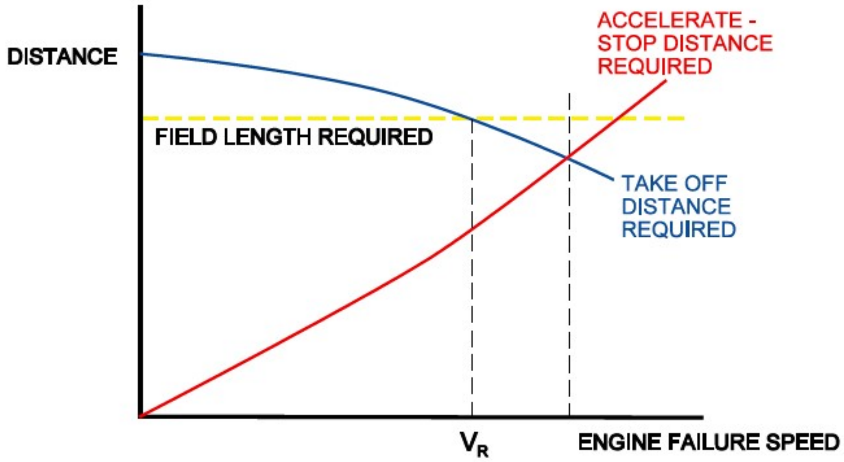
2) If V_1 greater than V_{MBE}

At high weight, altitude and temperature, the balanced field V_1 may exceed the V_{MBE}. V_1 would have to be reduced to V_{MBE} giving a TODR greater, and an ASDR which is less, than the balanced field length. The field length required would be equal to the TODR at V_{MBE}.



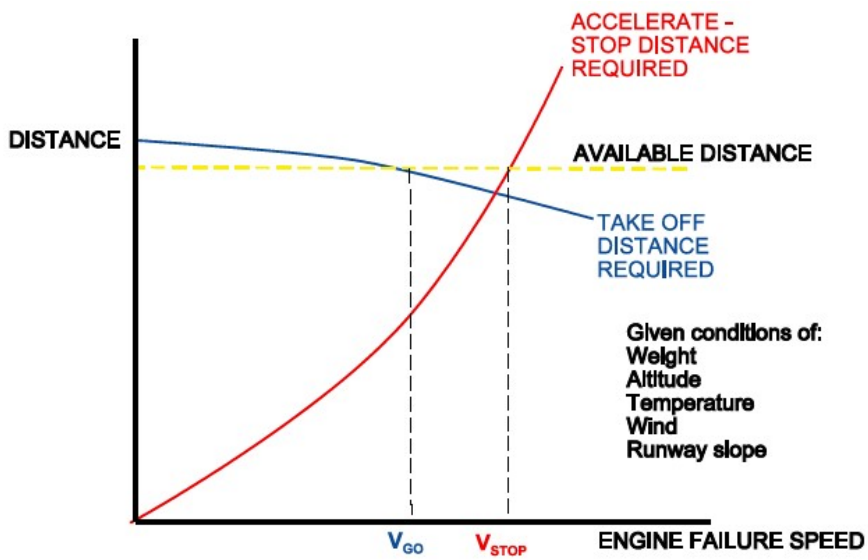
3) V_1 greater than V_R

If this exceeds V_R for the weight, V_1 will have to be reduced to V_R and the field length required will be equal to the TODR at V_R .



V_1 RANGE

If the balanced field available is greater than the balanced field required for the required takeoff mass and conditions there will be a range of speed within which V_1 can be chosen.



V_{GO} is the first speed at which the take-off can be completed within the distance available. V_{STOP} is the last speed at which the accelerate-stop could be completed within the distance. The V_1 speed can therefore be chosen anywhere between V_{GO} and V_{STOP}.

TAKE-OFF FROM AN UNBALANCED FIELD

If the take-off aerodrome is not a balanced field, the balanced field data can be used by assuming a balanced field equal to the lesser of the Take-off Distance Available and the Accelerate-stop Distance Available. This distance may exceed the Take-off Run Available unless the TORA becomes limiting.

PRESENTATION OF DATA

FIELD LIMIT BRAKE RELEASE MASS / FIELD LIMIT MASS
CLIMB GRADIENT LIMIT MASS
TYRE SPEED LIMIT MASS
BRAKE ENERGY LIMIT

BRAKE COOLING
The value of V_{MBE} obtained from the data assumes that the brakes are at ambient temperature before the start of take-off. If a take-off is abandoned following a recent landing, or after prolonged taxying the brakes will already be at a fairly high temperature, and their ability to absorb further energy will be reduced.

MAXIMUM TAKE-OFF MASS
Consideration of the mass determined by the field length available, the climb requirement, the tyre speed limit, and the brake energy limit will determine the maximum mass for take-off. It will be the lowest of the masses given by the above limitations.
This mass is called **the Performance Limited Mass**.
The Performance Limited Mass must then be compared to maximum structural mass and the lower of the two masses is then selected as the take-off mass.
This mass is known as **the Regulated Take-off Mass**.

If there are obstacles to be considered on the take-off flight path this may determine a further limitation on take-off mass.

CALCULATING TAKE OFF SPEEDS AND THRUST SETTINGS
When the maximum permissible take-off mass (regulated take-off mass) has been determined, it is necessary to find the corresponding take-off speeds V_1, V_R and V_2, and thrust settings.

B) Additional Take Off Procedure/ Non-Standard Take-Off Procedure

CONTAMINATED RUNWAYS

A runway is considered to be contaminated when more than 25% of the runway surface area (whether in isolated areas or not) within the required length and width being used, is covered by surface water, more than 3mm. deep, or by slush or loose snow, equivalent to more than 3mm. of water.

Slush, loose snow or standing water on the runway will affect both the Take-off distance Required and the Accelerate-stop Distance Required. The Take-off Distance Required will increase because of the additional wheel drag and impingement drag. The accelerate-stop distance will increase because of the increased distance to decelerate and the increased distance to stop resulting from the reduced runway coefficient of braking friction. For given distances available, the maximum take-off mass and the V1 will therefore be reduced compared to the dry runway. The greater the depth of contamination, the greater the mass reduction and the less the V_1 reduction.

➯ **Contaminated runway → Decrease TOM, V_1 reduces**

The acceleration distance should take account of the additional drag due to the gear displacement drag, and the spray impingement drag, and the decrease of drag which occurs above the aquaplaning speed.

For rotating tires: $$VP(kt) = 9\ X\sqrt{Tyre\ Pressure\ (PSI)}$$

For non-rotating tires: $$VP(kt) = 7{,}7\ X\sqrt{Tyre\ Pressure\ (PSI)}$$

PRESENTATION OF DATA

TAKE-OFF WITH INCREASED V_2 SPEED/ IMPROVED CLIMB PROCEDURE

This particular procedure is used when the performance limiting mass is the climb limit mass. When the climb performance is poor and is severely restricting the potential mass of the aeroplane. In the event of engine failure, the initial climb out speed is V_2. However, V_2 is not the best climb angle speed. V_2 is considerably slower than the best angle of climb speed V_X. Therefore, climbing out at V_2 produces a climb angle much less than if the aeroplane were to climb out at V_X.

What the improved climb procedure aims to achieve is to increase V_2 to be closer to V_X. This will greatly enhance the climb performance

With all the excess of runway it would be possible to stay on the runway for longer during the take-off to build up more speed, this will ensure that at rotation and at the screen height, a faster V_2 will be reached and this faster V_2 will be much closer to V_X. This ensures that the climb performance significantly improves. As a result of the improved climb performance, the climb limit mass can increase, which would increase the performance limited take-off mass and provide an improved regulated take-off mass.

TAKE-OFF WITH REDUCED THRUST

This procedure is referred to as the reduced thrust take-off, variable thrust take-off or assumed temperature take-off. However, Airbus uses the term Flexible take-off. The main reason for doing this procedure is to preserve engine life and also to help reduce noise. The procedure can be used any time the actual take-off mass is less than the maximum permissible take-off mass and that there is an available distance that greatly exceeds that which is required.
The maximum reduction in thrust from the full rated take-off thrust value is 25%.

Take-off with reduced thrust is not permitted with:

- Icy or very slippery runways
- Contaminated runways
- Anti-skid inoperative
- Reverse thrust inoperative
- Increased V_2 procedure
- Power Management Control (PMC) off

Reduced thrust take off procedure is not recommended if potential windshear conditions exist.

PROCEDURE

Essentially this procedure involves pretending or assuming that the temperature is a lot hotter than it actually is. Imagine for the moment that the outside air temperature was continually increasing and as a result the thrust produced by the engines continually decreasing. There will eventually be a temperature beyond which there will be insufficient thrust to complete a takeoff.
This temperature is then used as the assumed temperature and the thrust equating to this temperature is then set as the take-off thrust.

TAKE-OFF WITH ANTI-SKID INOPERATIVE

This take-off procedure is used when the anti-skid system is inoperative.
Class A aeroplanes have to demonstrate that in the event of engine failure, the aeroplane is able to stop within the confines of the runway. Therefore, the accelerate stop distance required must be less than or equal to the field available. If the anti-skid system doesn't work, then the stopping ability will be severely reduced and will cause the accelerate stop distance to increase dramatically.
To solve the problem, V1 is reduced. Reducing V1 decrease the accelerate stop distance, however it also increases the take-off distance.
To resolve this, the mass of the aeroplane is reduced, which will decreases both the accelerate stop distance and take-off distance required so that they remain within the available field lengths.

➷ **Anti-skid system inoperative → V_1 and the aeroplane mass decreases**

TAKE OFF QUICK SUMMARY

Take-off

From Brake release point to 35ft screen height or 15ft screen height with wet runway

Speeds

V_{EF}: The speed at which the critical engine is assumed to fail during takeoff
V_1: The takeoff decision speed
V_{MCG}: Ground minimum control speed
$V_{MC(A)}$: The (air) minimum control speed
V_{MCL}: Landing Minimum Control Speed
V_{MBE}: Maximum Brake Energy Speed
V_{MU} - Minimum Un-stick Speed
V_{LOF}: Lift-off Speed
V_R: Rotation Speed
V_{2MIN}: The minimum take-off safety speed, with the critical engine inoperative
V_2: Take-Off Safety Speed

Speeds comparison

V_1	V_{LOF}*	V_R	V_{2MIN}	V_2
$V_1 \geq V_{MCG}$ **$V_1 \leq V_{MBE}$** **$V_1 \leq V_R$**	**$V_{LOF} \geq 1.10V_{MU}$** With all eng **$V_{LOF} \geq 1.05V_{MU}$** With one eng inop	**$V_R \geq V_1$** **$V_R \geq 1.05V_{MCA}$**	**$V_{2MIN} \geq 1.13V_{SR}$** For 2 or 3 eng prop w/o sig reduc in one eng inop, or **$V_{2MIN} \geq 1.08V_{SR}$** For prop > 3 eng and jet w/ sig reduc in one eng inop **$V_{2MIN} \geq 1.1V_{MC}$**	**$V_2 \geq V_{2MIN}$** **$V_2 \geq V_R$ + speed gained at 35ft**

V_1 balanced when TODA equals ASDA (N-1 TODR = N-1 ASDR)

MAXIMUM TAKE-OFF MASS

the Performance Limited Mass: Lower mass compared among:

- Field length available
- Climb requirement
- Tyre speed limit
- Obstacles Limit
- Brake energy

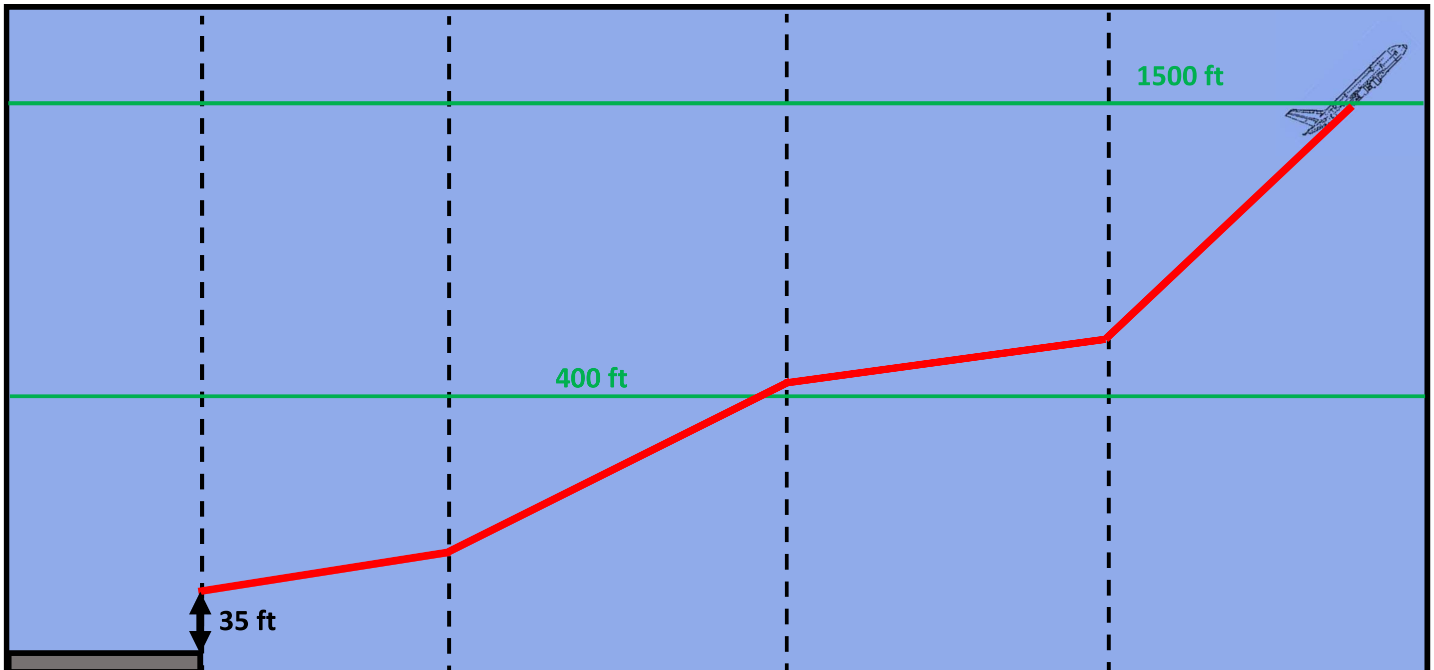
the Regulated Take-off Mass: Selected as the take-off mass, it’s the lowest between:

- The Performance Limited Mass must
- The maximum structural mass

C) Take Off Climb

The take-off climb or take-off flight path extends from 35 ft above the take-off surface to 1500 ft above the take-off surface.
However, with a contaminated runway take-off, the take-off climb begins at 15 ft and not 35 ft.

The climb is divided in 4 segments



Segment	**1**	**2**	**3**	**4**
Starts	35 ft	Gear up	≥ 400 ft AGL	Flaps Up; V_{FTO}; MCT
Actions	Select Gear Up	Climb to ≥ 400 ft AGL	Retract Flaps Accelerate to V_{FTO} Set MCT	Climb to 1500ft AGL
Speed	V_2	V_2	V_2; V_{ZF}; V_{FTO}	V_{FTO}
Ends	Gear Up	≥ 400 ft AGL	Flaps Up; V_{FTO}; MCT	1500 ft AGL
GRADIENTS				
2 engines	> 0% (positive)	≥ 2,4%	≥ 1,2%	
3 engines	≥ 0,3%	≥ 2,7%	≥ 1,5%	
4 engines	≥ 0,5%	≥ 3,0%	≥ 1,7%	

SEGMENT 1

- **Starts:** from 35ft (end of T/O) with aeroplane at V2 with one engine inoperative.
- **Objective:** at this point, the objective is to climb, as expeditiously as possible, which is difficult because of the lack of excess thrust due to the large amount drag created by the gear and flaps and the fact that only one engine is in operation. Therefore, the strategy is to retract the gear and flaps as soon as possible. Since retracting flaps at low speeds close to the ground is dangerous, the only option is to retract the gear.
- **Ends:** once the gear is up and locked.
- **Gradient:** During this segment the steady gradient of climb must be positive.

SEGMENT 2

- **Starts:** at the end of the first segment, when the gear is up.
- **Objective:** The objective now is to retract the flaps. However, flap retraction is not permitted below 400ft AGL, therefore the action by the pilot is simply to climb, at no less than V2, until 400 ft AGL is reached.
- **Ends:** once 400 ft is reached and flap retract can commence.
- **Gradient:** Since the aeroplane has had the main source of drag removed, the minimum gradient requirement is more severe at no less than 2.4%.

- ## SEGMENT 3
- **Starts:** at or above 400 ft AGL and is the flap retraction and acceleration segment.
- **Objective:** However, retracting the flaps will increase the stall speed. This reduces the aeroplanes safety margin. Therefore, the aeroplane must accelerate during flap retraction from V_2 to the Zero Flap speed (V_{ZF}) and then to the Final Take-Off speed (V_{FTO}). The V_{FTO} is also called the Final Segment speed and is intended to be the one engine inoperative best angle of climb speed. Once this has happened, thrust can be reduced from Maximum Take-Off Thrust (TOGA) to Maximum Continuous Thrust (MCT). In fact, TOGA is limited to only 5 minutes, therefore, acceleration and flap retraction must be complete by then.
- **Ends:** once the flaps are retracted
- **Gradient:** The acceleration phase of this segment poses a climb problem. To climb, excess thrust is needed. However, accelerating the aeroplane also requires excess thrust. Therefore, it is not possible to adequately accelerate and climb at the same time and, as such, this segment can be flown levelled up.

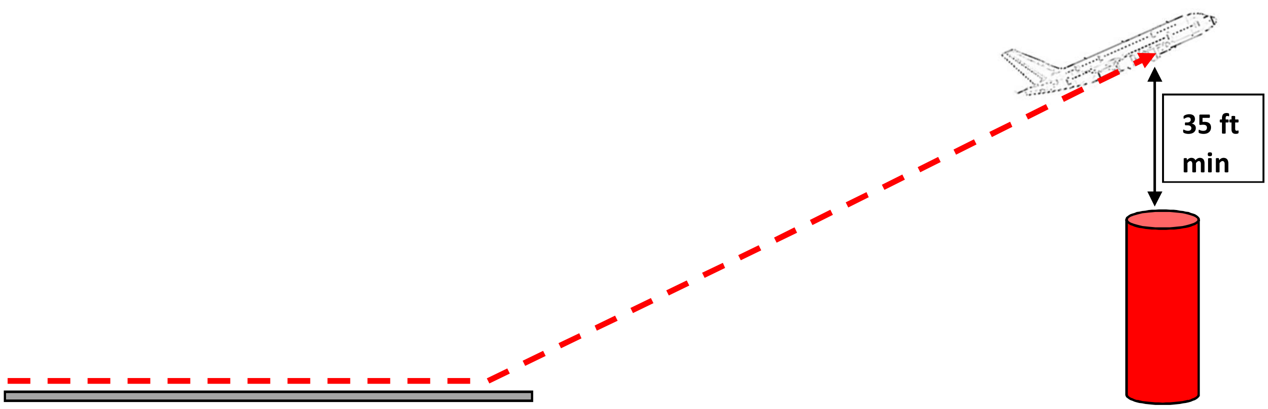
SEGMENT 4

- **Starts:** when the flaps are retracted, the final segment speed is achieved and
- the thrust is set to maximum continuous thrust.
- **Objective:** From this point the aeroplane is climbed to above 1500 ft AGL where the take-off flight path ends.
- **Ends:** When reaching 1500 ft AGL
- **Gradient:** The climb gradient for this last stage must not be less than 1.2%. One last point.

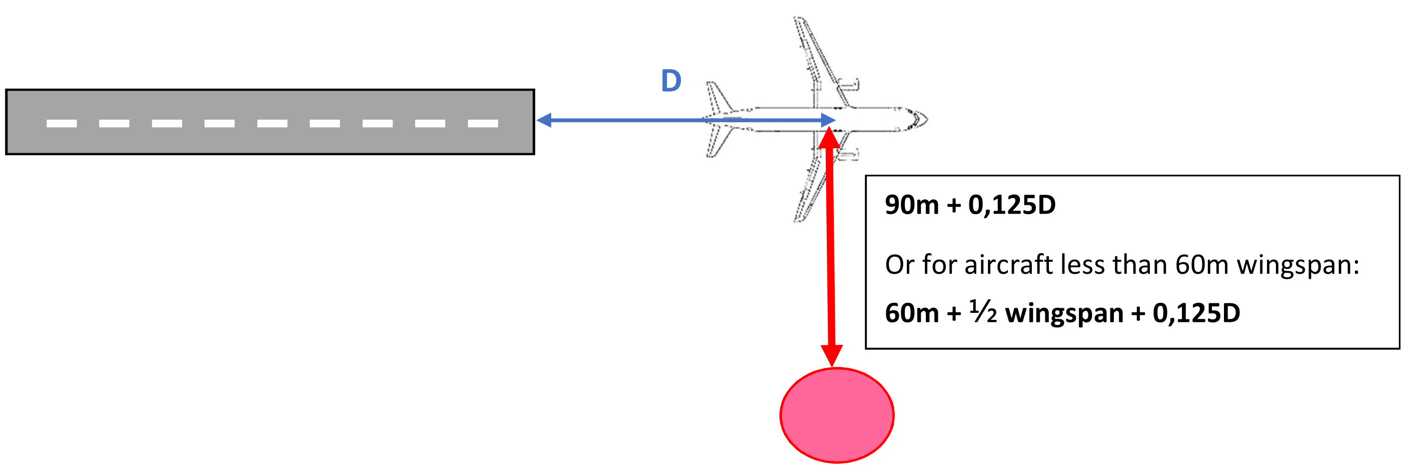
OBSTACLE CLEARANCE

- An operator must ensure that the net take-off flight path must clear all obstacles by a vertical margin of at least 35 ft, or

- If the aeroplane is unable to do so it must turn away from the obstacle and clear it by a horizontal distance of at least 90 m plus 0.125 x D, where D is the horizontal distance the aeroplane has travelled from the end of the take-off distance available.
  For aeroplanes with a wingspan of less than 60 m a horizontal obstacle clearance of half the aeroplane wingspan plus 60 m, plus 0.125 x D may be used.

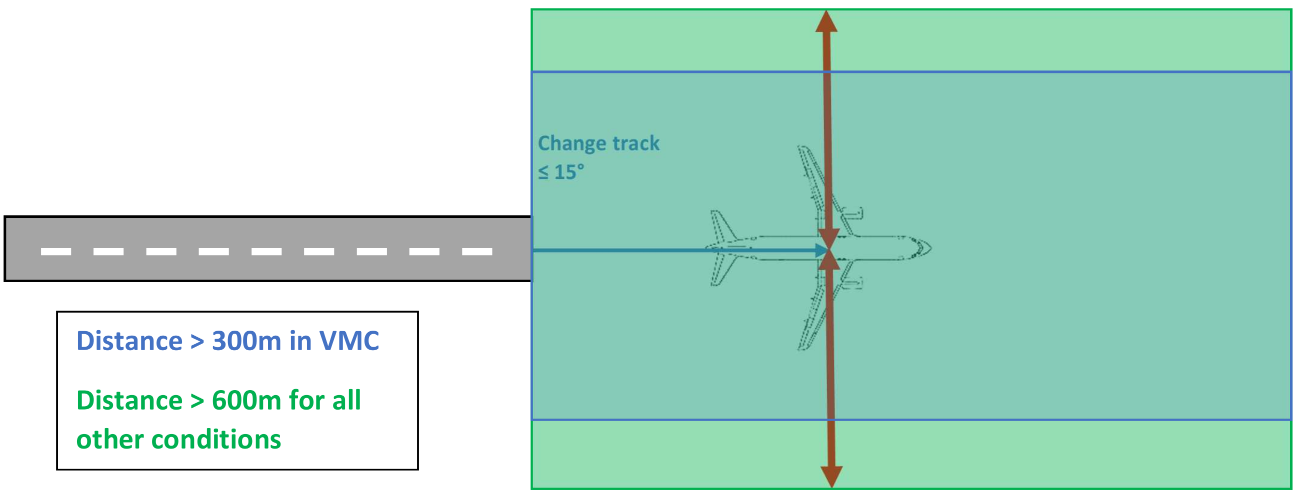


OR

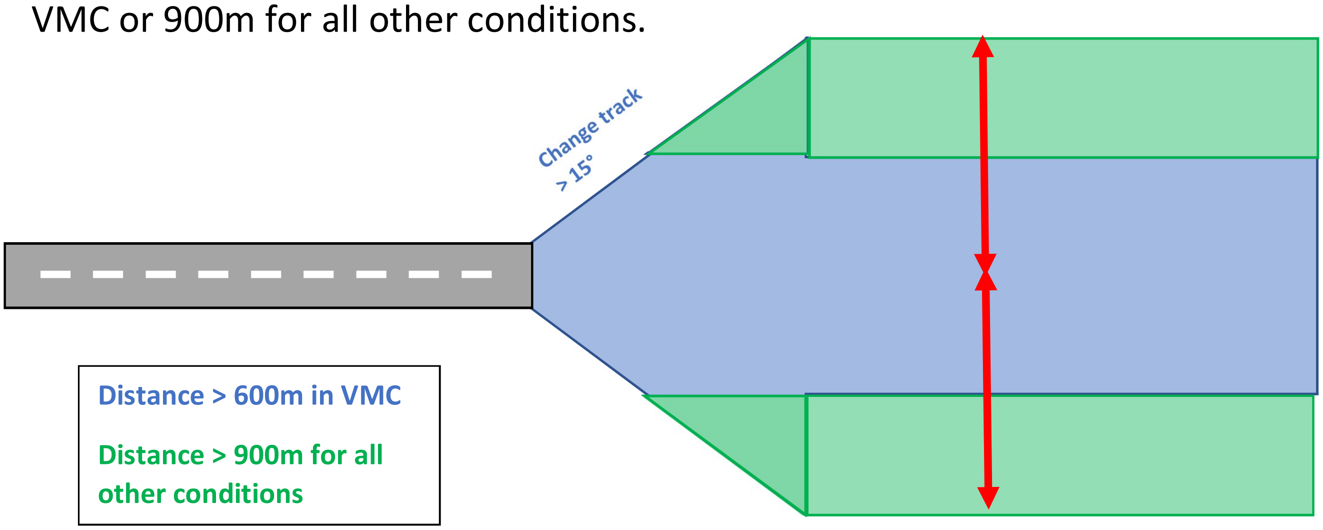


However, obstacles further away than the values shown below need not be considered. (Like for Class B)

Condition	**Maximum Semi-width**	
Change of Track Direction	**0° to 15°**	**Over 15°**
Able to Maintain Visual Guidance or same Accuracy	300 m	600 m
All Other Conditions	600 m	900 m



If the flight path requires track changes of more than 15°, obstacles need not be considered if the lateral distance is greater than 600m in VMC or 900m for all other conditions.



CALCULATING THE OBSTACLE CLEARANCE

- To work out the obstacle clearance of the aeroplane, the climb gradient needs to be known. But for calculating obstacle clearance must be the net climb gradient. Remember that the net gradient is the gross gradient diminished by a safety factor. In this case the safety factor changes depending on the number of engines.

The net gradient is the gross gradient reduced by:

- 0.8% for 2 engined aircraft
- 0.9% for 3 engined aircraft
- 1.0% for 4 engined aircraft

- When adjusting for wind to calculate the ground gradient, no more than 50% of the reported head wind and no less than 150% of the reported tailwind must be used.

- If the aeroplane is unable to clear the obstacle vertically, then, it can turn away from the obstacle and clear it horizontally. However, there is restriction on how much the aeroplane is allowed to turn. Clearly it is not safe if the aeroplane needs to bank sharply to clear the obstacle by the regulatory margins. Turning can increase the effective weight by imposing extra g loads and therefore the climb gradient is reduced, and stall speeds are increased. Allowance must be made for the effect of the turn on the climb gradient and speed.

The flight manual usually gives a gradient decrement for a 15° banked turn at V2. For greater bank angles:

- For 20° bank, use 2 x gradient decrement and V2 + 5 kt
- For 25° bank, use 3 x gradient decrement and V2 + 10 kt

TURNS ON THE FLIGHT PATH

- Turns are not allowed below a height of half the wingspan or 50ft whichever is greater.
- Up to 400ft, bank angle may not be more than 15°.
- Above 400 ft, bank angle may not be more than 25°.

EASA does permit operators to exceed these bank angles providing the operator uses special procedures and that these procedures have been approved by the relevant authority.
The special procedures must take account of the gradient loss from such bank angles and these must be published in the aeroplane flight manual.
The maximum bank angles that the special procedures allow is:

- up to 20° between 200 and 400 ft
- up to 30 ° between 400 and 1500 ft.

If any turn of more than 15° is required at any point in the take-off flight path, then the vertical clearance is increased to 50 ft instead of 35 ft.

PRESENTATION OF DATA

NOISE ABATEMENT (DEPARTURE) PROCEDURES (NADP)

Aeroplane operating procedures for the take-off climb shall ensure that the necessary safety of flight operations is maintained whilst minimizing exposure to noise on the ground.

There are 2 NADP:
NADP 1: To provide noise reduction for noise-sensitive areas in close proximity to the departure end of the runway
NADP 2: To provides noise reduction to areas more distant from the runway end

NADP 1

<u>This procedure involves a power reduction at or above the prescribed minimum altitude and the delay of flap/slat retraction until the prescribed maximum altitude is attained.</u>

At the prescribed maximum altitude, accelerate and retract flaps/slats on schedule whilst maintaining a positive rate of climb, and complete the transition to normal en-route climb speed.

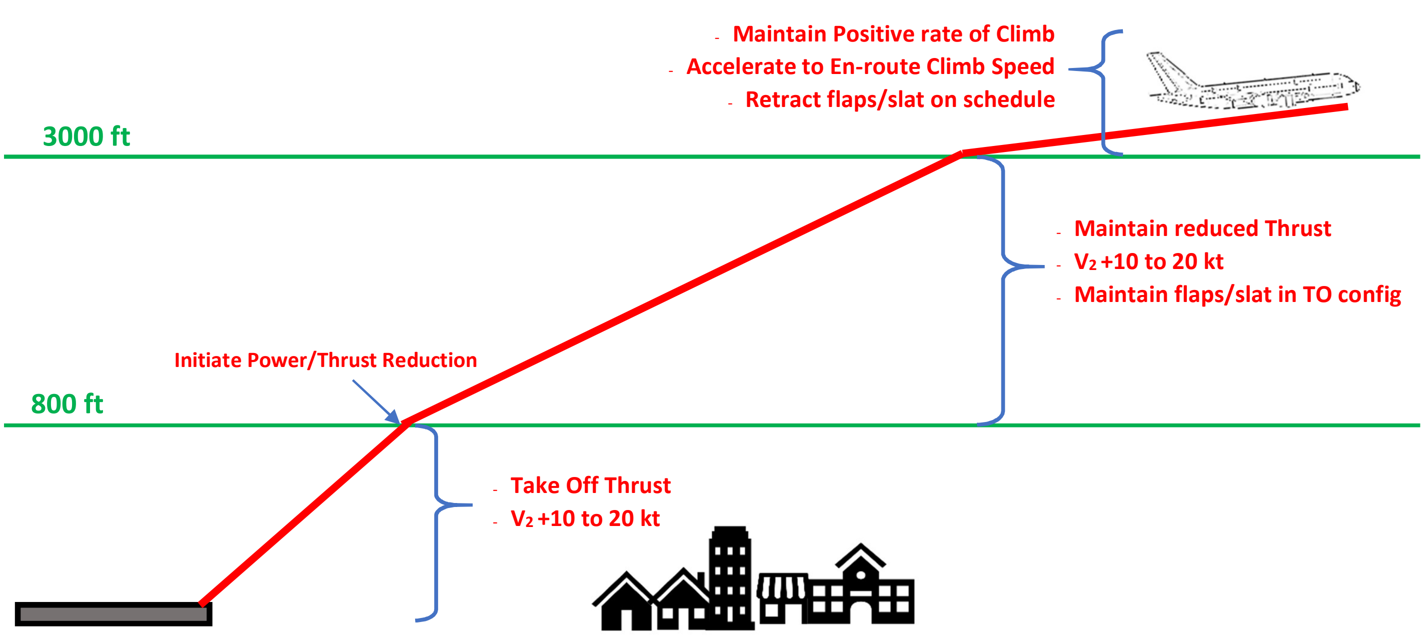
The noise abatement procedure is not to be initiated at less than 800 ft above aerodrome elevation.

The initial climbing speed to the noise abatement initiation point shall not be less than V_2+10 kt.

On reaching an altitude at or above 800 ft above aerodrome elevation, adjust and maintain engine power/thrust in accordance with the noise abatement power/thrust schedule provided in the aircraft operating manual. Maintain a climb speed of V_2 +10 to 20 kt, with flaps and slats in the take-off configuration.

At no more than an altitude equivalent to 3,000 ft above aerodrome elevation, whilst maintaining a positive rate of climb, accelerate and retract flaps/slats on schedule.

At 3,000 ft above aerodrome elevation, accelerate to en-route climb speed.



NADP 2

This procedure involves initiation of flap/slat retraction on reaching the minimum prescribed altitude. The flaps/slats are to be retracted on schedule whilst maintaining a positive rate of climb. The power reduction is to be performed with the initiation of the first flap/slat retraction **or** when the zero flap/slat configuration is attained.

At the prescribed altitude, complete the transition to normal en-route climb procedures.

The noise abatement procedure is not to be initiated at less than 800 ft above aerodrome elevation.

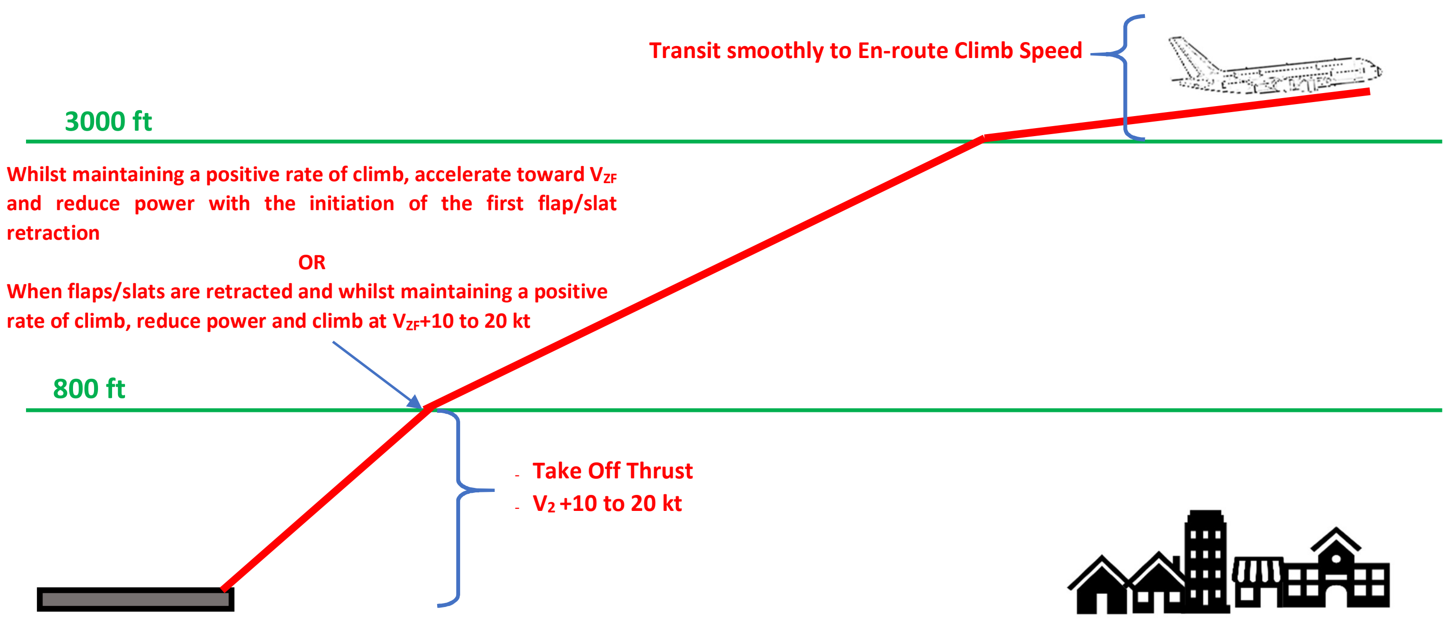
The initial climbing speed to the noise abatement initiation point is V_2 +10 to 20 kt.

On reaching an altitude equivalent to at least 800 ft above aerodrome elevation, decrease aircraft body angle/angle of pitch whilst maintaining a positive rate of climb, accelerate towards V_{ZF} and either:

- reduce power with the initiation of the first flap/slat retraction; or
- reduce power after flap/slat retraction.

Maintain a positive rate of climb and accelerate to and maintain a climb speed of V_{ZF}+to 20 kt to 3,000 ft above aerodrome elevation.

On reaching 3,000 ft above aerodrome elevation, transition to normal en-route climb speed.



The two procedures differ in that the acceleration segment for flap/slat retraction is either initiated prior to reaching the maximum prescribed height or at the maximum prescribed height. To ensure optimum acceleration performance, thrust reduction may be initiated at an intermediate flap setting.