LIMITATION

1) **Operating Limit**

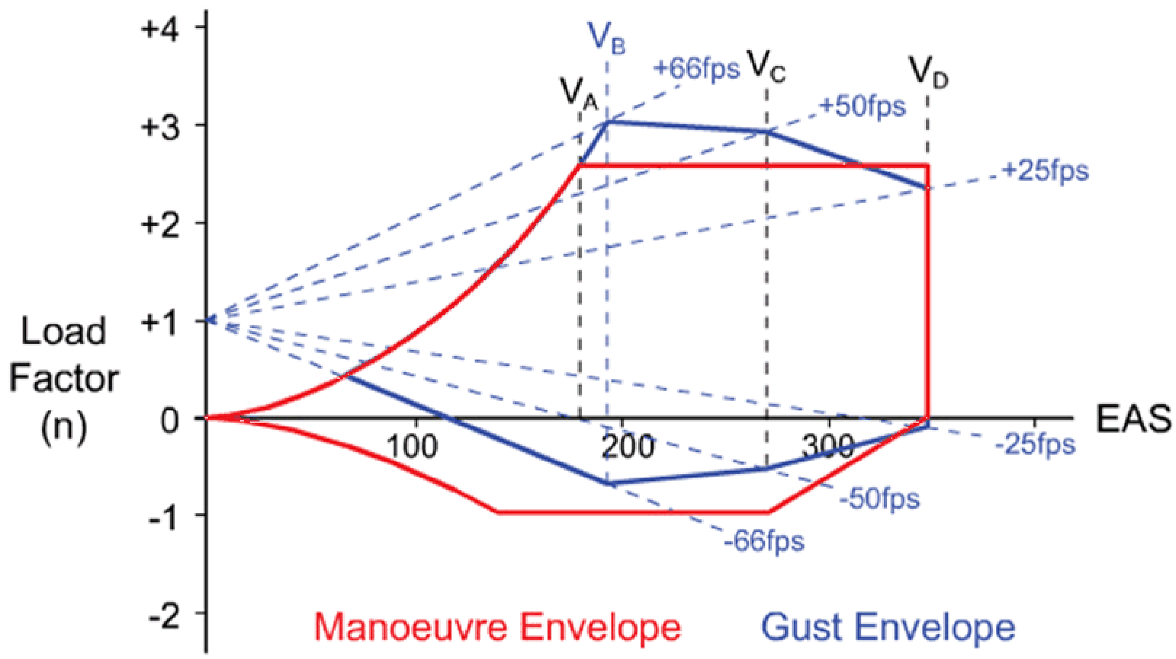
In service, an aircraft must observe certain speed limit. The limit may be set by various considerations, like

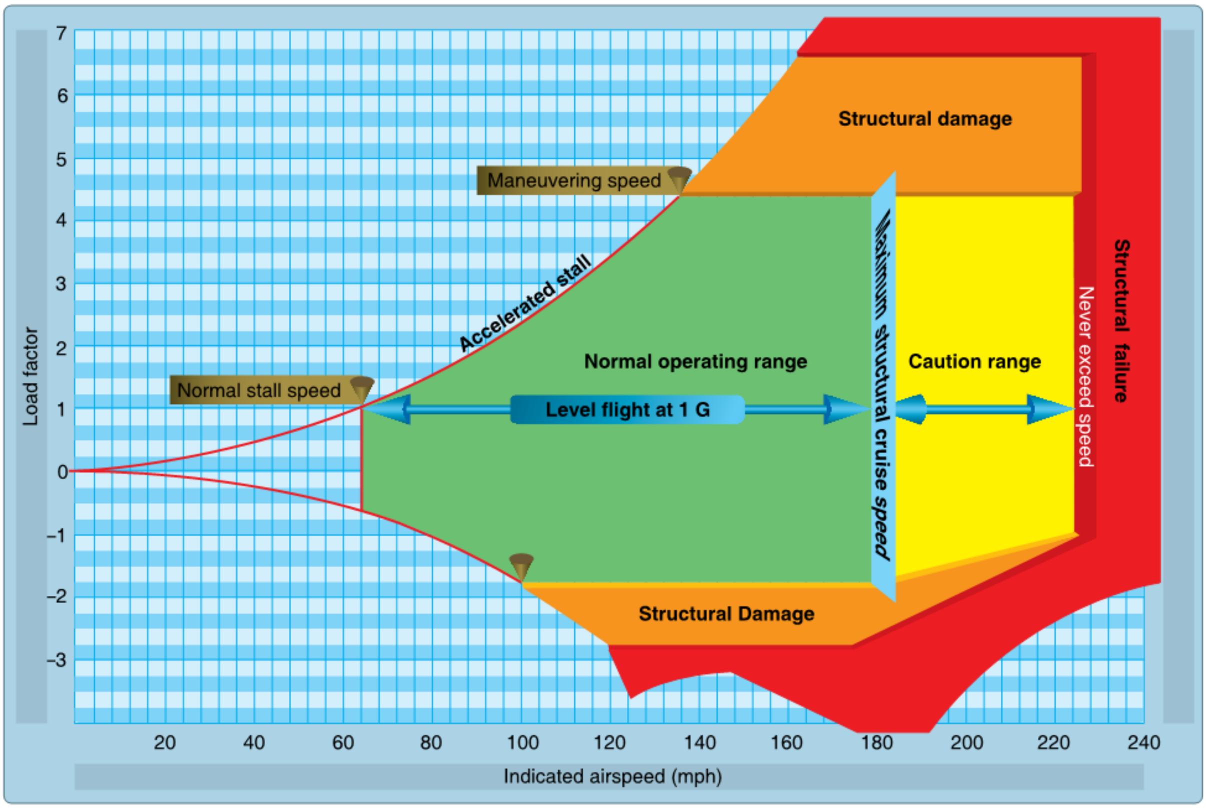
- Strength of the aircraft structure
- Stiffness of the aircraft structure
- Adequate control of the aircraft

2) **Load Factor**

Category: NORMAL +3,8g/-1,52g
UTILITY +4,4g/-1,6g
AEROBATIC +6,0g/-3,0g
TRANSPORT +2.5g/-1g (+2.0g with flaps)

3) **Manoeuvre Enveloppe (V-n Diagram) & Gust Enveloppe**





V_A : Design Manoeuvring Speed

The highest speed at which, full elevator deflection (nose up) can be made without exceeding the design limit load factor

$$VA = \mathrm{Vs1g} \times \sqrt{\mathrm{n}}$$

i.e for an aircraft, max limit load factor +2,5g and V_S= 60kt,

$$VA = 60 \times \sqrt{2{,}5} = 95kt$$

Note: If the aircraft's mass decrease, V_A decreases.

V_B : If an aircraft experiences a 66ft/s while flying at V_B, it would stall before exceeding the limit load factor. In turbulence, an aircraft would receive maximum protection damage by flying at V_B. In practice, a slightly higher speed is used in penetration in turbulence (V_{RA}/M_{RA})

V_{RA}/M_{RA}: Operation in Rough Air Speed

For flight in turbulence an airspeed must be:

- High enough to avoid stalling, and
- Low enough to avoid damage to the structure.

V_c : Design Cruise Speed

This speed is selected by the designer and used to assess the strength requirements in cruise.

V_D : Design Dive Speed

This is the maximum speed which has to be considered when assessing the strength of the aircraft. It is based on the principles of an upset occurring when the aircraft is flying at V_c, resulting in a shallow dive, during which the speed increases until recovery is made. This speed must also ensure that the aircraft is strong to withstand a vertical gust of 25ft/s.

V_{NE}: Never Exceed Speed (Small aircraft)

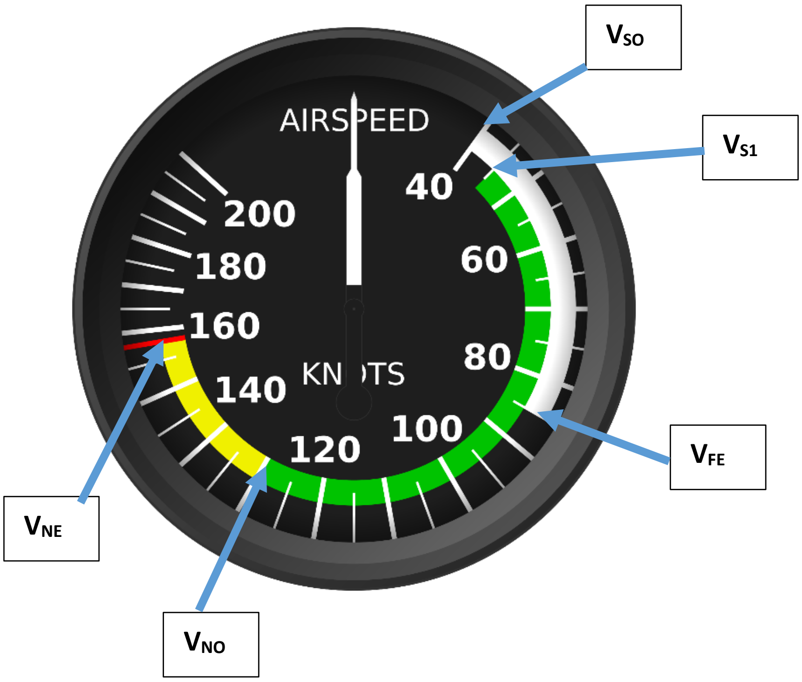
V_{NE} is set below V_D to allow for airspeed upset recovery (V_{NE}=0,9 V_D)

V_{NE} Is shown as a red line on the airspeed indicator

V_{NO}: Maximum Structural Cruise Speed (Small aircraft)

It is the normal operating cruise limit and must be not greater than the lesser of V_C or 0,89 V_{NE}

(On the airspeed indicator, V_{NO} is at the end of the green arc and beginning of yellow arc)



White Arc: starts from V_{SO} to V_{FE}
Flaps Operation Speed Range

Green Arc: starts from V_{S1} to V_{NO}
Normal Operation Speed Range

Yellow Arc: starts from V_{NO} to V_{NE}
Caution Operation Speed Range – To use only in smooth air and do not apply full deflection control

Red Line: V_{NE} – Never Exceed Speed

V_{MO} /M_{MO}: Maximum Operating Speed (Large aircraft)

It is speed that may not be exceeded in any regime of flight (climb, cruise or descent)

V_{MO} must not be greater than V_C and must be sufficiently below V_D

4) Speed Limitations

V_{SO}/V_{S0}: Stall speed in landing configuration (flaps and landing gears extended)
Beginning of the white arc on the airspeed indicator

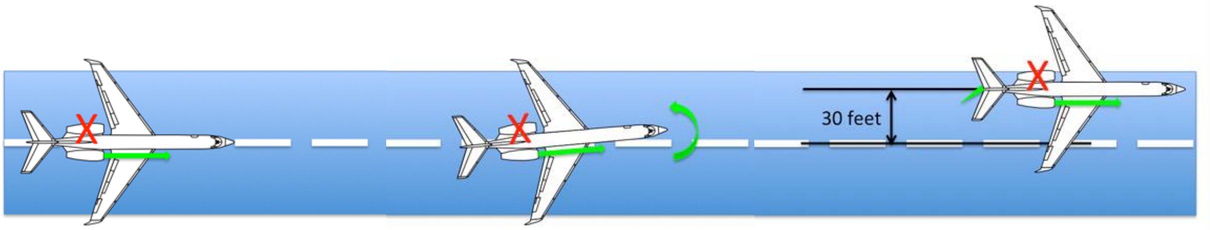
V_{S1}: Stall speed in a given configuration at 1g
Beginning of the green arc on the airspeed indicator ($V_{S1} > V_{SO}$)

V_{FE}: Maximum Speed Flaps Extended
Do not use the flaps above that speed – End of the white arc on the airspeed indicator
Usually the flaps will restrict the limit load factor.

V_{LE}: Maximum Speed Landing Gear Extended
Do not fly with the landing gear extended above that speed

V_{LO}: Maximum Speed Landing Gear Operation
Do not extend or retract the landing gear above that speed ($V_{LO} < V_{LE}$)

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.



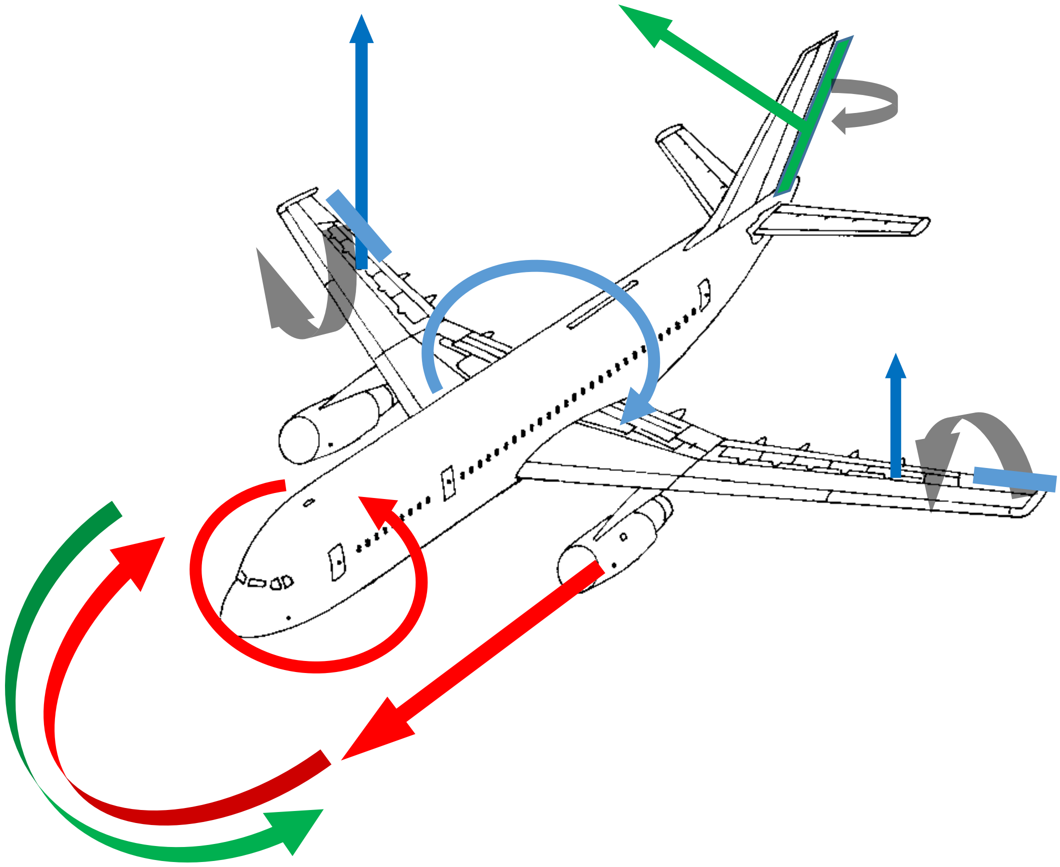
The alive engine will produce more thrust and the failed engine and so the aircraft will yaw. To counteract for this yawing moment, only the opposite rudder can be used. For the rudder to be effective, it must travel at a sufficient air speed. Therefore, if the engine supplies more thrust, the rudder 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

During V_{MCG} demonstration:
- Simulation is made with failure of the critical engine
- the aircraft shouldn't deviate more than 30 ft from the centreline when full rudder deflection is applied
- The nose wheel steering is disconnected to simulate wet and/or slippery runways conditions, only the aerodynamic force from the rudder are considered
- The CG is at most AFT limit to simulate maximum the worst case scenario (reduced arm)

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.



Affecting factors

Factors	**Less THURST, decrease V_{MCA}**	**More THURST, increase V_{MCA}**
Density (pressure, temp)	High pressure alt. High temp	Low pressure alt. Low temp

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

5) Aircraft Contamination

The contamination of the airframe (ie ice, heavy rain, etc) will

- Increase the weight of the aircraft → increase in V_S
- On the wing, the contamination spoils the pattern of the airflow → C_L decreases
- As well, it will spoil the profile of the aerofoil → Profile drag increases
- In some cases, the flight control can be jammed
- The propellers generates less thrust
- The engine can fail
- The contamination can block the static port and the pitot tube, leading to loss of the flight instruments and pilot confusion
- On the windshield and windows, the view is restricted

Prior to take-off, the aircraft must be cleared from all contaminants in all cases. And in flight, some aircraft are fit with equipment to fly into those conditions, but it is still favourable to avoid them.