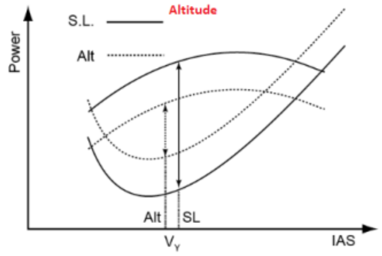
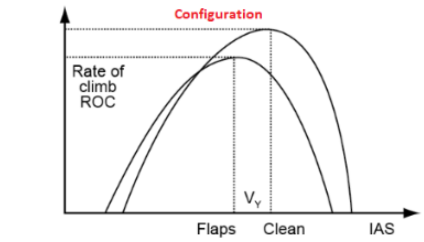
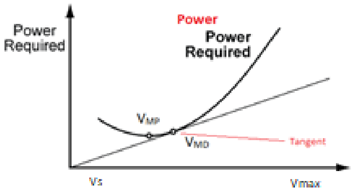
V-SPEEDS

V_X:
- **Best/max angle of climb** speed, climb at slower speed but steeper angle
- Max obstacle clearance
- Speed for which the **ratio of climb & forward speed is maximum**
- Max excess thrust (thrust available - thrust required = max = best angle)
- **Max obstacle clearance** with **no high lift devices,** may be **lower** or **equal** to V_Y

V_Y:
- Best rate of climb speed, climb at shallower angle but reach altitude faster
- Speed for best rate of climb, maximum height in **shortest time**
- Maximum excess power (power available - power required = max = best R/C)

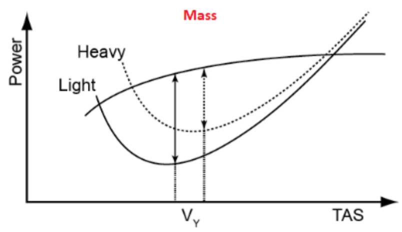


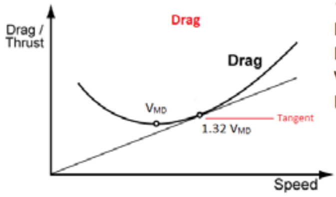




V_{MP}: Best endurance(Props)

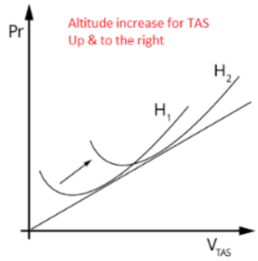
V_{MD}:
Best TAS/Power ratio
Best max L/D ratio
Best range (Props)

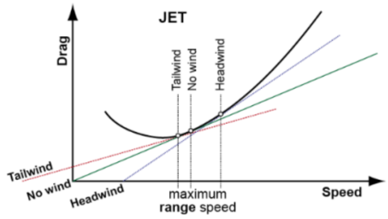




V_{MD}
Best max L/D ratio
Best glide
Vx & best endurance (Jets)
Best range (Props)

1.32 V_{MD}
Best range (Jets)
Best EAS/Drag ratio





**** Remember **power required** curve vs **drag/thrust** curve. Tangent for <u>power req</u> = V_{MD} & for <u>drag/thrust req</u> = 1.32 V_{MD}*

Jets:
- V_{MD} = **<u>min thrust required/min drag speed (Min thrust = min drag)</u>**
- Best angle of climb V_X = V_{MD} = Best **endurance** = speed for **max L/D = Holding speed**
- Best rate of climb V_Y = 1.32V_{MD} = speed for **best range** = Best EAS/Drag ratio = Best NAM/kg

Propeller:
- Best angle of climb V_X = V_{MP} = Best **endurance**
- Best rate of climb V_Y = V_{MD} = Best **range** = speed for **max L/D**

Jet aircraft		Propeller aircraft	
V_X	V_Y	V_X	V_Y
V_{MD}	1.32 V_{MD}	V_{MP}	V_{MD}
best endurance	best range	best endurance	best range
Max L/D			max L/D

Glide:
- **V_{MP}**: For maximum **<u>glide endurance</u> (Both** jets & prop) min ROD
- **V_{MD}**: Minimum drag for **maximum range** (Glide further) **proportional to aircraft mass**

Drift down:
- Best speed to descend after OEI (**Jets**): V_{MD} = V_X (Least rate of descent) (Best OEI angle of climb speed)
- Best speed to descend after OEI (**Props**): V_{MD} = V_Y (Best OEI rate of climb speed turboprops)
- **V_X – V_{XSE} – V_{YSE} – V_Y**

V_S: Stall speed/min steady flight speed airplane is **controllable**
V_{SR}: Reference stalls speed (6% higher than V_S)
V_{SO}: Stall speed/min steady flight speed airplane is controllable in **landing configuration**
V_{REF}:
- Landing reference speed = **V_{SO} x 1.3**
- Constant in **turbulent conditions**
- Landing speed: 1.23 V_{SRO} = V_{REF} (Up to 50ft)

V_P: Aquaplaning speed
V_{LO}: Maximum speed for **landing gear operation**

V_{LOF}: Lift off speed
- Short runways **higher flaps** to take-off faster **lower V_{LOF}** but lowers **climb performance**
- Distant obstacles **lower flaps** higher **V_{LOF},** higher **ground roll distance**
- **Higher with increased mass**

V_{MCG}:
- Min control speed on the ground
- **No nose-wheel steering & no crosswind** used for determination
- Determined by **engine thrust & rudder deflection**
- Determined by **primary aerodynamic control only**
- $V_{MCG} < V_{EF} < V_1$

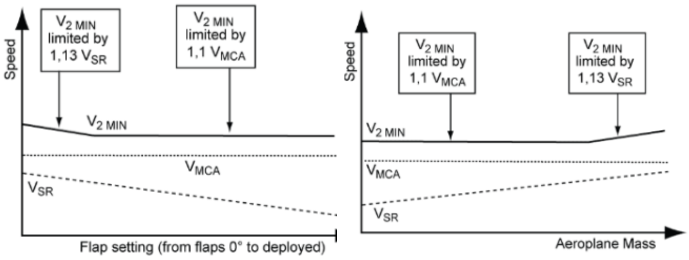
V_1:
- Pilot decides to **abort take-off AT** V_1 (At the last resort)
- Limited by $V_{MCG,}$ V_R & V_{MBE}
- Min value V_{MCG}, max value V_R
- Must not be exceeded by V_{MBE}
- **Can** be **higher** than V_{MU}
- Value exceeds correct V_1 value = ASD will exceed the ASDA
- V_1 increase but V_R the same = Increased **ASD**
- Higher value used with constant mass: TODR decrease & ASDR increase
- Reduced by **inoperative anti-skid** (Because you are braking manually you need a lower decision speed)
- OEI obstacle clearance reduces because of **contaminated runway**, but **climb performance remains constant**
- **Increased with mass (Because higher mass requires more lift = more speed)**
- **Down slope <u>decreases V_1</u>**

V_R:
- Speed at which **pilot should start** to **rotate** the aeroplane
- If aircraft rotates earlier: Stabilizer trim setting miscalculated, centre of gravity too far aft (Miscalculated V_R does **not cause** early rotation, it is just a calculated value)
- Speed to which rotation to the lift off angle is initiated
- Must not be less than $1.05V_{MCA}$ or V_1

V_{EF}: 2 seconds are for **recognition**

V_{MBE} (Max brake energy):
- Must not be exceeded by V_1
- If TOM is V_{MBE} limited, an **uphill** requires less brake energy thus allows an **increased mass** (A good thing)

V_2:
- Take-off safety speed/**take off climb speed** or **speed at 35ft**
- May not be less than **1.13 V_{SR}** for **turbojets**
- May not be less than **1.08 V_{SR}** for **turboprops**
- May not be less than **1.10 V_{MCA}**
- **Limited by V_{MCA}**: Large flap angles, high air pressure & low aircraft weight (What is good for thrust also increases adverse yaw OEI)
- **Decreases with higher flaps**
- **Increased V_2 procedure(Improved take-off climb/climb performance procedure):**
  - Only possible when **an excess field length** is available **(ASD is not limiting)**
  - Further screen height along runway
  - Increases **TODR & climb gradient** for a given TOM
- V_{2MIN}:
  - Decrease with higher flaps if not limited by V_{MCA}
  - Uses V_{SR} & V_{MCA}



V speeds affected by:
- Mass: Lower mass, lower speeds
- Density altitude: Density altitude increase, thrust decrease, lower V_{MCA} to counteract yaw OEI
- Low field elevation = lower speeds
- Flap settings: Higher flaps = decreased stall speed

Numbers, formulas & factors to remember

V speeds:
V_Y (Jets) = $1.32V_{MD}$
V_{SR}: Reference stalls speed (6% higher than V_S)
V_R: $1.05V_{MCA}$ or V_1
V_{REF}:

- Landing reference speed = V_{SO} x 1.3
- Landing speed: 1.23 V_{SRO} = V_{REF} (Up to 50ft)

V_2:

- 1.13 V_{SR} for turbojets
- 1.08 V_{SR} for turboprops
- 1.10 V_{MCA}

Take off safety speeds Class B:

- Multi engine = **1.1 x V_{MC}**
- Single engine = **1.2 x V_{S1}**

Service ceiling:

- Piston ROC < 100ft/min
- Jet ROC <500ft/min

Absolute ceiling: ROC = 0ft/min

Clearway:

- **50% of TORA**
- Area 152m (Min width 500ft) wide under control of airport authorities

TODA:

- **150%** of TORA

No stopway & clearway:

- **(TOD x 1.25) < or = TORA**

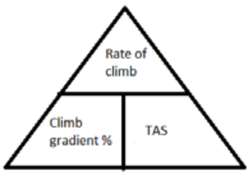
With stopway & clearway:

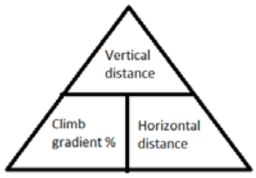
- **TOD < or = TORA**

Upslope:

- **TOD + 5% for each 1%** upslope

Glide slope = descent angle
Descent gradient = tan descent angle x 100
Climb gradient % = ((Thrust – drag) ÷ weight) x 100





Climb: Thrust = Drag + Wsinγ
Descent flight: **T + Wsinγ = D**
Lift = Wcosγ

C_L/C_D max at 4°

Specific fuel consumption (Jet): Fuel flow ÷ unit of thrust
Specific range (SPEED OVER DRAG RATIO):

- Number of **miles per unit mass of fuel**
- TAS ÷ fuel flow (Prop = V_{MD}, Jets = 1.32 V_{MD})
- Propeller aircraft at **medium altitude** better **engine efficiency** (Power required increases with altitude)

Runway factor Class B:
Landing: x **1.43**(Regulatory factor) x **1.15** (Grass up to 20cm) x **1.15** (Wet paved)
Take-off: x **1.2** (Dry) x **1.3** (Wet) x **1.0** (Wet paved)

Runway **without** stopway or clearway available:
- TORA: 1.25
Runway **with** stopway or clearway:
- ASDA: 1.3
- TODA: 1.15
- TORA: 1.0
(ASS 1.3, TOD 1.15, TOR 1)

Slope factor:
1% = + 0.05 for **UPSLOPE FOR TAKE-OFF**
1% = + 0.05 for **DOWNSLOPE FOR LANDING**

Rate of climb = Gradient % x ground speed

Net take-off flight path: Clears obstacle distance of beginning **50ft to 1500ft**
Climb rate requirement: **300ft/min** with **all** engines operating at **max continuous power**

Drift down procedure: Procedure for one engine inoperative
Gross gradient of **climb: - 0.5%**
Gross gradient of **descent: + 0.5%**

Compliance planning stage: **300ft/min** climb with **all engines** operating

After take-off:
Bank angle below 50ft (screen height) = 0 after take-off

	$0 – 15^{o}$	15^{o}
VMC	300m	600m
IMC	600m	900m

Clearance width (D = Distance from end of TODA):
Wingspan > 60m: 90m + 0.125D
Wingspan < 60m: 60m + (1/2 wingspan) + 0.125D

Turning after take-off:
- No turns below 50ft
- 15^{o} from 50 – 400ft
- 25^{o} >400ft

Climb angle (^{o}) = Climb gradient (%) x (3/5)

ROC = Still air climb gradient (%) x TAS
ROC = Effective wind climb gradient (%) x GS
More accurate formula: ROC = Climb gradient (%) x TAS x (6080/6000)

Gradient % = (Altitude difference x 100) ÷ horizontal distance
Vertical height clearance = [Screen height + altitude difference] – obstacle elevation

Gradient % = (T/W – D/L) x 100

Solving questions:
ROC in VMC = ROC all engine x 0.77
ROC in IMC = Assume OEI ROC

Time to climb to cloud base:
(Cloud base – screen height) ÷ ROC in VMC

Time to climb from cloud base to above height clearance over obstacle:
[(Obstacle height + clearance) – cloud base] ÷ ROC OEI

Distance = GS x total time

	1^{st}	2^{nd}	3^{rd}	4^{th}
Starts	35ft	Gear up	Retracting flaps & accelerating to V_{FTO}	Flaps up, V_{ZF}, MCT
Actions	Select gear up	Climb to >400ft	Retract flaps, accelerate to V_{FTO}	Climb to 1500ft
Ends	Gear up	>400ft	Flaps up, V_{FTO}, MCT	1500ft
Thrust	Take-off	Take-off	Take-off	MCT
Speed	V_2	V_2	V_2 - V_{ZF} - V_{FTO}	V_{FTO}
2 engines	Positive	2.4%	1.2%	
3 engines	0.3%	2.7%	1.5%	
4 engines	0.5%	3%	1.7%	

PCN/ACN:
ACN **may exceed** the **PCN by 10%**
- 1^{st} acronym: Load capacity
- 2^{nd} acronym: F = +10%, R = + 5%

MTOM calculation:
Gradient (%) = (T – D)/W x 100
*Determining MTOM assume **one engine fails**

Climb gradient (%) = ((Thrust – drag) ÷ weight) x100 = constant ÷ weight x 100
Net flight path gradient is **smaller** than gross

Gross gradient:
- 0.8% - 2 engine
- 0.9% - 3 engine
- 1% 4 engine

Drag = W ÷ L/D ratio
Gradient = (T – D)/W x 100

Class A **vertical interval <u>during</u>** drift down = **2000ft**

Maximum landing distance at **destination & alternate** (Always the same) Class A:
Turboprop = x 0.7
Jet = x 0.6 (Jet & wet 1.92 because (1 ÷ 0.6) x 1.15)
Wet safety factor: ÷ 1.15 (+15%)

Theory to just remember:

- FOR JET PROPELLED: **Speed over drag ratio** is maximum RANGE SPEED
- Aeroplane with **reciprocating engine** flying at **constant AOA, mass & configuration** with **increasing altitude** the **drag remains unchanged** but the **TAS increases**
- Altitude increase effect on V_X & V_Y in **IAS:** V_X **constant** & V_Y **decrease**
- Maximum horizontal speed occurs when: **Maximum thrust = total drag**
- Any **acceleration** during climb with <u>**power constant**</u> **decreases ROD & angle of climb**
- **Minimum gross gradient** does **not account for wind**
- Take off performance data is generally determined by the manufacturers by calculations **only a few values are verified by flight tests**
- V_{MCG} found **with nose wheel steering inoperative** as it must be valid in both wet & dry conditions
- Glide **range increases** when $\mathbf{C_L}$ **is reduced**
- **Fuel mileage in NM/KG: Lowers with FORWARD CG**
- **Down slope** reduces V1 & **reduces TODR (More than increases ASDR)**

Important to understand

- **Effect of GLIDING/DESCENDING:** When you **descend at constant MACH**, your IAS increases (as you are **pitching down**) so **decreases** coefficient of lift, descent angle **increases** (Because pitching down makes it steeper)
- Turboprops are **CLASS A,** pistons/reciprocating are **class B**