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Take-Off

- Review Climbing and Slipping
- Definition and Motivation
- Take-Offs
 - **Normal, Short-Field, Soft-Field, Crosswind**
 - Factors
- Summary and Questions
- Pre-Flight Briefing



Review Climbing

- Define and state the two important reference speeds for climbing.
- Where do we find the relevant performance data?
- How do we maintain a selected climb airspeed given a fix power setting?
- What factors affect climb performance?
- How do we maintain *coordinated flight* during a climbing turn?



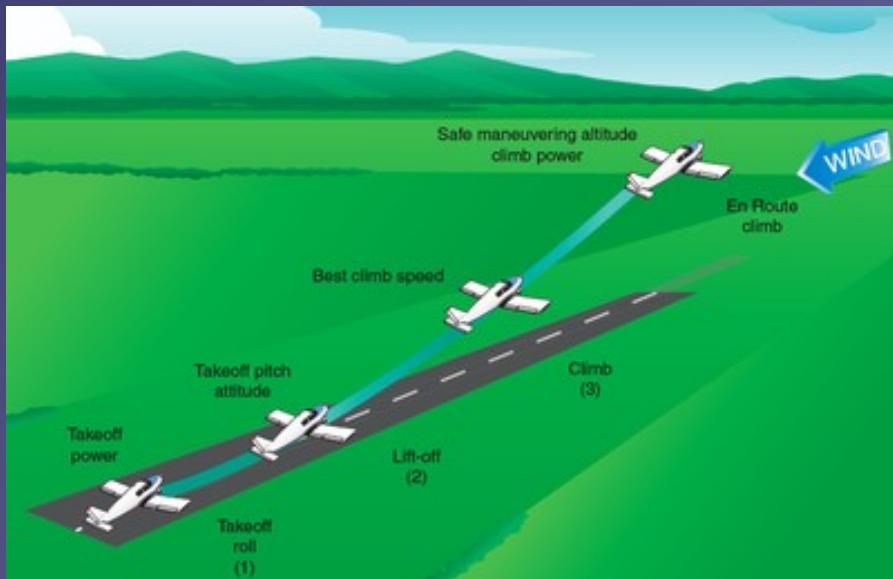
Definition and Motivation



- *Act of leaving a supporting surface including the immediately preceding and following acts*
- Leaving the ground and *becoming airborne*
- Essential maneuver used in every single flight



Normal Take-Off



- Criteria: **hard uncontaminated surface**, **long runway**, **no obstacles**, **low density altitude**, **no or steady headwind**
- Check **environment** and consult **performance** data in POH
- Pre-take-off checks according to **checklists** in POH
- **Mixture** full rich, lean for maximum RPM above **3000 ft DALT**
- Conduct passenger, crew departure and emergency **briefings**



Normal Take-Off – Line Up



Check Approach Sector



Align Centerline



Crosscheck Instruments



- Check **approach sector** and callout *Approach Sector Clear*
- Align with **runway centerline** using **power**, **rudder** and **brakes**
- Keep **nose-wheel** centered and *ideally* stop before take-off run
- Crosscheck **runway heading**, **magnetic compass**, **heading indicator**



Normal Take-Off – Run



- Callout **Take-Off** before initiating take-off run
- *Smoothly* apply **full power** keeping **straight** with **rudder**
- Use **runway end** as **reference** for directional control
- Check RPM/ASI and callout **RPM Checked, Airspeed Alive**
- Continue to accelerate to rotation speed (**V_r = 55 KIAS**)
- *Gently* apply **elevator** back-pressure to lift off nose-wheel



Normal Take-Off – Initial Climb

Positive Rate



Adjust Attitude



Maintain Airspeed



Control Direction

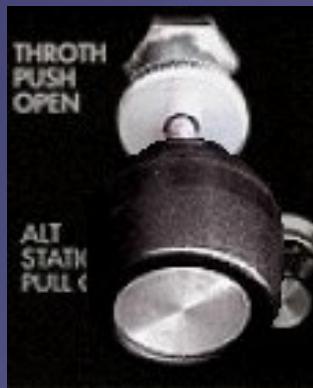


- Establish **nose-up attitude** aligning nose with **horizon**
- Check altitude and VSI and callout *Positive Rate*
- Accelerate to *normal climb airspeed (80 KIAS)*
- Adjust and maintain **nose-up attitude** for **climb airspeed**
- **Trim** to eliminate elevator control pressure as *required*
- Maintain directional control and control **yaw** with **rudder**



Aborted / Rejected Take-Off

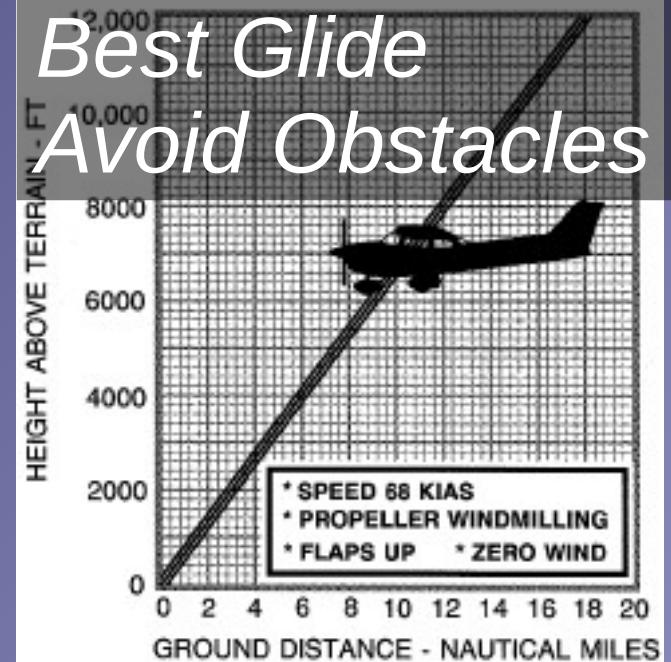
Power Idle



Apply Brakes



*Best Glide
Avoid Obstacles*



- Reasons: failures, traffic, animals, humans
- During take-off run: **power idle**, apply **brakes**, keep **straight**
- Immediately after take-off *with* sufficient runway: **power idle**, **flaps as required**, land **straight ahead**
- Immediately after take-off *without* sufficient runway: establish **best glide airspeed (68 KIAS)**, avoid major turns and **obstacles**

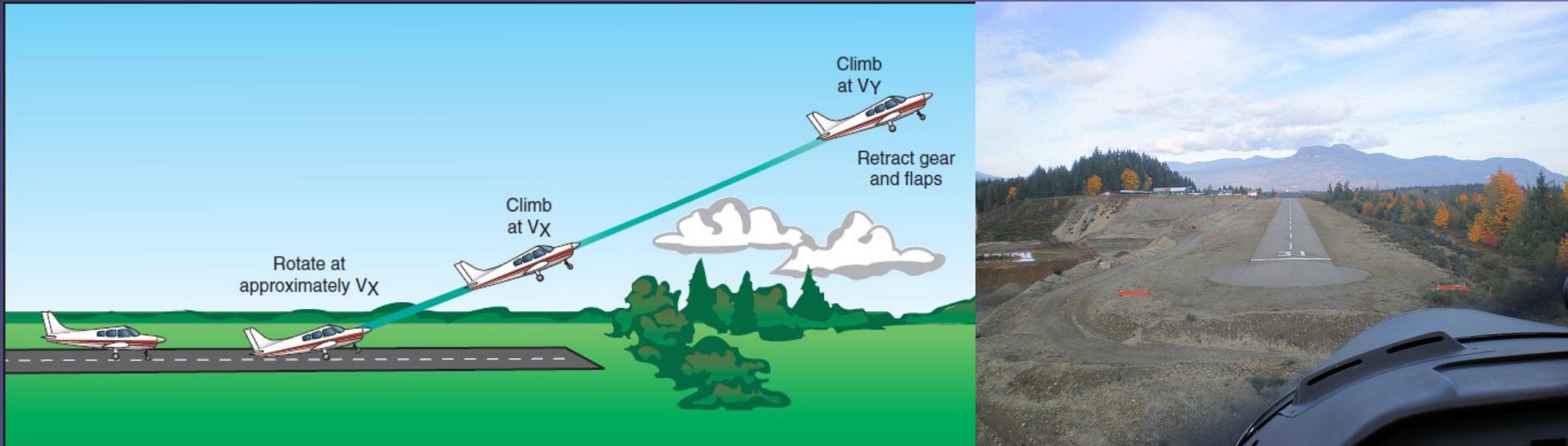


Safety Considerations

- Continue **lookout** and maintain **situational awareness**
- Remain within ATC **clearance** limits (line-up, take-off)
- Comply with ATC **instructions** (hold short)
- Inform ATC if *unable* to follow instructions
- Consider leaving **ground effect**: *induced* versus *effective* angle of attack



Short-Field Take-Off



- Criteria: **hard uncontaminated surface, short runway, obstacles, high density altitude, no or steady headwind**
- Check **environment** and consult **performance** data in POH
- Pre-take-off checks according to **checklists** in POH
- **Mixture full rich, lean for maximum RPM** above **3000 ft DALT**
- Conduct passenger, crew departure and emergency **briefings**



Short-Field Take-Off – Line Up



Check Approach Sector



Align Centerline



Crosscheck Instruments

- Check approach sector and callout **Approach Sector Clear**
- Align with **runway centerline** using **power, rudder and brakes**
- Keep **nose-wheel** centered and stop before take-off run
- Crosscheck **runway heading, magnetic compass, heading indicator**



Short-Field Take-Off – Run

Flaps 10°



Hold Brakes



Full Power



Release Brakes



- Set **flaps 10°**, apply and hold **brakes**
- Smoothly apply full power and check *static RPM* (**2300-2400**)
- Callout **Take-Off** before initiating take-off run
- Release **brakes** to initiate take-off run
- Apply *slight elevator* back-pressure
- Check RPM/ASI and callout **RPM Checked, Airspeed Alive**
- Keep straight with **rudder** accelerating to lift-off (**V_r = 44..51 KIAS**)



Slight Back-Pressure



Short-Field Take-Off – Initial Climb

Positive Rate



Adjust Attitude



Maintain V_x



Clear Obstacles, V_y



- Check altitude and VSI and callout *Positive Rate*
- Accelerate to *best angle of climb airspeed ($V_x = 62 \text{ KIAS}$)*
- Adjust and maintain **nose-up attitude** for **airspeed** and **trim**
- Maintain directional control and control **yaw** with **rudder**
- Transition to *best rate of climb airspeed ($V_y = 74 \text{ KIAS}$) after obstacles cleared and trim*
- Retract **flaps** at **safe altitude (400 ft AGL)** in **white arc**



VICTORIA FLYING CLUB

Take-Off Performance

SHORT FIELD TAKEOFF DISTANCE AT 2550 POUNDS

CONDITIONS:

Flaps 10°
 Full Throttle Prior to Brake Release
 Paved, level, dry runway
 Zero Wind
 Lift Off: 51 KIAS
 Speed at 50 Ft: 56 KIAS

Press Alt In Feet	0°C		10°C		20°C		30°C		40°C	
	Grnd Roll Ft	Total Ft To Clear 50 Ft Obst	Grnd Roll Ft	Total Ft To Clear 50 Ft Obst	Grnd Roll Ft	Total Ft To Clear 50 Ft Obst	Grnd Roll Ft	Total Ft To Clear 50 Ft Obst	Grnd Roll Ft	Total Ft To Clear 50 Ft Obst
S. L.	860	1465	925	1575	995	1690	1070	1810	1150	1945
1000	940	1600	1010	1720	1090	1850	1170	1990	1260	2135
2000	1025	1755	1110	1890	1195	2035	1285	2190	1380	2355
3000	1125	1925	1215	2080	1310	2240	1410	2420	1515	2605
4000	1235	2120	1335	2295	1440	2480	1550	2685	1660	2880
5000	1355	2345	1465	2545	1585	2755	1705	2975	1825	3205
6000	1495	2605	1615	2830	1745	3075	1875	3320	2010	3585
7000	1645	2910	1785	3170	1920	3440	2065	3730	2215	4045
8000	1820	3265	1970	3575	2120	3880	2280	4225	2450	4615

NOTES:

1. Short field technique as specified in Section 4.
2. Prior to takeoff from fields above 3000 feet elevation, the mixture should be leaned to give maximum RPM in a full throttle, static runup.
3. Decrease distances 10% for each 9 knots headwind. For operation with tail winds up to 10 knots, increase distances by 10% for each 2 knots.
4. For operation on dry, grass runway, increase distances by 15% of the "ground roll" figure.

SHORT FIELD TAKEOFF DISTANCE AT 2400 POUNDS

CONDITIONS:

Flaps 10°
 Full Throttle Prior to Brake Release
 Paved, level, dry runway
 Zero Wind
 Lift Off: 48 KIAS
 Speed at 50 Ft: 54 KIAS

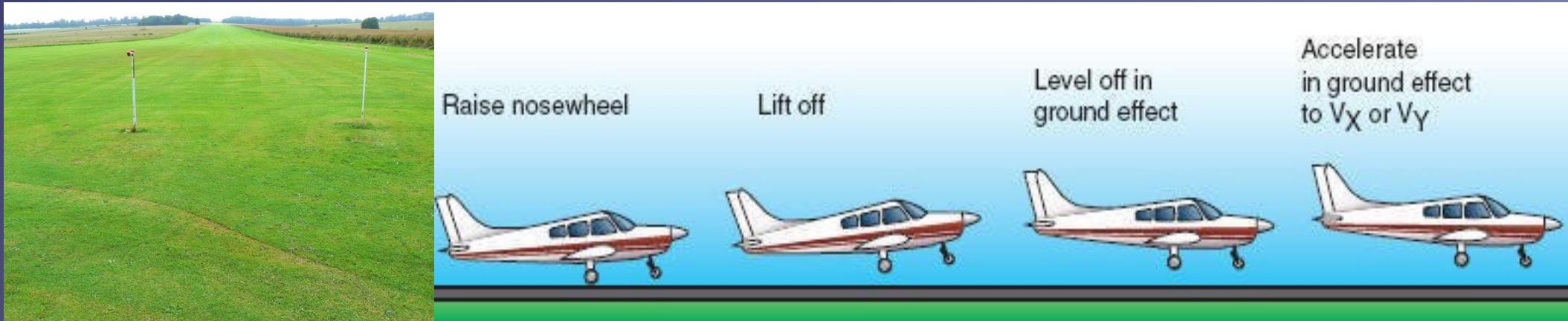
Press Alt In Feet	0°C		10°C		20°C		30°C		40°C	
	Grnd Roll Ft	Total Ft To Clear 50 Ft Obst	Grnd Roll Ft	Total Ft To Clear 50 Ft Obst	Grnd Roll Ft	Total Ft To Clear 50 Ft Obst	Grnd Roll Ft	Total Ft To Clear 50 Ft Obst	Grnd Roll Ft	Total Ft To Clear 50 Ft Obst
S. L.	745	1275	800	1370	860	1470	925	1570	995	1685
1000	810	1390	875	1495	940	1605	1010	1720	1085	1845
2000	885	1520	955	1635	1030	1760	1110	1890	1190	2030
3000	970	1665	1050	1795	1130	1930	1215	2080	1305	2230
4000	1065	1830	1150	1975	1240	2130	1335	2295	1430	2455
5000	1170	2015	1265	2180	1360	2355	1465	2530	1570	2715
6000	1285	2230	1390	2410	1500	2610	1610	2805	1725	3015
7000	1415	2470	1530	2685	1650	2900	1770	3125	1900	3370
8000	1560	2755	1690	3000	1815	3240	1950	3500	2095	3790

NOTES:

1. Short field technique as specified in Section 4.
2. Prior to takeoff from fields above 3000 feet elevation, the mixture should be leaned to give maximum RPM in a full throttle, static runup.
3. Decrease distances 10% for each 9 knots headwind. For operation with tail winds up to 10 knots, increase distances by 10% for each 2 knots.
4. For operation on dry, grass runway, increase distances by 15% of the "ground roll" figure.



Soft-Field Take-Off



- Criteria: soft, rough or contaminated surface, long runway, no obstacles, low density altitude, no or steady headwind
- Check environment and consult performance data in POH
- Pre-take-off checks according to checklists in POH
- Mixture full rich, lean for maximum RPM above 3000 ft DALT
- Conduct passenger, departure and emergency briefings



Soft-Field Pre-Take-Off

Cessna 172 Cr. XIST

PREFLIGHT INSPECTION	
1. Aircraft documents	CHECK
2. Fire extinguisher	CHECK
3. Seats/Harnesses	SECURE
4. Control Lock	REMOVE
5. Light switch	ON
6. Ignition switch	OFF
7. Electrical equipment, radios	ON
8. Master	ON
9. Flaps	DOWN
10. Fuel gauges	CHECK QUANTITY
11. Master	OFF
12. External inspection	CHECK

PASSENGER BRIEFING

1. Doors, windows
2. Seats/Harnesses
3. Fire Extinguisher
4. Master
5. ELS
6. Controls
7. Smoking
8. Mobile
9. Loose Articles - Secure

ENGINE START

1. Documents, safety equipment
2. Passenger Briefing
3. Seats/Harnesses
4. External inspection
5. Avionics Power Switch
6. Propeller
7. Fuel valve
8. Master
9. Throttle
10. Carb Heat
11. Master
12. Beacon Light
13. Propeller area
14. Propeller area
15. Master
16. Throttle
17. Oil pressure
18. Master

BEFORE TAKE OFF

1. Engine Doors, Windows, Seats - SECURE
2. Primer - LOCKED
3. Master - BOTH
4. Mag - COLD
5. Carb Heat - BOTH
6. Master - AS REQUIRED
7. Flaps - SET T.O.
8. Fuel - BOTH
9. Fuel - COLD
10. Flight Instruments - CHECK
11. Flight Controls - FREE & CORRECT
12. Take off Clearance - OBTAIN

LINING UP

1. Time of - RECORD
2. Transponder - ALT (check code)
3. Landing Light - ON
4. Ground Lights - ON

BEFORE LANDING

1. Primer - LOCKED
2. Master - OFF
3. Mag - BOTH
4. Carb Heat - COLD
5. Fuel Valve - BOTH
6. Breaker, Belts, Harnesses - CHECK
7. Seats, Belts, Harnesses - SECURE

AFTER START

1. Avionics Power Switch - ON
2. Flaps - RETRACT
3. Nav Lights - OFF
4. Transponder - STANDBY
5. Radios - SET
6. Altitude - COPY
7. Flight Instruments - SET
8. Fuel - OBTAIN
9. Tax clearance - OBTAIN
10. Brake - CHECK
11. Flight Instruments - CHECK

AFTER LANDING

1. Flight plan - CLOSED
2. Transponder - OFF
3. Oil - OFF
4. Wing Flaps - UP
5. Ground Lights - OFF
6. Landing Lights - OFF

SHUT DOWN

1. Flight plan - 1210 check tone
2. Avionics Power - OFF
3. Master - OFF
4. Mag - OFF
5. Live mag check at idle
6. Master - Idle Cut Off
7. Mag - OFF
8. Master - OFF

Briefings

Mixture

Flaps 10°



- Complete pre-take-off checks and briefings on *supporting surface*
- Conduct passenger, crew departure and emergency **briefings**
- Set **flaps (10°)** and lean **mixture** as required on *supporting surface*
- Setup aircraft for *rolling take-off* on *soft surface*
- Observe ATC clearances and instructions



Soft-Field Take-Off – Line Up

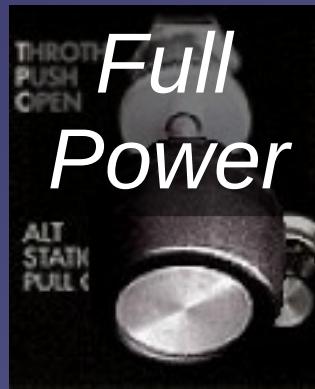
Relieve Nose-Wheel and Keep Rolling



- Apply and hold **elevator** back-pressure to relieve **nose-wheel**
- Check approach sector and callout **Approach Sector Clear**
- Perform *rolling take-off* – *ideally* do not stop after centerline alignment
- Crosscheck **runway heading**, **magnetic compass**, **heading indicator**



Soft-Field Take-Off – Run



- Callout **Take-Off** before initiating take-off run
- *Smoothly* apply **full power** keeping **straight** with **rudder**
- Use **runway end** as **reference** for directional control
- Apply *slight* **elevator** back-pressure to raise **nose-wheel**
- Check RPM/ASI and callout **RPM Checked, Airspeed Alive**
- Lift off at *slowest* **airspeed** possible **commensurate**



Soft-Field Take-Off – Initial Climb



- Level-off and remain in **ground effect** *immediately* after lift-off
- Accelerate in **ground effect** to desired **climb airspeed (V_x , V_y)**
- If *best angle of climb ($V_x = 62 \text{ KIAS}$)* is used for initial climb, then
- Transition to *best rate of climb ($V_y = 74 \text{ KIAS}$)* after clearing obstacles
- Retract **flaps** at **safe altitude (400 ft AGL)** in **white arc**

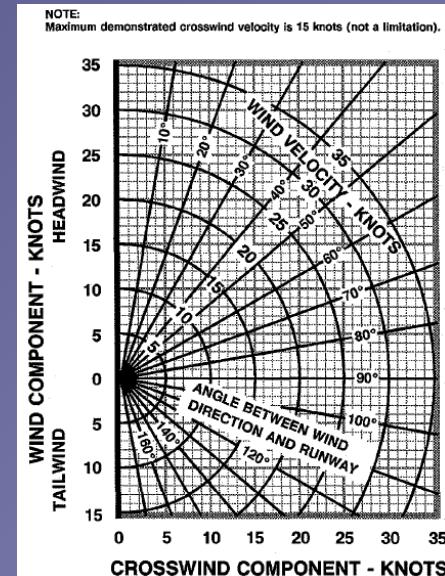
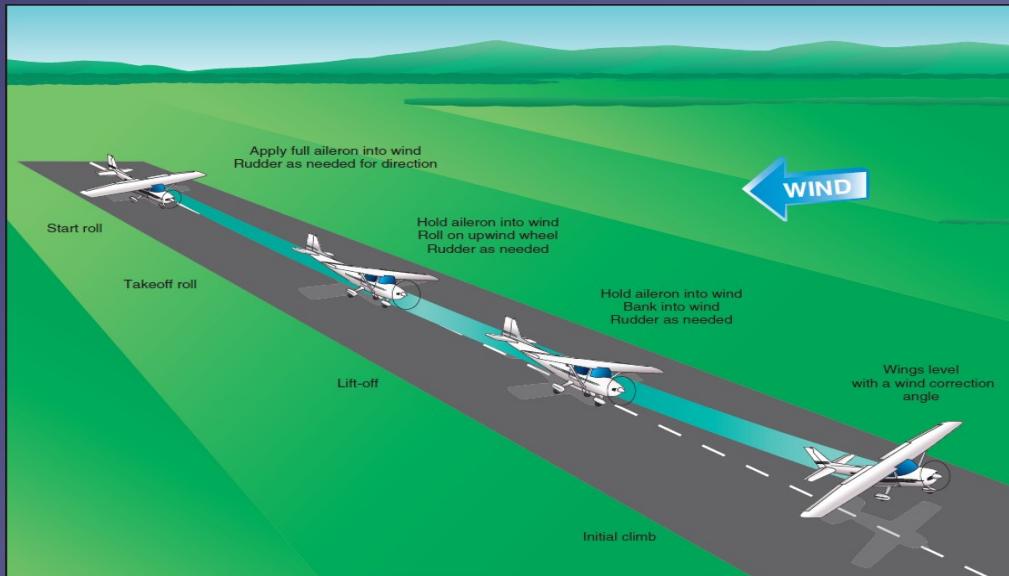


Review Slipping

- Define a slip and explain the difference between a side and a forward slip and their applications.
- Mentally perform a side slip and state all observations and actions.



Crosswind Take-Off



- Criteria: steady or changing gusty **crosswind** component
- Check **environment** and consult **performance** data in POH
- Pre-take-off checks according to **checklists** in POH
- Maximum demonstrated **crosswind** component **15 knots**
- Mixture *full* rich, lean for maximum **RPM** above **3000 ft DALT**
- Conduct passenger, departure and emergency **briefings**



Crosswind Take-Off – Run



Minimum
Flaps

*Full Aileron
Into Wind*



Keep Straight

*Reduce Aileron,
Briskly Lift Off*

- Use *minimum flap* setting required and *hold full ailerons* into the wind
- Callout *Take-Off* before initiating take-off run
- *Smoothly* apply *full power* keeping *straight* with *rudder*
- Use **runway end** as **reference** for directional control
- Check RPM/ASI and callout *RPM Checked, Airspeed Alive*
- Continue to accelerate to *slightly higher* lift-off speed
- *Gradually* reduce aileron input – *neutralized* ailerons required at lift-off
- *Briskly* apply **elevator** back-pressure to lift off



Crosswind Take-Off – Initial Climb



Level Wings



Coordinated Turn into Wind

- Check altitude and VSI and callout ***Positive Rate***
- Perform **coordinated turn into** the wind to establish a crab *while* maintaining **runway track**
- Accelerate to desired **climb airspeed (V_x, V_y)**
- Adjust and maintain **nose-up attitude** for **climb airspeed** and **trim**
- Retract **flaps** at safe altitude (**400 ft AGL**) in **white arc**

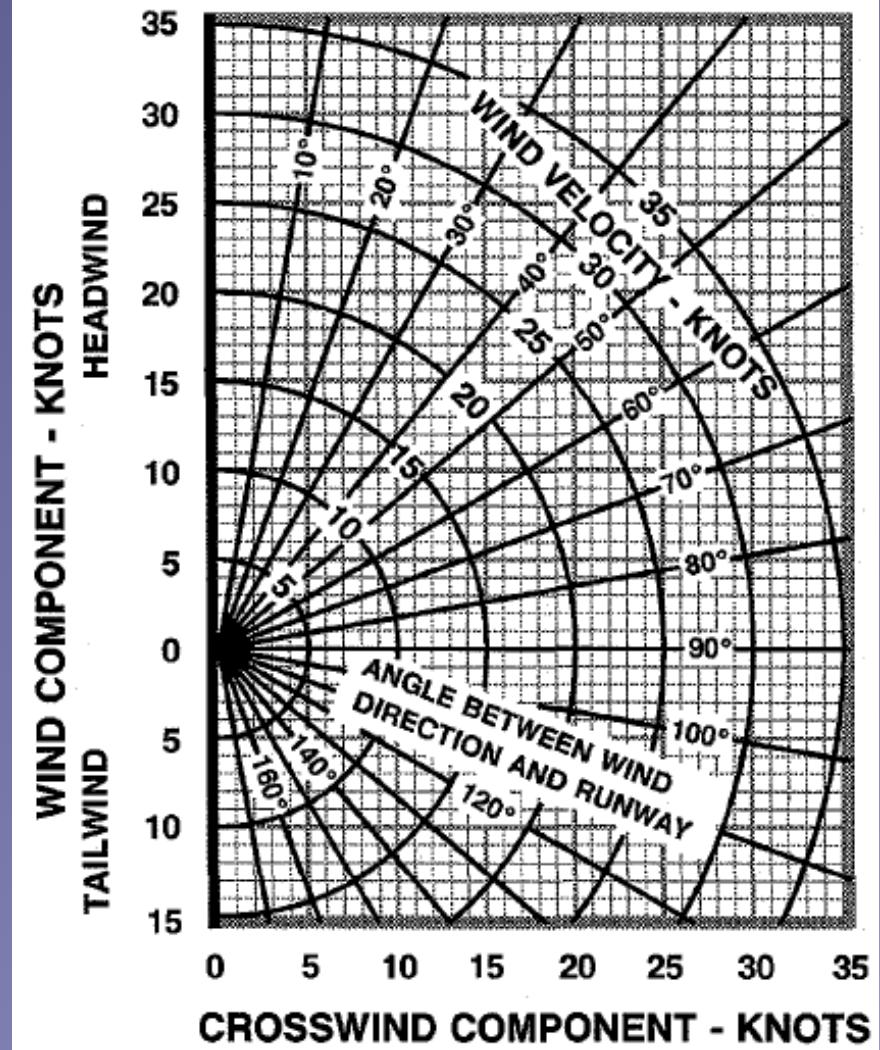


VICTORIA FLYING CLUB

Crosswind Component



NOTE:
Maximum demonstrated crosswind velocity is 15 knots (not a limitation).



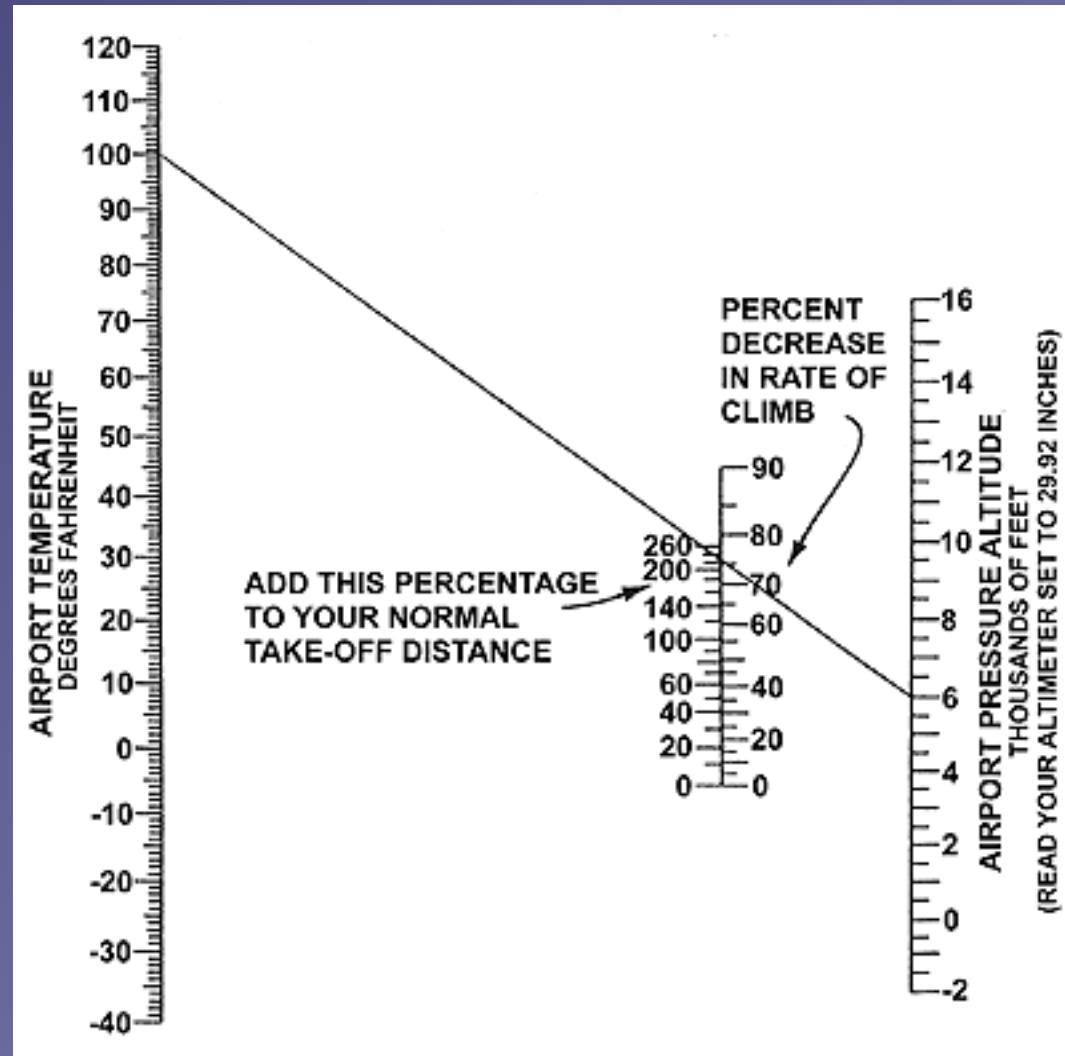


Take-Off Factors

- Runways and **aerodrome** environment
- **Surface** material (hard, soft, rough) and **slope**
- Surface **contamination** (wet, dry, slush, snow, ice)
- **Air density** (altitude, pressure, temperature, humidity)
- **Wind** and turbulence (head-/tailwind, gusts, windshear)
- **Wake** turbulence
- **Obstacles**
- **Weight** and **balance**
- Ground effect, wheelbarrowing, weathercocking



Density Altitude – Koch Chart





High Density Altitude Operations



- Check **environment** and consult **performance** data in POH
- Pre-take-off checks according to **checklists** in POH
- Lean for *maximum RPM* above **3000 ft DALT**
- *High* (high density altitude = low air density), *hot*, *humid*



VICTORIA FLYING CLUB

Special Take-Offs



- Take-offs featuring combined factors
- Soft, short, high, hot, gusty, heavy, contaminated...



Wheelbarrowing



- *Higher* load on the **nose-wheel**
- Tendency to pivot about the nose wheel may result in ground loop
- *Before* pivoting: ease back **elevator** to reduce weight on **nose wheel**
- *After* pivoting: *relax* forward **elevator** and abort if not stopped



Summary / Quiz

- What are the factors affecting take-offs and the selection of a take-off type?
- Mentally perform a short-field take-off and state all observations and actions.
- Mentally perform a soft-field take-off and state all observations and actions.
- Mentally perform a crosswind take-off and state all observations and actions.



Pre-Flight Briefing

- Exercise
- Training Area
- Departure and Arrival Procedures
- Weather Briefing / NOTAMs
- Aircraft and Documents
- Time and Fuel Requirements
- Safety Considerations and Responsibilities

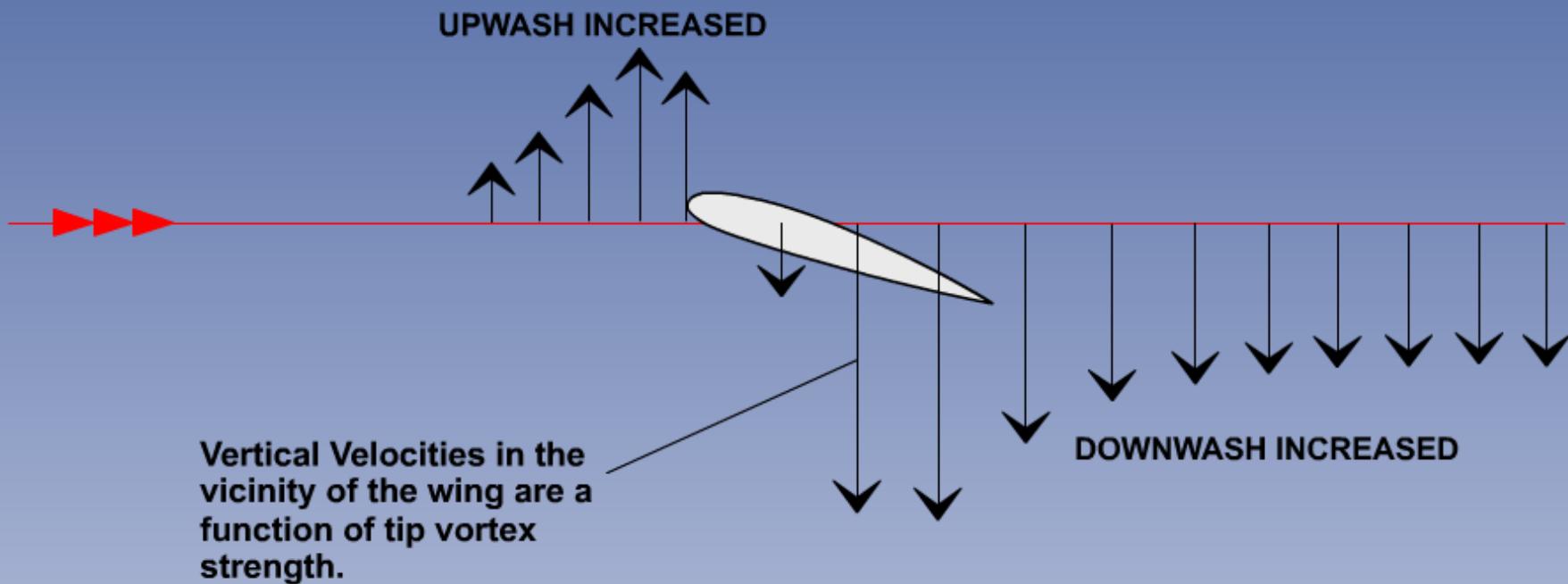


Additional Materials

- Additional materials for Take-Off
- Flight Instructor Guide – Exercise 16
- Flight Instructor Guide – Lesson Plans 3, 4, 12, 14, 16, 18



Induced AoA – Upwash and Downwash

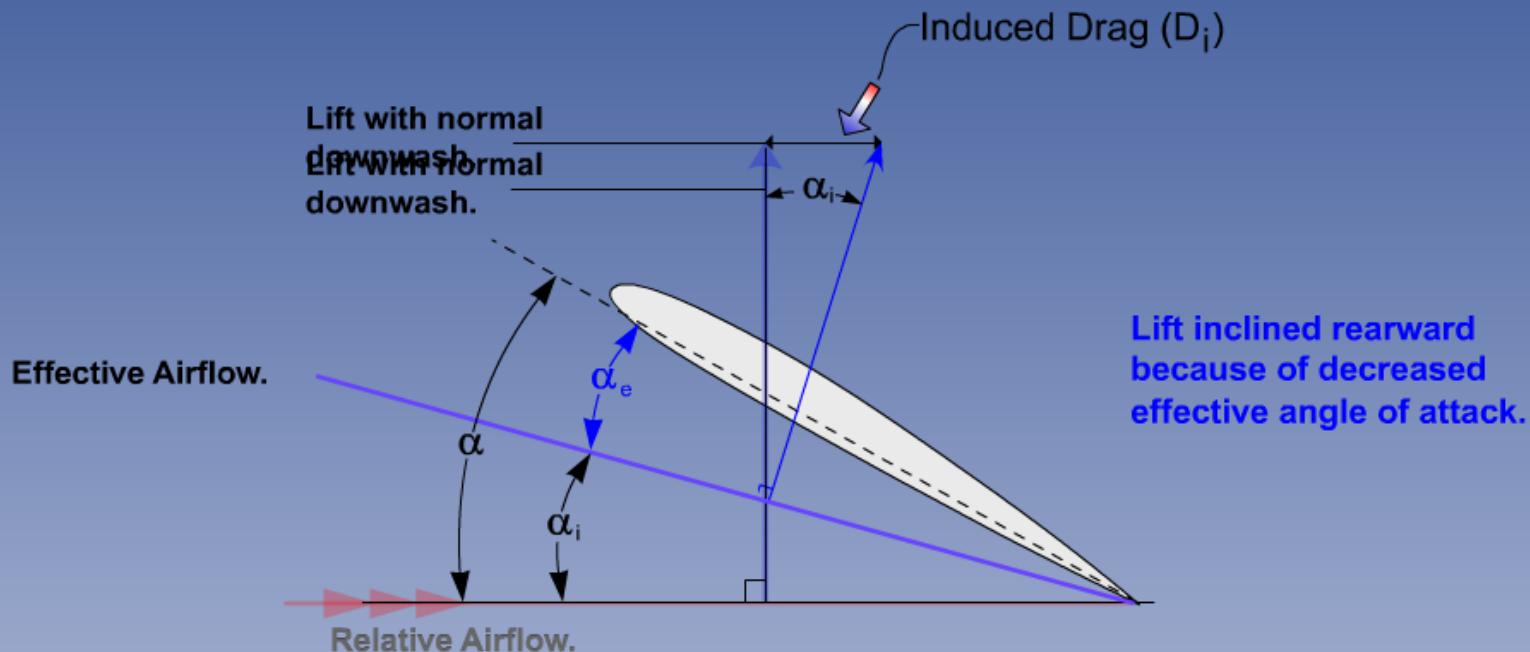


Induced Downwash

The vertical velocities are greatest close to the wing and are a function of vortex strength, with a proportional reduction in effective angle of attack.



Effective Angle of Attack



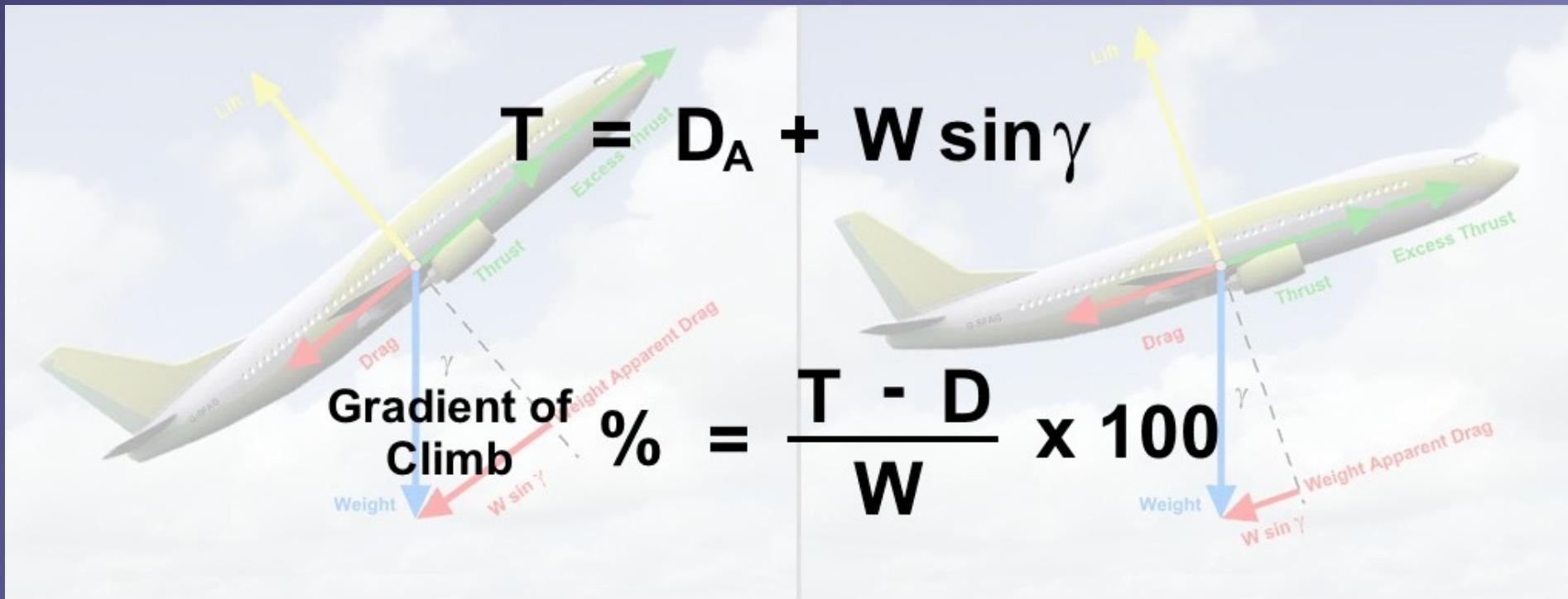
α_e Effective angle of attack
 α_i Induced angle of attack

Induced Downwash

The localised reduction in effective angle of attack causes the lift generated to be less than it would be if there were no spanwise flow. To replace this lost lift, the wing must be flown at a higher angle of attack, tilting the lift vector rearwards and creating induced drag.



Angle or Gradient of Climb

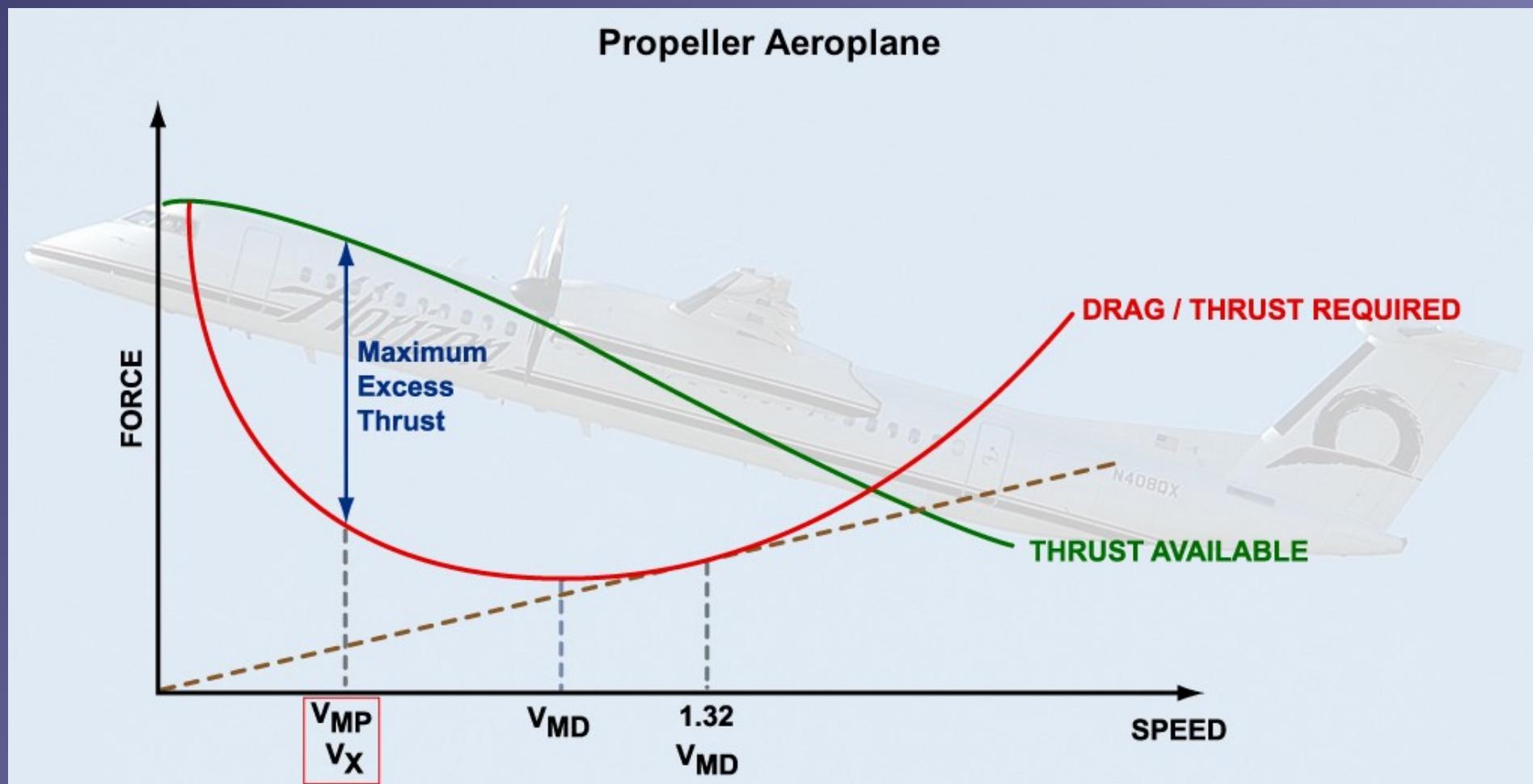


Maximum excess thrust available gives maximum angle or gradient of climb

- Weight increases weight apparent drag and excess thrust required
- Weight increases lift required and lift induced drag

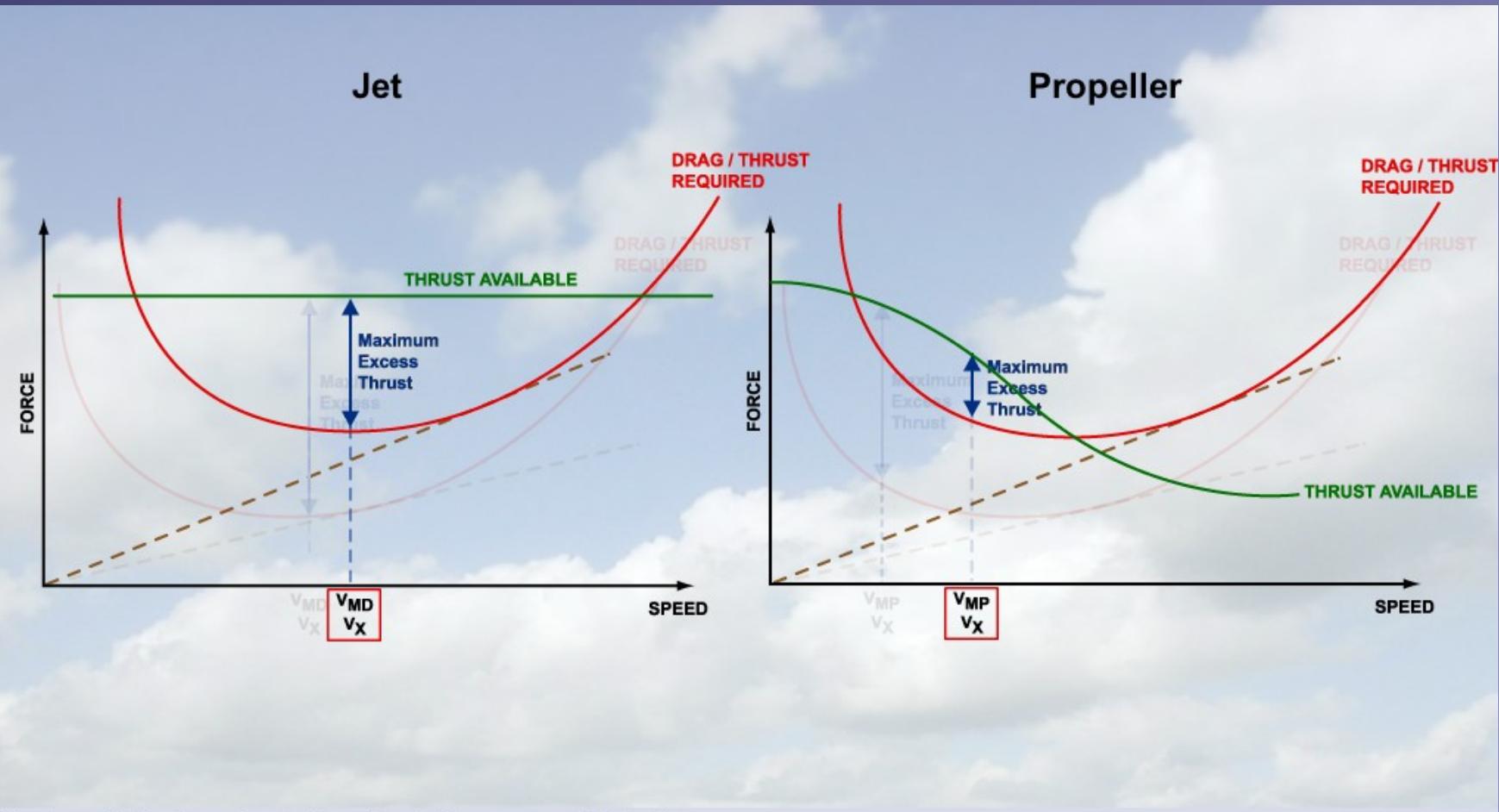


Maximum Excess Thrust





Weight and Excess Thrust

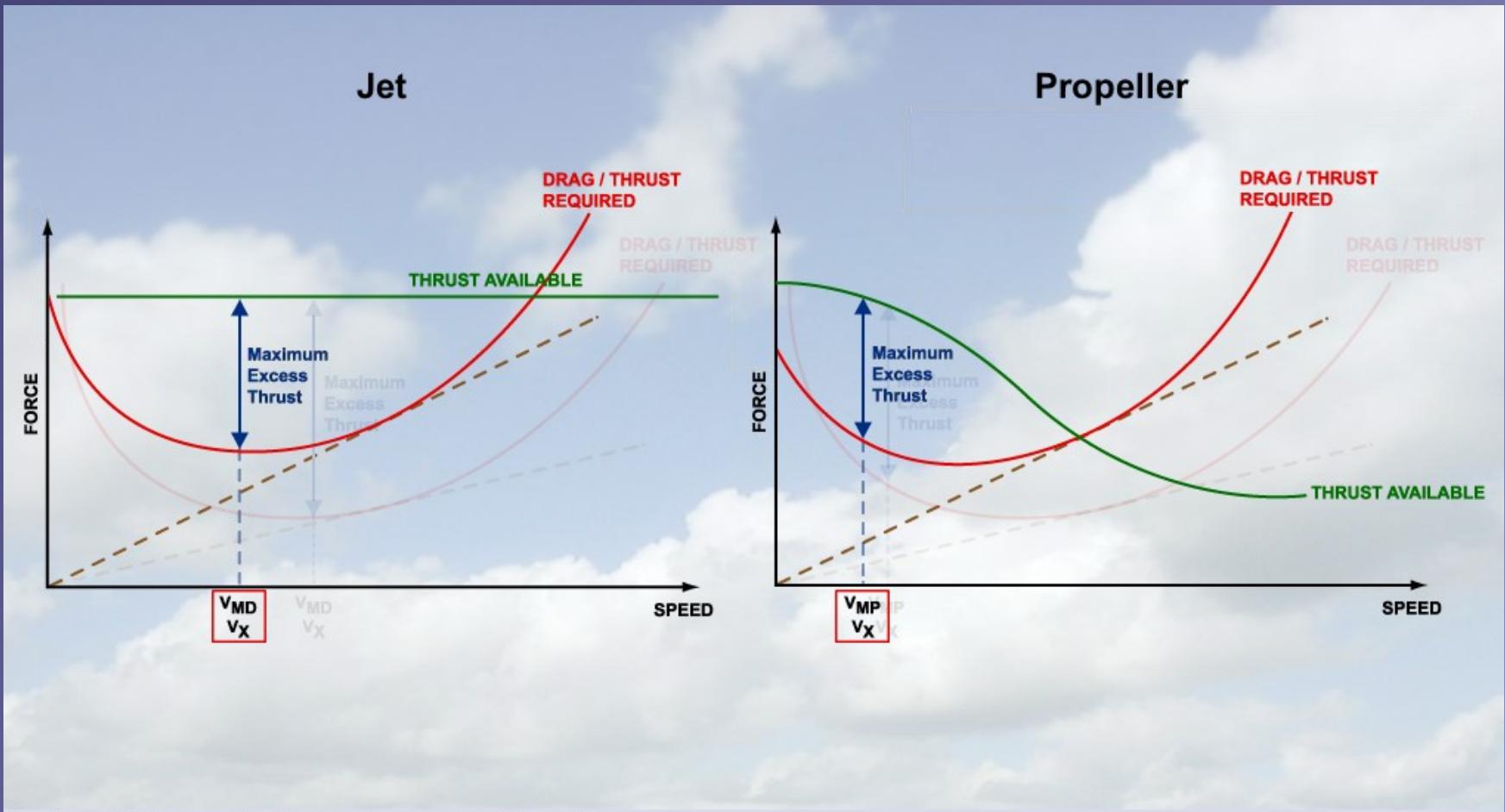


Factors Affecting Angle/Gradient - Increasing Weight

Effects 2 and 3. Increasing weight requires more lift. This increases induced drag and therefore total drag. The result is a decrease in excess thrust and a decrease in the climb angle. V_x increases.



Configuration and Excess Thrust

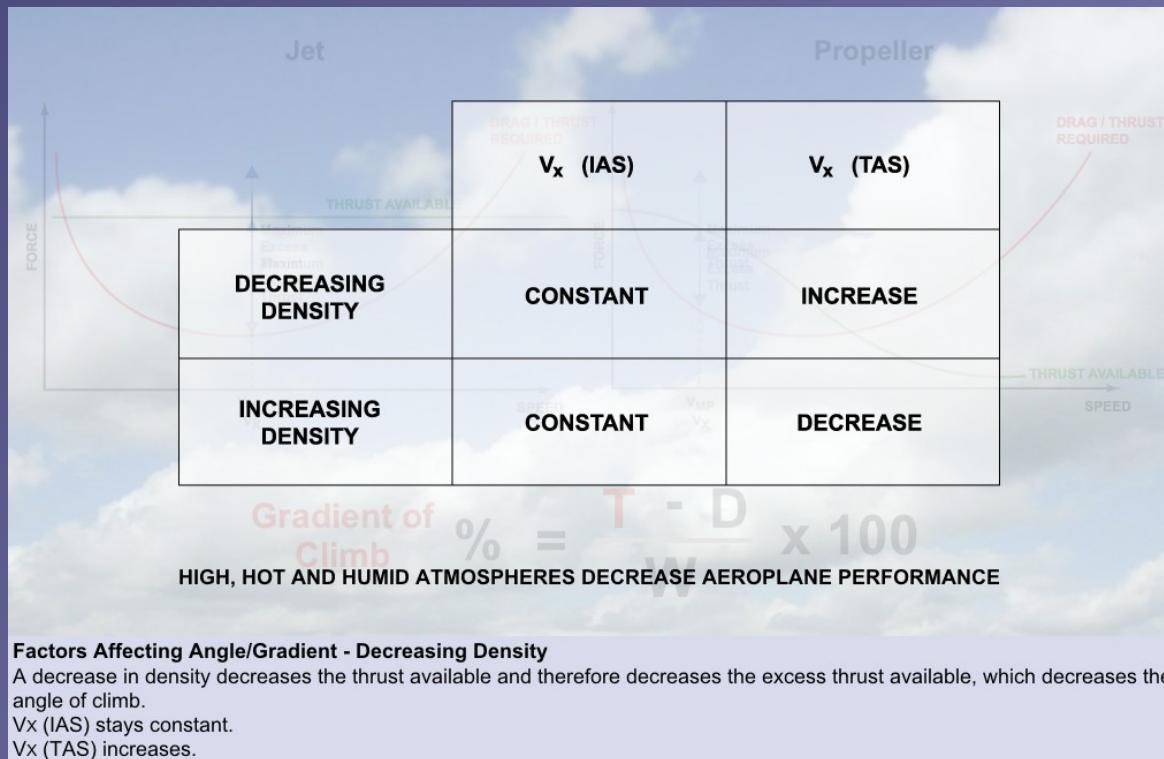


Factors Affecting Angle/Gradient - Configuration

Flaps and undercarriage deployed increase parasite drag and therefore total drag. The result is a decrease in excess thrust and a decrease in the climb angle. V_x decreases.



Air Density and Excess Thrust



- V_x remains essentially **constant** (IAS) for thrust-rated engines (jet)
- V_x may **increase** (IAS) for power-rated engines (piston propeller)



Rate of Climb

$$\text{Rate of Climb} = \frac{\text{Excess Power}}{W}$$

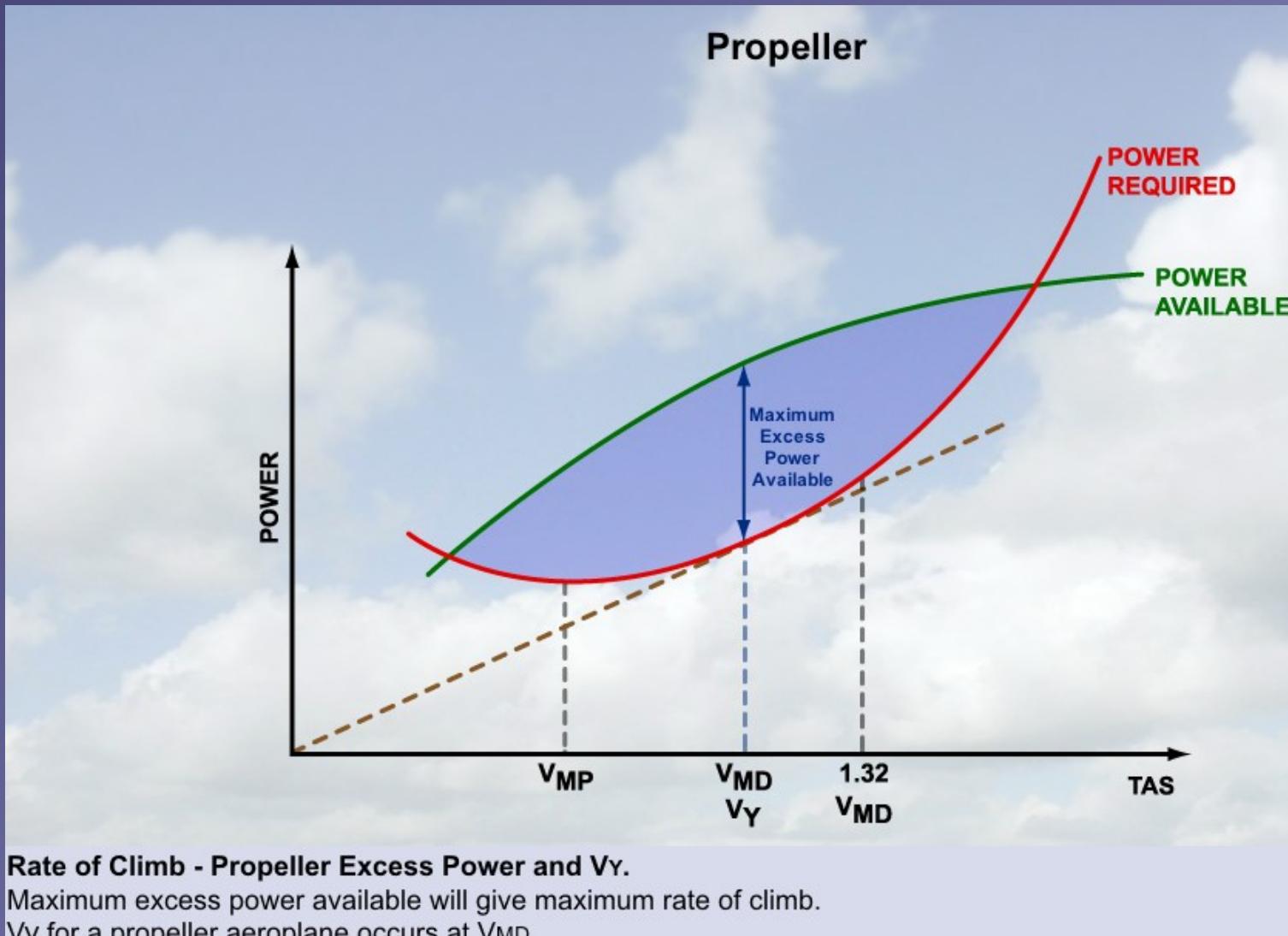
Power Available - Power Required

Maximum Excess Power Available gives Maximum Rate of Climb

- Rate of climb depends on both angle of climb and airspeed
- Forces multiplied with speeds give powers
- $F * v = F * s / t = W / t = P$

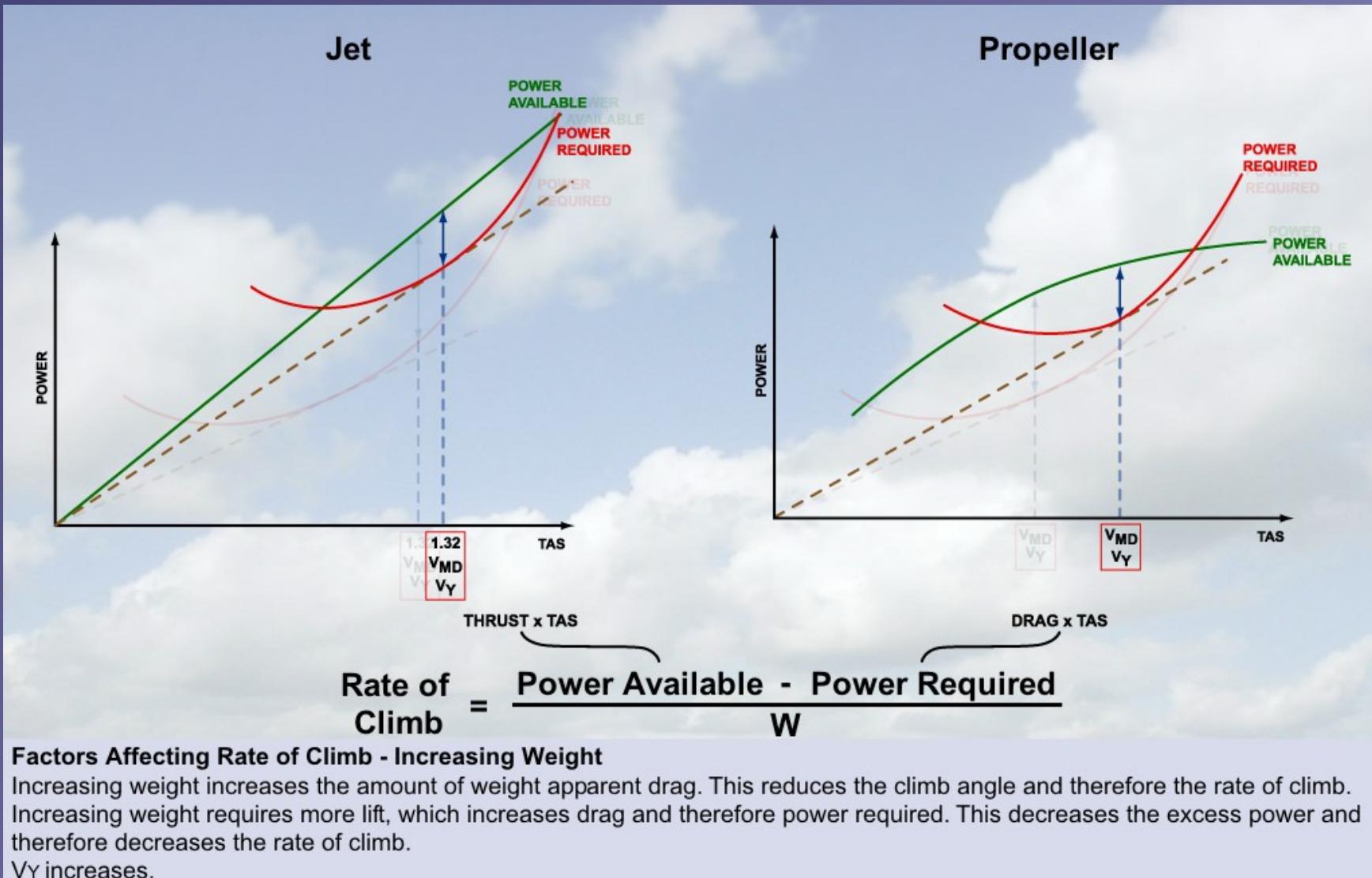


Maximum Excess Power



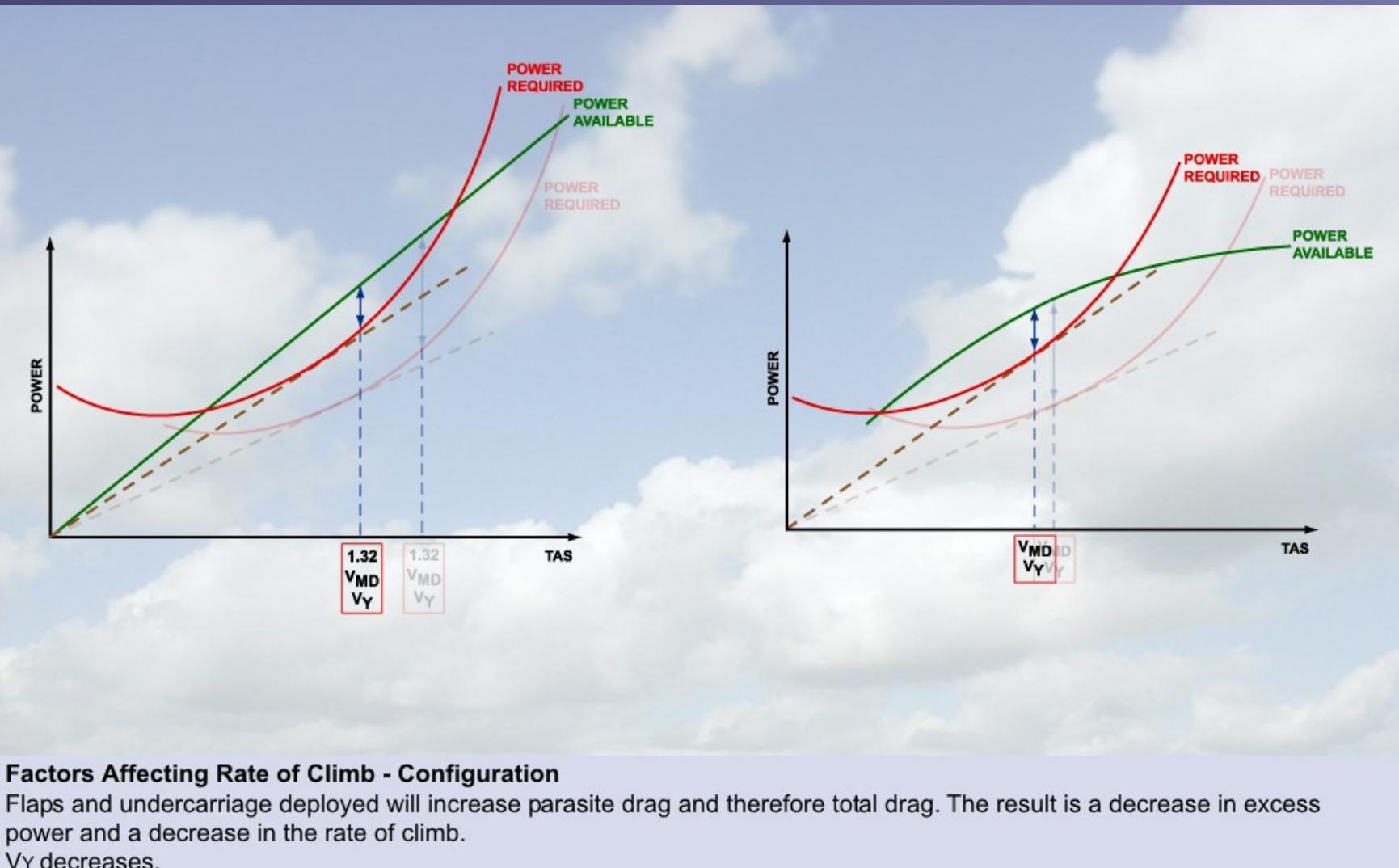


Weight and Excess Power



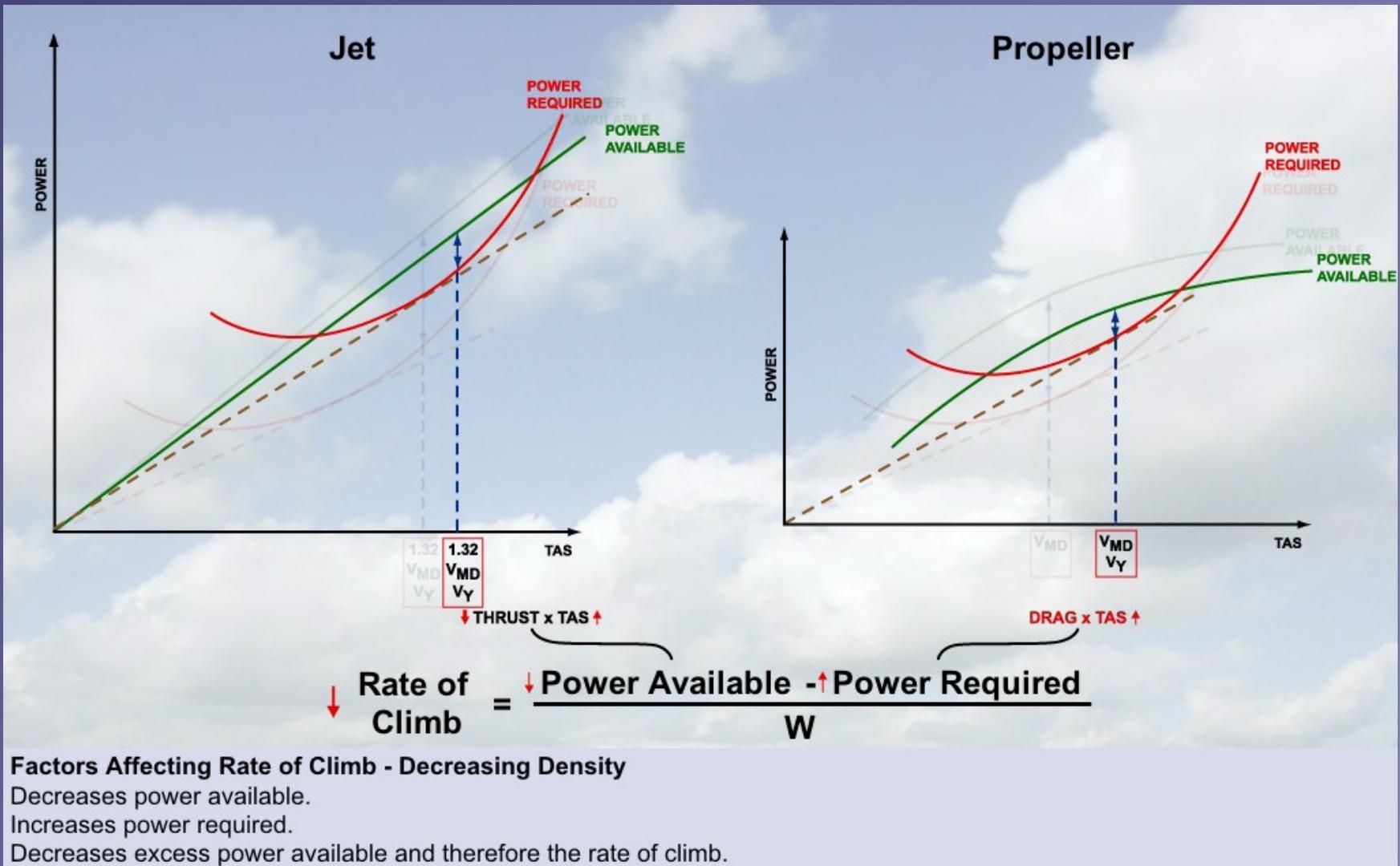


Configuration and Excess Power



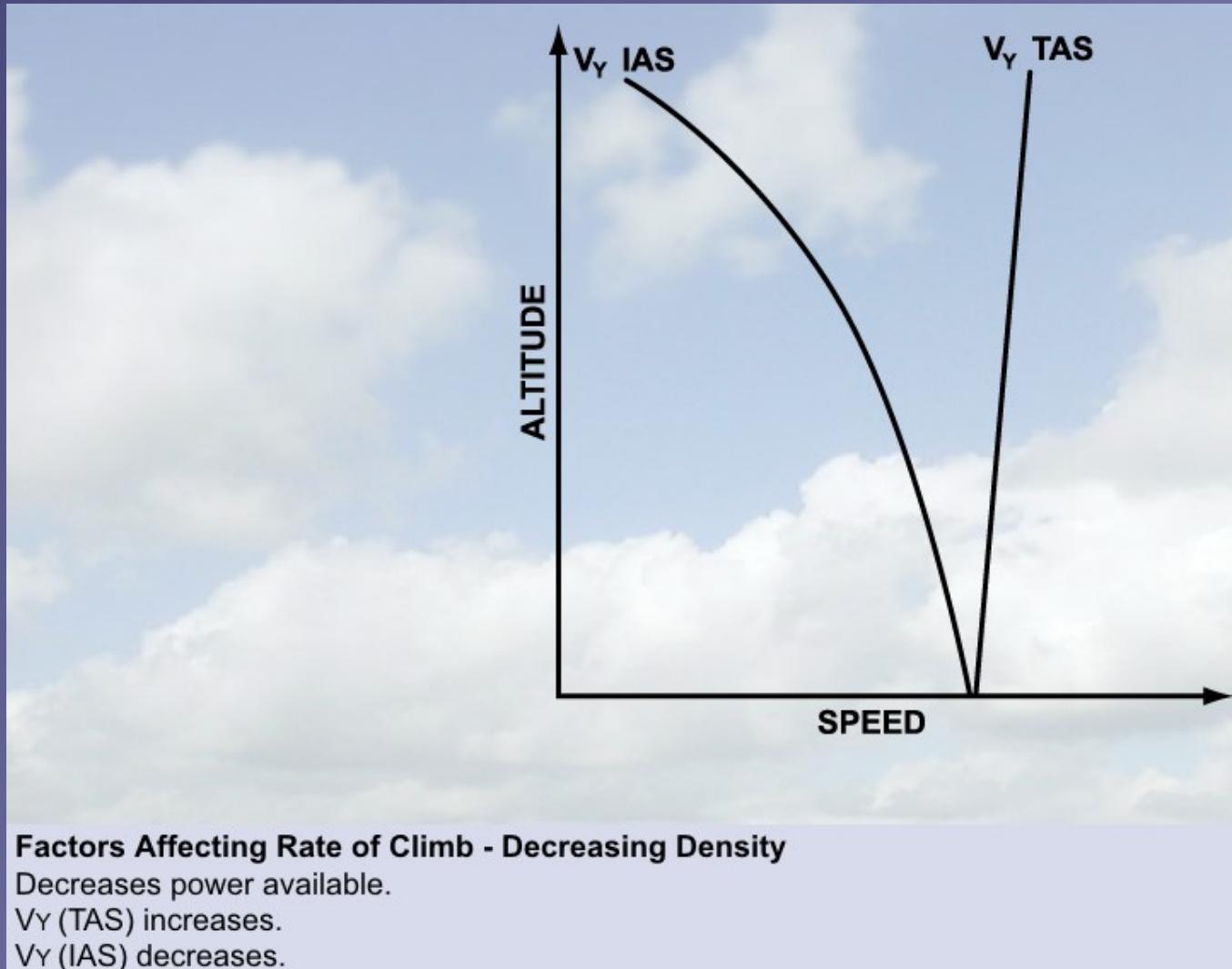


Air Density and Excess Power





V_y – True versus Indicated Airspeed

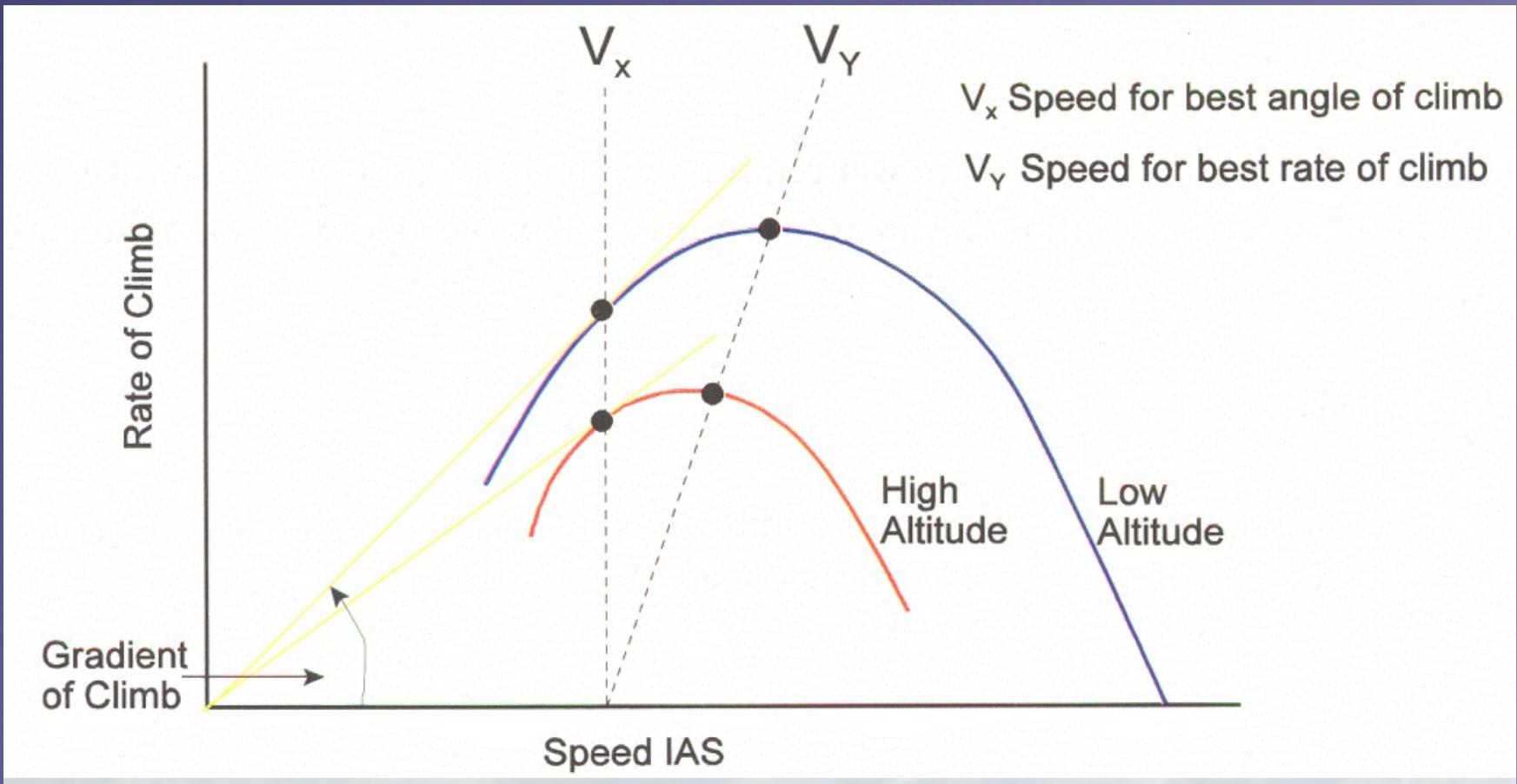


Factors Affecting Rate of Climb - Decreasing Density

- Decreases power available.
- V_y (TAS) increases.
- V_y (IAS) decreases.



Absolute and Service Ceiling



Factors Effecting Rate of Climb - Ceiling Altitude

Absolute Ceiling - The altitude where the rate of climb is zero and where $V_y = V_x$

Service Ceiling - The altitude where the best rate of climb airspeed will produce a specific rate of climb.