VICTORIA FLYING CLUB

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- Bookings, Questions

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Flight for Range and Endurance

- Review Straight and Level Flight
- Definition and Motivation
- Flight for **Range**
  - Diagrams, Maximum Range (Experimental)
- Flight for **Endurance**
  - Diagrams, Maximum Endurance (Experimental)
- Summary and Questions
- Pre-Flight Briefing

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Review Straight and Level Flight

- *Attitude plus power equals performance!*
- Mentally perform a power reduction from the cruise power setting while maintaining straight and level flight.
- What effect does the power reduction have on the airspeed and the fuel consumption?
- What effect does the power reduction have on the estimated time of arrival?

Definition and Motivation

- Airspeed and fuel flow can be traded off
- **Range** – achievable **distance** per **fuel** unit (air versus ground range): **destinations**, **alternates**
- **Endurance** – achievable **time** per **fuel** unit: **holding** or **orbiting** procedures, cockpit **management** / **decision making**, **economy**
- **Maximum range** – *best* achievable **distance**
- **Maximum endurance** – *best* achievable **time**

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CRUISE PERFORMANCE

CONDITIONS:
2550 Pounds
Recommended Lean Mixture

Pressure Altitude Feet	RPM	20°C BELOW STANDARD TEMP			STANDARD TEMPERATURE			20°C ABOVE STANDARD TEMP		
		% MCP	KTAS	GPH	% MCP	KTAS	GPH	% MCP	KTAS	GPH
2000	2550	83	117	11.1	77	118	10.5	72	117	9.9
	2500	78	115	10.6	73	115	9.9	68	115	9.4
	2400	69	111	9.6	64	110	9.0	60	109	8.5
	2300	61	105	8.6	57	104	8.1	53	102	7.7
	2200	53	99	7.7	50	97	7.3	47	95	6.9
	2100	47	92	6.9	44	90	6.6	42	89	6.3
4000	2600	83	120	11.1	77	120	10.4	72	119	9.8
	2550	79	118	10.6	73	117	9.9	68	117	9.4
	2500	74	115	10.1	69	115	9.5	64	114	8.9
	2400	65	110	9.1	61	109	8.5	57	107	8.1
	2300	58	104	8.2	54	102	7.7	51	101	7.3
	2200	51	98	7.4	48	96	7.0	45	94	6.7
	2100	45	91	6.6	42	89	6.4	40	87	6.1
6000	2650	83	122	11.1	77	122	10.4	72	121	9.8
	2600	78	120	10.6	73	119	9.9	68	118	9.4
	2500	70	115	9.6	65	114	9.0	60	112	8.5
	2400	62	109	8.6	57	108	8.2	54	106	7.7
	2300	54	103	7.8	51	101	7.4	48	99	7.0
	2200	48	96	7.1	45	94	6.7	43	92	6.4

Cruise Performance POH Section 5

- Consider **conditions**
- Select pressure **altitude**
- Select **temperature**
- Select **power** setting
- Interpolate as required
- Determine **airspeed** and **fuel flow**

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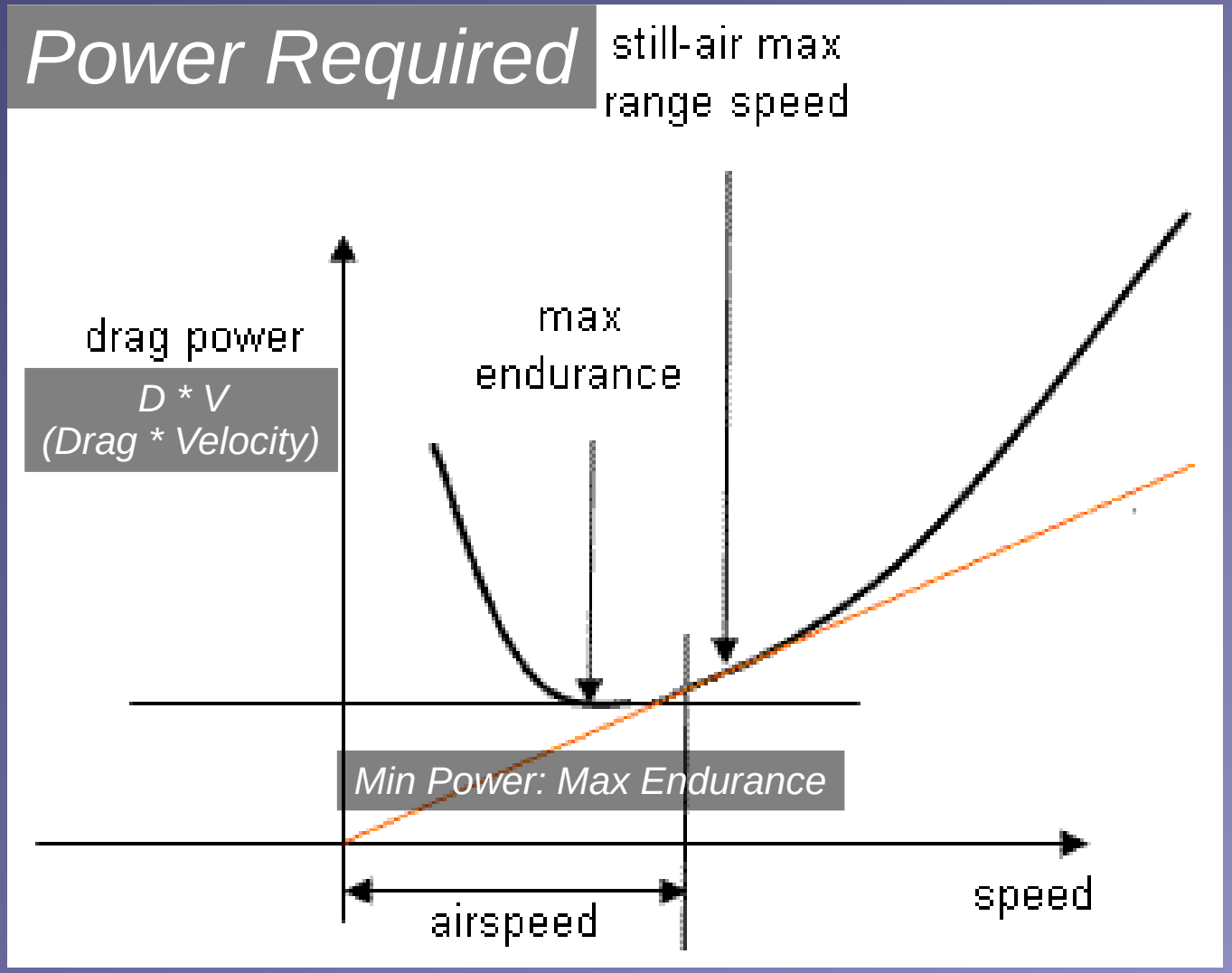
Flight for Endurance



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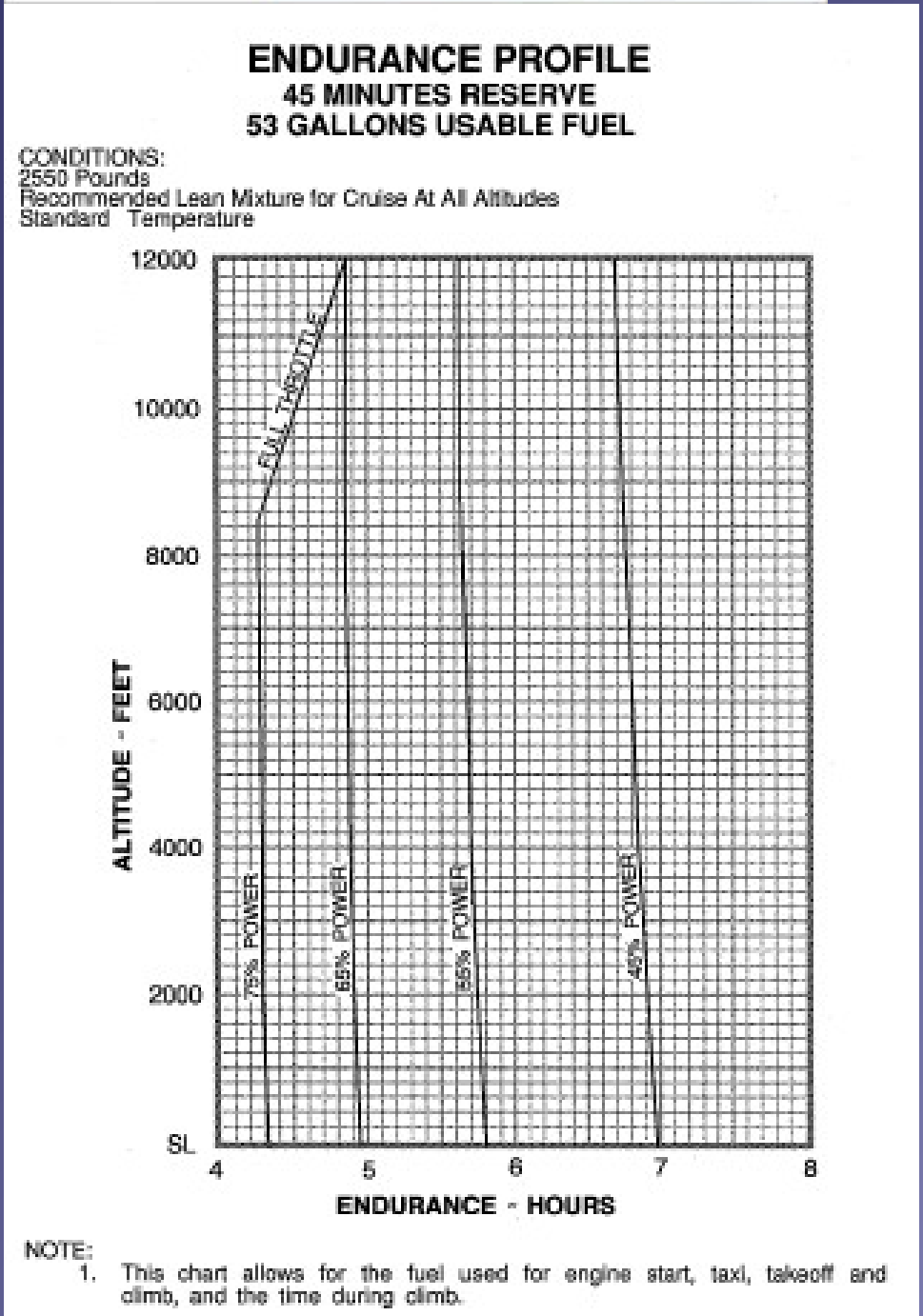

Endurance Profile POH Section 5

- Consider **conditions**
- Select pressure **altitude**
- Select **power** setting
- Determine **endurance**
- **Endurance** decreases with altitude for power-rated engines
- Specific fuel consumption (**SFC**) increases *slightly* with altitude for power-rated engines (piston-propeller)

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Flight for Maximum Endurance (Experimental)

- Reduce **power** in ***100 RPM*** steps maintaining **level flight** with *stable* **airspeed** and **trim**
- *Unstable* decreasing airspeed indicates slow flight range – more power required
- Reset **cruise power** and then decrease **power** to *slightly* higher *stable* setting to compensate for turbulence and possible required turns
- Lean **mixture** as recommended
- Notice reduced control responses due to reduced airflow

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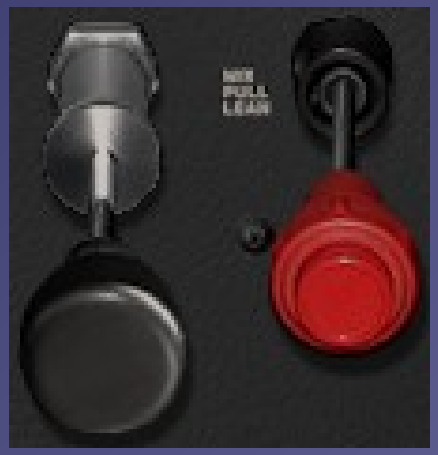
Leaning



- *Slowly* turn **mixture** knob out / *anticlockwise* until a drop in RPM can be observed
- Turn the **mixture** knob back in / *clockwise* until the RPM has increased again (***2-3 turns***)
- Check **fuel flow** and **exhaust gas temperature**

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Endurance - Instruments

- **Attitude**, **Power** → Airspeed (about ***50-60 KIAS***), Altitude
- **Mixture** → Exhaust Gas Temperature, Fuel Flow

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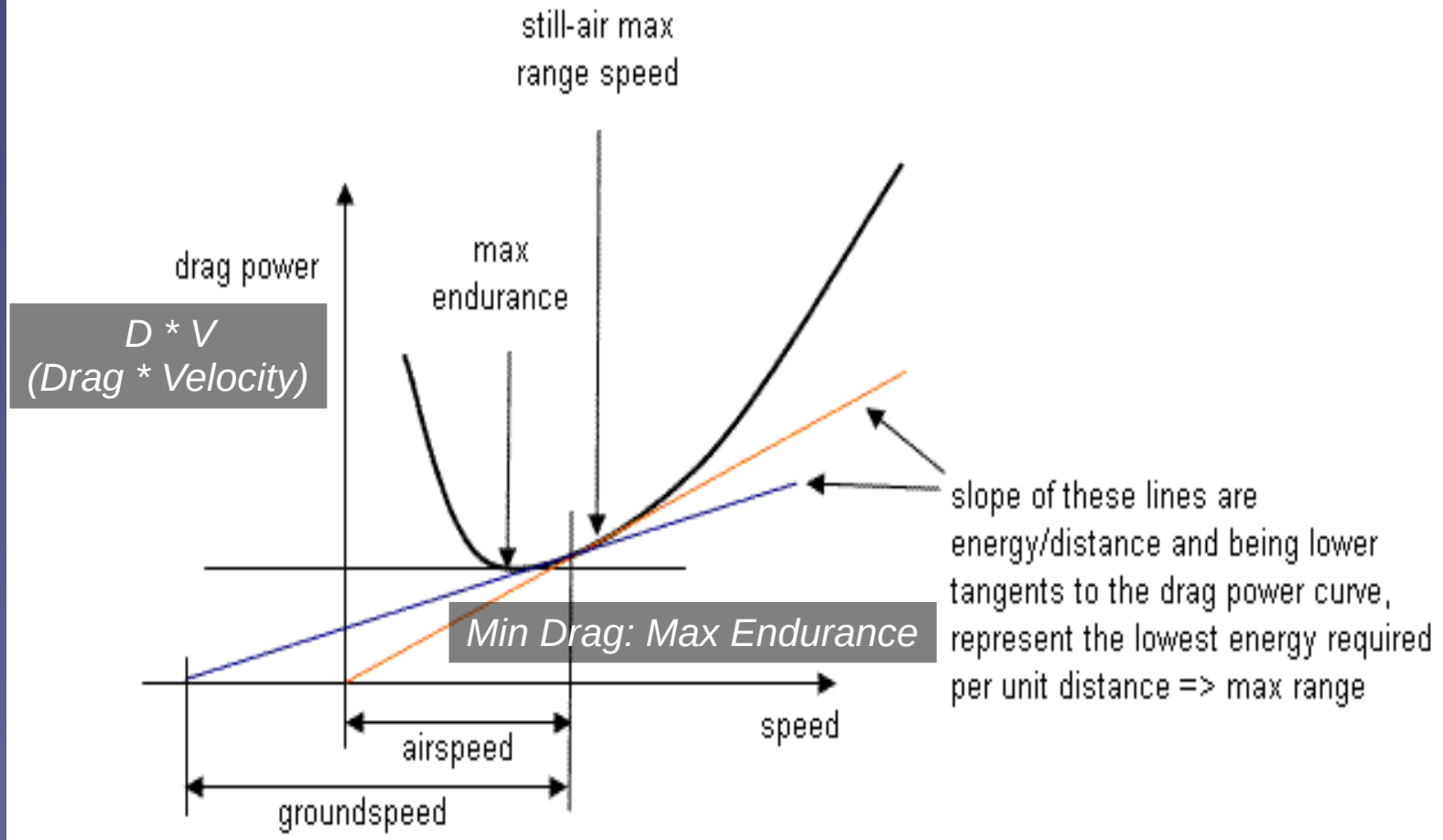
Flight for Range

Power Required

Optimize both power <u>and</u> speed



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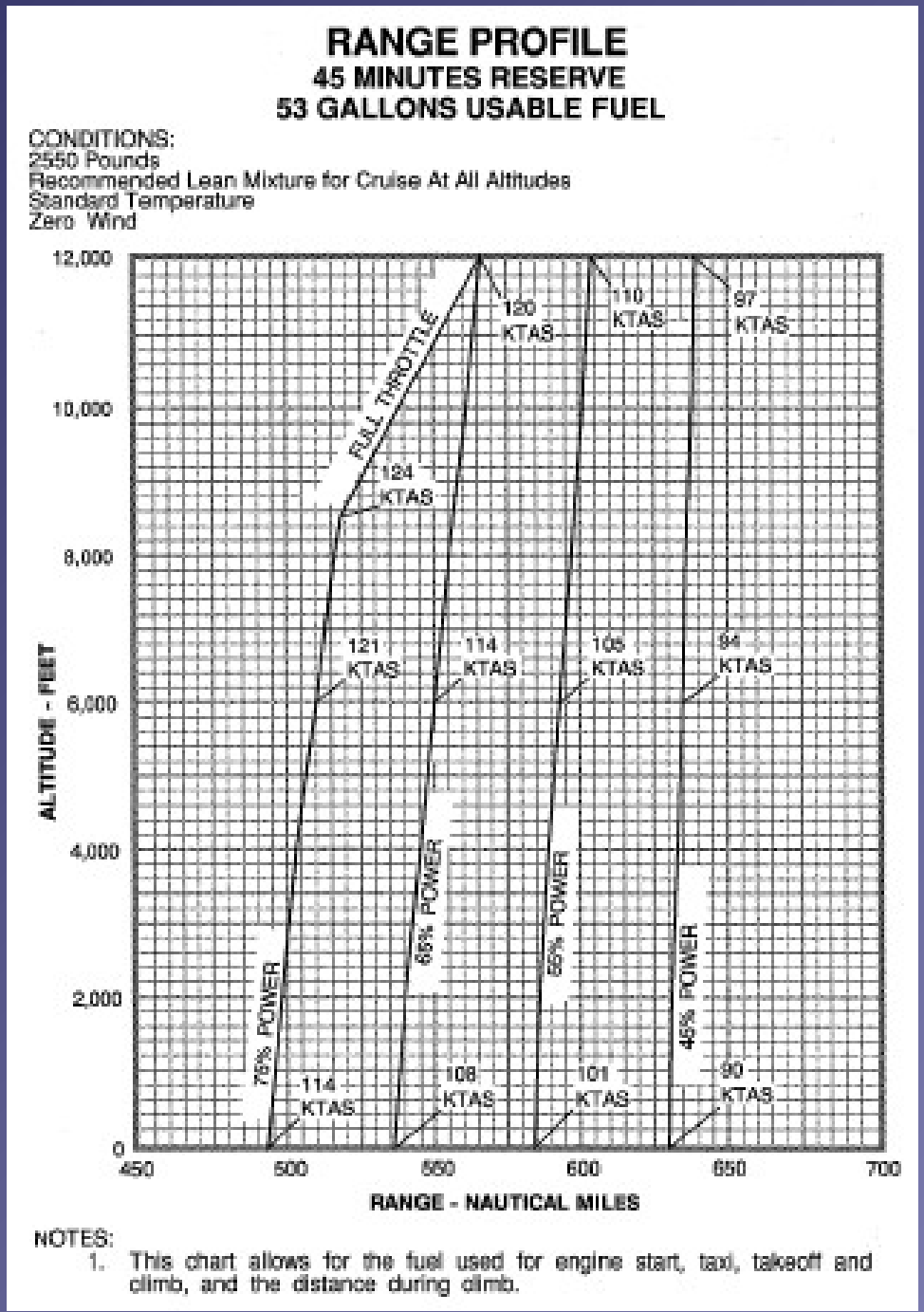

Range Profile POH Section 5

- Consider **conditions**
- Select pressure **altitude**
- Select **power** setting
- Determine **range**
- **Range** increases with increasing altitude
- True airspeed (**TAS**) increases with increasing altitude

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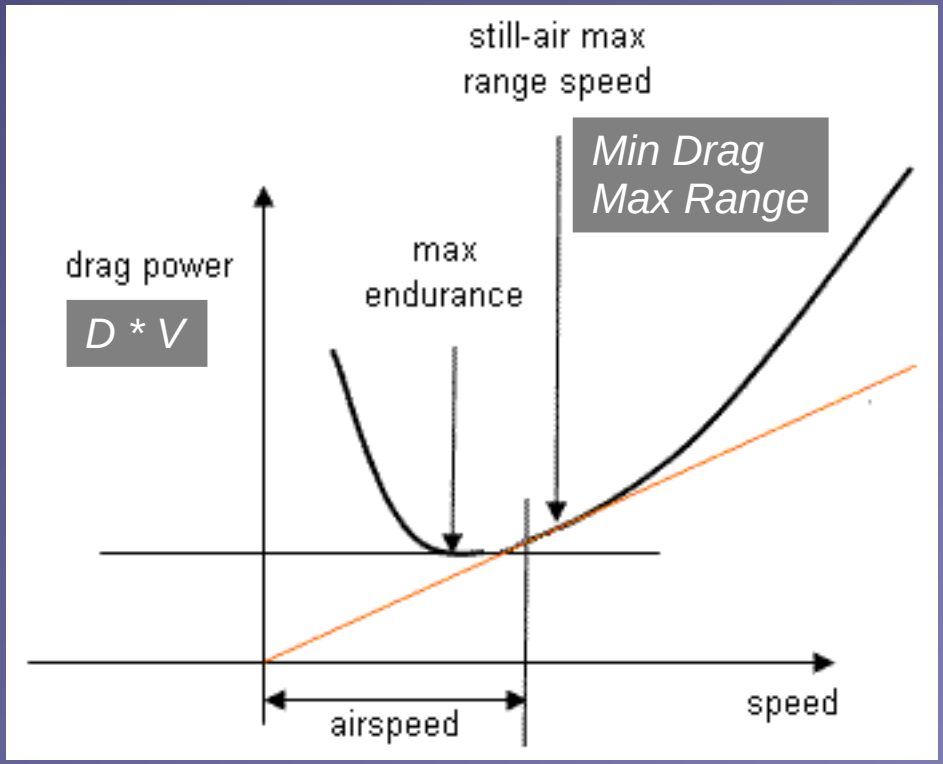
Flight for Maximum Range



- Increase **power** in ***100 RPM*** steps until a *non-linear* increase in **airspeed** can be observed
- Maintain **level** flight, **trim** and lean **mixture** as recommended (rich of peak)

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Range – Instruments

- **Attitude**, **Power** → Airspeed (about ***70-80 KIAS***), Altitude
- **Mixture** → Exhaust Gas Temperature, Fuel Flow

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Factors Affecting Range and Endurance

- **Endurance**: fuel available, power setting, flap setting (**configuration**), **weight**, center of gravity, **air density** (altitude, temperature, humidity), contamination, mixture, **turbulence**
- Range: fuel available, power setting, flap setting (**configuration**), **weight**, center of gravity, **air density** (altitude, temperature, humidity), contamination, mixture, **wind** (air versus ground range)

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Summary / Quiz

- Define range, maximum range, endurance and maximum endurance.
- Give examples for when flight for range or endurance is preferable.
- What are the main factors that influence range and endurance and how do they affect them?
- Mentally configure the airplane for best range and endurance and state all required actions, respectively.

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Pre-Flight Briefing

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

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Additional Materials

- Additional materials for flight for range and endurance
- Flight Instructor Guide – Exercise 10, Lesson Plan 4

Specific Fuel Consumption

- Jet:
  - *SFC = Fuel Consumption / Unit of Thrust*
  - *Fuel Flow = SFC * Thrust*
- Propeller:
  - *SFC = Fuel Consumption / Unit of Power*
  - *Fuel Flow = SFC * Power*

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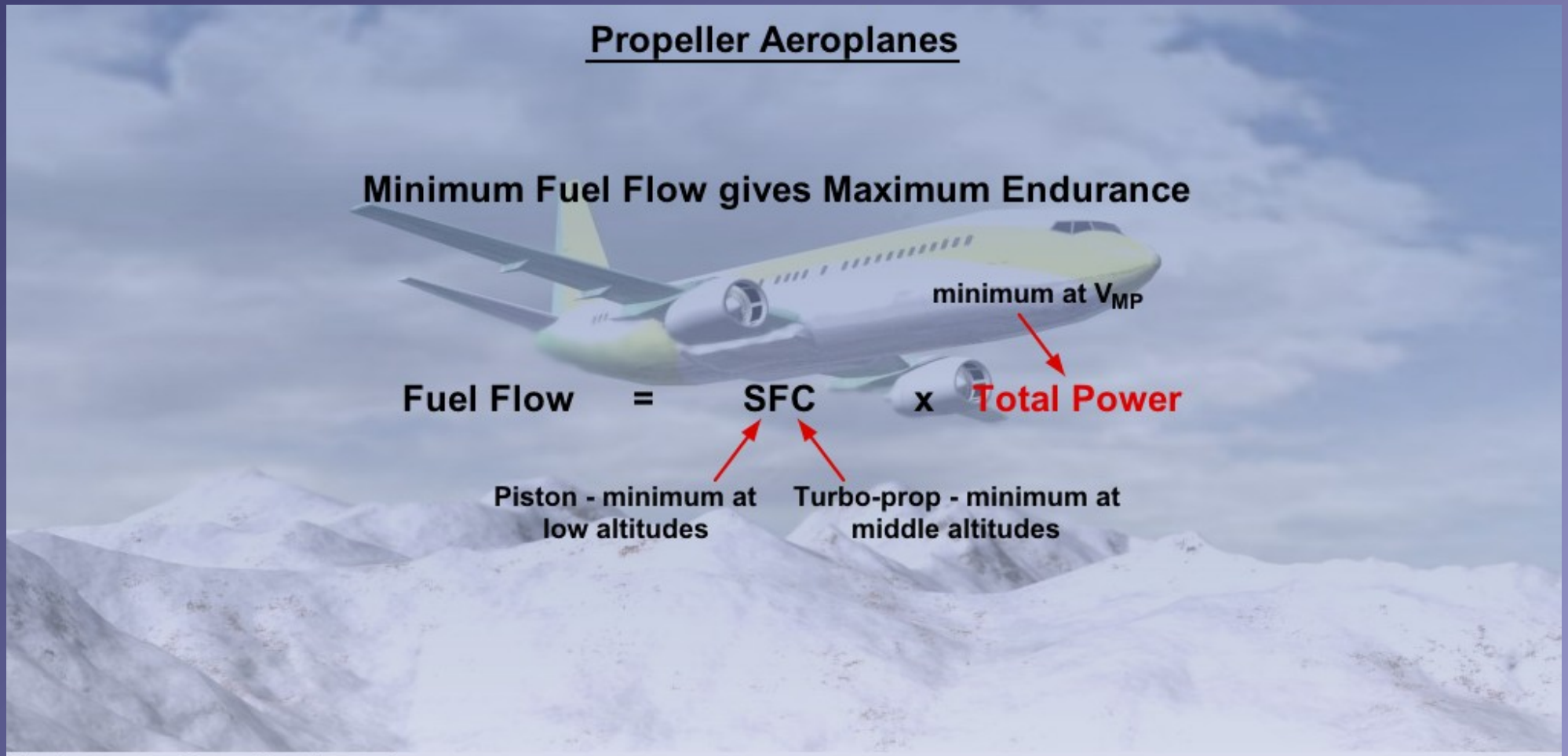
Maximum Endurance



Endurance - Propeller Aeroplane

For maximum endurance, a propeller aeroplane must fly at V_{MP} and operate either at low or middle altitudes.

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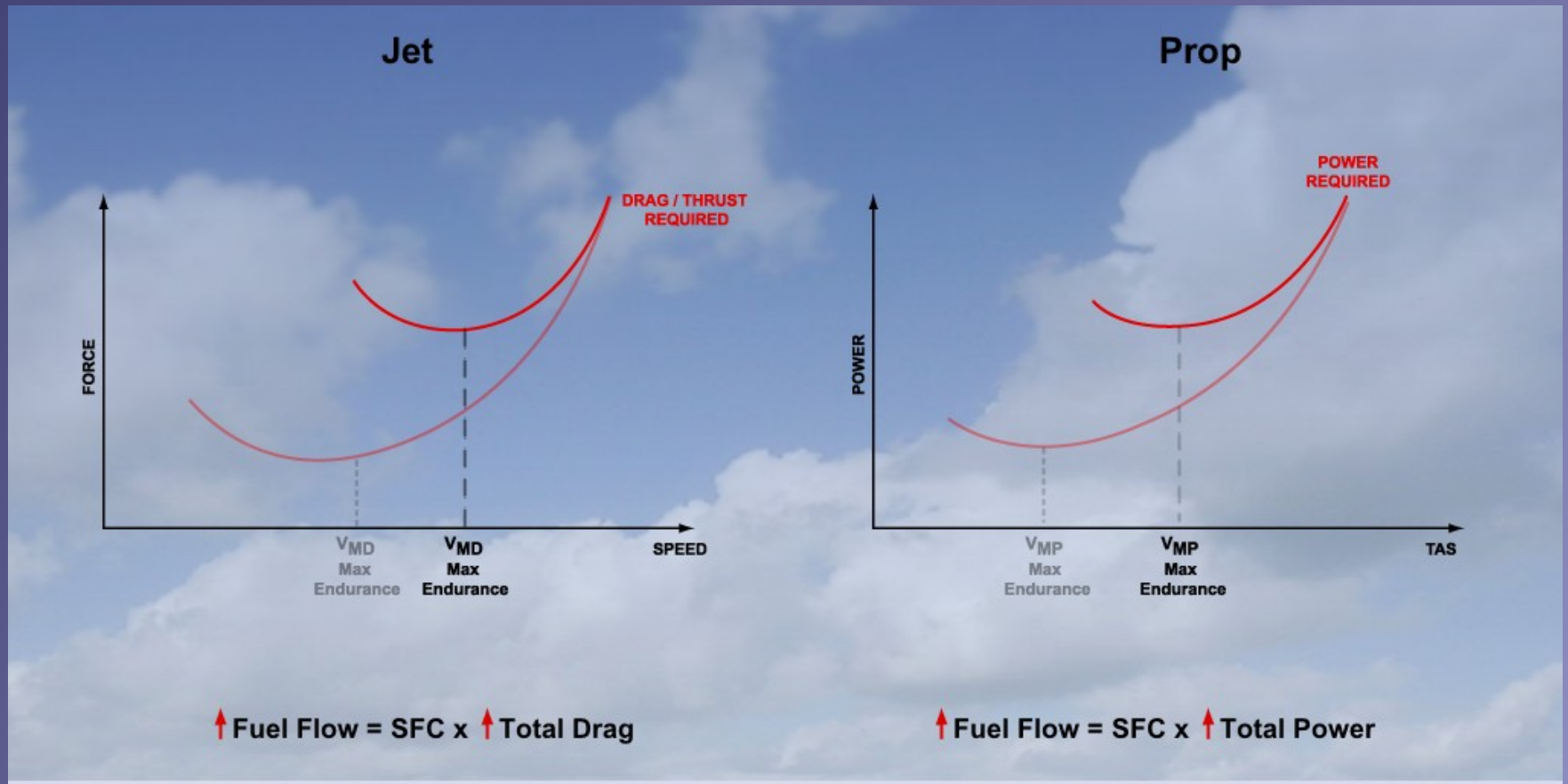
Weight and Endurance



Factors Affecting Endurance - Weight

Increasing weight will increase the drag and power required and therefore increase the fuel flow and decrease endurance. The speed for maximum endurance increases.

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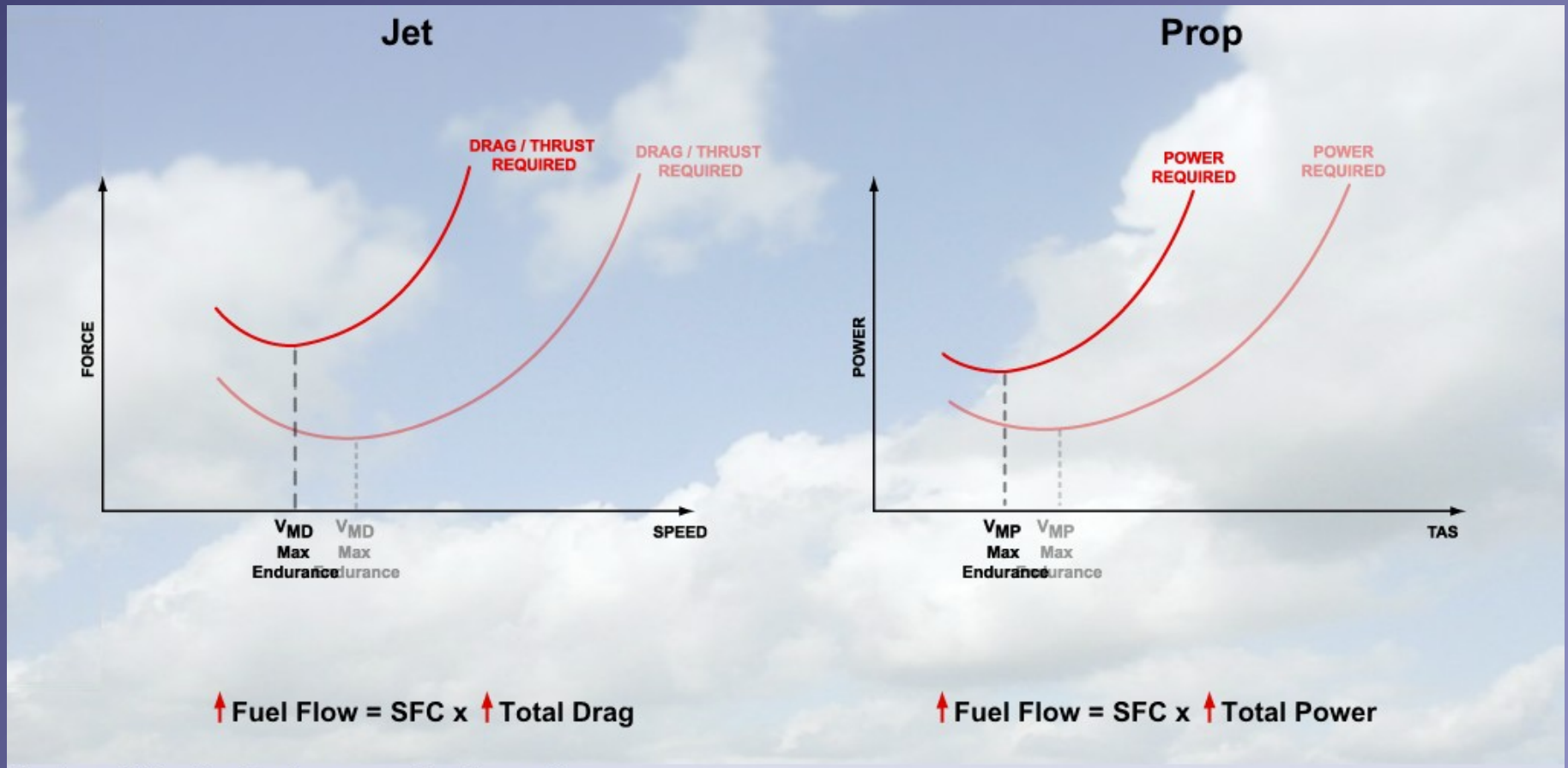
Configuration and Endurance



Factors Affecting Endurance - Configuration

Deploying flaps and undercarriage will increase the drag and power required and therefore increase the fuel flow and decrease endurance.

The speed for maximum endurance decreases.

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Altitude and Endurance

Factors Affecting Endurance - Wind and Altitude

Wind has no effect on the endurance of the aeroplane.
Jet aeroplanes reach maximum endurance above the tropopause.
Turbo-propeller aeroplanes reach maximum endurance at about 10,000 ft.
Piston engine aeroplanes reach maximum endurance at mean sea level (MSL).

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Specific Range

- Specific Air Range
  - *Air Range = Air Distance / Unit of Fuel*
  - *SAR = TAS / Fuel Flow*
  - *Jet: SAR = TAS / SFC * Thrust Required*
  - *Propeller: SAR = TAS / SFC * Power Required*
- Specific Ground Range
  - Ground Range = Ground Distance / Unit of Fuel
  - SGR = GS / Fuel Flow
  - Jet: SGR = GS / SFC * Thrust Required
  - Propeller: SGR = GS / SFC * Power Required
- *Maximize* **TAS** or **GS** while *minimizing* **SFC**

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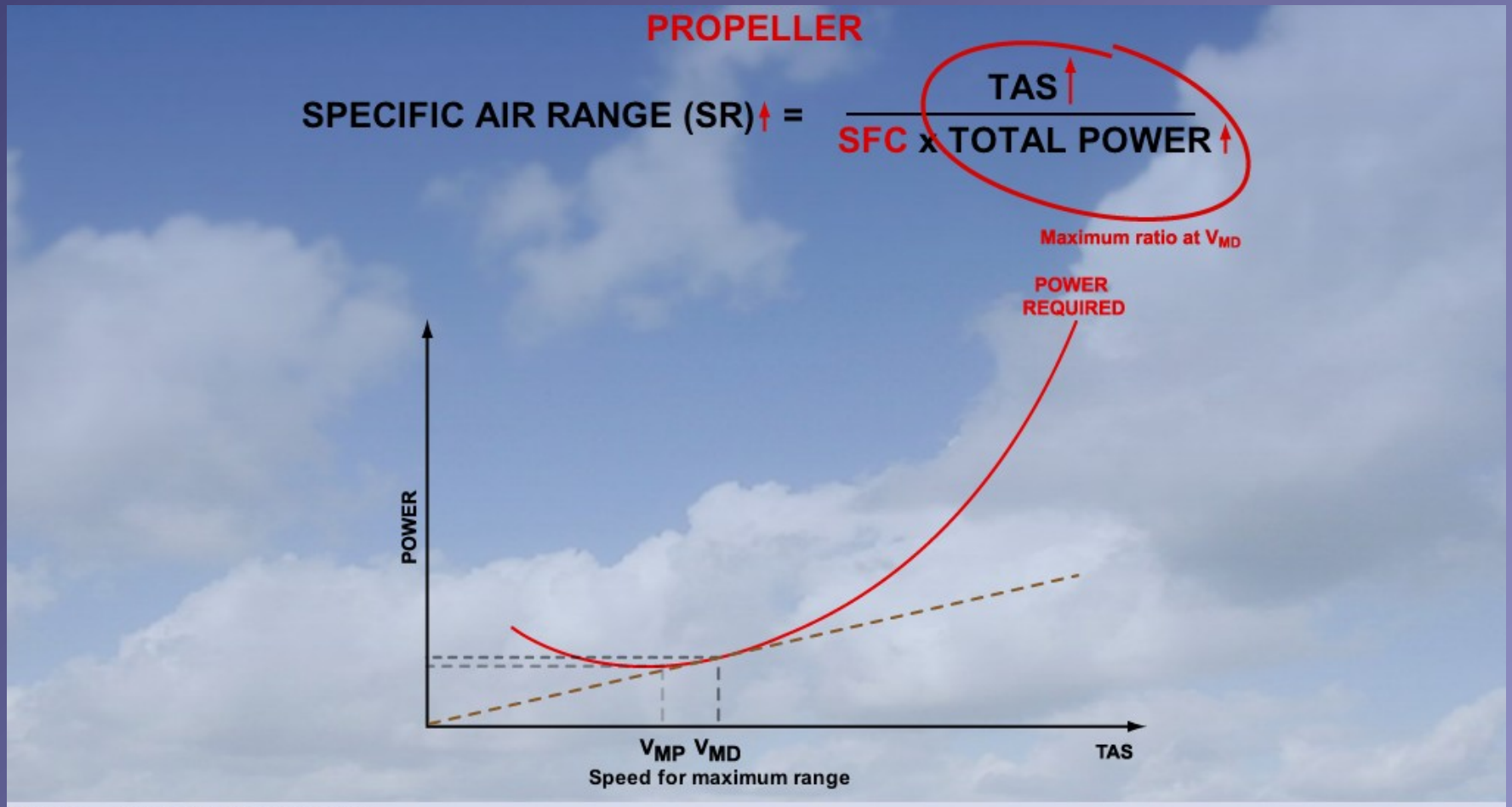
Maximum Air Range



Range - Propeller Aeroplane

For maximum range, a propeller aeroplane must fly at V_{MD} and as high as possible.

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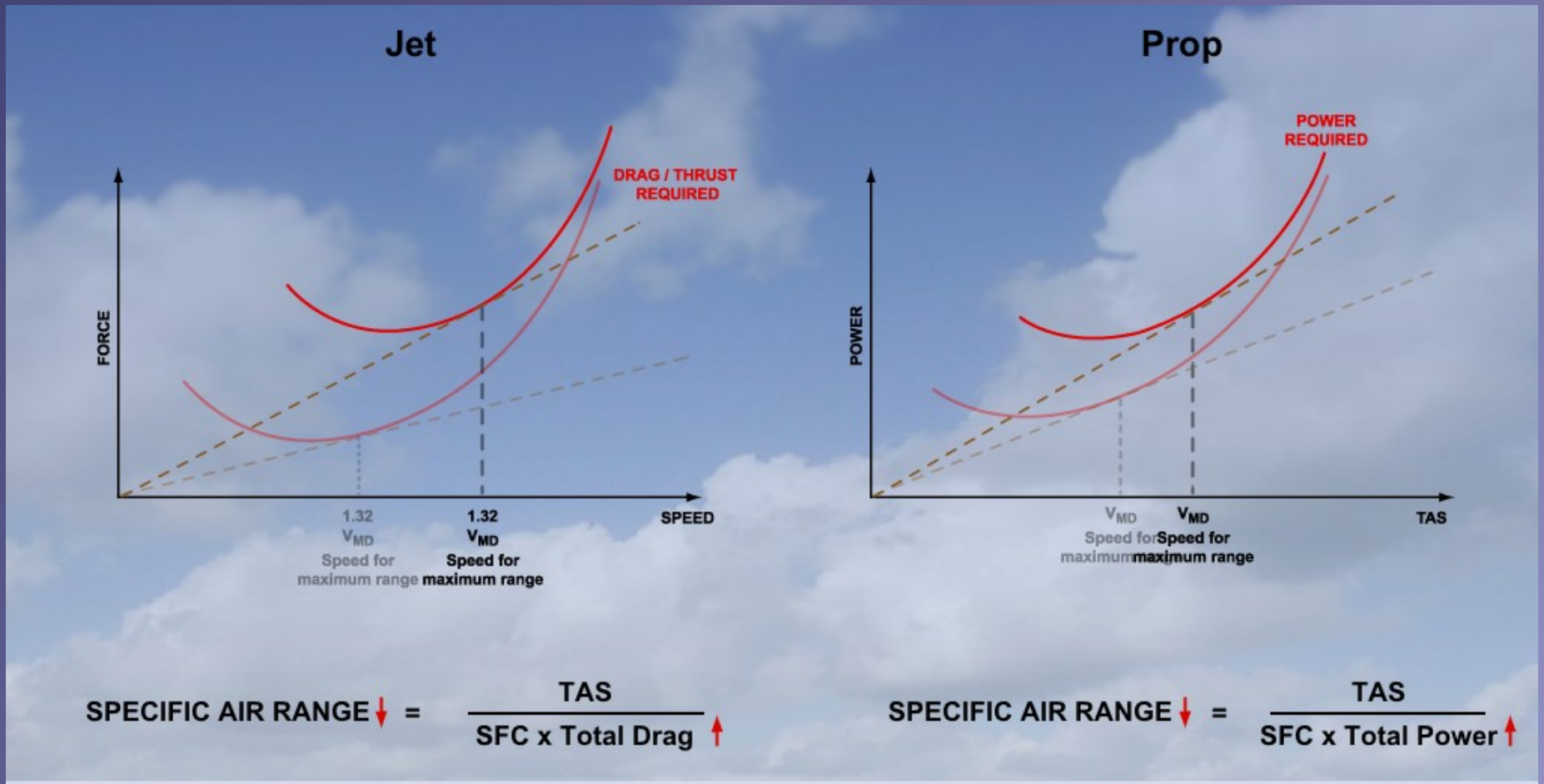
Weight and Range



Factors Affecting Range - Weight

Increasing weight will increase the drag and power required and therefore increase the fuel flow and decrease range. The speed for maximum range increases.

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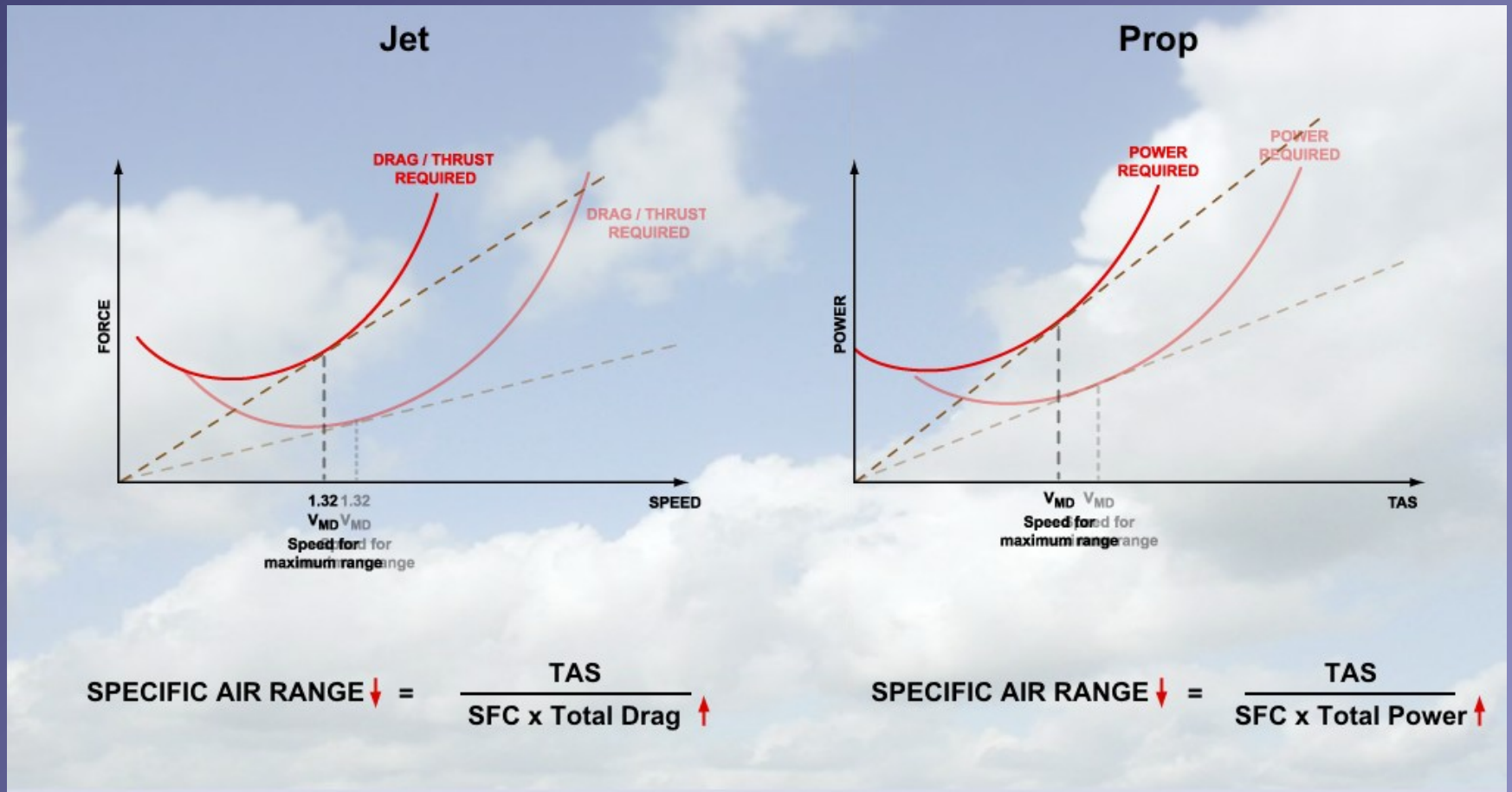
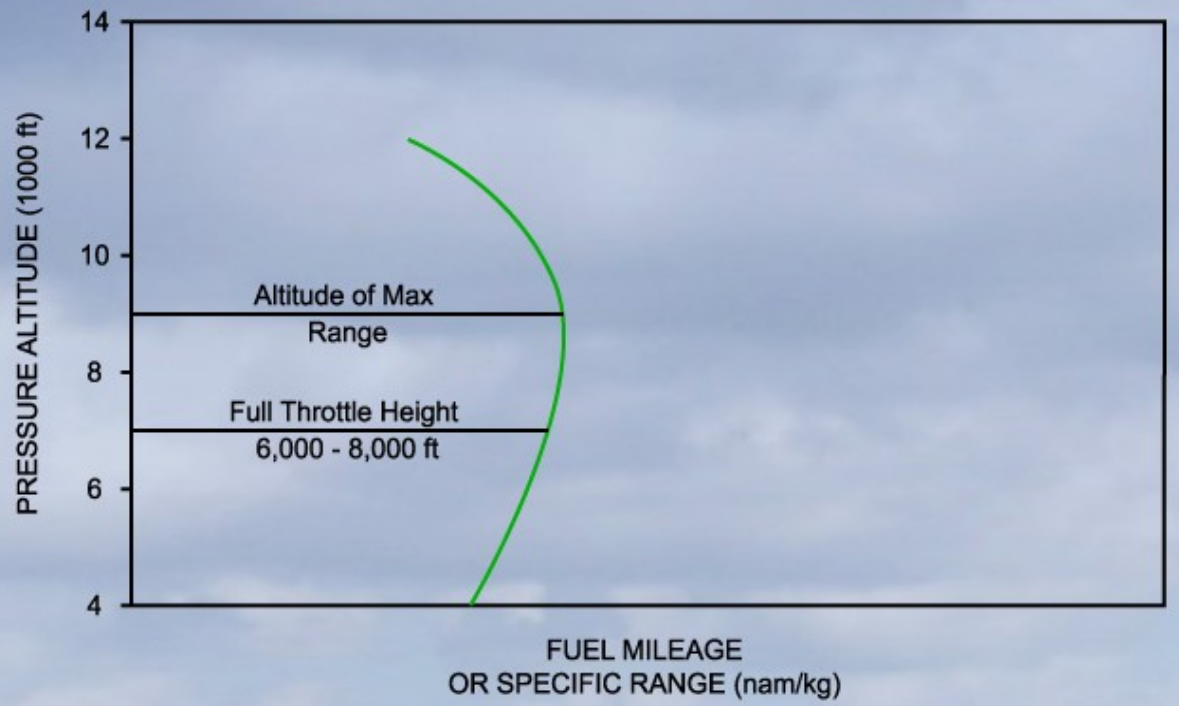
Configuration and Range



Factors Affecting Range - Configuration

Deploying the flaps and undercarriage will increase the drag and power required and therefore increase the fuel flow and decrease range.

Altitude and Range



↑SPECIFIC AIR RANGE = TAS ↑ / ~~SFC~~ x Total Power ↑

Factors Affecting Range - Altitude - Propeller Aeroplane

Piston Engine propeller aeroplanes specific range increases with altitude till just above full throttle height (6,000 - 8,000 ft).