CPL Theory Meteorology (CMET)

CAE Oxford Aviation Academy

CMET 2 – Atmospheric Pressure

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Document Identification	
Document Category	Training Material
Document Revision Number	
Document Issue Date	
Document Status	Draft
Document Title	
Document Identification	MBWTRG-TRM-XXX

2. Related Documents

Related Documents	Document Identification

CAE Oxford Aviation Academy

CMET 2 – Atmospheric Pressure

Amendments made to this document since the previous version are listed below. All amendments to this document have been made in accordance with CAE OAAM's document management procedure.

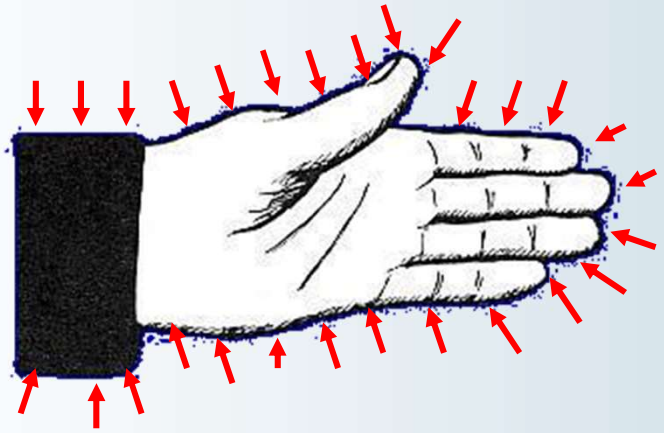
Slide	Changes

ATMOSPHERIC PRESSURE

Atmospheric Pressure – What is it?

- The gases present in our atmosphere are made up of tiny particles suspended in the air known as molecules – collectively we call them air molecules

- **The combined weight of all the air molecules exerts a force** in all directions – this is atmospheric pressure



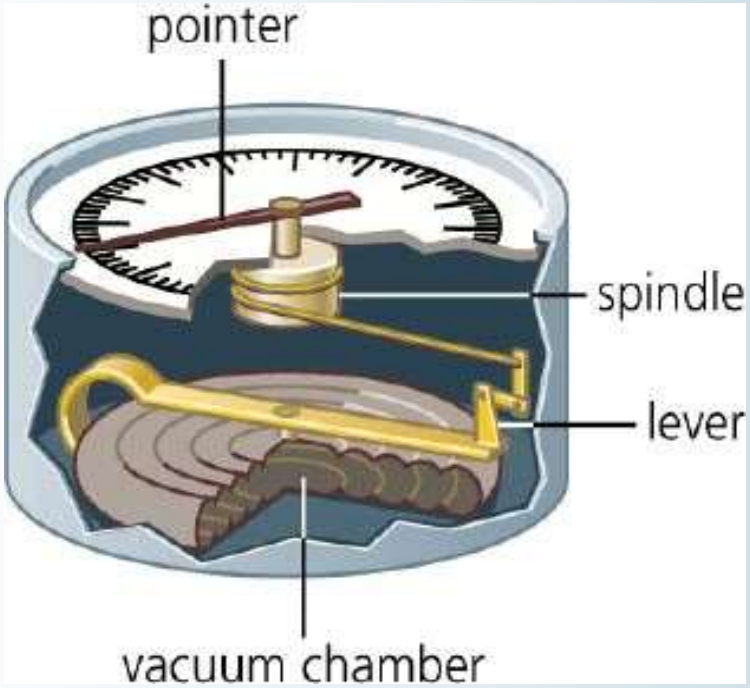
$$P = \frac{F}{A}$$

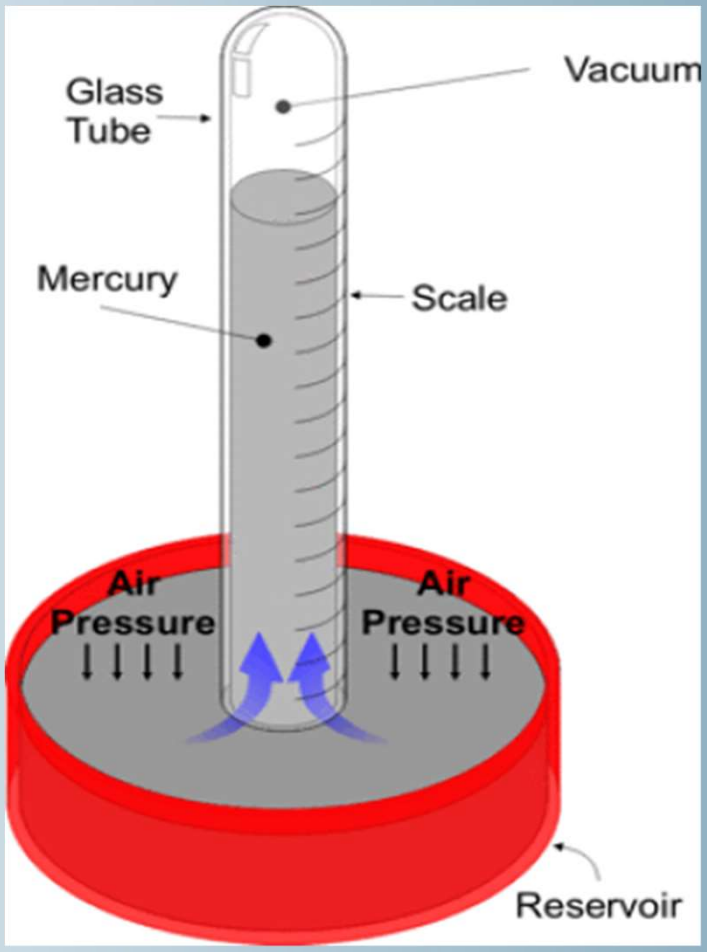
Atmospheric Pressure – How do we measure it?

- There are two common ways to measure atmospheric pressure:

1. Using a Mercury (Hg) Barometer

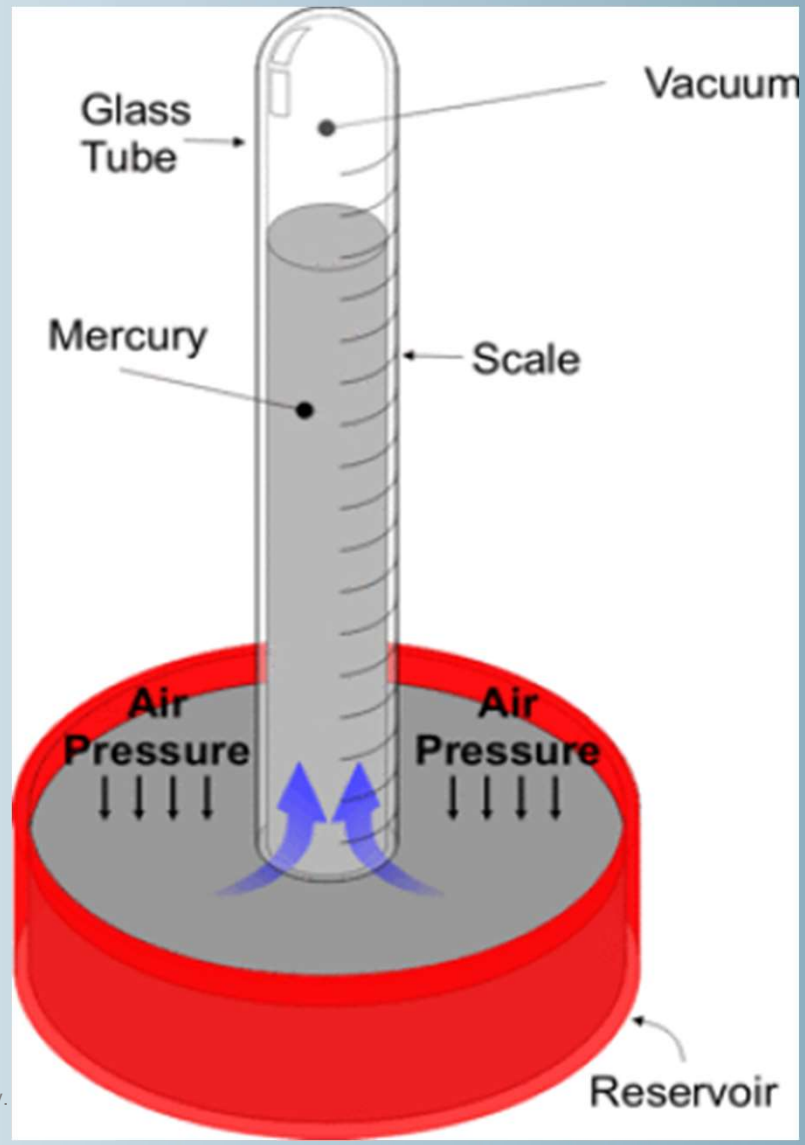
2. Using an Aneroid Barometer





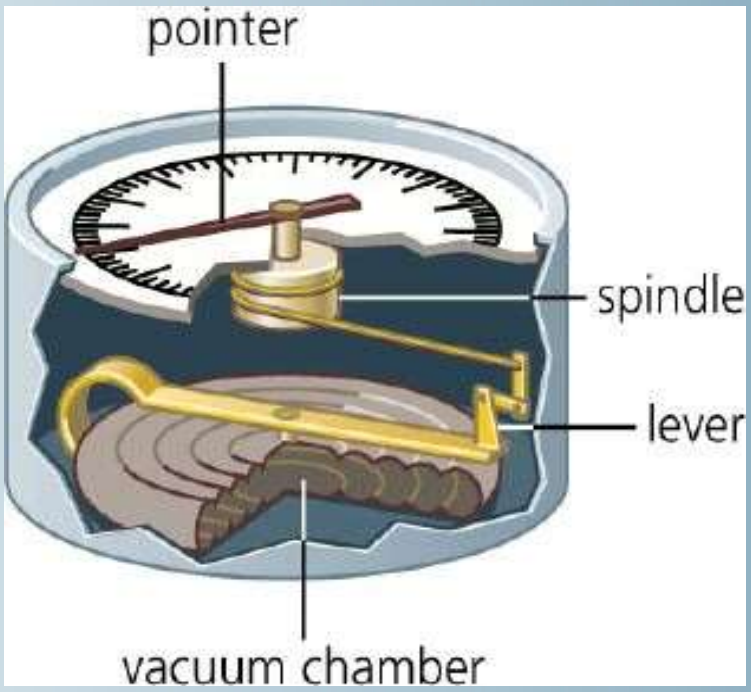
Atmospheric Pressure – How do we measure it?

- A **Mercury Barometer** is the **more accurate** of the two
- An evacuated tube (tube with no air molecules inside it) is placed with the open end immersed in a pool of mercury
- Air pressure acting on the mercury in the pool causes it to rise up the tube
- How far the mercury rises up the tube will depend on how strong the air pressure is
- **The mercury will rise until the weight of the column of air pressing down on the mercury in the pool equals the weight of the mercury inside the tube**



Atmospheric Pressure – How do we measure it?

- An Aneroid Barometer consists of a flexible metal chamber which is partially evacuated
- This chamber is fixed at one end and can expand or contract depending on the pressure of the air around it
- The other end is linked to a dial which is calibrated in pressure units (or in the case of our altimeters – in feet!)

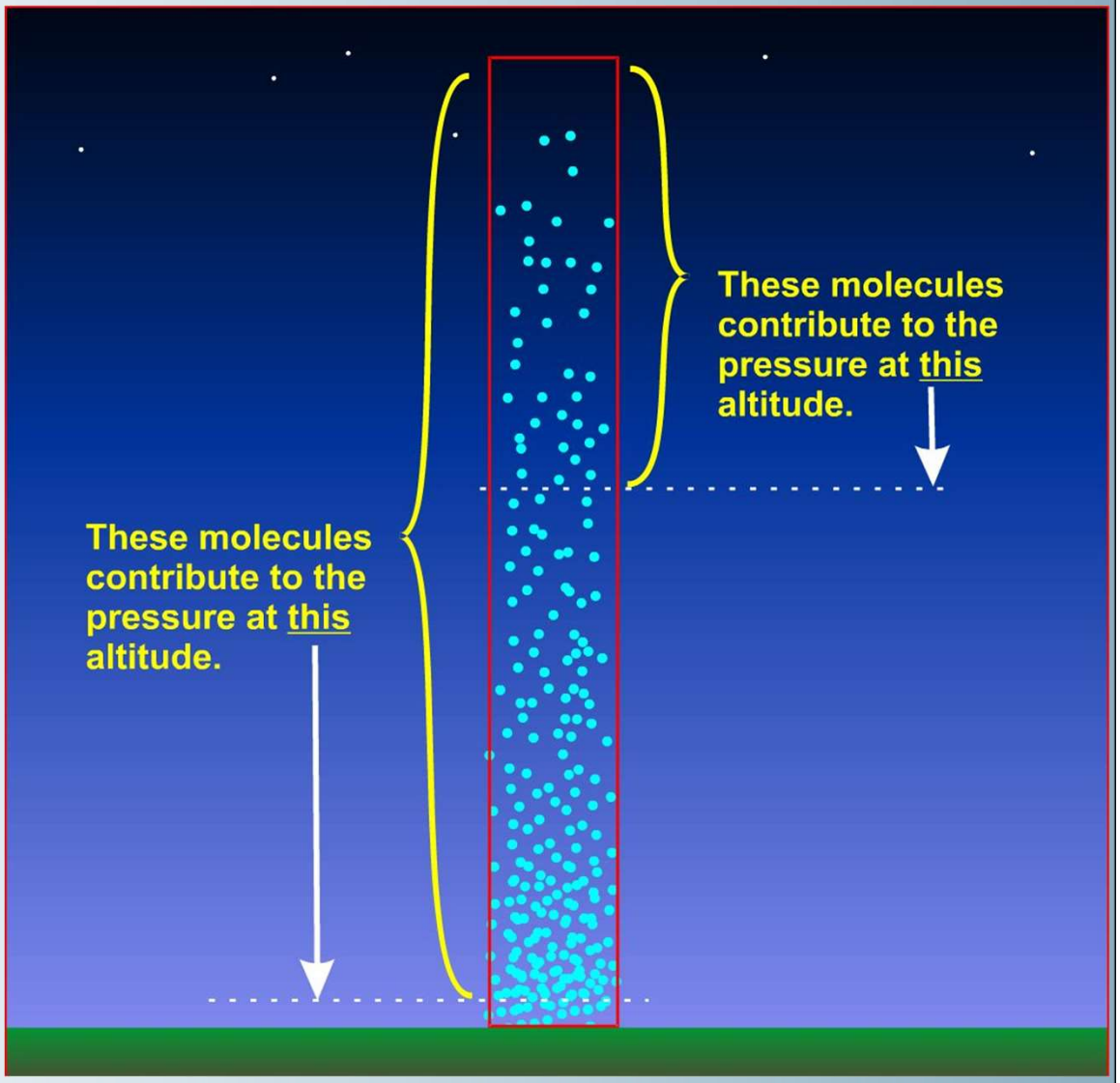


Units of Pressure

- Inches of Mercury (''Hg)
  e.g. an aircraft manifold pressure gauge
- Hectopascals (hPa)
  e.g. an altimeter (note that 1hPa=100N/m²)
- Millibars (Mb) – millibars and hectopascals are interchangeable

Vertical Pressure Distribution

- Atmospheric Pressure reduces with altitude
- This makes sense because pressure is related to the weight of air molecules
- Due to gravity, there are more air molecules closer to earth's surface and hence a greater pressure



Vertical Pressure Distribution

- At low level (below 5000ft), pressure reduces at an approximate rate of:

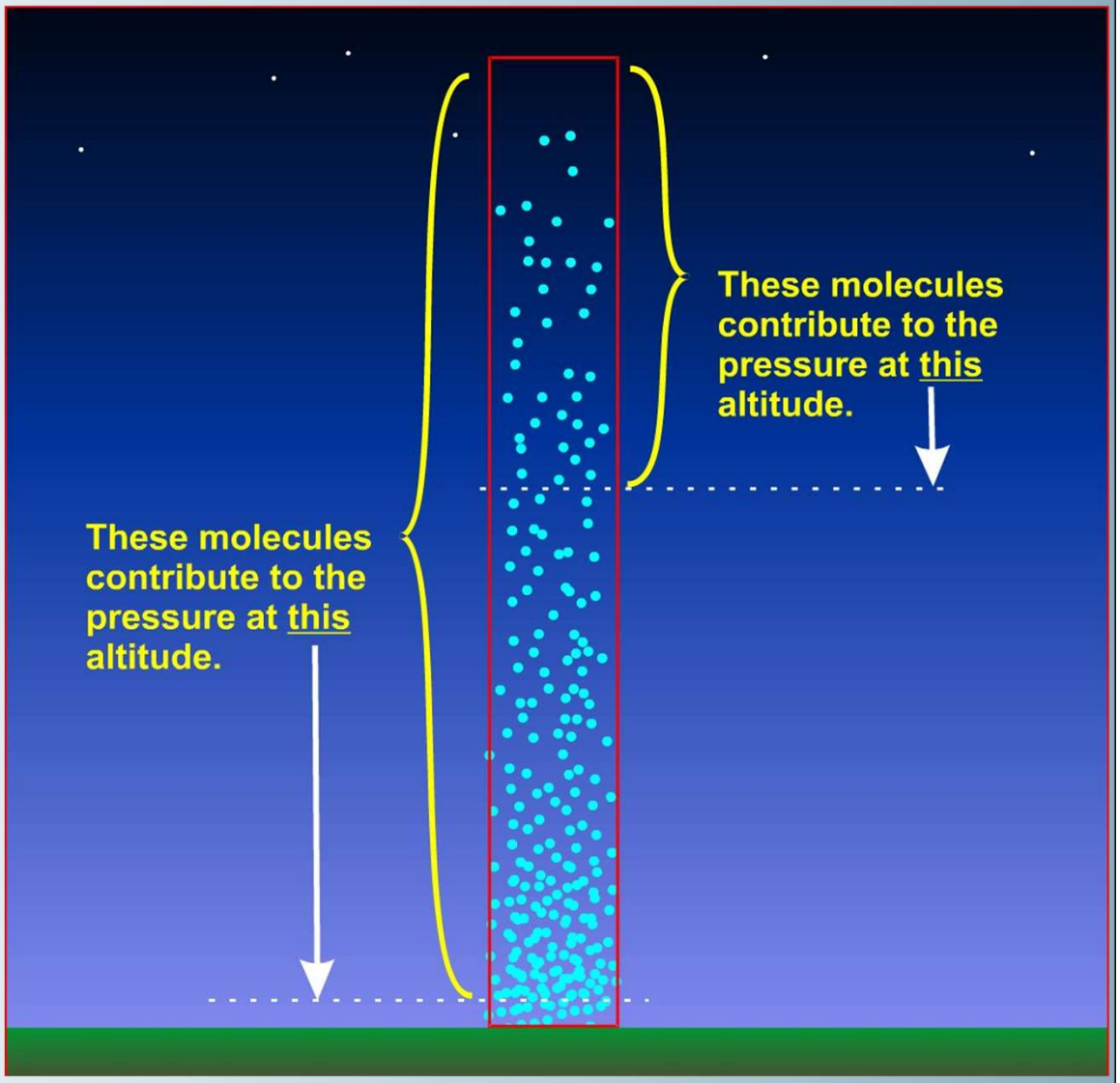
- 1 hPa per 30 feet

- 1 “Hg per 1000 feet

- We use this figure, 1hPa/30ft, as the **standard pressure lapse rate**

- However, above 5000ft, or indeed in ***non-standard* conditions**, the pressure will change at a different rate

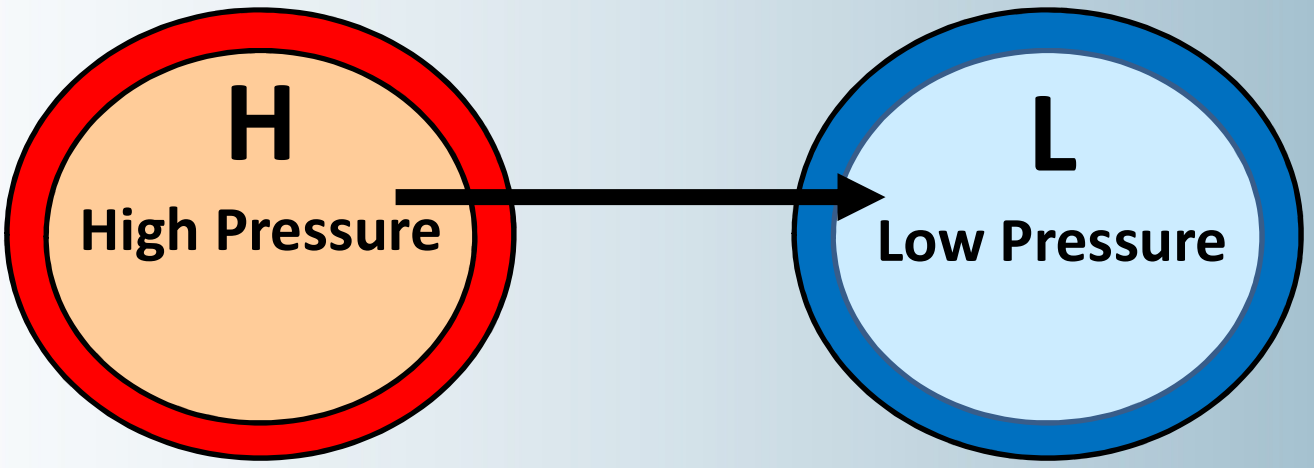
- This will become important at ATPL Level Meteorology.



Horizontal Pressure Distribution

- Atmospheric Pressure not only changes with altitude, but also from place to place
- As you might have heard – weather systems exist that are referred to as “High Pressure Systems” and “Low Pressure Systems” – more on this later
- For now, remember the basic movement of air pressure:

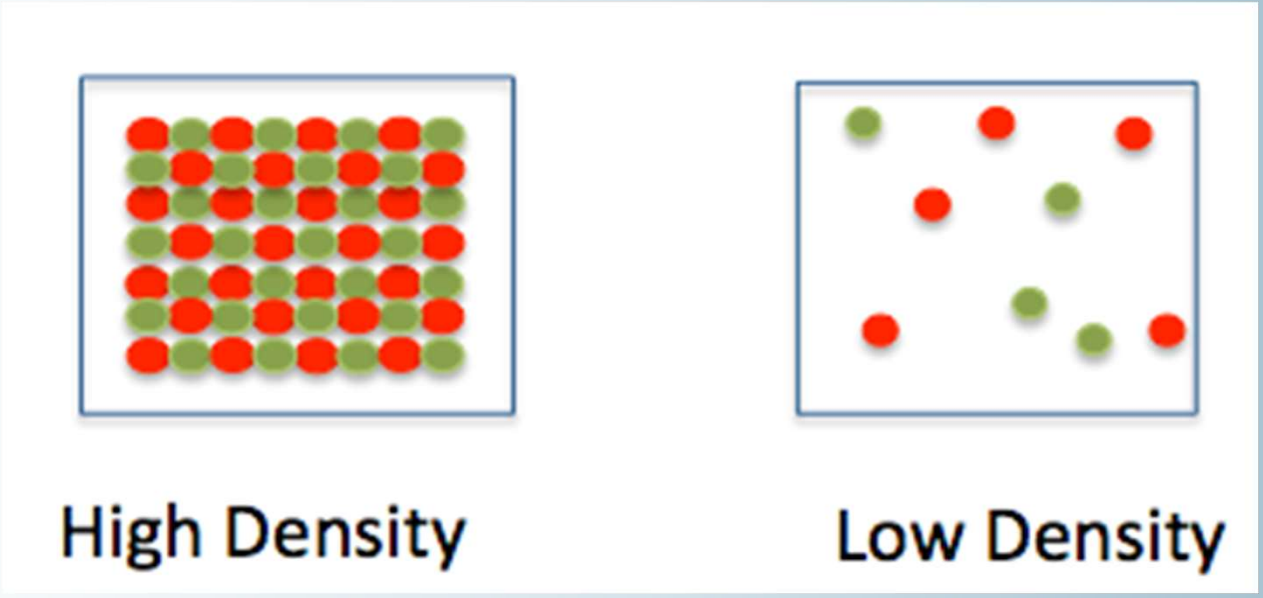
“Air will move FROM a HIGH pressure TO a LOW pressure.”



ATMOSPHERIC DENSITY

Atmospheric Density – What is it?

- Air Density refers to the **mass of air**
- In other words, **how close the molecules are together**



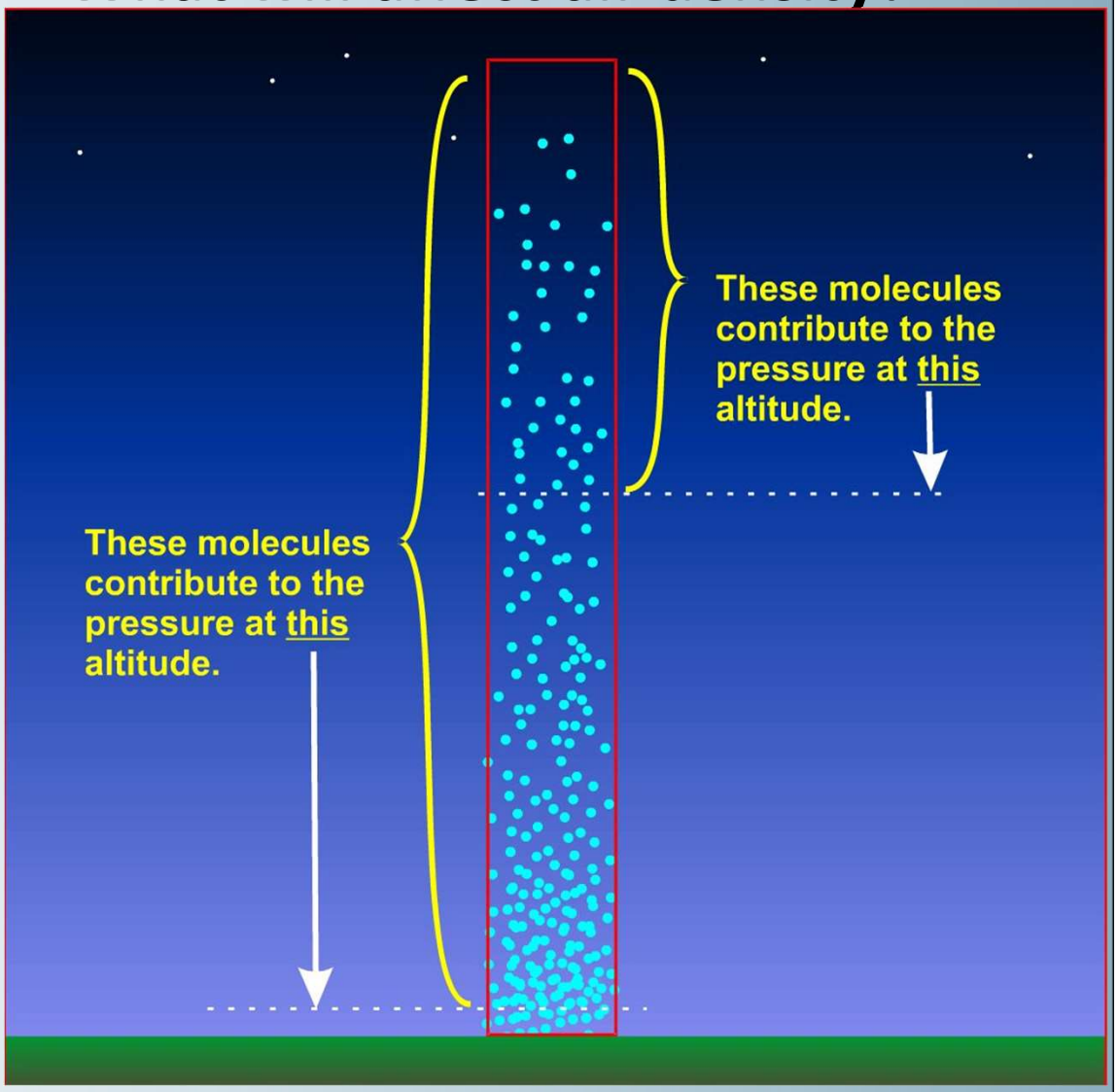
- Both boxes have the same amount of space in them – **the same volume**
- However, the box on the left has a lot more molecules inside it
- It will therefore have a **greater mass** and will be **more dense**

Atmospheric Density – What will affect air density?

Air Density depends on 3 factors:

Pressure:

- Density and Pressure are directly related
- A decrease in pressure results in a decrease in density

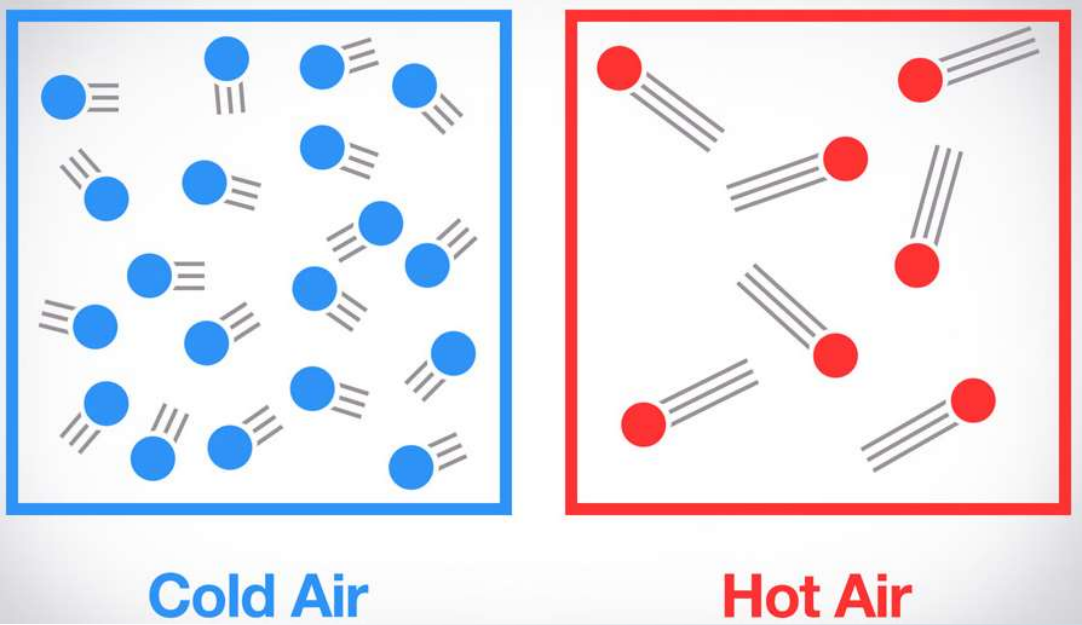


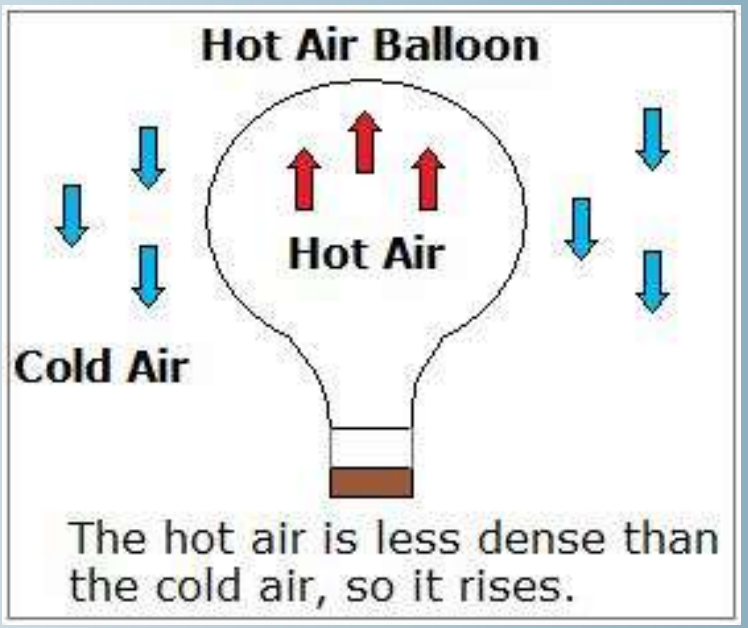
Atmospheric Density – What will affect air density?

Air Density depends on 3 factors:

Temperature:

- Density and Temperature are **inversely related**
- An increase in temperature results in a decrease in density (assuming constant pressure and increased volume)



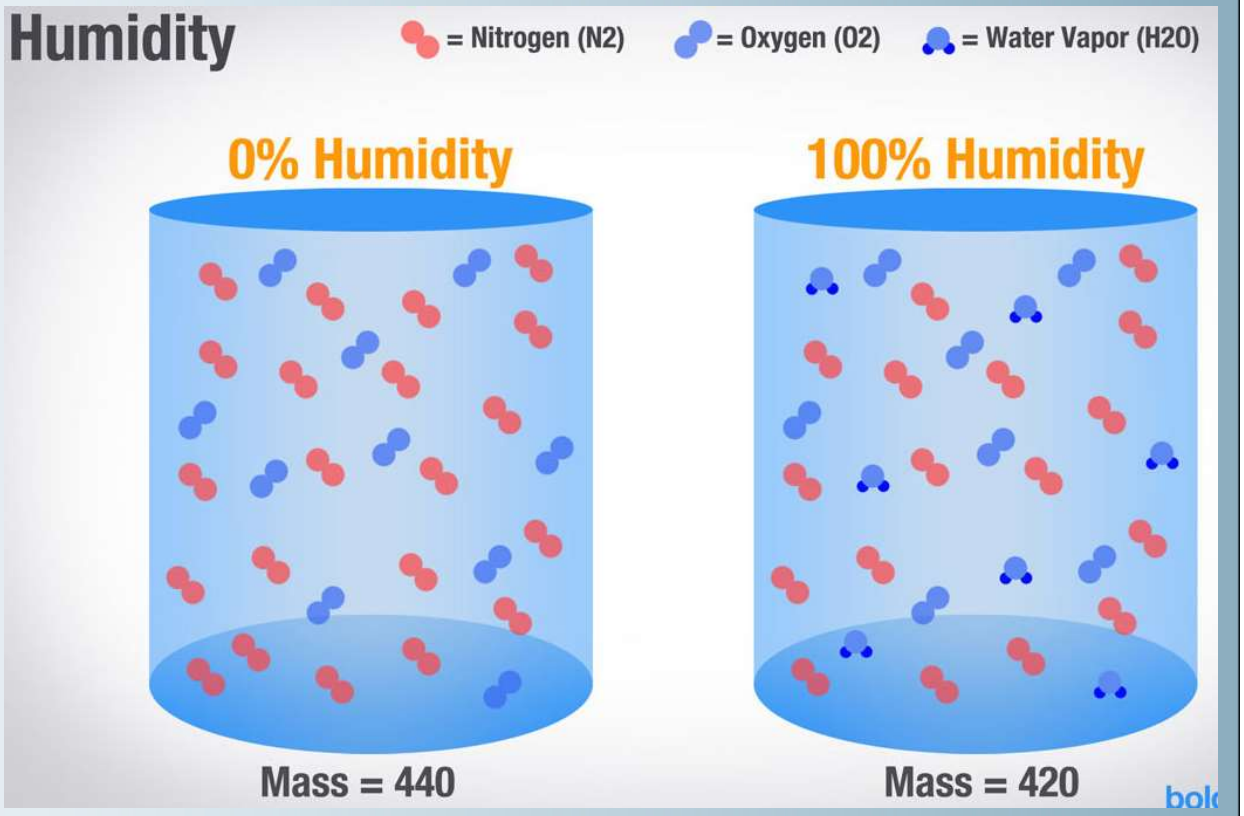


Atmospheric Density – What will affect air density?

Air Density depends on 3 factors:

Humidity:

- Density and Humidity are **inversely related**
- An increase in humidity results in a decrease in density
- This is because a molecule of water vapour has less mass than an average air molecule
- So, increasing the concentration of water vapour lowers the overall mass of a given volume of air – therefore decreasing the density



Atmospheric Density – Why is density important?

- Density is important as it directly affects aircraft performance

- A decrease in air density has the following effects on an aircraft:

1. **Less air is flowing over the surface area of the wings, meaning that less lift will be generated**

2. **The propeller blades are rotating through less air, meaning that less thrust will be generated**

3. **There will be less air taken into the engine, meaning that less power will be generated**

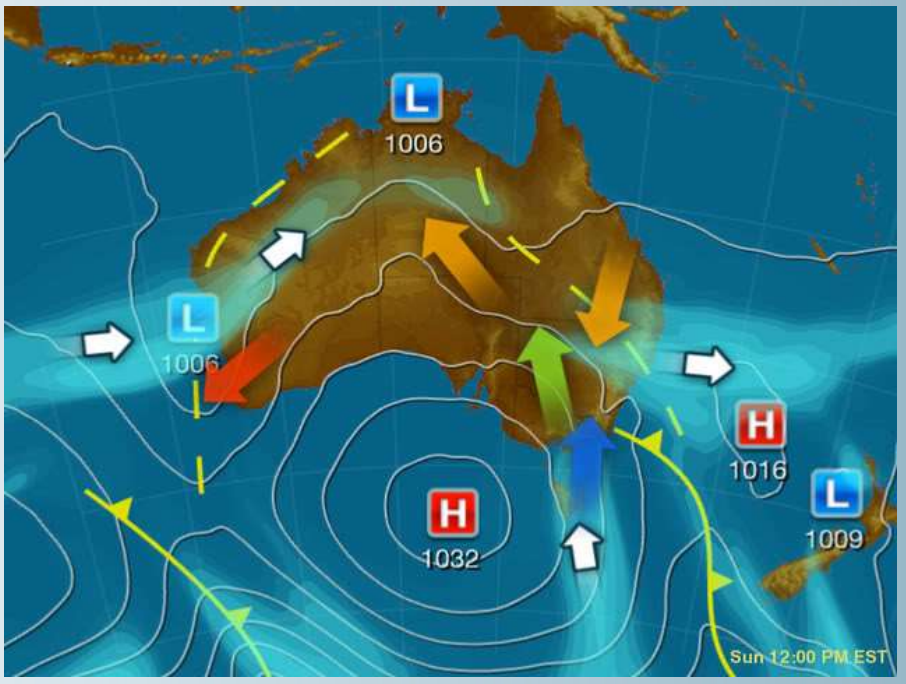
PRESSURE VARIATION

Pressure Variation

- Atmospheric Pressure varies from place to place – it does not remain constant

- It varies over time due to:

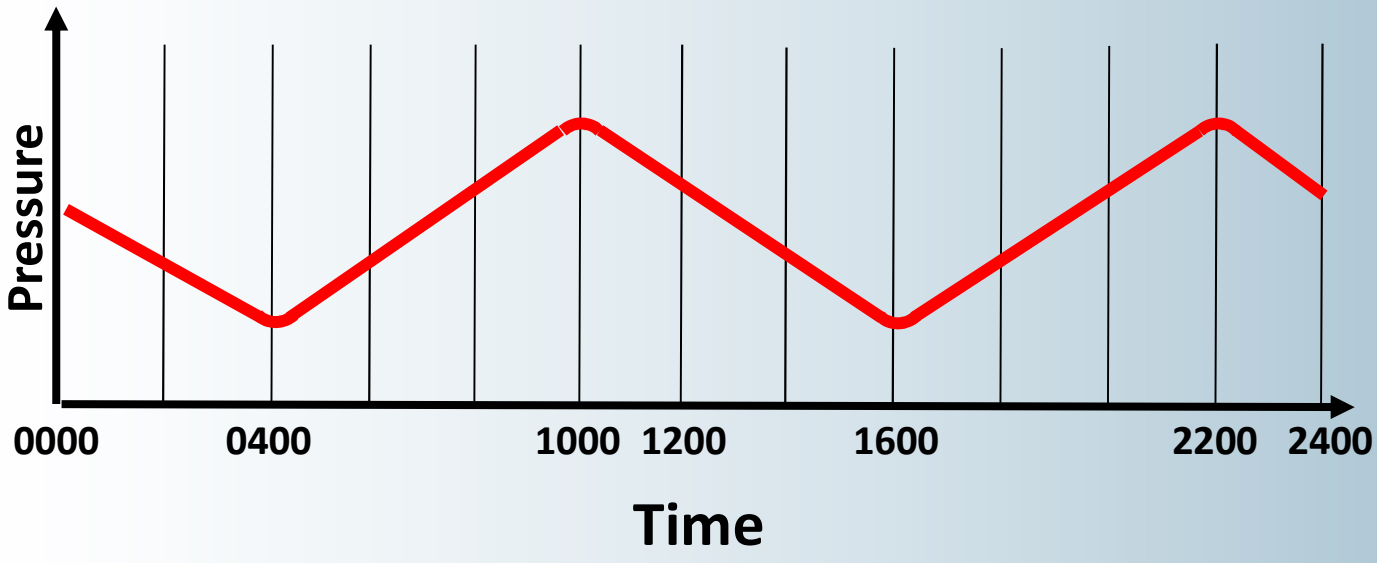
1. The movement of pressure systems across the country and their changing intensity



2. The Semi-Diurnal Pressure Variation

Pressure Variation – Semi-Diurnal Pressure Variation

- Semi-diurnal variation is basically a rhythmic variation in pressure **over 12 hours**
- It is caused by the atmosphere itself expanding and contracting as it warms and cools
- The **greatest variation (up to 5hPa) occurs in the tropics** – here at Moorabbin, we may only see a 1hPa change!



Over 24 hours, Atmospheric Pressure will be:

- Greatest at 1000 hours and 2200 hours
- Smallest at 0400 hours and 1600 hours

Remember: "*10 is higher than 4*"

HAZARDOUS EFFECT OF ATMOSPHERIC PRESSURE VARIATION

Hazardous Effect of Atmospheric Pressure Variation

- Atmospheric Pressure varies due to:

  1. The movement of weather systems across the country

  2. The diurnal variation of pressure

- This is hazardous to pilots as we set a constant QNH pressure setting on our altimeter – but in reality, pressure is constantly changing!

- The effect is this:

  1. When flying from **high to low** pressure, the altimeter will **over-read**

  2. When flying from **low to high** pressure, the altimeter will **under-read**

- This gives us reduced terrain clearance (if the altimeter over-reads, you will think you are higher than you actually are)

Hazardous Effect of Atmospheric Pressure Variation

Remember:

"High to Low, look out below!"

Hazardous Effect of Atmospheric Pressure Variation

Atmospheric pressure variation may also give us reduced traffic separation. Consider the following example

LOW

995 hPa pressure level

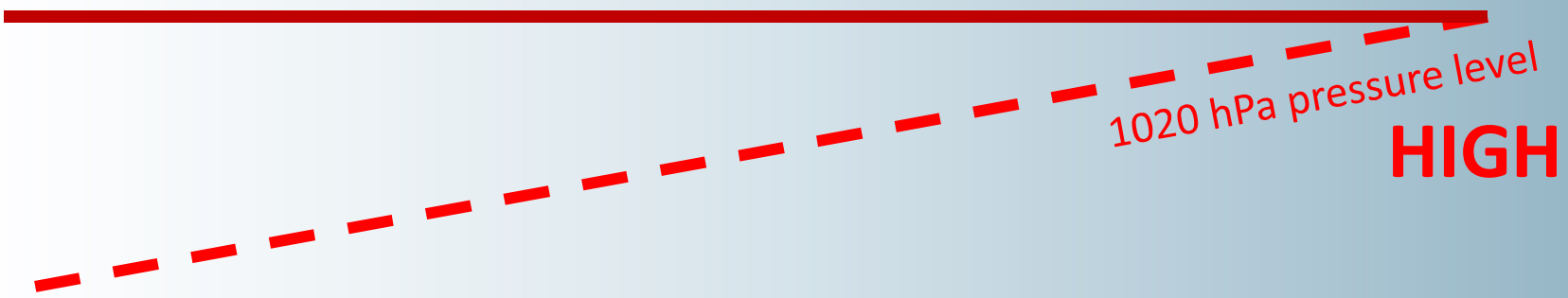
1020 hPa pressure level

HIGH

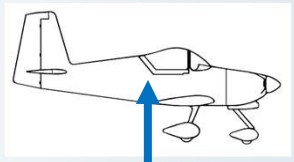
Hazardous Effect of Atmospheric Pressure Variation

LOW

995 hPa pressure level



Hazardous Effect of Atmospheric Pressure Variation



7500 ft

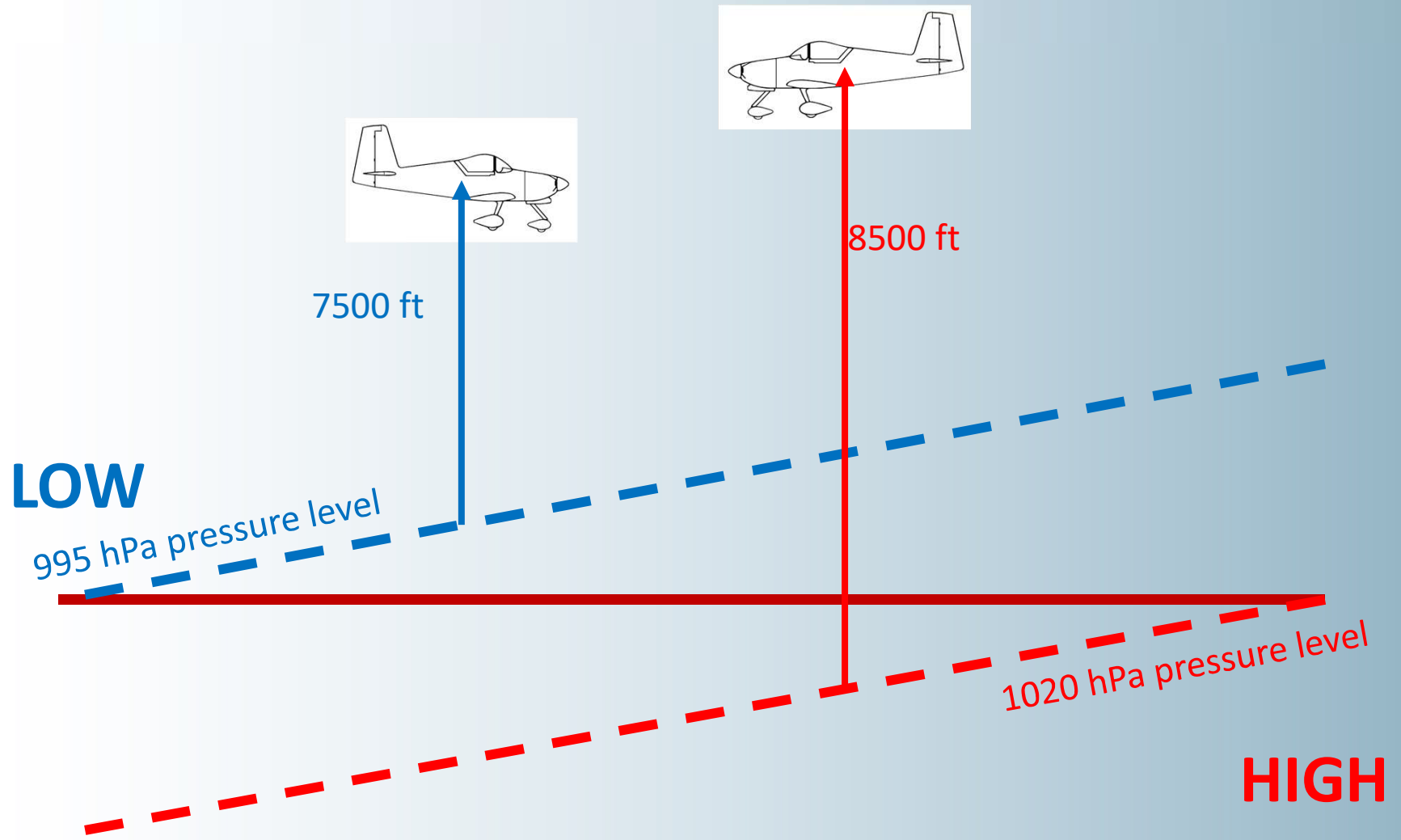
LOW

995 hPa pressure level

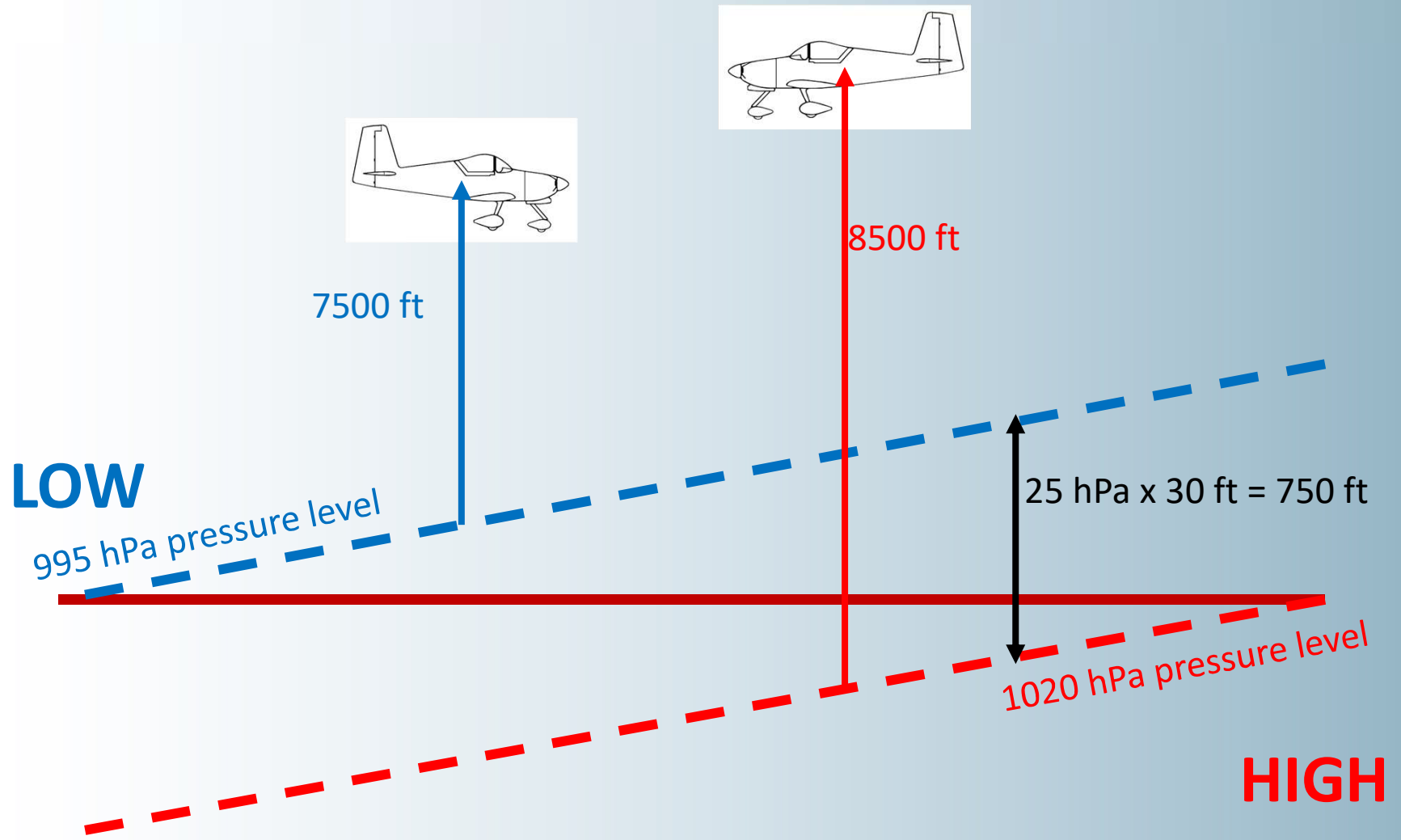
1020 hPa pressure level

HIGH

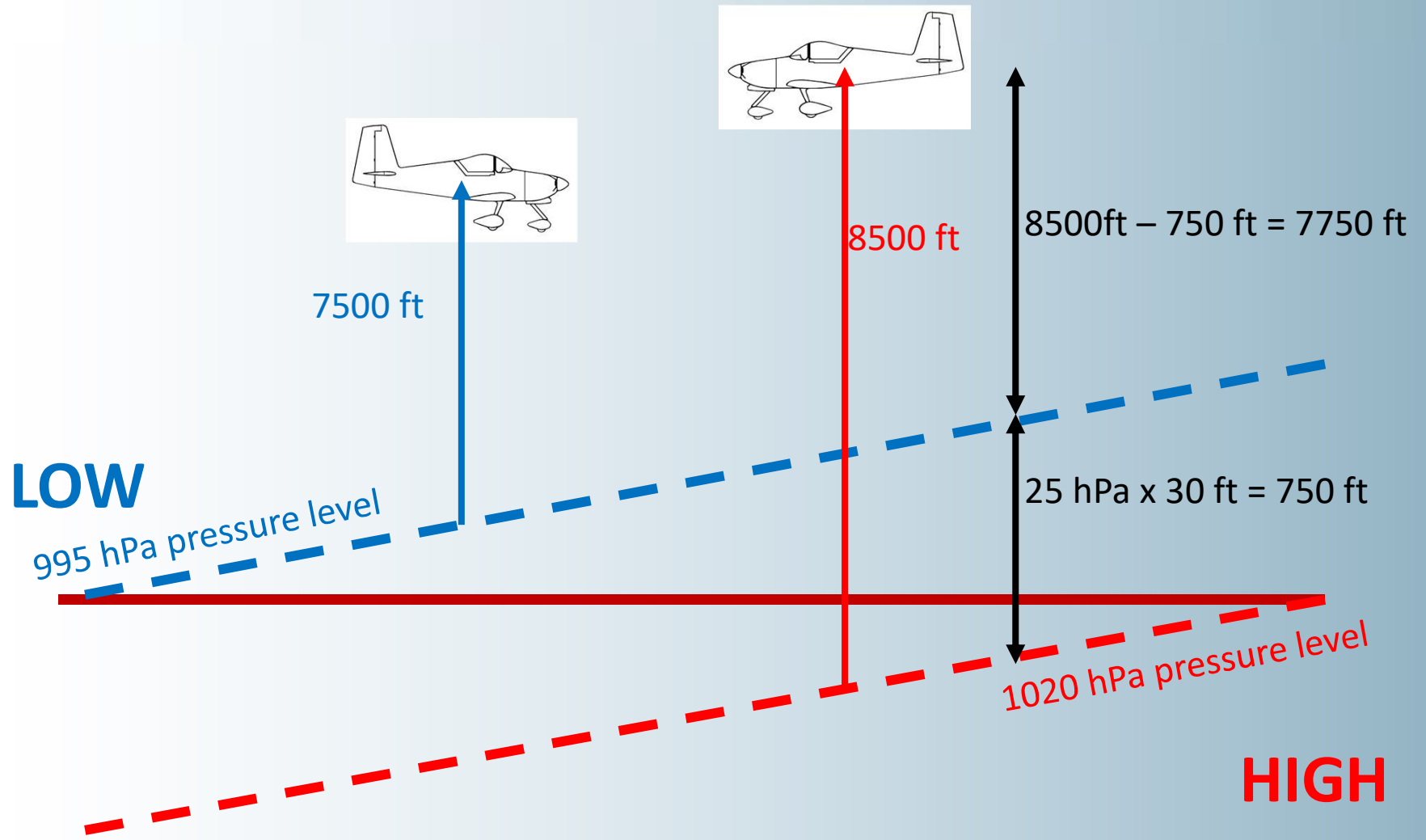
Hazardous Effect of Atmospheric Pressure Variation



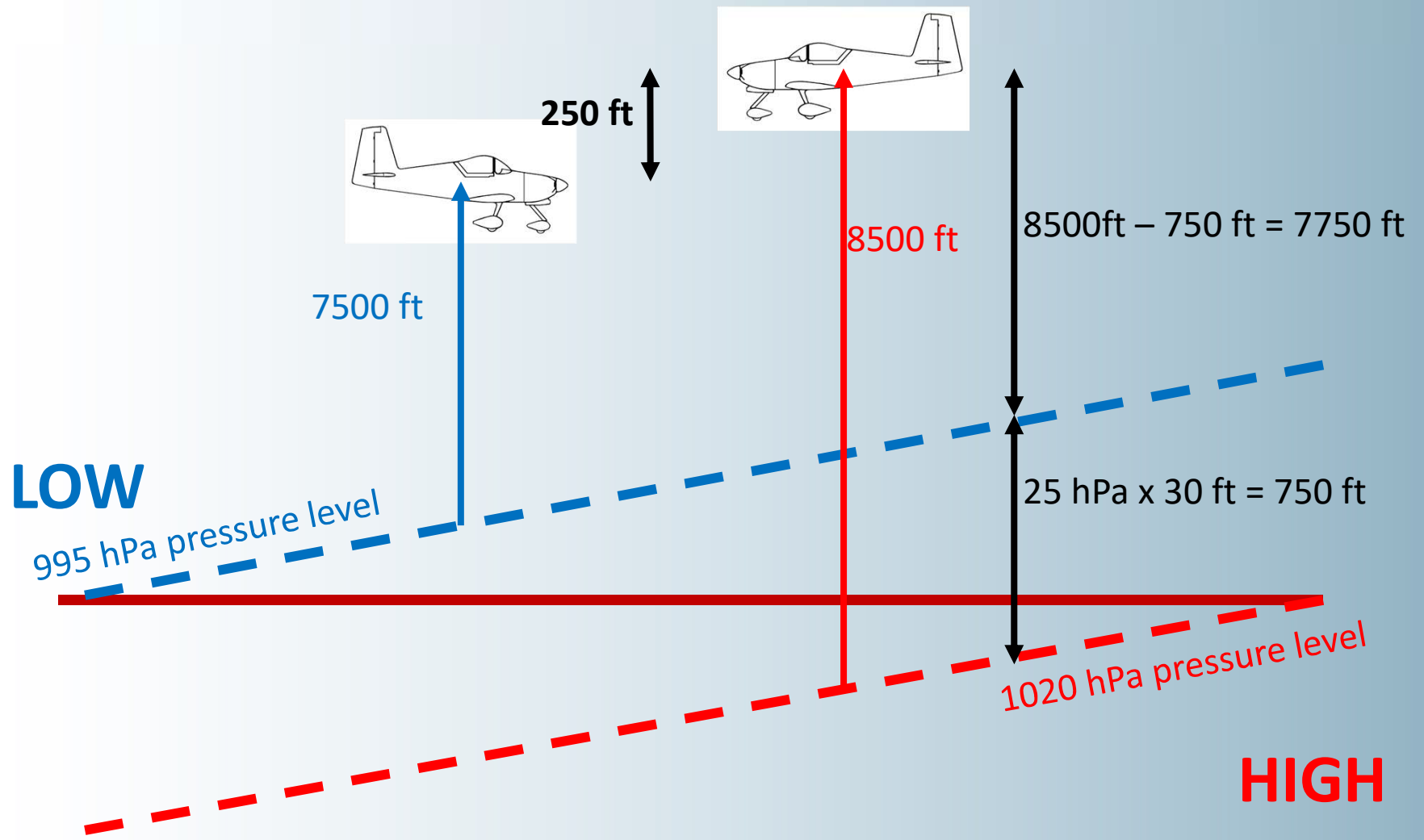
Hazardous Effect of Atmospheric Pressure Variation



Hazardous Effect of Atmospheric Pressure Variation



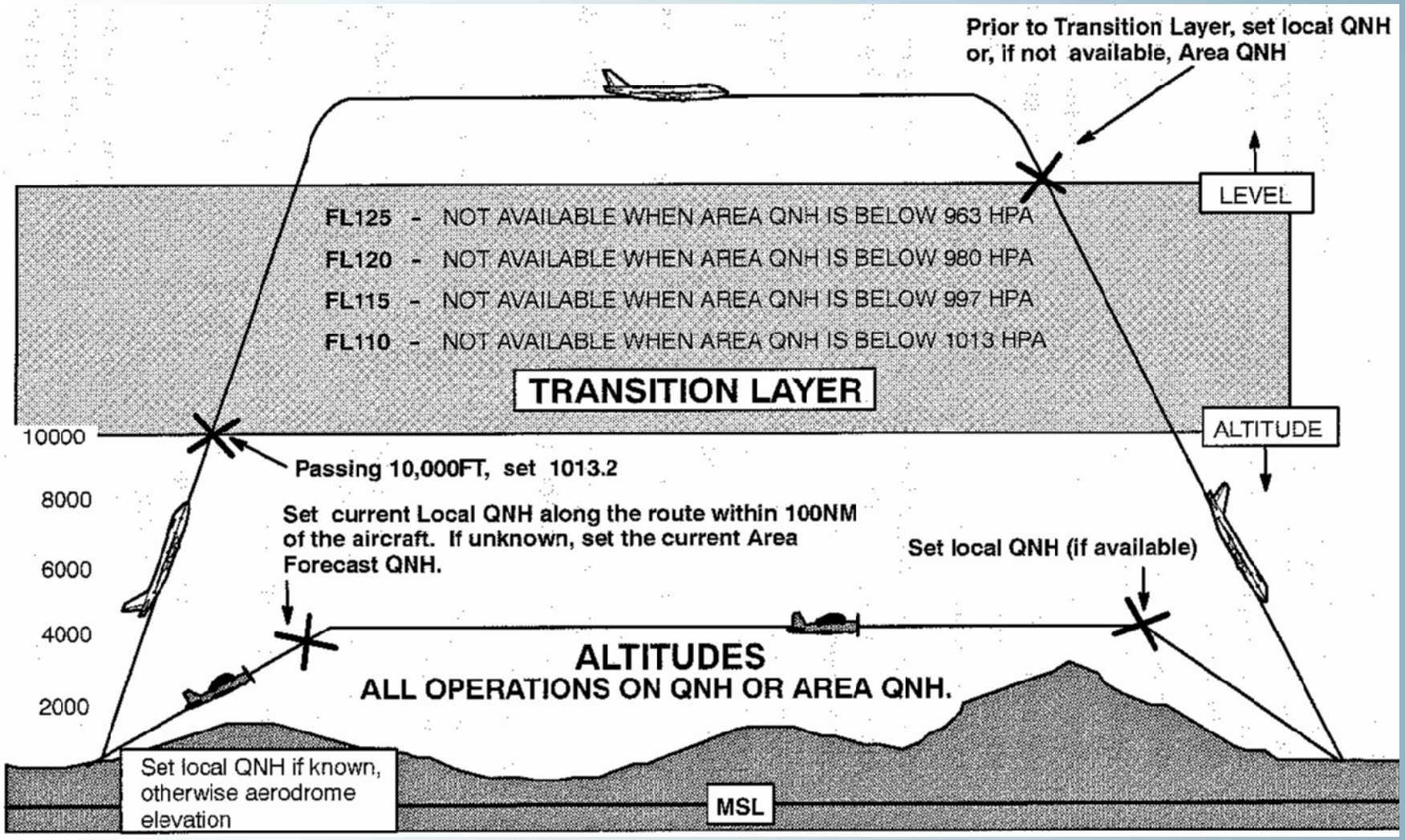
Hazardous Effect of Atmospheric Pressure Variation



Hazardous Effect of Atmospheric Pressure Variation

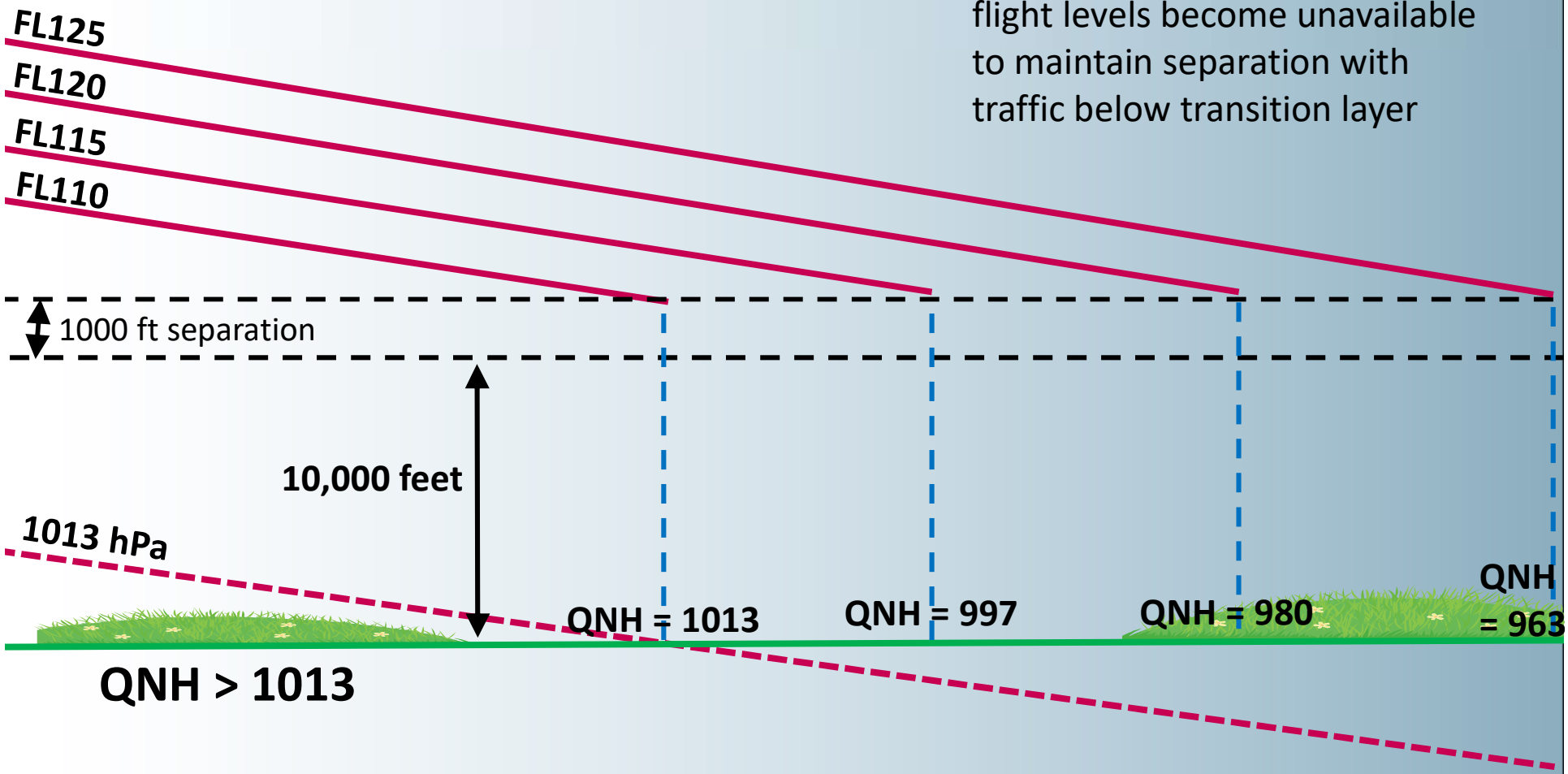
- We can see that at high altitude (for transport jets etc.) it is important that all aircraft are operating using a standard altimeter setting
- Above 10,000 feet, aircraft operate with a common altimeter setting of 1013 hPa. This will indicate an aircraft's **FLIGHT LEVEL**
- 10,000 feet (the **transition altitude**) marks the base of the **Transition Layer**
- The Transition Layer is a layer of airspace that separates aircraft using the two different datum (QNH or 1013 hPa)
- The Transition Layer must always be at least 1000 feet thick and no flying is permitted in this layer

Transition Altitude & Layer



Transition Altitude & Layer

With decreasing QNH, the lower flight levels become unavailable to maintain separation with traffic below transition layer



WHAT ABOUT AIRCRAFT BELOW 10,000 FEET? HOW DO THEY ACHIEVE SEPARATION?

VFR Cruising Levels

CAR 173 & AIP ENR 1.7 OR VFRG page 3.55-3.56

- The answer is relatively simple:

  - VFR and IFR flights are designated different altitudes at which they may cruise

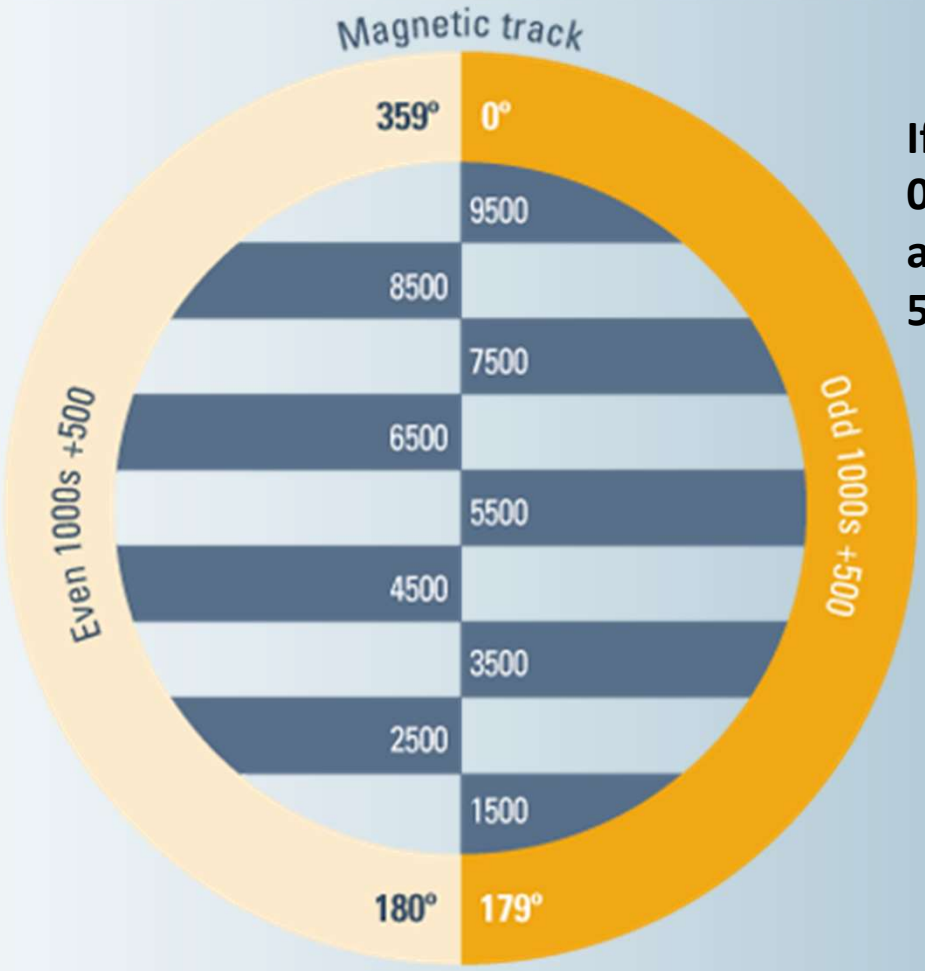
  - Aircraft flying in opposite directions are also designated different altitudes at which they may cruise

  - A standard pressure setting in a given area may also be used (Area QNH)

  - Area QNH is valid for 3 hours and will be within +/- 5 hPa of any actual QNH in that area

VFR Cruising Levels

CAR 173 & AIP ENR 1.7 OR VFRG page 3.55-3.56



If your TRK° M is from 0-179, you must cruise at an ODD number + 500' e.g. 3500'

If your TRK° M is from 180-359, you must cruise at an EVEN number + 500' e.g. 4500'

VFR Cruising Levels

CAR 173 & AIP ENR 1.7 OR VFRG page 3.55-3.56

- IFR levels operate the same way but without the "+500" on the even or odd numbers

- Cruising Levels should be followed:

- When above 5000 ft

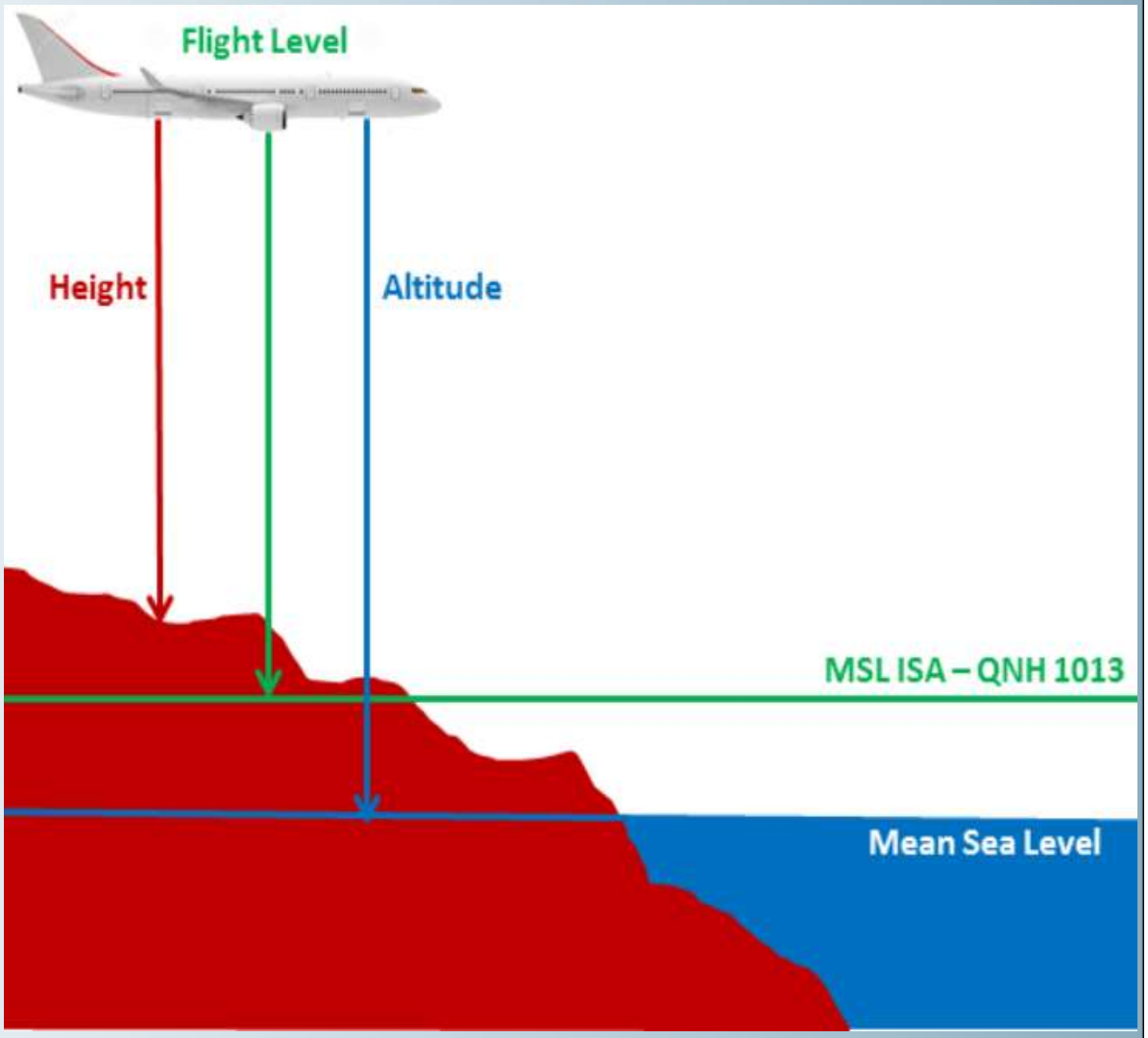
- When practicable below 5000 ft (aircraft may fly at any altitude they wish)

Q CODES USED IN AVIATION

Q Codes Used in Aviation

Flight Level:

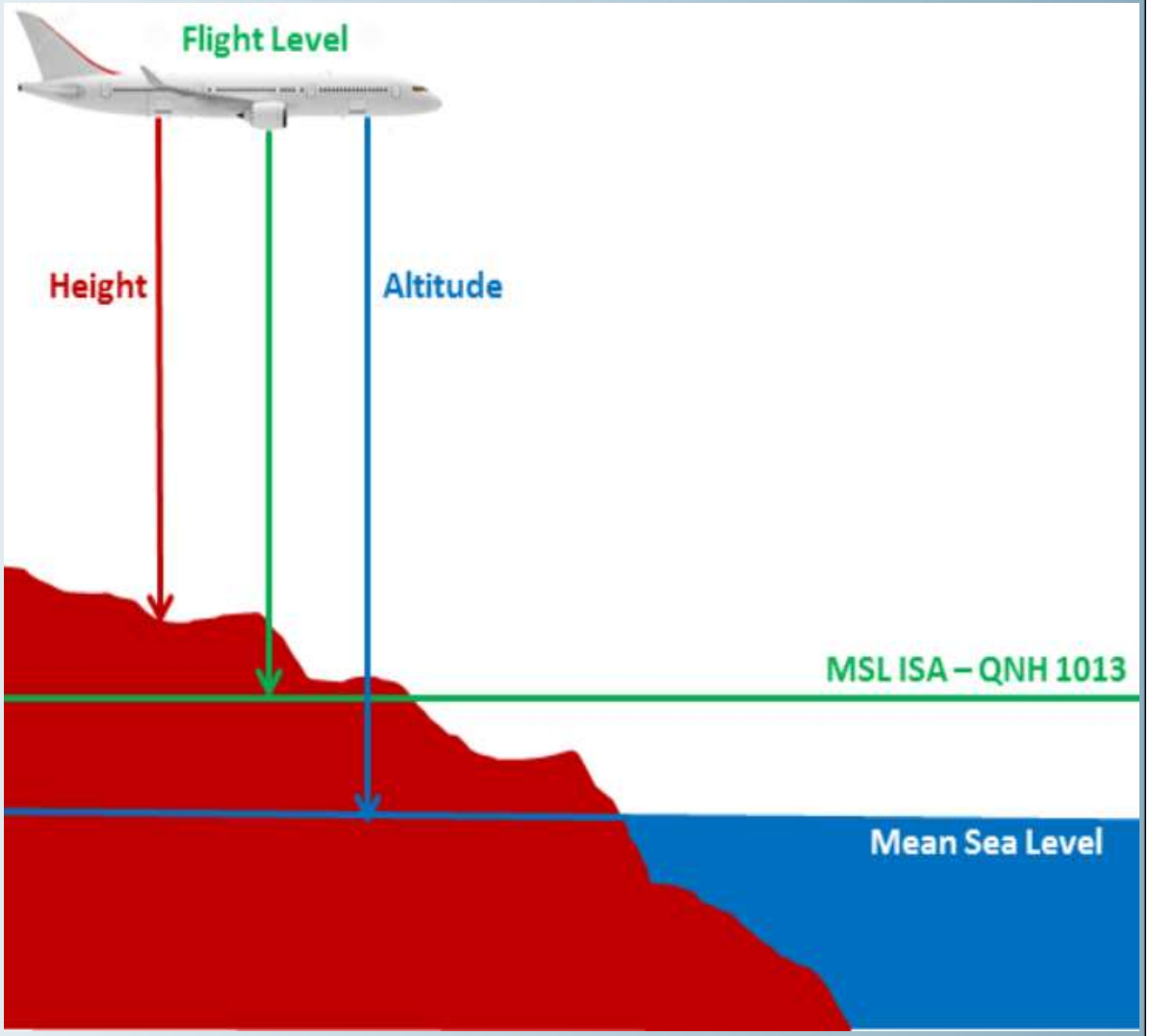
- Set **QNE** – the standard pressure (MSL ISA Pressure)
- The altimeter will indicate **Pressure Height** or **Flight Level**
- We use this when operating above the **transition layer**
- The **transition layer** is from **10,000 feet (the transition altitude)** up to FL110-125 (depending on the QNH)



Q Codes Used in Aviation

Altitude:

- Set **QNH** – the atmospheric pressure at MSL
- The altimeter will indicate **approximate altitude** (vertical distance AMSL) of the aircraft
- Note that it is **not the true altitude**
- Our altimeters are calculated for the vertical pressure distribution present **in ISA** – but the conditions are very rarely ISA!
- So, there will always be some error present



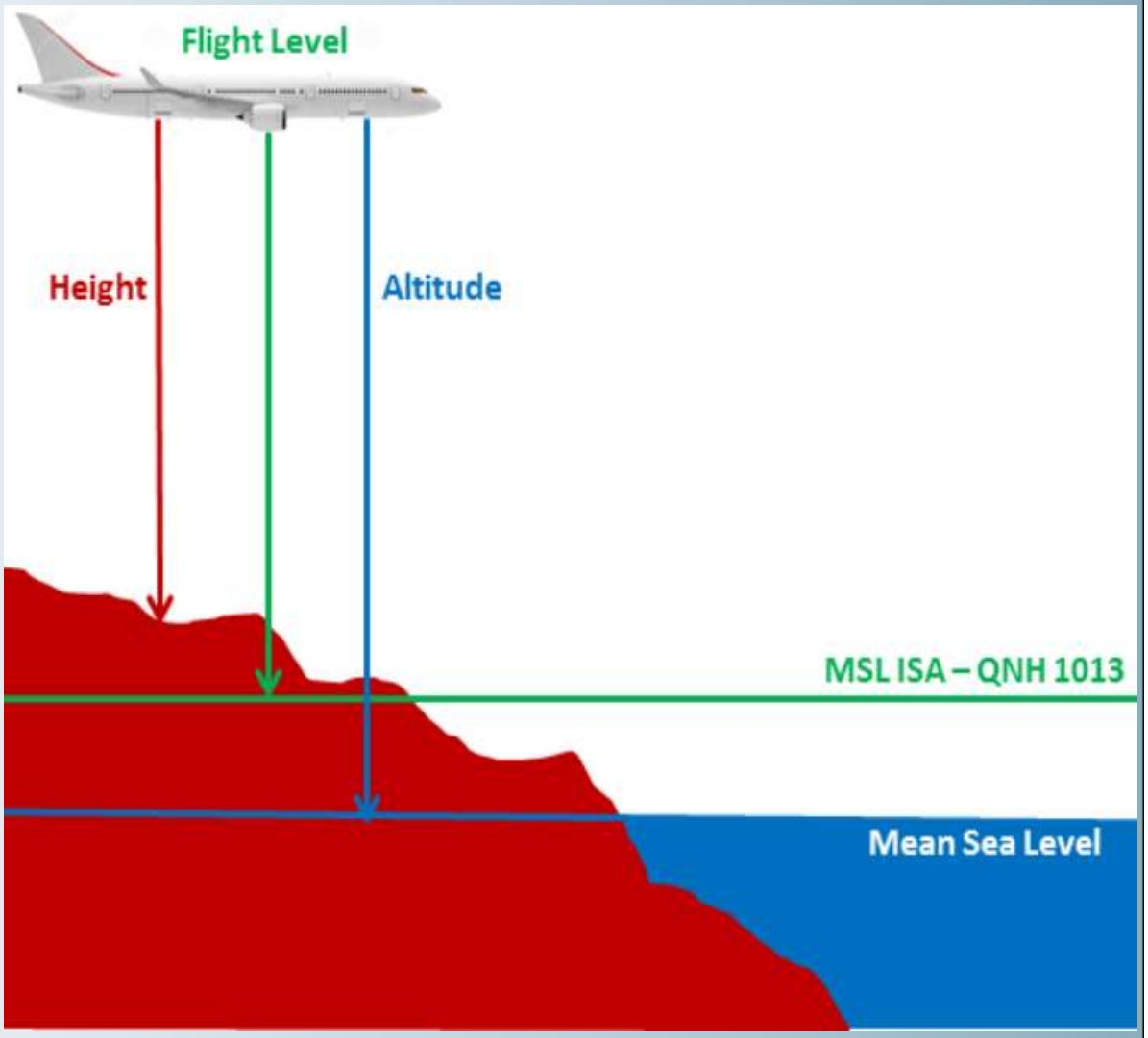
Q Codes Used in Aviation

Altitude:

- QNH corrected for non-ISA conditions is known as QFF
- QFF is **not used in aviation**
- A setting of QNH will more correctly read:

1. The elevation of the aerodrome on landing

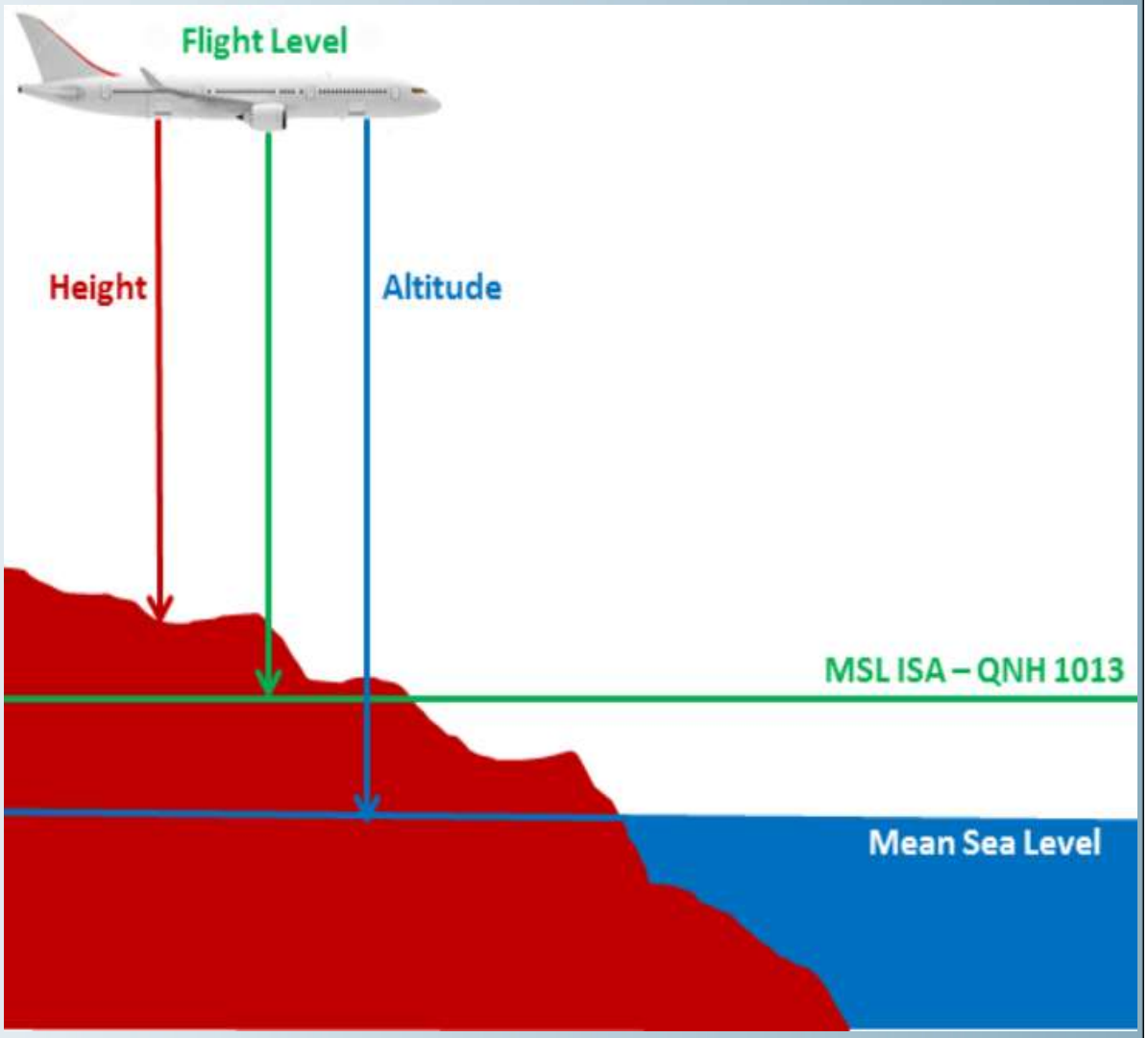
2. The elevation of the aerodrome when at a known point on the airfield e.g. the ARP



Q Codes Used in Aviation

Height:

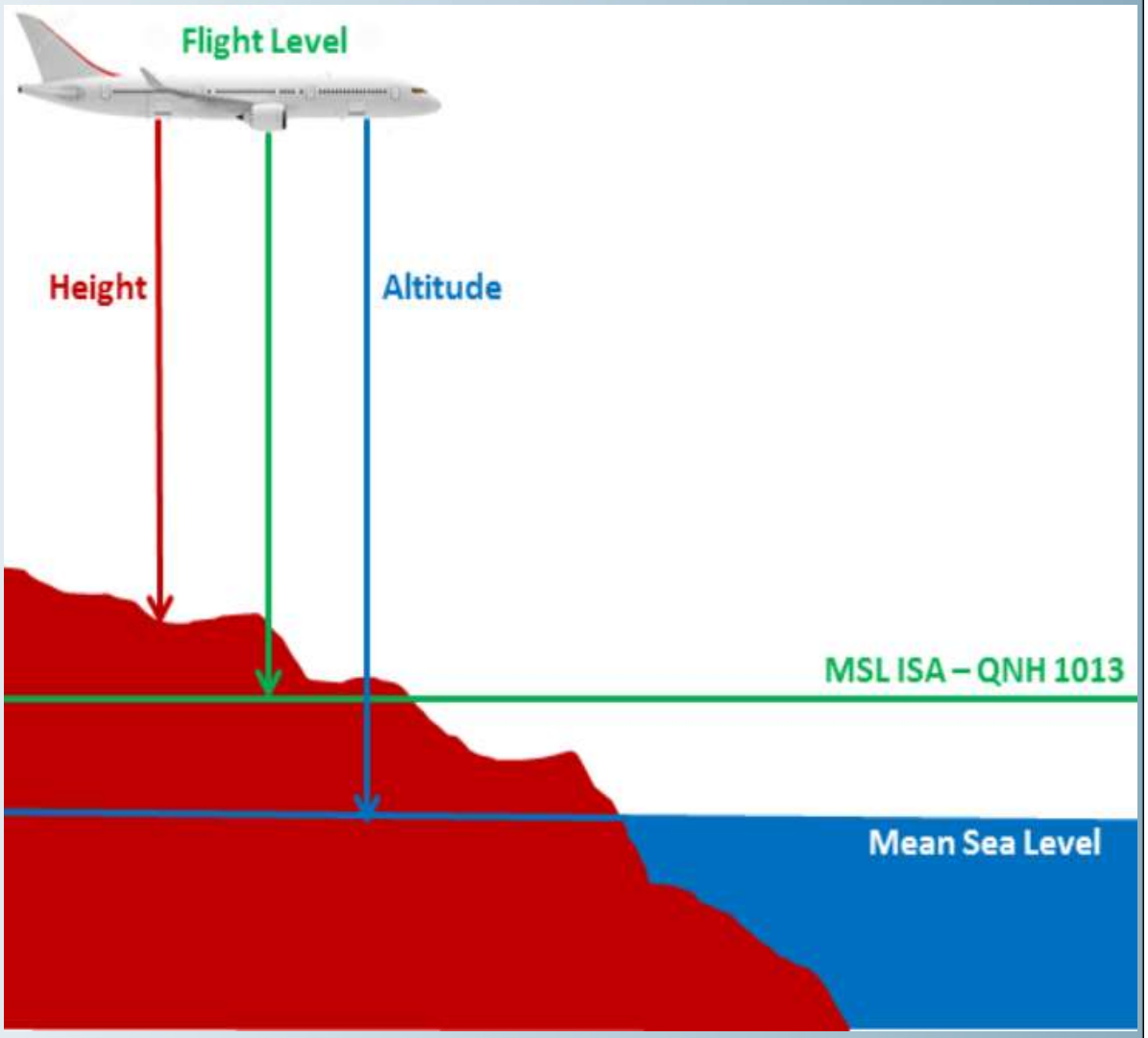
- Set **QFE** – station level pressure
- QFE is rarely used in Australia – it shows the height above or below the reference pressure point – which may be aerodrome level
- For example, to set the aerodrome QFE, you would set the subscale on the altimeter to 0 feet



Q Codes Used in Aviation

Height:

- To obtain QNH from QFE, you would apply the correction of 1hPa/30’
- Note that this assumes the air is dry and conforms to ISA
- In reality, however, the rate of change of pressure depends on the humidity and temperature of the air
- At high altitude, pressure reduces more slowly and the lapse rate might look like 1hPa/100’



Q Codes Used in Aviation

Meteorological MSL Pressure:

- Meteorologists use a more complicated method of calculating MSL Pressure
- This setting would be known as **QFF**
- Temperature and water vapour content are considered for the correction to MSL
- This is **not used in aviation**