



2022  
SSA Webinar Series

Black Forest Soaring Society Ground School Series

# Air Data Systems

By Dave Rolley

Feb 4, 2022

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while we allow registrants to sign in.

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Program hosts:  
Cindy B., Dave Rolley, Alice & Mark Palmer

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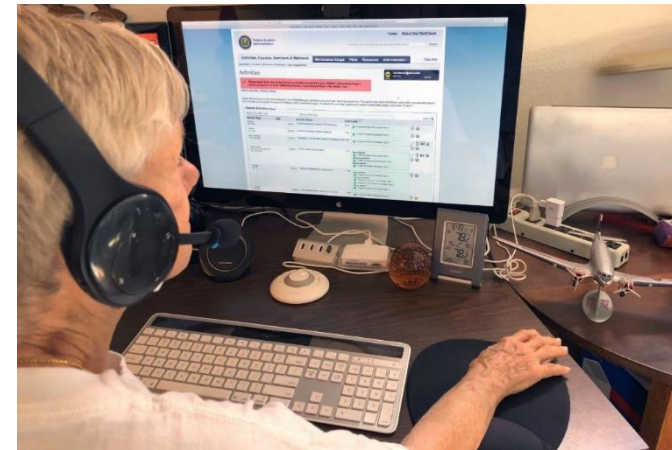
- ▶ *WINGS* Pilot Proficiency Program
  - On line records retention
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# Need help with *WINGS*?

- **Watch these videos**
  - FAA WINGS Program
    - <https://www.youtube.com/watch?v=IMSmacwIxz4>
  - Where are my WINGS credits and how do I use them?
    - <https://youtu.be/Ynd0aCDrGmA>
  - Instructor Portal
    - <https://www.youtube.com/watch?v=5uOUD2zF3FM>



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# Webinars

| Title                                                            | Handouts             | Date       |
|------------------------------------------------------------------|----------------------|------------|
| Mid-America Spring Seminar - Chicagoland                         |                      | 02/27/2021 |
| Intro to Portable Gliding Computers - Black                      |                      | 02/26/2021 |
| AirData Systems: Airspeed, Altimeter, & Va                       | Handout              | 2/12/2021  |
| Introduction to Cross-Country - Black Fore                       |                      | 01/29/2021 |
| Top 5 Tips to Help You Soar Faster and Far                       |                      | 08/12/2020 |
| Buying & Selling Gliders, New & Used (I've                       |                      | 07/17/2020 |
| Zen & the Art of Aerotowing -- for the Gliderpilot - C. Brickner | Q & A's              | 06/09/2020 |
| Emergency Locator Devices & Other Safety Equipment - John DeRosa |                      | 05/12/2020 |
| Intermediate-Advanced Thermaling in Gliders - Eric Carden        | Vocabulary           | 04/14/2020 |
| How To Get The Most out of your LXNAV glide computer -P. Remde   | Handout1<br>Handout2 | 06/19/2019 |

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This Evening's Presenter :

**Dave Rolley**

active soaring pilot.

Leader of BFSS XC Ground School



Assisted via Chat by  
Alice and Mark Palmer, BFSS, CFI-Gs

# 2022 Soaring Seminars



- January 21: Introduction to Cross Country
  - Initial XC strategy using GlidePlan software to illustrate the concepts.
- February 4: Air Data Systems: Airspeed, Altimeter, and Variometers
  - Examines the quantities being measured and converted to useful information. Focuses on variometer types and uses
- February 18: Intro to portable gliding computers
  - Cockpit workload management, equipment and software.
  - In class flight example using XCSoar, SeeYou Mobile, and ClearNav..
- March 4: Speed to Fly
  - Glider performance
  - Modern approach for Speed to Fly
- March 18: Soaring Pilot Physiology
  - Physiological considerations for soaring pilots
- April 6: Collision Avoidance Technology
  - Transponders and FLARM, types of units, usage, what they can, and what they cannot do.
- April 16: Model based weather forecasting:
  - Examples using the Front Range RASP tool and SkySight
- April 29: Flight Tracking
  - Satellite based (SPOT, InReach), Smart Phone based, FLARM based, Transponder based (ADS-B Out)
- May 13: Online Soaring Contest
  - It's all for fun but if it isn't on the OLC it didn't happen.

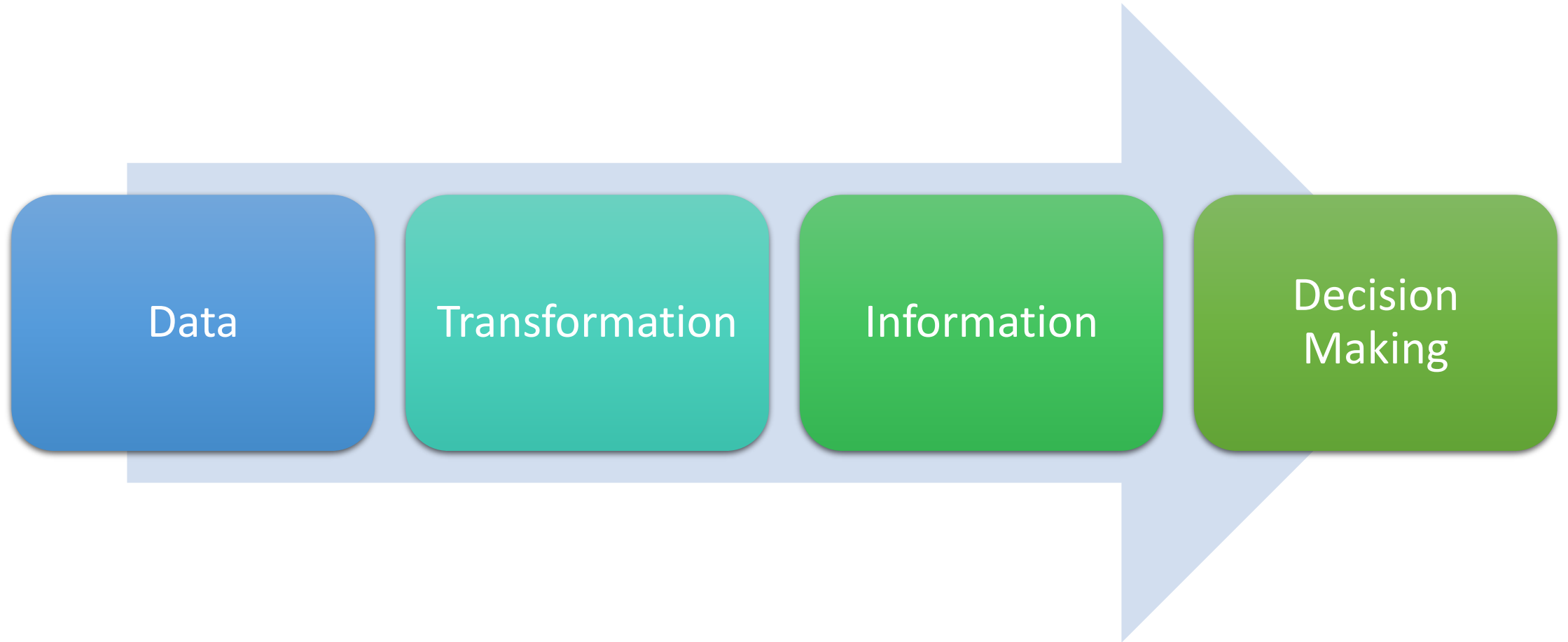
# Acknowledgements

- Slides with a light blue header are from Richard Lancaster
  - ASK-21 glider outlines Copyright 1983 Alexander Schleicher GmbH & Co.
  - All other content on those slides Copyright 2008 Richard Lancaster.

# Course Purpose

- Understand the Air Data System in a Glider
- Gain Greater Insight to Variometers
- Develop Tools to Use Inflight

# Decision Support





# Atmosphere

# [ Atmospheric pressure and altitude ]

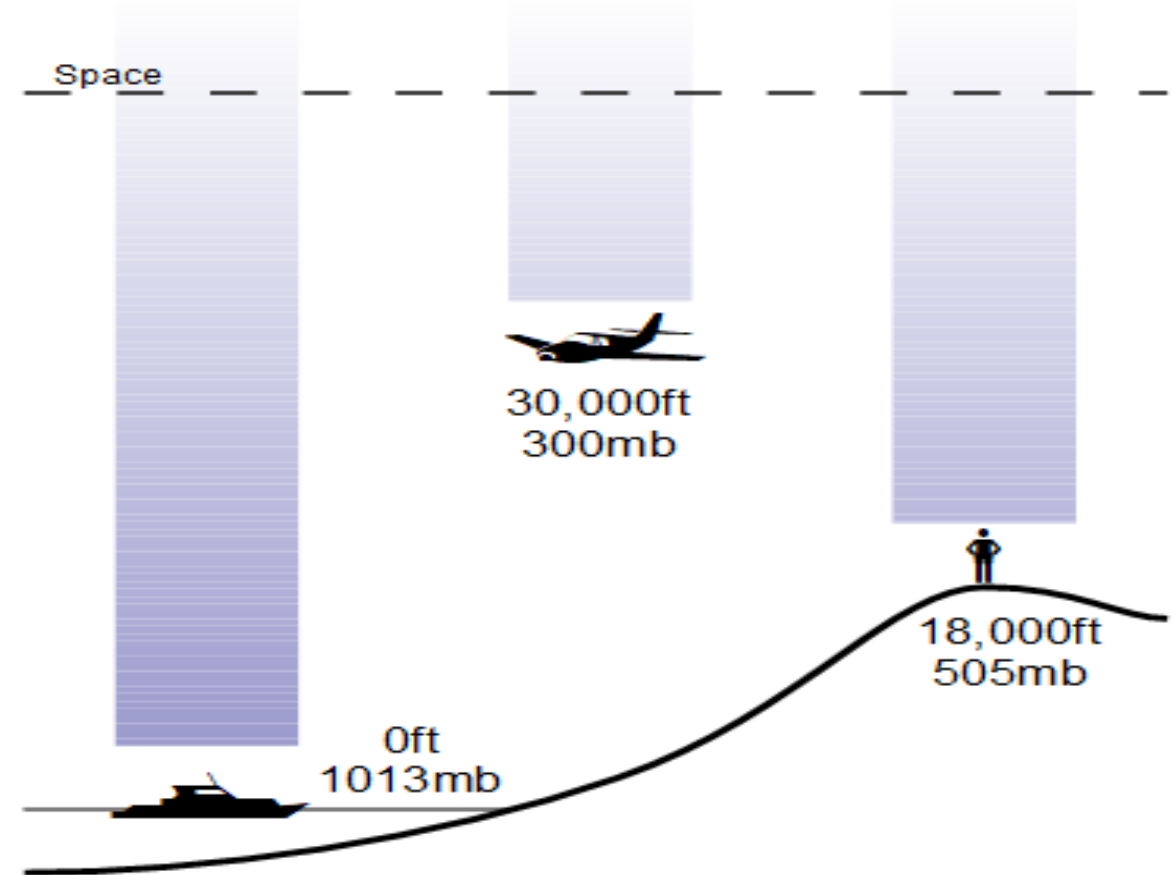
1 Atmospheric pressure is caused by the weight of the column of air above a given location.

At sea level the overlying column of air exerts a force equivalent to 10 tonnes per square metre.

2 The higher the altitude, the shorter the overlying column of air and hence the lower the weight of that column.

3 Therefore:  
**“Atmospheric pressure decreases with altitude.”**

At 18,000ft atmospheric pressure is approximately half that at sea level.



# Standard Atmosphere



## Barometric Pressure

Mercury Column

- 760 mm Hg
- 29.9213 in Hg

Air Pressure

- 1013.250 mb
- 14.696 psi

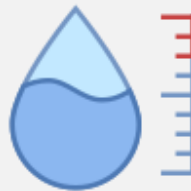


## Temperature

288.15 K

59 °F

15°C



## Humidity

0% Humidity

# Air Pressure



1013.25 mb = 14.69595 PSI



1mb = 0.01450377 PSI

# International Standard Atmosphere Air Density



**Pressure**  
101.325 kPa

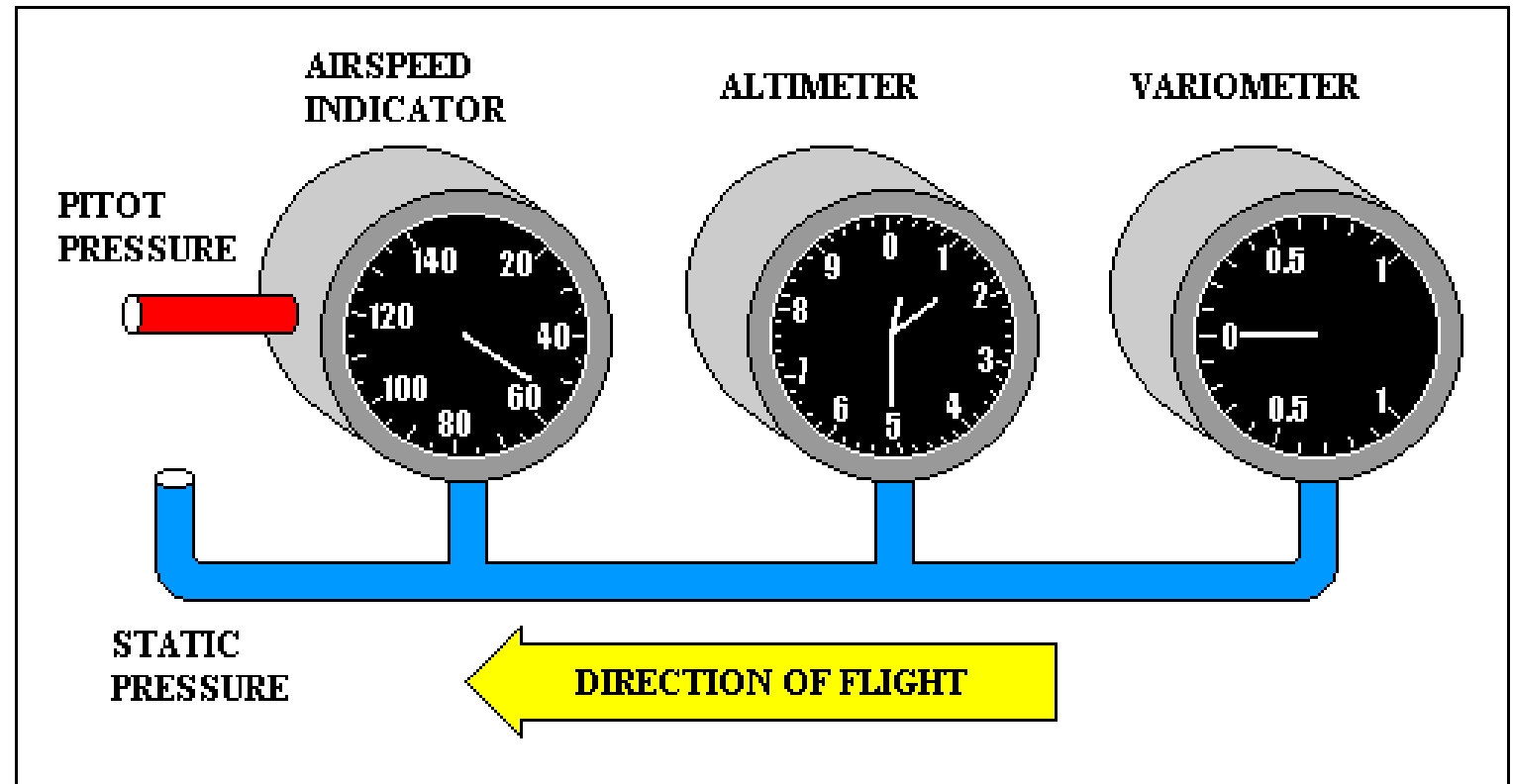


**Temperature**  
15°C



**Density**  
**1.225 kg/m<sup>3</sup>**  
0.001225 g/cm<sup>3</sup>  
(rho, ρ)  
0.0023769  
slug/(cu ft)  
0.0765 lb/(cu ft)

## Basic Air Data System





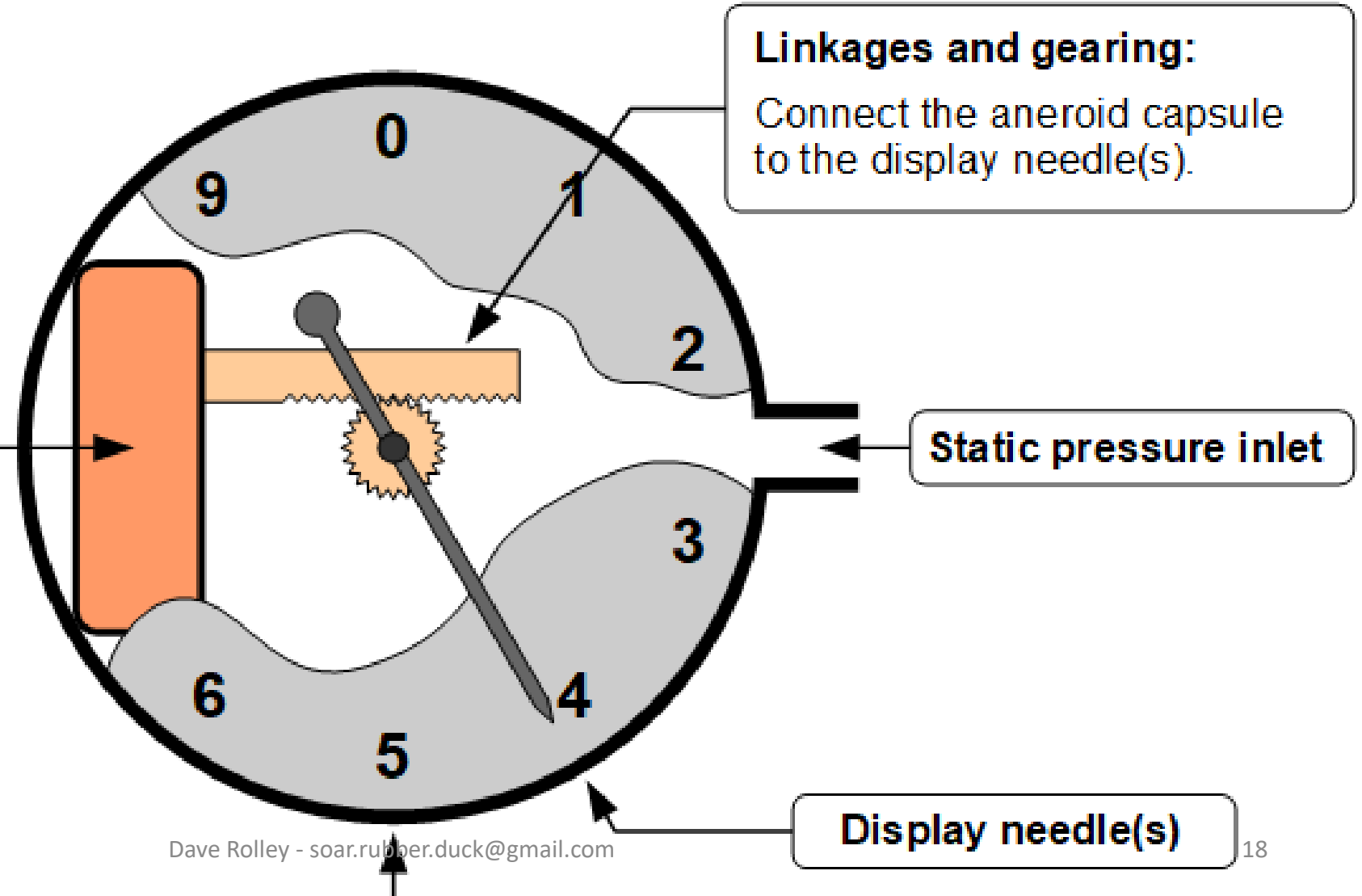
# Altimeter

# [ Altimeter anatomy ]

## Aneroid capsule:

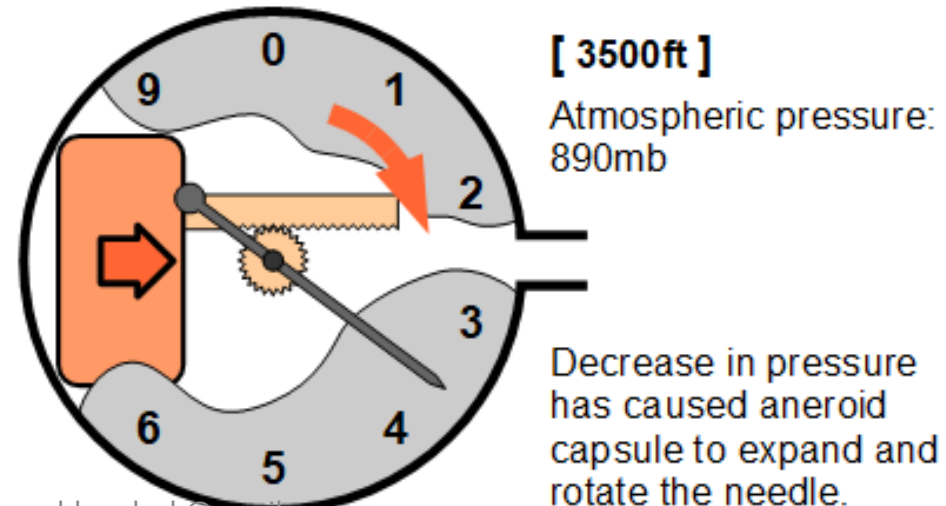
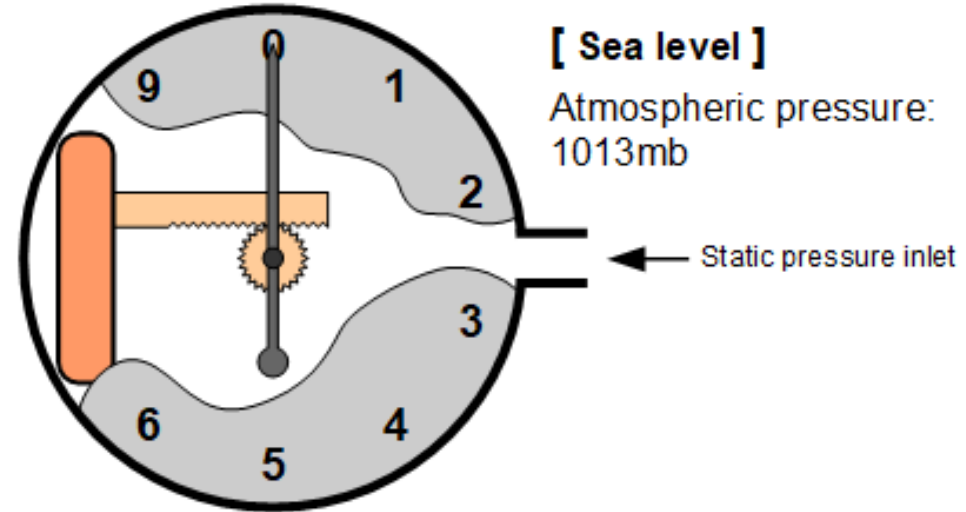
A sealed copper and beryllium alloy capsule from which the air has been removed.

The capsule is springy and designed to compress as the pressure around it increases and expand as it decreases.



# [ Altimeter operation ]

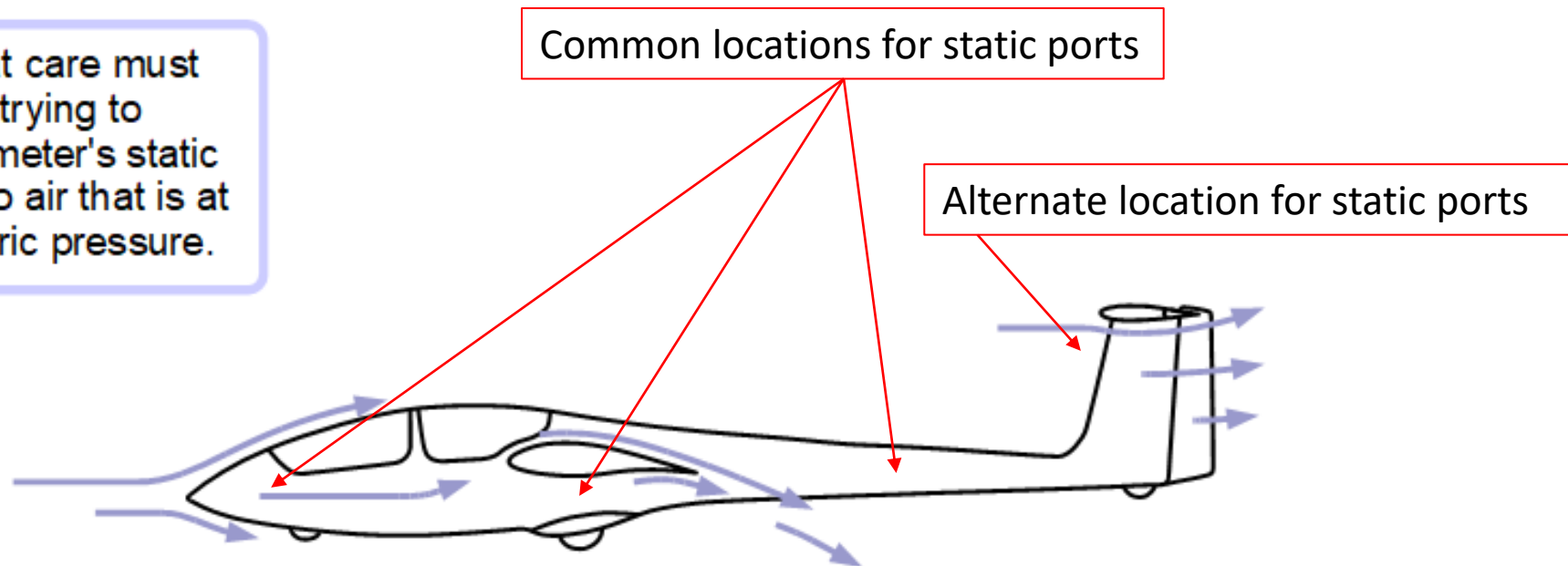
- 1** The altimeter's static pressure inlet must be exposed to air that is at local atmospheric pressure.
- 2** The pressure of the air inside the altimeter's casing will therefore equalise to local atmospheric pressure via the static pressure inlet.
- 3** Atmospheric pressure decreases with altitude.
- 4** As atmospheric pressure decreases the aneroid capsule expands, moving the linkages and hence rotating the display needle(s).



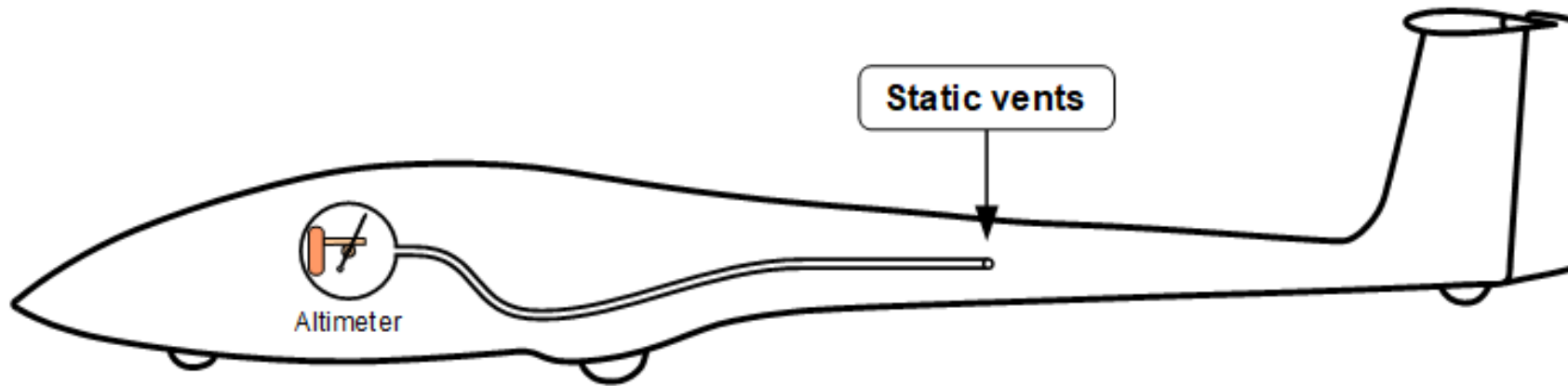
# [ Atmospheric pressure disturbances ]

1 An aircraft moving through the atmosphere changes the pressure of the air surrounding it. This is how wings generate lift. Even the air inside the cockpit will not quite be at local atmospheric pressure.

2 This means that care must be taken when trying to expose the altimeter's static pressure inlet to air that is at local atmospheric pressure.



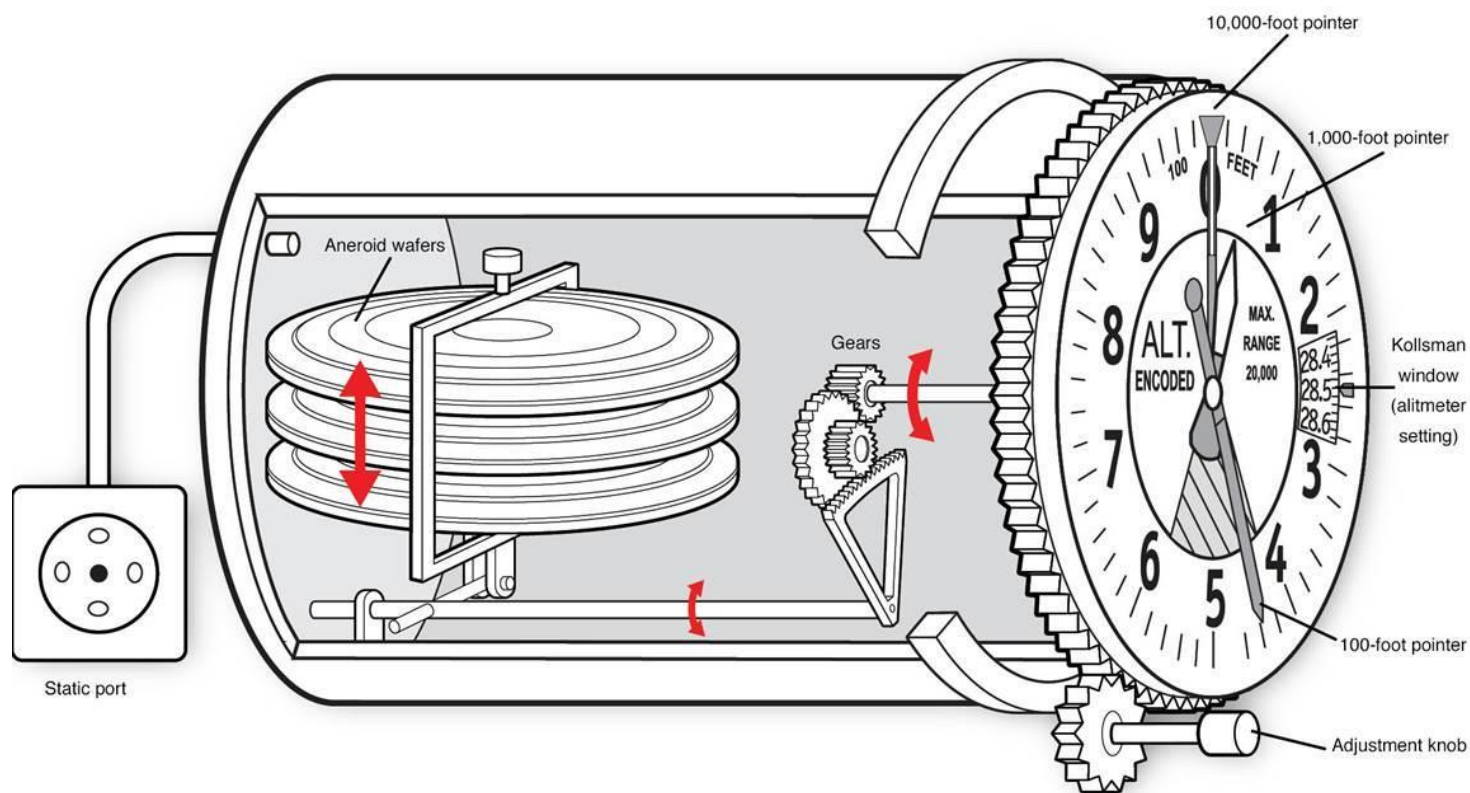
# [ Static vents and altimeter pipework ]



- 1 When designing a glider, the engineers will try to find a location on the fuselage where the passing airflow exerts a pressure on the aircraft's surface that is close to local atmospheric. They do this using a combination of their experience, calculations and test results. On a glider, such a point is often located about half way down the tail boom.

- 2 A pair of “**static vent holes**” are drilled into the fuselage at this location and connected to the altimeter's static pressure inlet via a flexible plastic tube. This allows the air in the altimeter's casing to equalise with local atmospheric.

# Barometric Pressure Adjustment



- Previous slides showed an altimeter
- When an adjustment for local barometric pressure is added the instrument becomes a sensitive altimeter
- Barometric pressure value used to adjust an altimeter is the “sea level adjusted” value
- Local barometric pressure reported as if the reading had been taken at sea level



## 3-Pointer Altimeter

- Long thin pointer is in tens of thousands of feet
- Short length pointer is in thousands of feet
- Medium length pointer is in hundreds of feet
- Window on right side displays reference atmospheric pressure, adjusted by knob on bottom left
- Altimeter is reading 10,180 feet MSL with a barometric pressure setting of 29.92 inHg
- Stripes at the bottom are fully concealed at 15,000 feet and above and fully visible at 10,000 feet and below. At 10,180 feet partially hidden.

# Altimeter Demonstration

1

Water Manometer

2

Suction applied to  
static system

3

Apply gently

4

Clamp & hold for 5  
minutes, change  
indicates a leak

5

Release gently

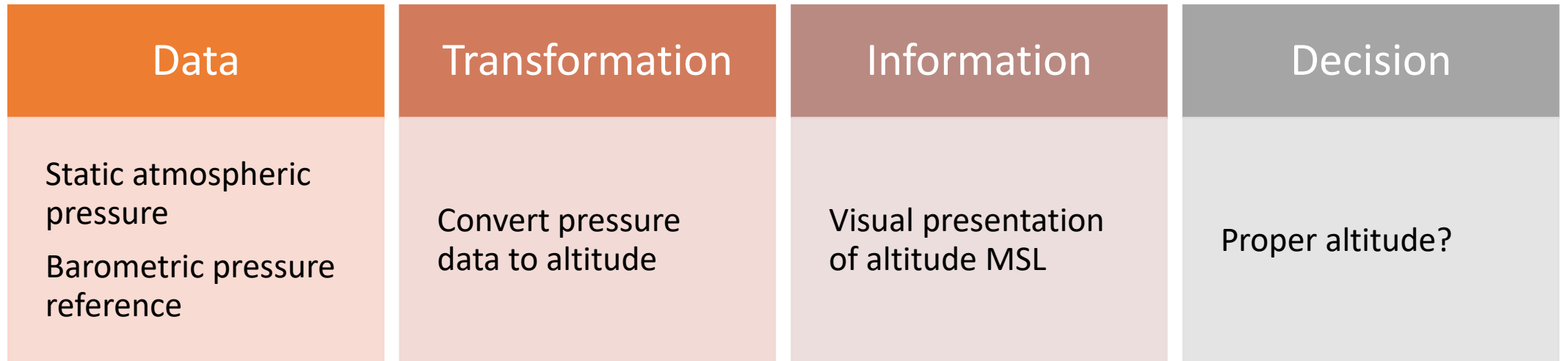
# Water Manometer – Static Configuration



# Static System Test



# Altimeter Decision Aid



# Airspeed Indicator

# Airspeeds

Indicated Airspeed: Speed shown on the airspeed indicator.

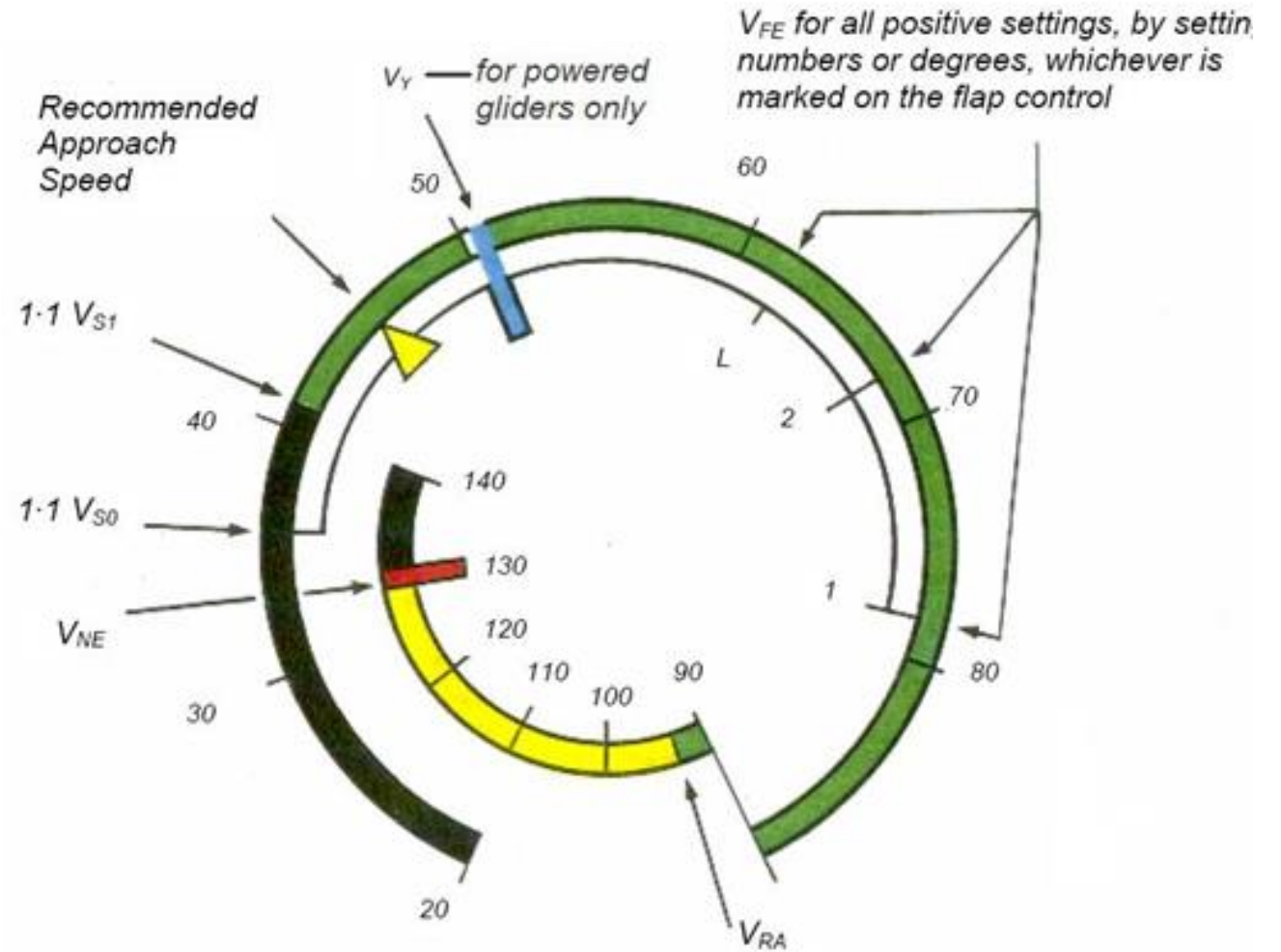
Calibrated Airspeed: Indicated Airspeed corrected for position installation error.

Equivalent Airspeed: Calibrated Airspeed corrected for compressibility.

True Airspeed: Equivalent Airspeed corrected for temperature and pressure altitude.

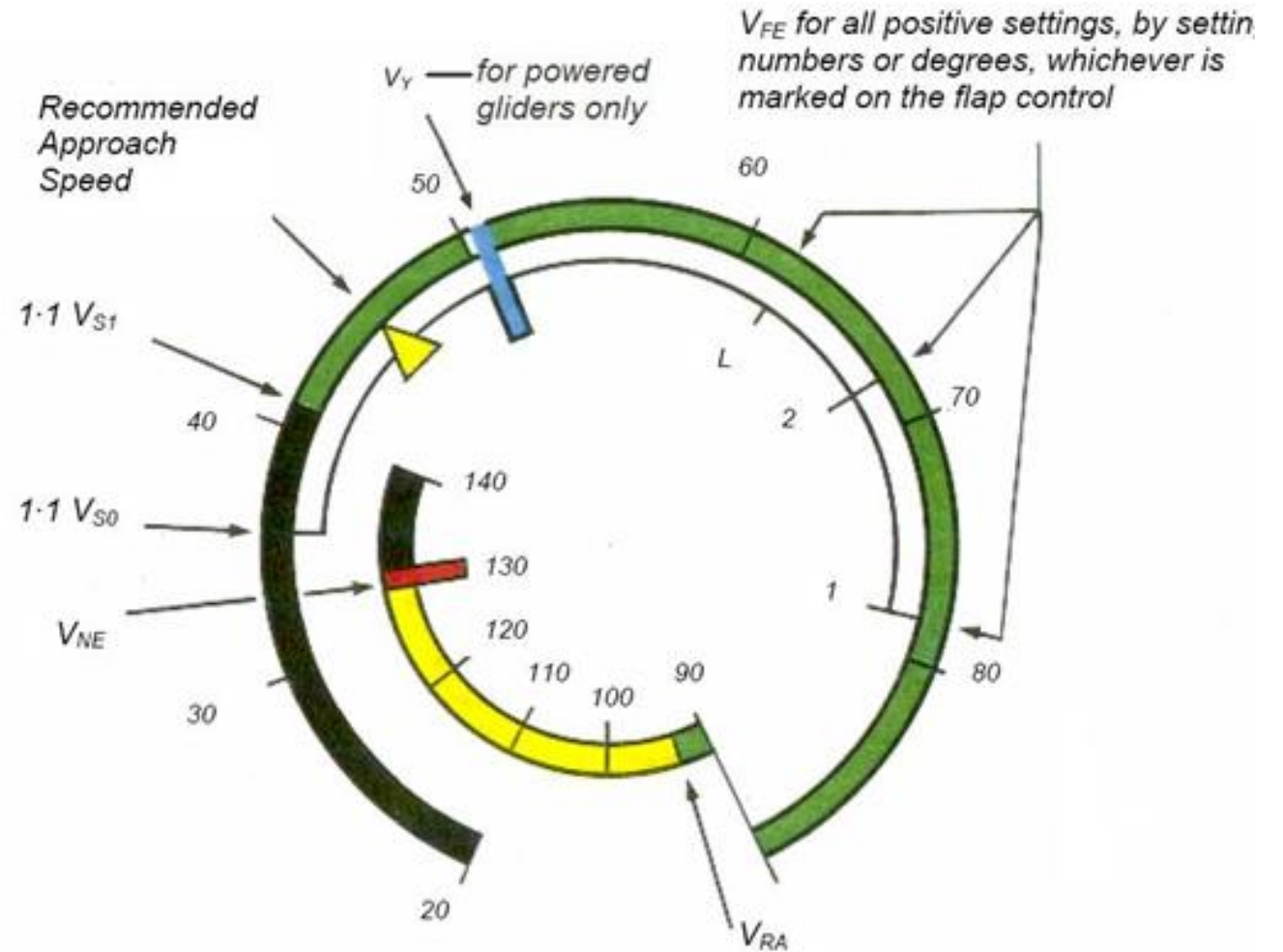
# Airspeed Indicator (ASI)

- Safe operation of the aircraft
- Example ASI:
  - 1 ½ turn instrument
  - 0 at the overlap
  - Non-linear scale
  - Knots
- Example EASA CS-22 markings
  - Bottom of White Arc is  $1.1 V_{S0}$
  - Bottom of Green Arc is  $1.1 V_{S1}$
- USA markings:
  - Bottom of White Arc is  $V_{S0}$
  - Bottom of Green Arc is  $V_{S1}$
- Yellow Triangle
  - Basis for approach speed
  - Not recommended pattern speed



# Airspeed Indicator Markings

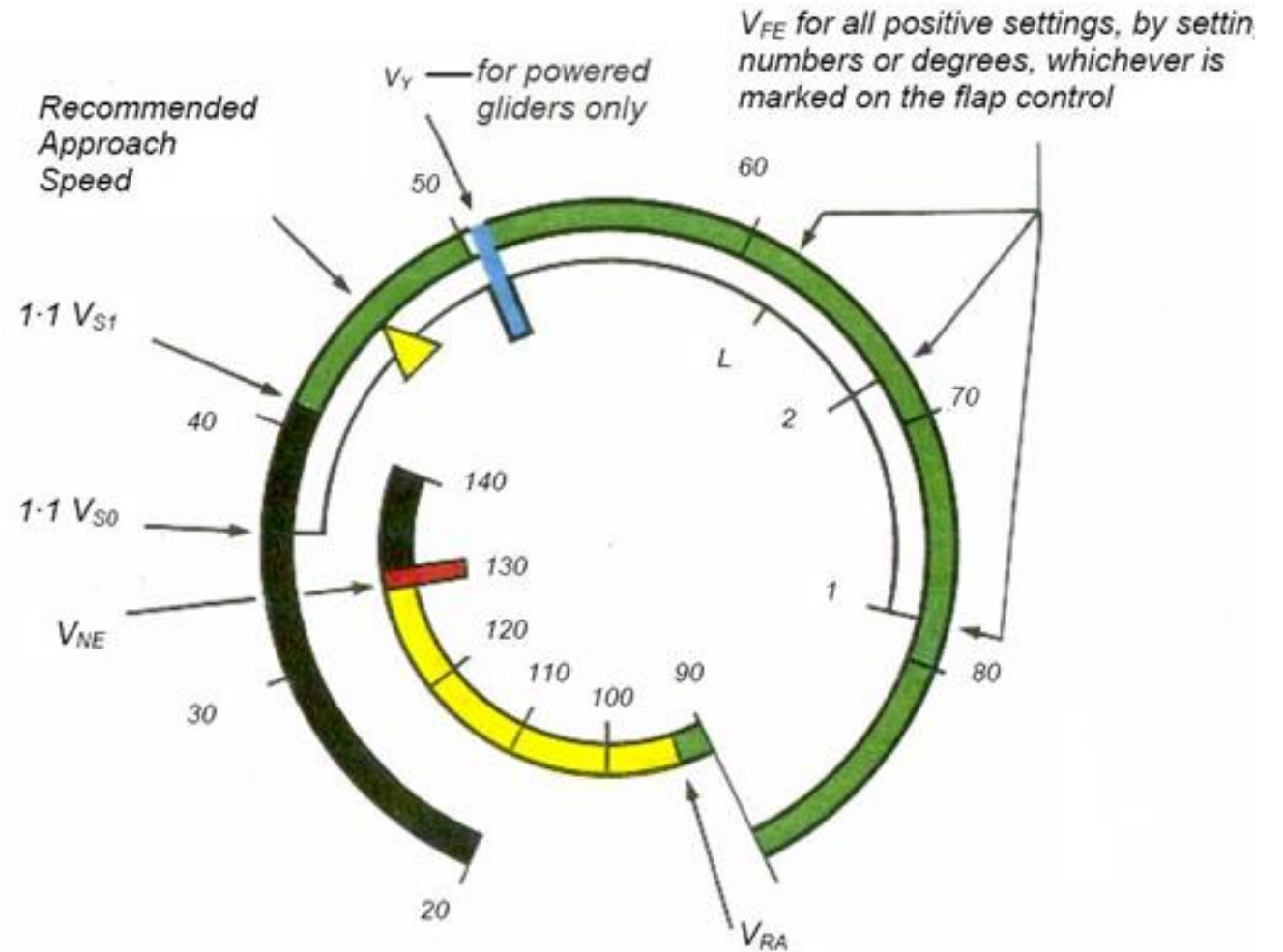
- White arc—flap operating range
  - Bottom —  $1.1 V_{S0}$  wing flaps and landing gear in the landing position
  - Top — maximum positive flaps extended speed.
- Green arc – normal operations
  - Bottom —  $1.1 V_{S1}$  Maximum weight, neutral wing flaps, and landing gear retracted
  - Yellow triangle marks minimum approach speed in calm conditions
  - Top — allowable rough-air speed
- Yellow arc — caution range
  - Smooth air only
- Red line — never-exceed speed
  - Maximum speed in smooth air



# Airspeed Indicator – 1

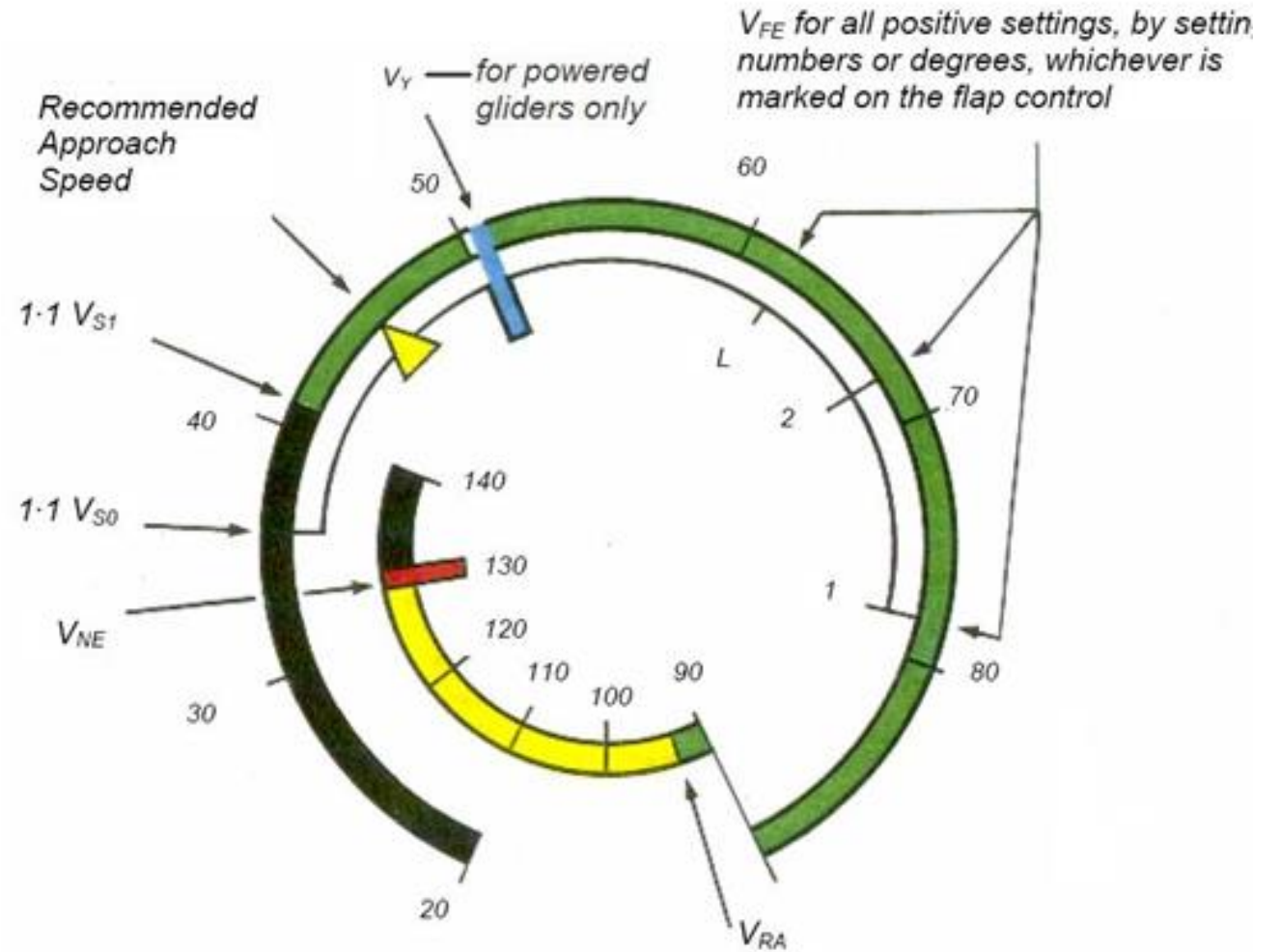
## “V” Speeds

- 1.1  $V_{s0}$ : Bottom of white arc.
  - Stall speed in landing configuration.
- 1.1  $V_{s1}$ : Bottom of green arc.
  - The stalling speed or the maximum steady flight speed obtained in a specific configuration (Usually "clean").
- $V_Y$ : Best rate of climb speed
  - Powered gliders only
- $V_{FE}$ : Top of white arc.
  - Maximum flap extended speed
  - Different maximum speeds may be specified for partial flap extension



# Airspeed Indicator – 2 “V” Speeds

- Green & Yellow arcs
  - $V_{RA}$  : CS-22: Rough air speed
  - $V_{NO}$  : FAA: Maximum structural cruising speed
- $V_{NE}$ : Red line & Yellow arc
  - Never Exceed Speed (VNE)



Maximum  
Permitted  
Speed  
Duo Discus

| Altitude |        | VNE (IAS) |       |
|----------|--------|-----------|-------|
| Meters   | Feet   | KPH       | Knots |
| 0-2000   | 0-6562 | 262.8     | 142   |
| 3000     | 9843   | 253       | 137   |
| 4000     | 13123  | 241       | 130   |
| 5000     | 16404  | 228       | 123   |
| 6000     | 19685  | 215       | 116   |
| 7000     | 22966  | 204       | 110   |
| 8000     | 26247  | 192       | 104   |
| 9000     | 29528  | 180       | 97    |
| 10,000   | 32808  | 170       | 92    |

Maximum  
Permitted  
Speed  
Ventus bT

| Altitude |          | VNE (IAS) |       |
|----------|----------|-----------|-------|
| Meters   | Feet     | KPH       | Knots |
| 0-5,000  | 0-16,404 | 250       | 135   |
| 6,000    | 19,685   | 249       | 134   |
| 7,000    | 22,966   | 235       | 127   |
| 8,000    | 26,247   | 222       | 120   |
| 9,000    | 29,528   | 209       | 113   |
| 10,000   | 32,808   | 197       | 122   |
| 12,000   | 39,360   | 171       | 106   |

# CS 22.1505 Air-speed limitations

## Text

- a) All flight speeds must be stated in terms of air-speed indicator readings (IAS).  
(See AMC 22.1505(a))
- b) The never exceed speed,  $V_{NE}$ , must not exceed 0.90 times the maximum speed demonstrated in flight tests ( $V_{DF}$ ).
- c)  $V_{DF}$  must not exceed the design maximum speed,  $V_D$  and must not be less than 0.9 times the design maximum speed according to CS 22.335(f).

## Relationship

- $V_{ne} \leq 0.9 * V_{df}$ 
  - Provides a 10% margin
- $V_{df} \leq V_d$  and
- $V_{df} \geq 0.9 * V_d$ 
  - Generally less than a 10% margin

# CS 22.629 Flutter

- a) The sailplane must be free from flutter, aerofoil divergence, and control reversal in each configuration and at each appropriate speed up to at least  $V_D$ . Sufficient damping must be available at any appropriate speed so that aeroelastic vibration dies away rapidly.
- b) Compliance with sub-paragraph (a) must be shown by:  
(compliance methods not shown)

# Flutter

- Flutter is not ancient history
- Causes:
  - Design and/or construction
    - Should be discovered and eliminated by the engineering and certification process
  - Damage to the aircraft
    - May not be apparent until the airframe flutters
    - Watch Gordon Macdonald's video on a damaged Libelle
      - <https://www.youtube.com/watch?v=1R5k0FC2a-E>
  - Maintenance issues
    - Inspections that don't find airframe damage
    - Improperly maintained control system components

# Airframe - Flutter



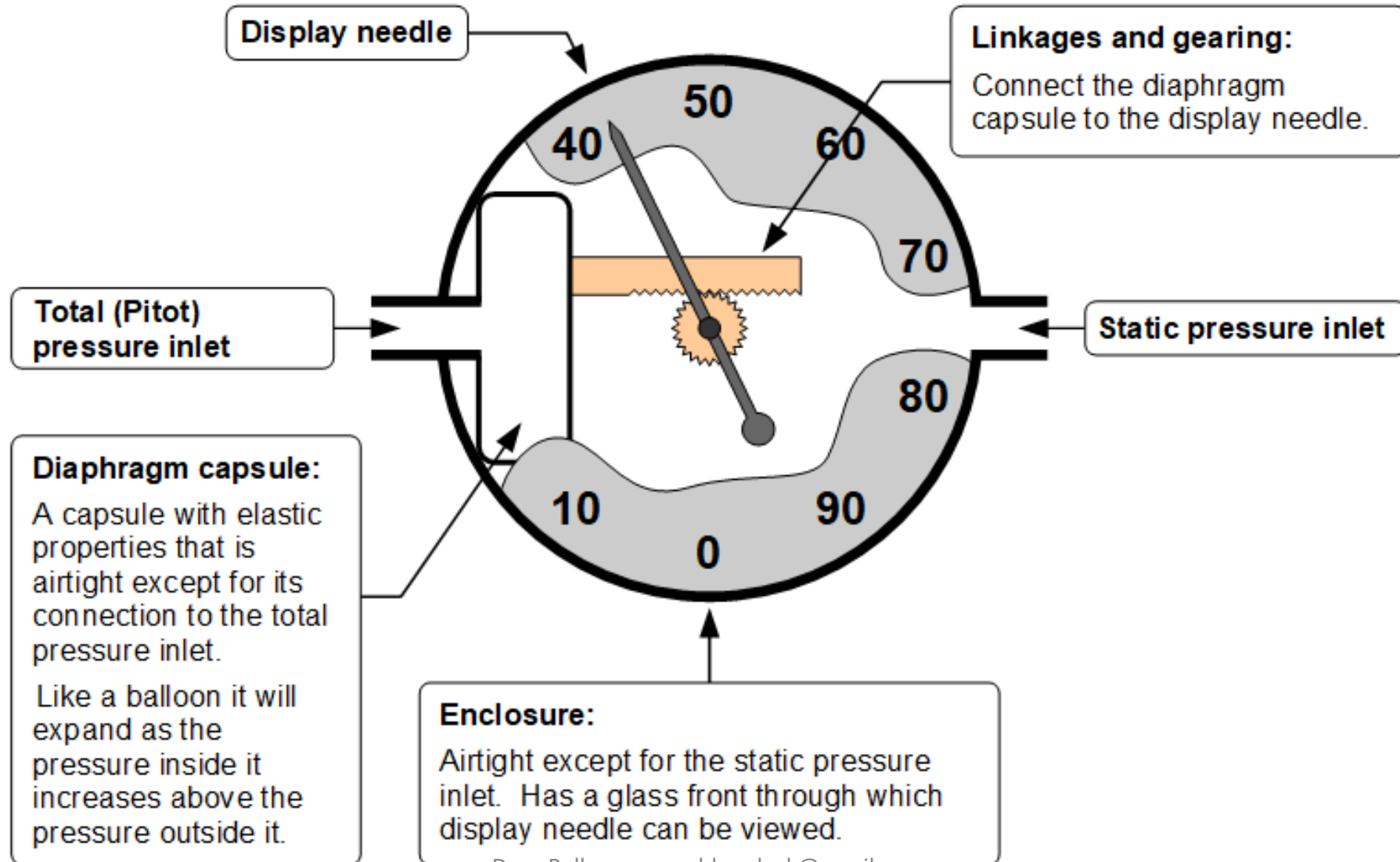
# Airframe - Testing



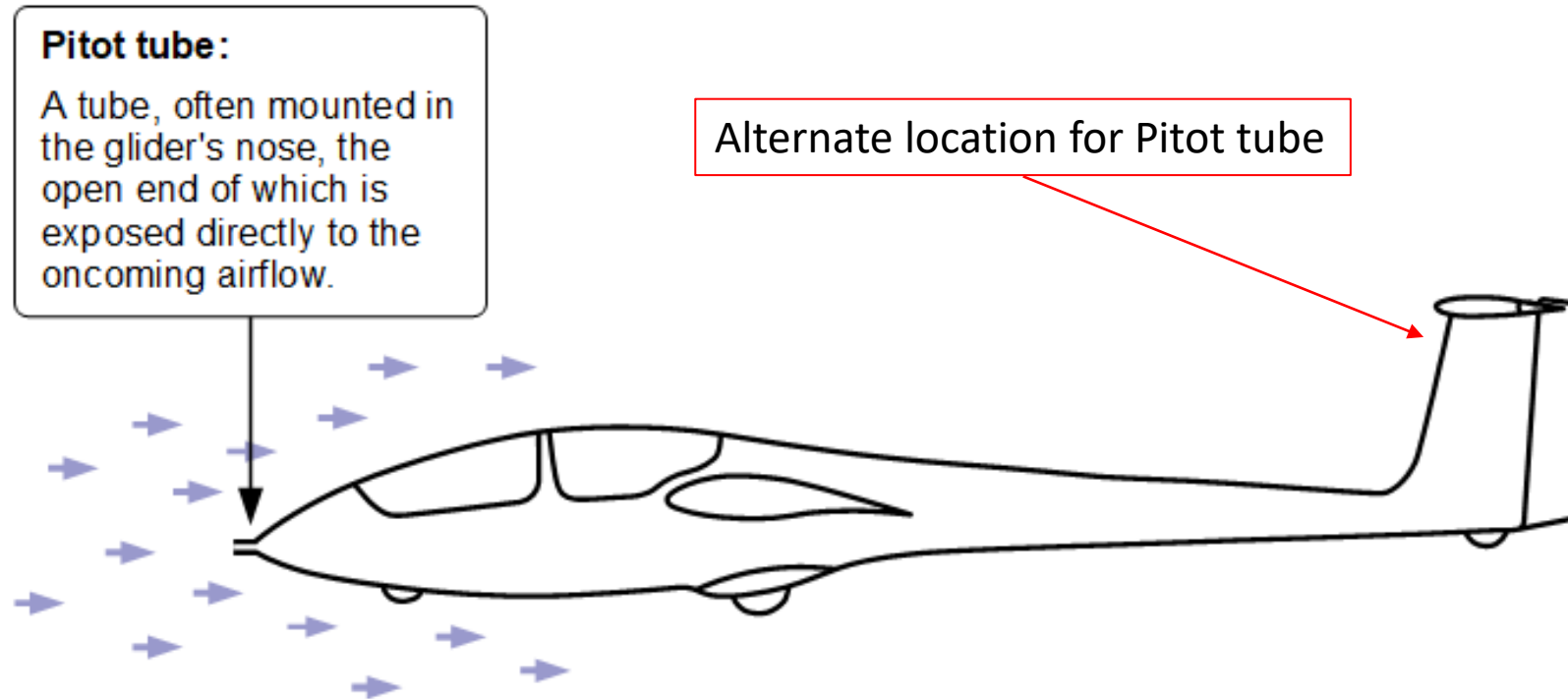
## Perlan 2 Flutter Exciters



# [ ASI anatomy ]

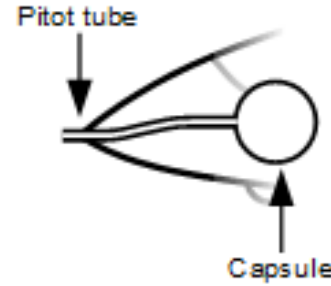


# [ The Pitot tube ]

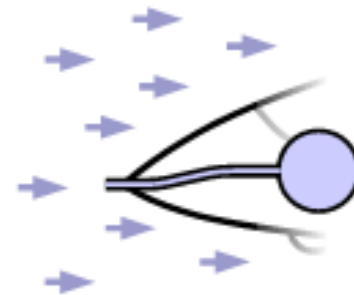


# [ Pitot tube characteristics ]

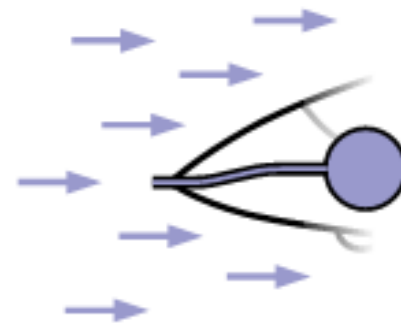
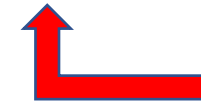
- 1 When a glider is in flight, the oncoming air will try to flow into the open end of the Pitot tube.
- 2 Connecting a capsule to the back end of the Pitot tube will mean that the air flowing in has nowhere to go. The pressure in the capsule will therefore rise until it is high enough to prevent any further air from entering.
- 3 Increasing the airspeed of the glider will cause the force exerted by the oncoming air to rise. More air will therefore be able to push its way into the capsule and hence the pressure within the capsule will increase.
- 4 **The pressure inside the capsule will therefore increase as airspeed increases.**



**[ Speed: 0kts ]**  
No oncoming airflow.  
Capsule pressure: 1013mb  
E.g. sea level atmospheric



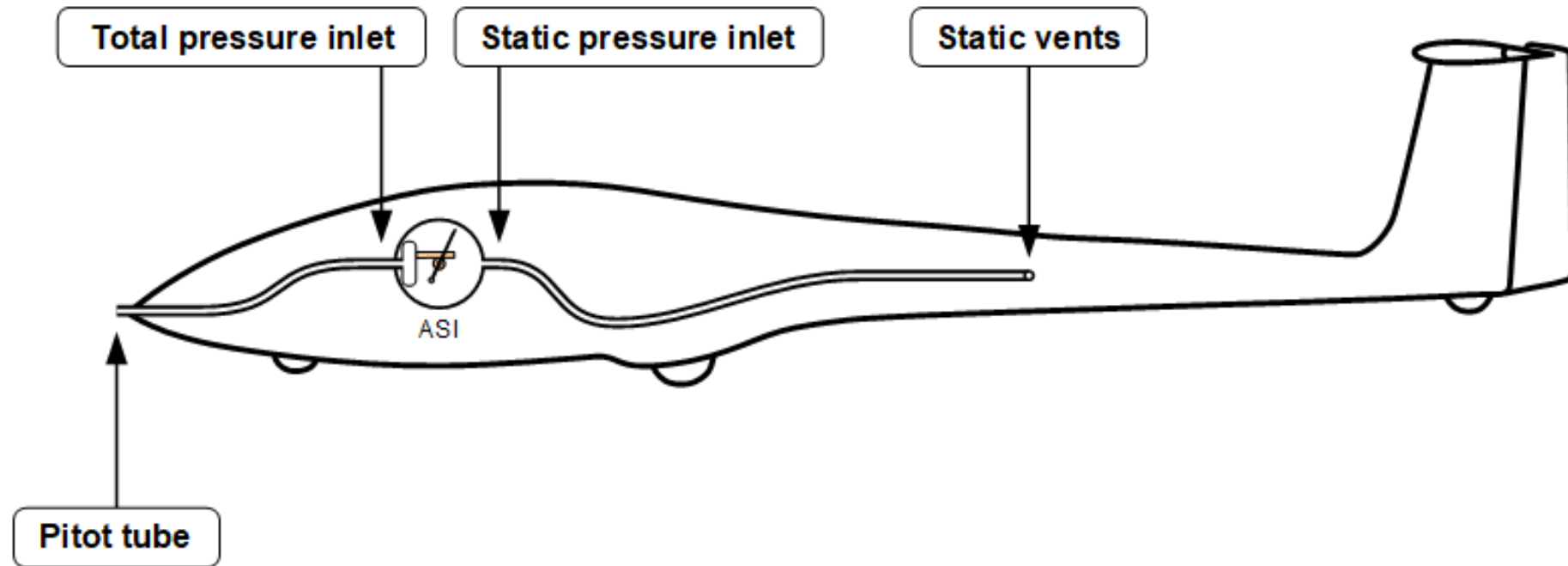
**[ Speed: 30kts ]**  
Capsule pressure: 1015mb  
Sea level atmospheric  
+ 2mb due to oncoming airflow



**[ Speed: 60kts ]**  
Capsule pressure: 1019mb  
Sea level atmospheric  
+ 6mb due to oncoming airflow

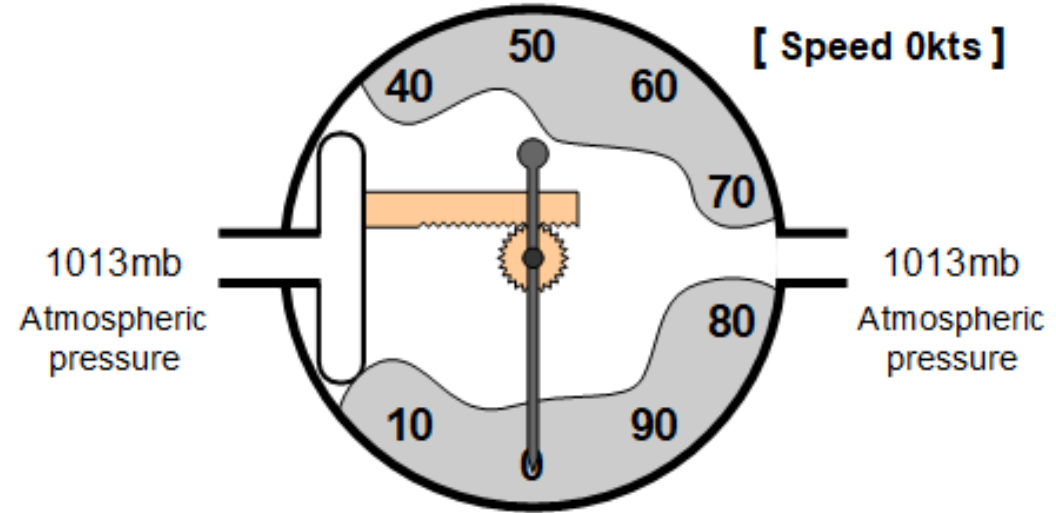


# [ ASI pipework ]

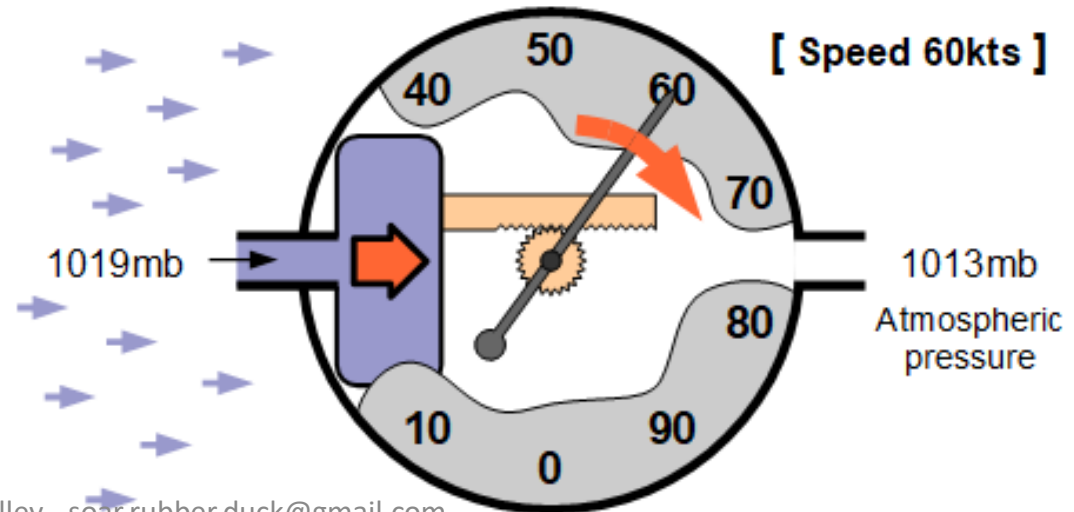


# [ ASI operation ]

**1** In a stationary aircraft, the air throughout the ASI will have equalised with local atmospheric pressure. The diaphragm capsule will therefore be collapsed like a deflated balloon and the needle will be displaying zero.



**2** As airspeed increases, the pressure inside the diaphragm capsule will rise above local atmospheric due to the force exerted down the Pitot tube by the oncoming airflow. The capsule will therefore inflate like a balloon, moving the linkages and rotating the needle.



# ASI Demonstration

1

Water Manometer

2

Pressure applied  
to pitot system

3

Apply gently

4

Clamp & hold for 5  
minutes, change  
indicates a leak

5

Release gently

# Water Manometer – Pitot Configuration



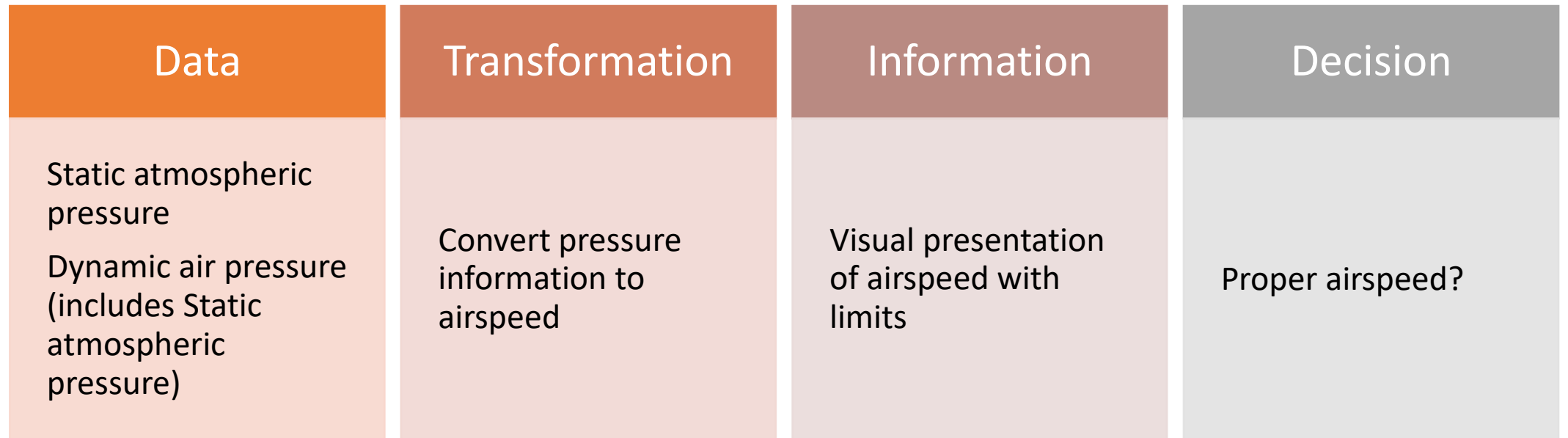


## Pitot System Test

# Pitot / Static Check Reference

- **AC 43.13-1B**
  - CHAPTER 12. AIRCRAFT AVIONICS SYSTEMS
    - SECTION 4. PITOT/STATIC SYSTEMS
      - 12-57. SYSTEM LEAK TEST
      - 12-58. STATIC SYSTEM TESTS
      - 12-59. TEST PITOT SYSTEM
      - 12-60. MAINTENANCE PRECAUTIONS
      - 12-61. REPLACING LINES

# Airspeed Decision Aid



# Important!

Because of how they are used in the National Airspace System, primary Altitude and Airspeed indications must derive from approved pitot and static sources



# Variometer

# Variometers

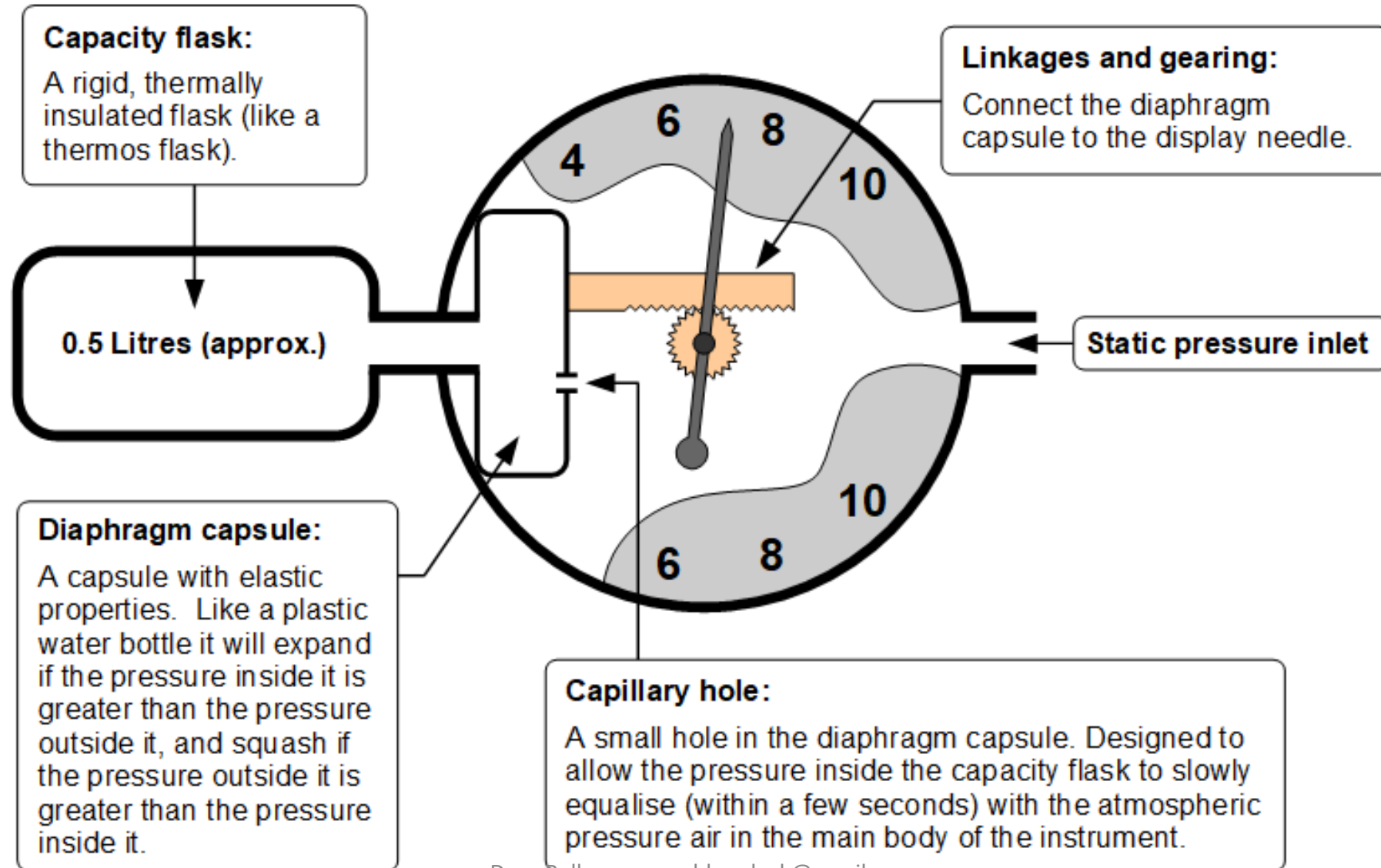
Uncompensated Variometer

Total Energy (TE) Compensated Variometer

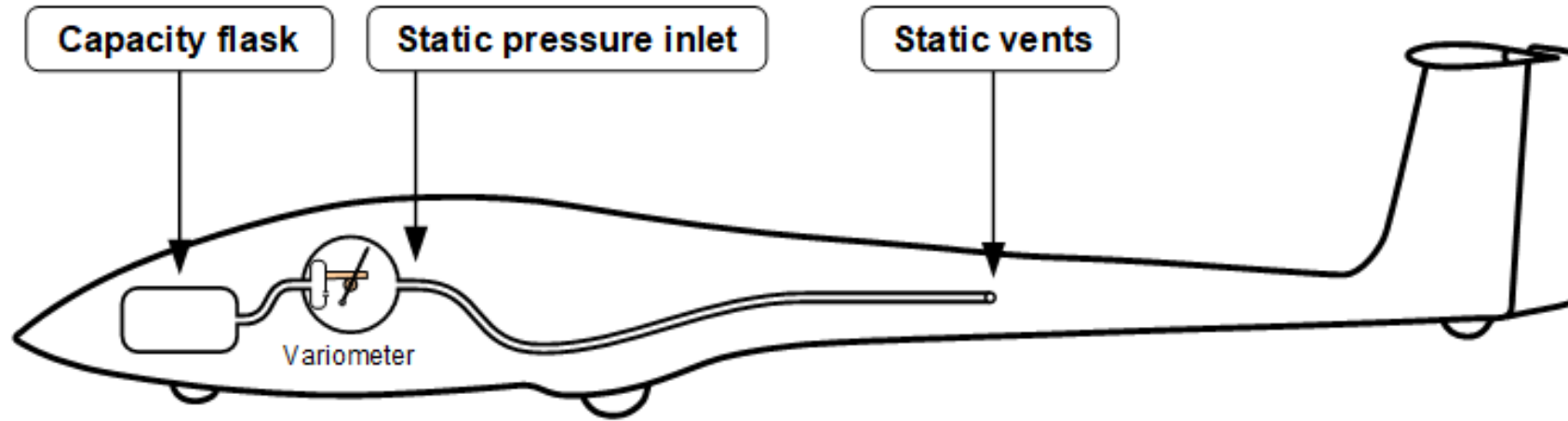
Netto (or Airmass) Variometer

Relative Netto (or Super Netto) Variometer

# [ Diaphragm variometer anatomy ]



# [ Variometer pipework : uncompensated ]



1 A variometer that is connected to the pipework shown above is termed as being **uncompensated**.

2 This style of pipework was used in the early days of gliding and is the pipework used in powered aircraft today.



Because of its relative simplicity we will first discuss the operation of the uncompensated variometer before moving on to the total energy compensated system's used in modern gliders today...

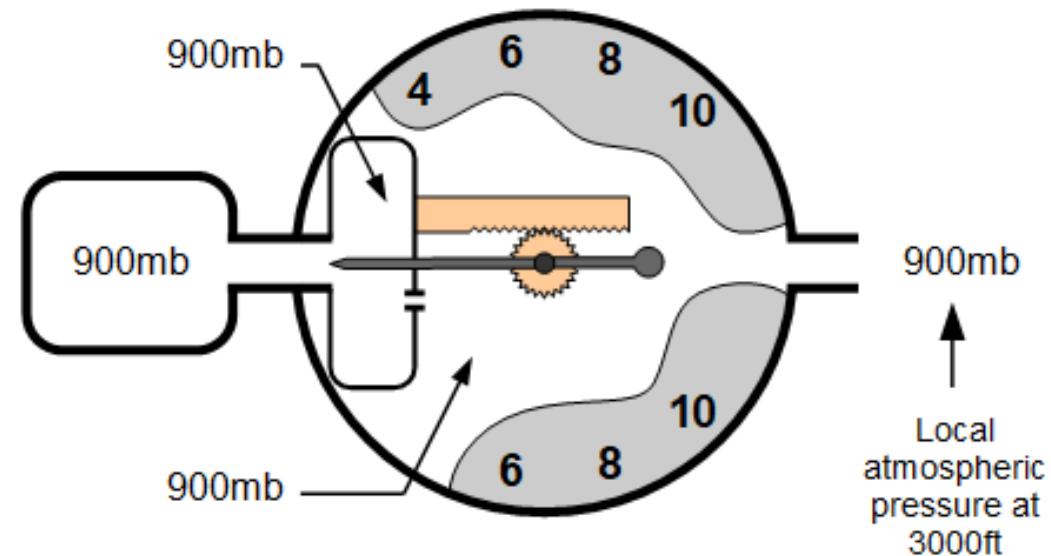
# [ Uncompensated variometer : level flight ]

1 In level flight, the pressures throughout the variometer and capacity flask will equalize to the local atmospheric pressure at the flight altitude via the static vents.

2 Hence there will be no difference between the pressure inside and the pressure outside the diaphragm capsule.

3 The capsule will therefore neither be squashed nor inflated and the display needle will point to zero.

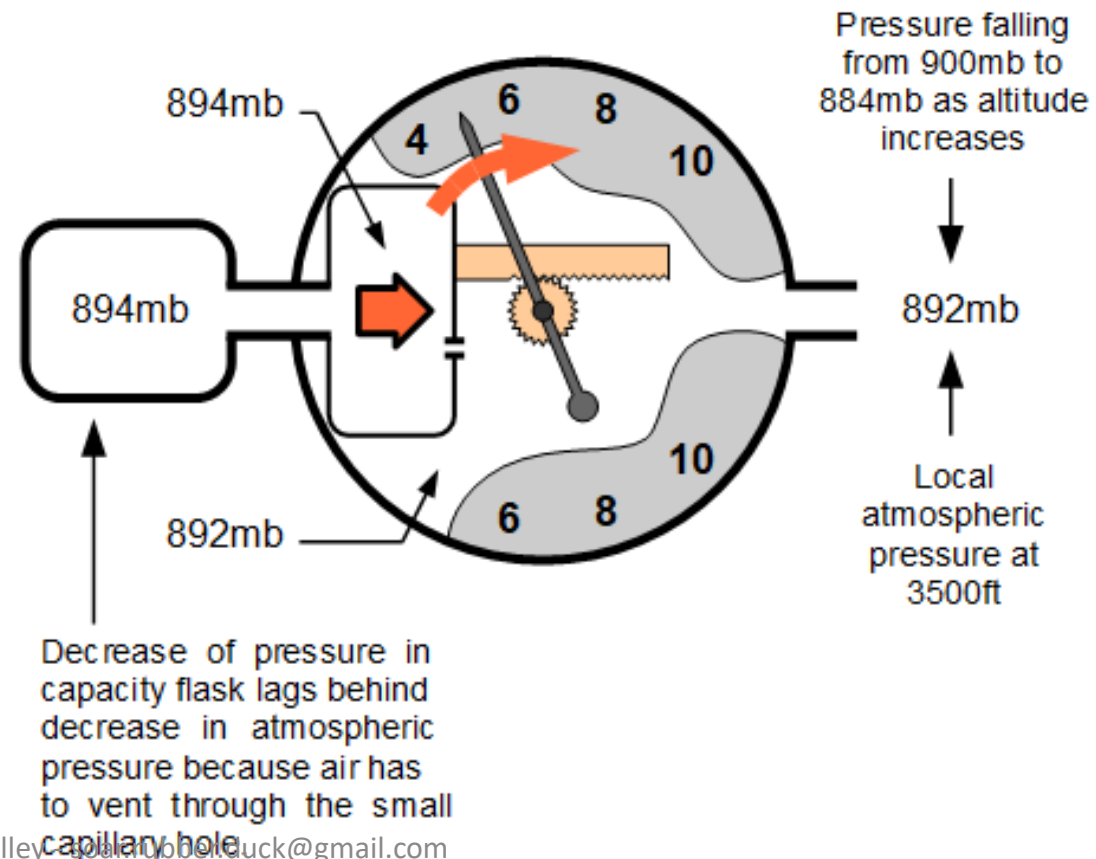
[ Altitude 3000ft – level flight ]



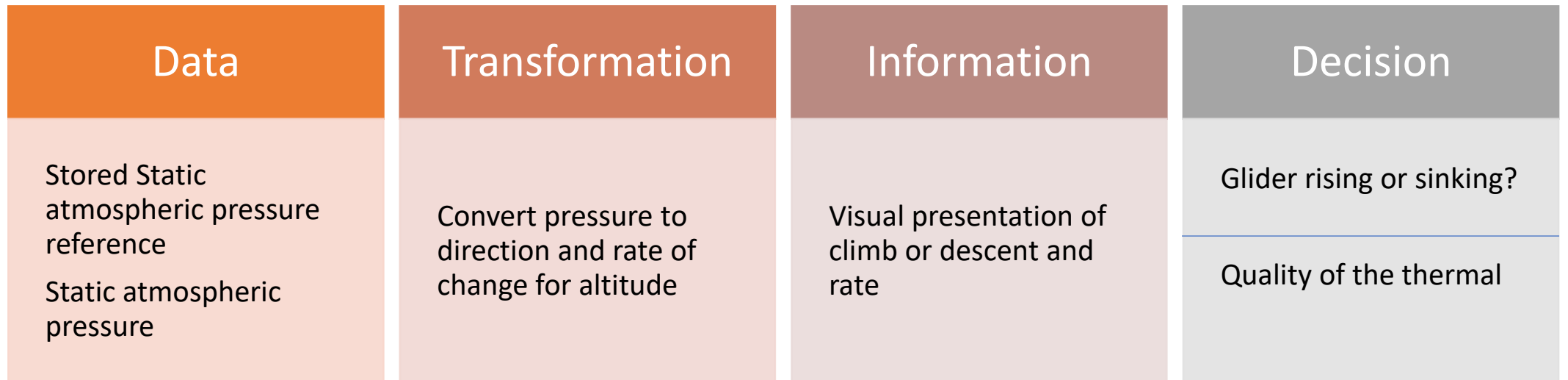
# [ Uncompensated variometer : height gain ]

- 1 As a glider climbs the atmospheric pressure around the glider will fall.
- 2 The pressure inside the variometer's case will match this pressure drop almost instantaneously.
- 3 However the pressure of the air inside the capacity flask will take several seconds to "catch up" because it has to vent through the small capillary hole.
- 4 Therefore during a climb, the pressure inside the capacity flask and diaphragm capsule will be slightly higher than the pressure inside the variometer's case. The diaphragm capsule will therefore expand, rotating the display needle to show an increasing altitude.

[ Altitude 3500ft during climb from 3000ft to 4000ft ]



# Uncompensated Variometer Decision Aid



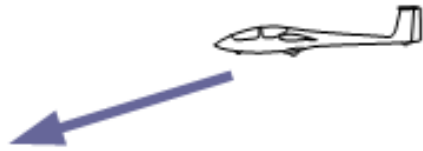
# Total Energy Compensated Variometer

Removes / reduces effect of pilot induced  
“stick” thermals

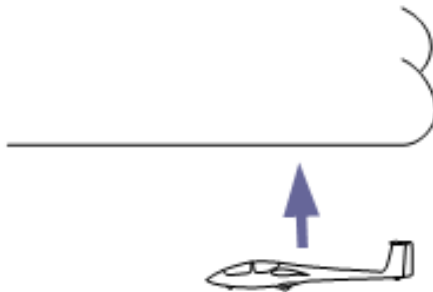
# [ Uncompensated vario characteristics ]

➡ An uncompensated variometer will display changes in altitude generated by...

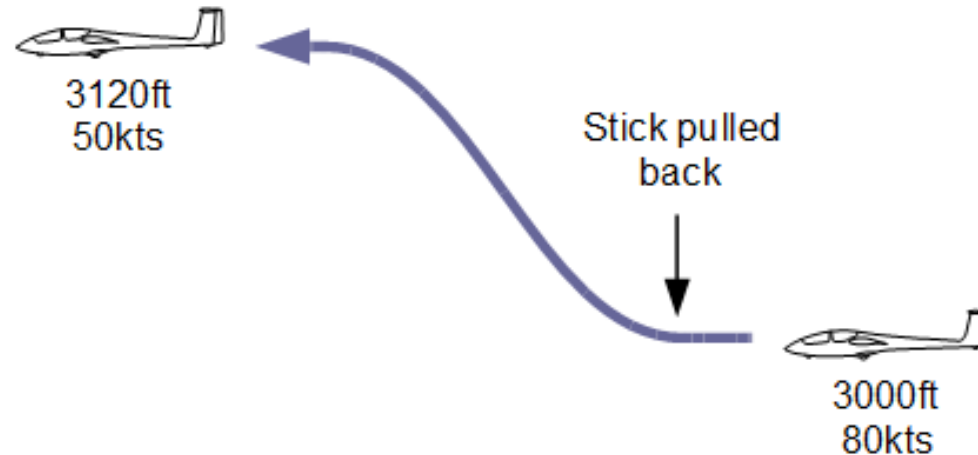
- 1** The natural sink rate of the glider.



- 2** External up or down drafts that cause the glider to gain or lose altitude (E.g. thermals).



- 3** Changes in altitude caused by the glider slowing down or speeding up. (E.g. if you pull back on the stick the glider will slow down and gain altitude as speed is converted into height)



As a glider pilot you don't actually want a variometer to display this type of altitude change, because every time you slow down you will think you are in a strong thermal.

# Energy

## Potential

Energy possessed by a body by virtue of its position relative to others, stresses within itself, electric charge, and other factors.

## Kinetic

Energy which a body possesses by virtue of being in motion

## Total

Sum of all different types of energies a body can have.

# Glider Energy

Potential

Proportional to  
Altitude

Kinetic

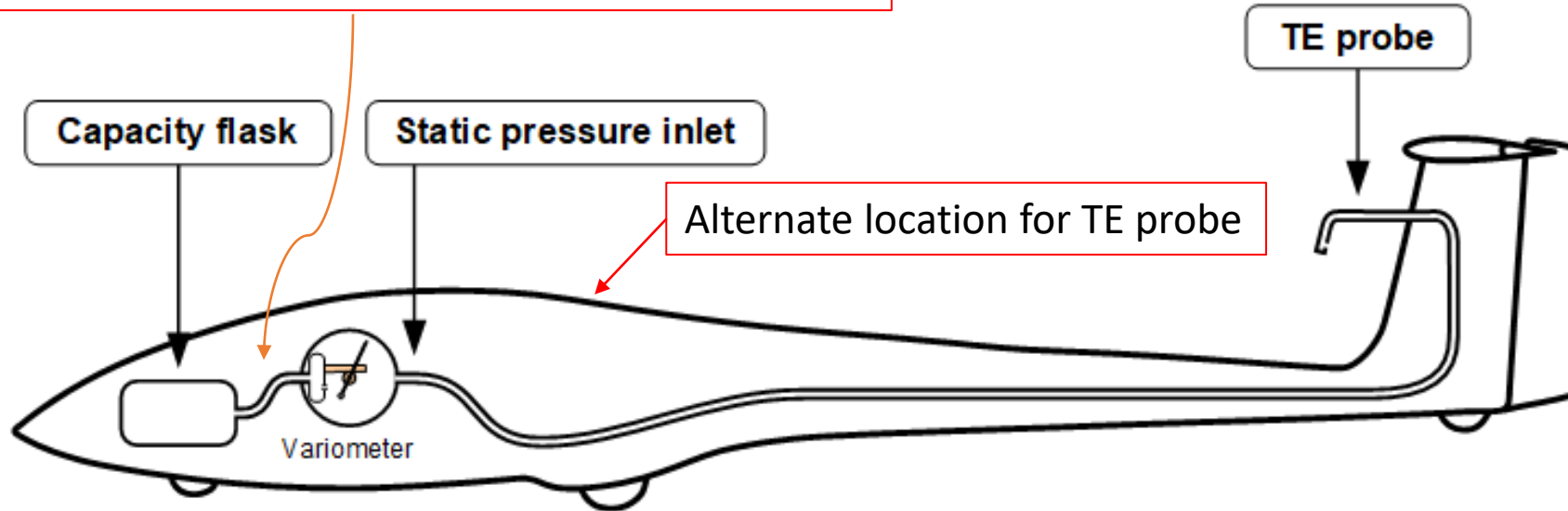
Proportional to the square  
of  
Airspeed

Total

Altitude  
combined with  
Airspeed

# [ Variometer pipework : TE compensated ]

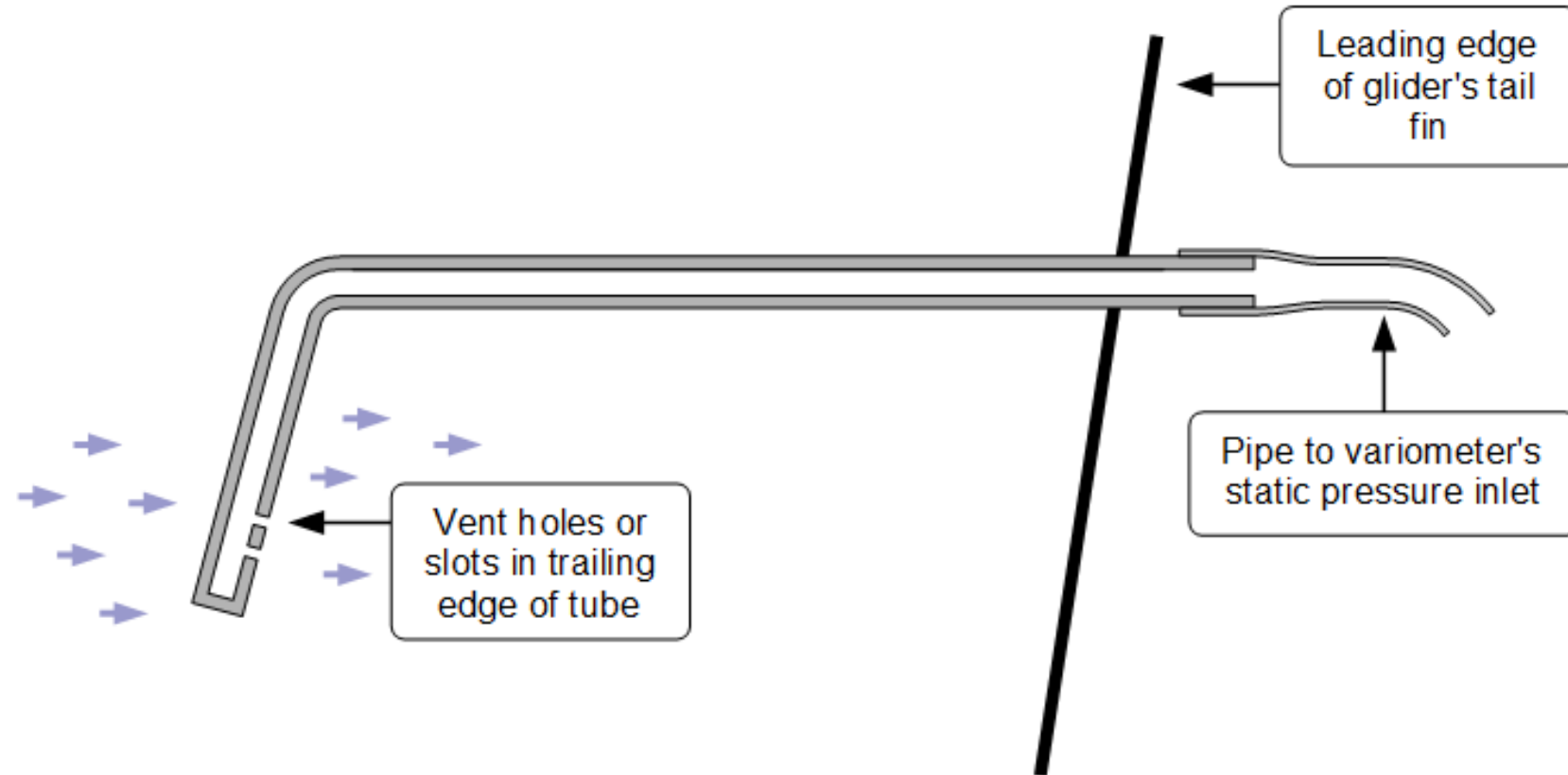
Alternate approach: Diaphragms and additional plumbing



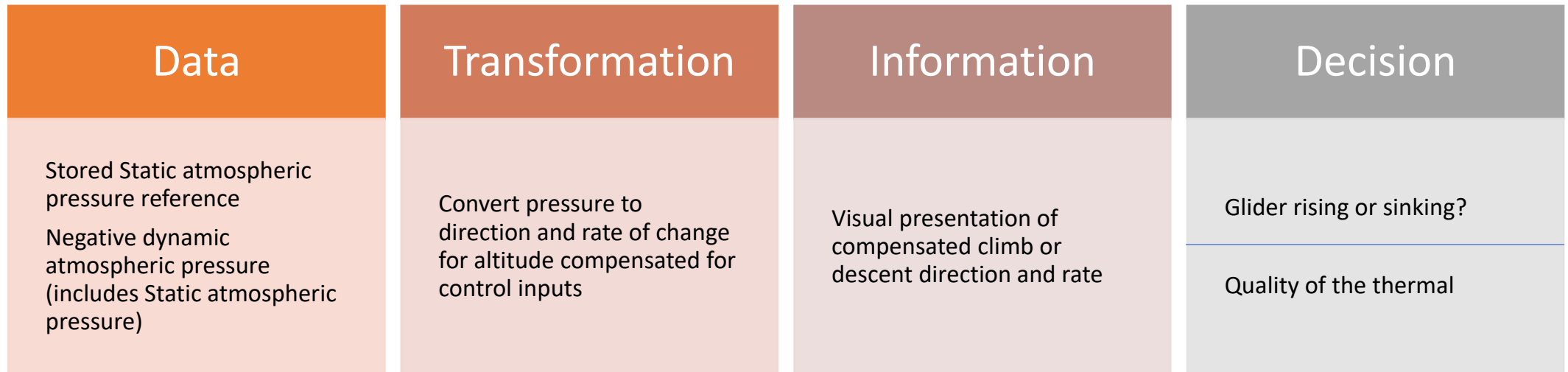
1 A variometer connected to a Total Energy (TE) probe rather than the static vents will not display altitude changes that are caused by changes in the glider's speed.

2 The variometer will still display altitude changes caused by the glider's natural sink rate and external up and down drafts such as thermals.

# [ “Bent pipe” style TE probe anatomy ]



# Total Energy Compensated Variometer Decision Aid



# Netto Variometer

Adjusts for sink rate of glider at a given speed (polar curve)



May adjust for the wing loading due to water ballast

# Netto Shows Airmass Movement

| Airspeed (Kts) | Polar Sink Rate (Kts) | Polar Sink Rate @ Min Sink (Kts) | Air Mass Movement (Kts) |                     |                  |                     |                  |                     |
|----------------|-----------------------|----------------------------------|-------------------------|---------------------|------------------|---------------------|------------------|---------------------|
|                |                       |                                  | -5                      |                     | 0                |                     | 5                |                     |
|                |                       |                                  | TE Vario Reading        | Netto Vario Reading | TE Vario Reading | Netto Vario Reading | TE Vario Reading | Netto Vario Reading |
| 60             | -1.4                  | 0                                | -6.4                    | -5                  | -1.4             | 0                   | 3.6              | 5                   |
| 70             | -1.8                  | 0                                | -6.8                    | -5                  | -1.8             | 0                   | 3.2              | 5                   |
| 80             | -2.4                  | 0                                | -7.4                    | -5                  | -2.4             | 0                   | 2.6              | 5                   |
| 90             | -3.1                  | 0                                | -8.1                    | -5                  | -3.1             | 0                   | 1.9              | 5                   |
| 100            | -4                    | 0                                | -9                      | -5                  | -4               | 0                   | 1                | 5                   |

- Note the difference between the TE Vario Reading and the Netto Vario Reading for airmass movement of -5, 0, & 5 knots
- If the glider is equipped with a TE Vario the highlighted box gives an example of what the readings would be on the TE Vario for 0 airmass movement
- If the glider's airspeed is 80 Kts the TE Vario would read -2.4 Kts.
  - Less negative indicates the glider is operating in a rising airmass
  - More negative indicates the glider is operating in a sinking airmass
- Goldenrod highlighted areas become the cockpit decision aid for Airmass Movement

(Ventus bT polar)

Example Netto  
Decision Aid for  
use with a TE Vario  
(Ventus bT Polar)

| AS  | Airmass "0" |
|-----|-------------|
| 60  | -1.4        |
| 70  | -1.8        |
| 80  | -2.4        |
| 90  | -3.1        |
| 100 | -4.0        |

# Netto Variometer Decision Aid

| Data                                                                                                                                                                                                                         | Transformation                                                                                                                                                                                                                                   | Information                                                                                                                                 | Decision                                                   |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------|
| Stored Static atmospheric pressure reference<br>Negative dynamic atmospheric pressure (includes Static atmospheric pressure)<br>Airspeed (Dynamic air pressure, Static atmospheric pressure)<br>Glider Polar<br>Glider mass? | Convert pressure to direction and rate of change for altitude compensated for control inputs adjusted for airspeed and glider polar<br><hr/> If thermalling behaves like a TE Vario (relatively low airspeed & small overall airspeed variation) | Visual presentation of airmass motion around the glider<br><hr/> If thermalling, visual presentation of climb or descent direction and rate | Airmass rising or sinking?<br><hr/> Quality of the thermal |

# Relative Netto Variometer

Indicates vertical speed glider would achieve IF at thermalling speed

- Calculated as Netto reading minus glider's minimum sink

When thermalling, pilot needs to know glider's vertical speed instead air mass movement

- Relative Netto Variometer switches to variometer

# Relative Netto Shows Potential Climb Rate

| Airspeed<br>(Kts) | Polar Sink<br>Rate (Kts) | Polar Sink<br>Rate @<br>Min Sink<br>(Kts) | Air Mass Movement (Kts) |                                       |                     |                                       |                     |                                       |                     |                                       |                     |                                       |                     |                                       |                     |                                       |                     |                                       |
|-------------------|--------------------------|-------------------------------------------|-------------------------|---------------------------------------|---------------------|---------------------------------------|---------------------|---------------------------------------|---------------------|---------------------------------------|---------------------|---------------------------------------|---------------------|---------------------------------------|---------------------|---------------------------------------|---------------------|---------------------------------------|
|                   |                          |                                           | 0                       |                                       | 1                   |                                       | 2                   |                                       | 3                   |                                       | 4                   |                                       | 5                   |                                       | 6                   |                                       | 7                   |                                       |
|                   |                          |                                           | TE Vario<br>Reading     | Relative<br>Netto<br>Vario<br>Reading | TE Vario<br>Reading | Relative<br>Netto<br>Vario<br>Reading | TE Vario<br>Reading | Relative<br>Netto<br>Vario<br>Reading | TE Vario<br>Reading | Relative<br>Netto<br>Vario<br>Reading | TE Vario<br>Reading | Relative<br>Netto<br>Vario<br>Reading | TE Vario<br>Reading | Relative<br>Netto<br>Vario<br>Reading | TE Vario<br>Reading | Relative<br>Netto<br>Vario<br>Reading | TE Vario<br>Reading | Relative<br>Netto<br>Vario<br>Reading |
| 60                | -1.4                     | -1.2                                      | -1.4                    | -1.2                                  | -0.4                | -0.2                                  | 0.6                 | 0.8                                   | 1.6                 | 1.8                                   | 2.6                 | 2.8                                   | 3.6                 | 3.8                                   | 4.6                 | 4.8                                   | 5.6                 | 5.8                                   |
| 70                | -1.8                     | -1.2                                      | -1.8                    | -1.2                                  | -0.8                | -0.2                                  | 0.2                 | 0.8                                   | 1.2                 | 1.8                                   | 2.2                 | 2.8                                   | 3.2                 | 3.8                                   | 4.2                 | 4.8                                   | 5.2                 | 5.8                                   |
| 80                | -2.4                     | -1.2                                      | -2.4                    | -1.2                                  | -1.4                | -0.2                                  | -0.4                | 0.8                                   | 0.6                 | 1.8                                   | 1.6                 | 2.8                                   | 2.6                 | 3.8                                   | 3.6                 | 4.8                                   | 4.6                 | 5.8                                   |
| 90                | -3.1                     | -1.2                                      | -3.1                    | -1.2                                  | -2.1                | -0.2                                  | -1.1                | 0.8                                   | -0.1                | 1.8                                   | 0.9                 | 2.8                                   | 1.9                 | 3.8                                   | 2.9                 | 4.8                                   | 3.9                 | 5.8                                   |
| 100               | -4                       | -1.2                                      | -4                      | -1.2                                  | -3                  | -0.2                                  | -2                  | 0.8                                   | -1                  | 1.8                                   | 0                   | 2.8                                   | 1                   | 3.8                                   | 2                   | 4.8                                   | 3                   | 5.8                                   |

- Yellow highlighted box contains the glider's polar at Min Sink, this assumes thermalling at the Min Sink speed.
- Goldenrod highlight indicates the TE Vario readings of interest at the various airspeeds and airmass movement values
- Green highlight indicates the Relative Netto readings of interest at the various airspeeds and airmass movement values
- Highlighted pairs at 3, 4, 5, 6, & 7 knots airmass value represent likely minimum climb rates (Relative Netto) the pilot would want for that airspeed and the value the TE Vario would be showing.

(Ventus bT polar)

# Relative Netto Potential Climb Rates @ 2 Knots Thermal Sink Rate

| Airspeed<br>(Kts) | Polar Sink<br>Rate (Kts) | Polar Sink<br>Rate @<br>Min Sink<br>(Kts) | Air Mass Movement (Kts) |                                       |                     |                                       |                     |                                       |                     |                                       |                     |                                       |                     |                                       |                     |                                       |                     |                                       |
|-------------------|--------------------------|-------------------------------------------|-------------------------|---------------------------------------|---------------------|---------------------------------------|---------------------|---------------------------------------|---------------------|---------------------------------------|---------------------|---------------------------------------|---------------------|---------------------------------------|---------------------|---------------------------------------|---------------------|---------------------------------------|
|                   |                          |                                           | 0                       |                                       | 1                   |                                       | 2                   |                                       | 3                   |                                       | 4                   |                                       | 5                   |                                       | 6                   |                                       | 7                   |                                       |
|                   |                          |                                           | TE Vario<br>Reading     | Relative<br>Netto<br>Vario<br>Reading | TE Vario<br>Reading | Relative<br>Netto<br>Vario<br>Reading | TE Vario<br>Reading | Relative<br>Netto<br>Vario<br>Reading | TE Vario<br>Reading | Relative<br>Netto<br>Vario<br>Reading | TE Vario<br>Reading | Relative<br>Netto<br>Vario<br>Reading | TE Vario<br>Reading | Relative<br>Netto<br>Vario<br>Reading | TE Vario<br>Reading | Relative<br>Netto<br>Vario<br>Reading | TE Vario<br>Reading | Relative<br>Netto<br>Vario<br>Reading |
| 60                | -1.4                     | -2                                        | -1.4                    | -2                                    | -0.4                | -1                                    | 0.6                 | 0                                     | 1.6                 | 1                                     | 2.6                 | 2                                     | 3.6                 | 3                                     | 4.6                 | 4                                     | 5.6                 | 5                                     |
| 70                | -1.8                     | -2                                        | -1.8                    | -2                                    | -0.8                | -1                                    | 0.2                 | 0                                     | 1.2                 | 1                                     | 2.2                 | 2                                     | 3.2                 | 3                                     | 4.2                 | 4                                     | 5.2                 | 5                                     |
| 80                | -2.4                     | -2                                        | -2.4                    | -2                                    | -1.4                | -1                                    | -0.4                | 0                                     | 0.6                 | 1                                     | 1.6                 | 2                                     | 2.6                 | 3                                     | 3.6                 | 4                                     | 4.6                 | 5                                     |
| 90                | -3.1                     | -2                                        | -3.1                    | -2                                    | -2.1                | -1                                    | -1.1                | 0                                     | -0.1                | 1                                     | 0.9                 | 2                                     | 1.9                 | 3                                     | 2.9                 | 4                                     | 3.9                 | 5                                     |
| 100               | -4                       | -2                                        | -4                      | -2                                    | -3                  | -1                                    | -2                  | 0                                     | -1                  | 1                                     | 0                   | 2                                     | 1                   | 3                                     | 2                   | 4                                     | 3                   | 5                                     |

- Thermalling sink rate has been increased to 2 knots to account for increased drag from banked flight
- Goldenrod highlighted areas become the cockpit decision aid for Airmass Movement

(Ventus bT polar)

Example Relative  
Netto Decision Aid  
for use with a TE  
Vario  
(Ventus bT Polar)

| AS  | Airmass<br>"0" | Climb<br>Threshold |
|-----|----------------|--------------------|
| 60  | -1.4           | 1.6                |
| 70  | -1.8           | 2.2                |
| 80  | -2.4           | 2.6                |
| 90  | -3.1           | 2.9                |
| 100 | -4.0           | 3.0                |

# Relative Netto Variometer Decision Aid

| Data                                                                                                                                                                                                                                                                              | Transformation                                                                                                                                                                                                                        | Information                                                                                                                                      | Decision                                                       |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------|
| Stored Static atmospheric pressure reference<br>Negative dynamic atmospheric pressure (includes Static atmospheric pressure)<br>Airspeed (Dynamic air pressure, Static atmospheric pressure)<br>Glider Polar<br>Glide climb rate performance at specific airspeed<br>Glider mass? | Convert pressure to direction and rate of change for altitude, compensated for control inputs, adjusted for airspeed and glider polar, & then compared to thermalling climb performance<br><br>If thermalling behaves like a TE Vario | Visual presentation of potential climb rate in current airmass<br><br>If thermalling, visual presentation of climb or descent direction and rate | Is it worth stopping to thermal?<br><br>Quality of the thermal |

# What's New





# Questions

Next Time

Same Bat Channel, Same Bat Time

February 18

Introduction to Portable Gliding Computers



2022  
SSA Webinar Series

BFSS – XC Beginner Ground School Series

Thank You,  
Alice, Mark and presenters

Prepping for a new summer.....

Feb 4, 2022