CPL Theory
Human Factors (CHUF)

CHUF 7 – Ergonomics

1. Document Identification

Document Identification	
Document Category	Training Material
Document Revision Number	1.0 (uncontrolled when printed)
Document Issue Date	28/02/2019
Document Status	Active
Document Title	CHUF 7 – Ergonomics
Document Identification	MBWTRG-TRM-1434

2. Amendment Record

Amendments made to this document since the previous version are listed below. All amendments to this document have been made in accordance with CAE OAA document management procedures.

Original Author		Date of Publication (DD/MM/YY)	
Slide	**Changes**	**Editor**	**Date (DD/MM/YY)**
37	Add "-Auto Pilot" to heading	Robin Pickhaver Samantha Maguire	20/09/19

3. Disclaimer

This presentation is for CAE training purposes only. Nothing in this presentation supersedes any legal or operational documents issued by the Civil Aviation Safety Authority (Australia) or its equivalent in any country, the aircraft, engine and avionics manufacturers or the operators of aircraft or systems and rules throughout the world..

ERGONOMICS

Ergonomics

- Aviation Human Factors can be divided into 4 sectors according to the **“SHELL” model**

Hardware

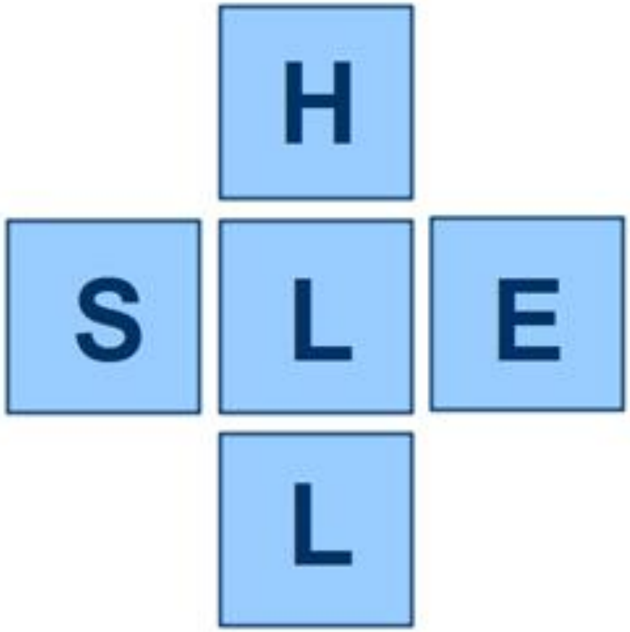
Physical aspects

- Controls
- Surfaces
- Displays
- Seats

Software

Non-Physical aspects

- SOPs
- Regulations
- Charts/Publications



Environment

Where the H & S operate

- Cabin/cockpit
- Weather
- Traffic/Airspace
- Terrain

Liveware

Humans

- Pilots
- Cabin Crew
- Ground Crew

- **Ergonomics** is concerned with the relationship between the Liveware and Hardware

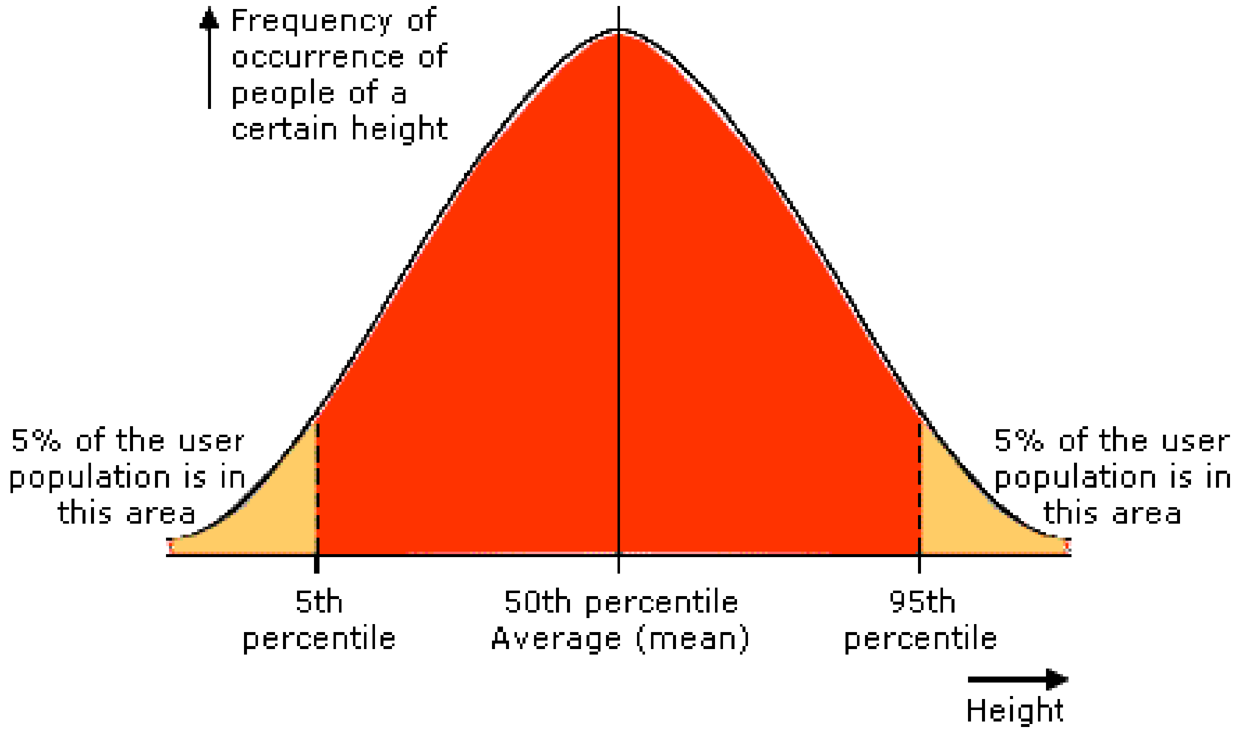
- In other words, ergonomics is the science of optimising the interface between pilots and the machines they operate – making aircraft more **“user friendly”**

COCKPIT

Cockpit

- Pilots come in all shapes and sizes – it is impossible to design a cockpit that will suit all

- An **anthropometric** range **(middle 90%)** is used when designing cockpits



- This means that whilst the **shortest 5% and tallest 5% are excluded**, the cockpit will be suitable for 90% of the population

Cockpit – Design Eye Position (DEP)

- The eye level of the pilot in the cockpit is extremely important for:

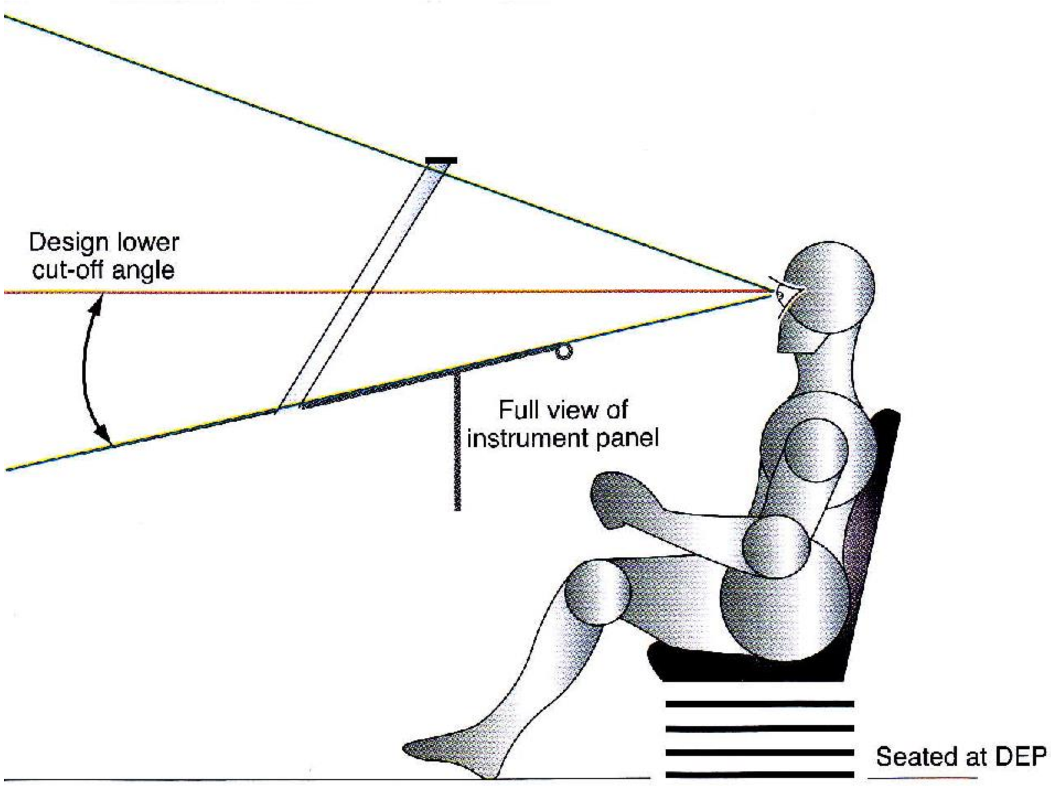
  1. **Viewing all the instruments and controls inside**

  2. **Viewing outside the cockpit, especially forwards and downwards**

- Cockpits are designed using a **Design Eye Position (DEP)**

- If the pilot's eye is at the DEP, then they will have sufficient vision inside and outside

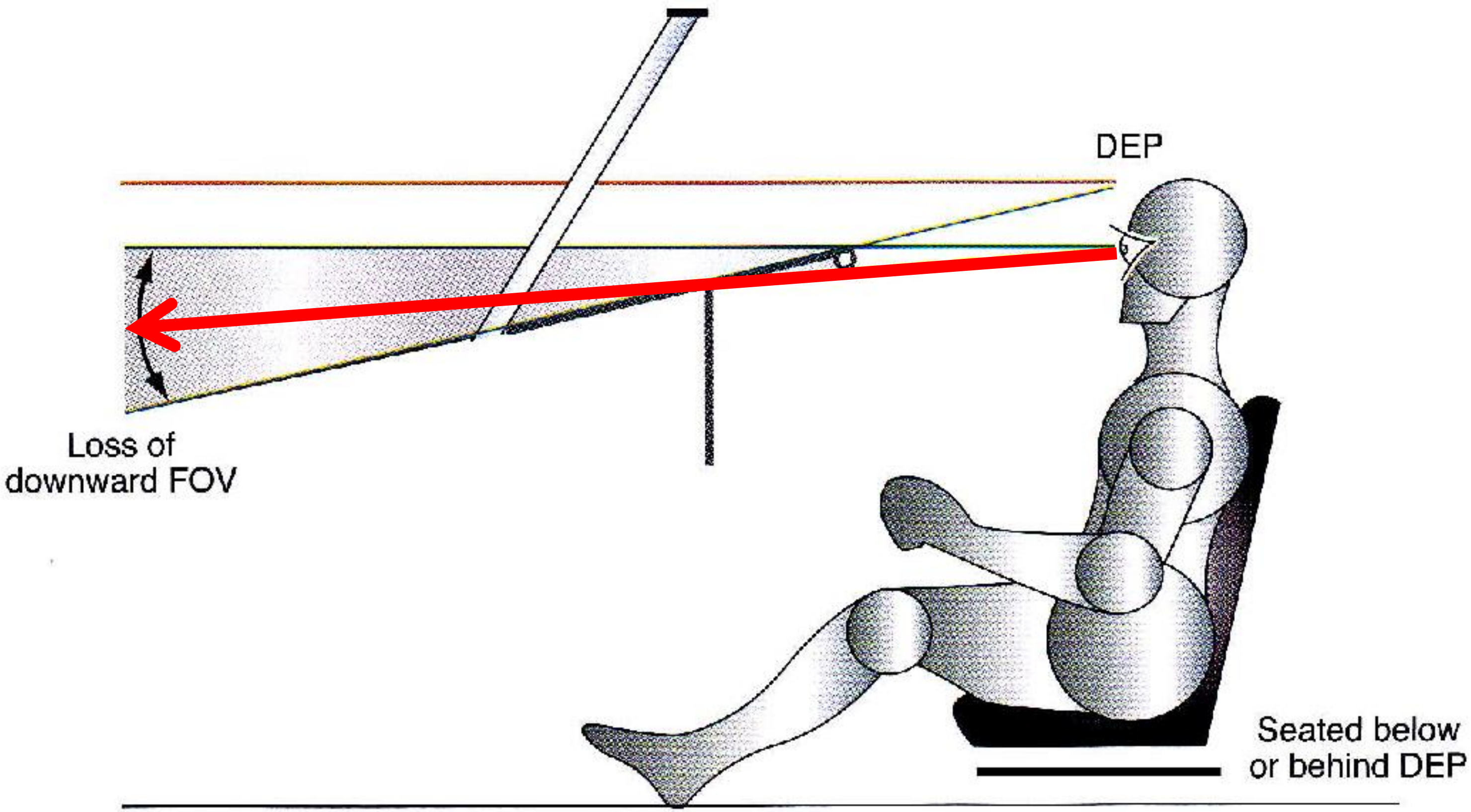
- **Cockpit Cut-Off Angle** is the angle from the horizontal at which the upper or lower surface of the windscreen blocks the pilot's view



Cockpit – Design Eye Position (DEP)

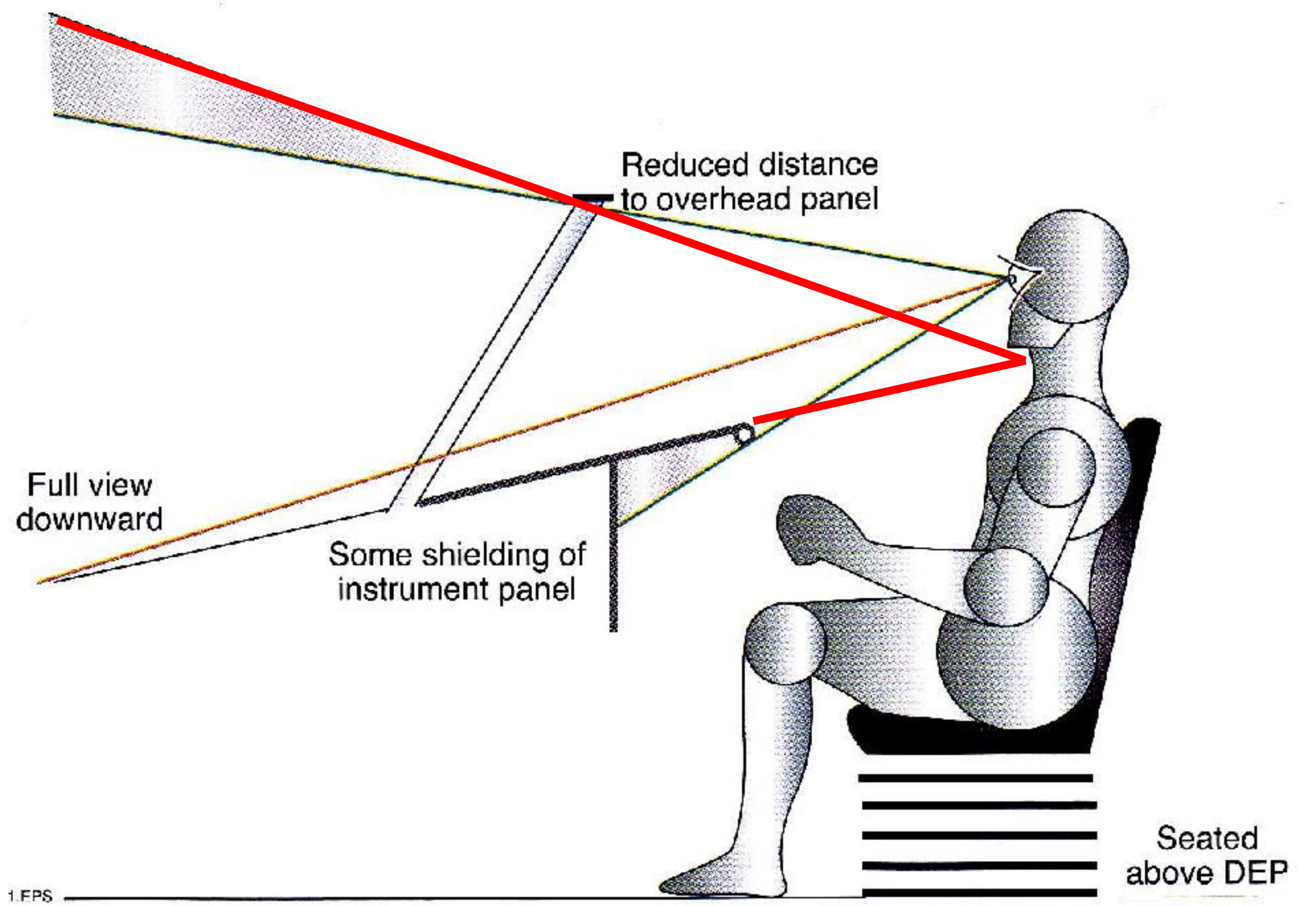
- Sitting below the DEP will reduce the Field of View (FOV) downwards

- **This is particularly hazardous on approach and landing**



Cockpit – Design Eye Position (DEP)

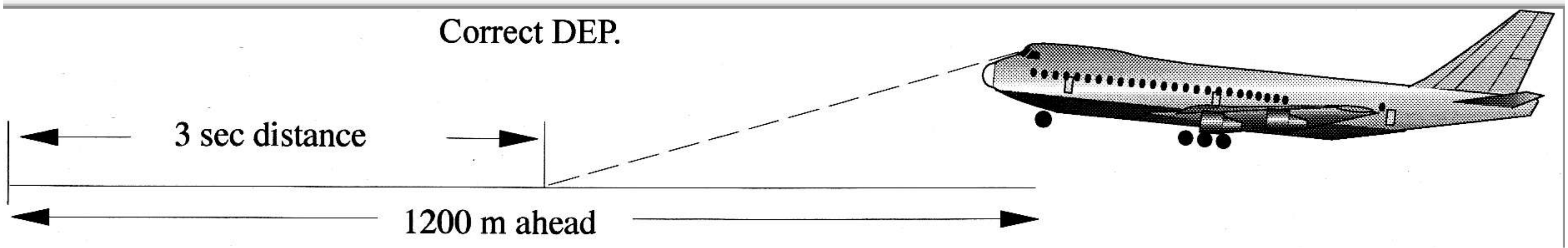
- Sitting above the DEP will reduce the FOV upwards and the instrument coming may obstruct some of the instruments from the pilot's view



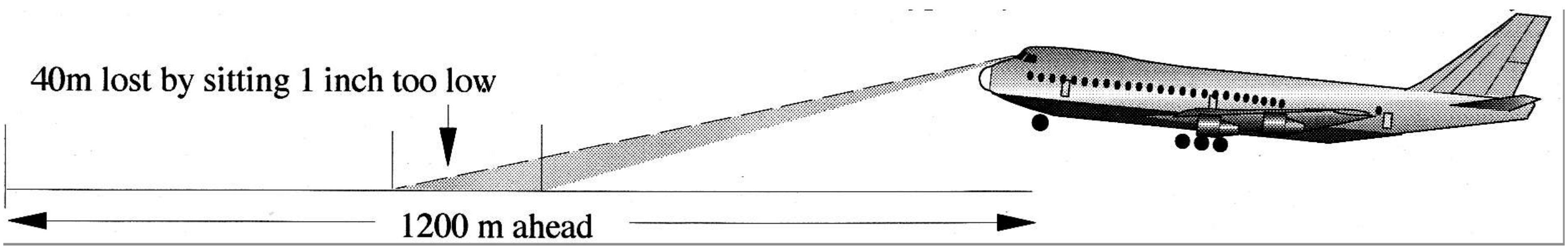
Cockpit – Design Eye Position (DEP)

- Seats should always be adjusted to the DEP, which may be marked on the central windscreen pillar

- The DEP is usually designed to give the pilot vision for a distance equal to 3 seconds at the approach speed when on the landing approach



- **As an example, sitting 1 inch below the DEP may reduce the forward FOV by 40m**



SAFETY HARNESSES

Safety Harnesses

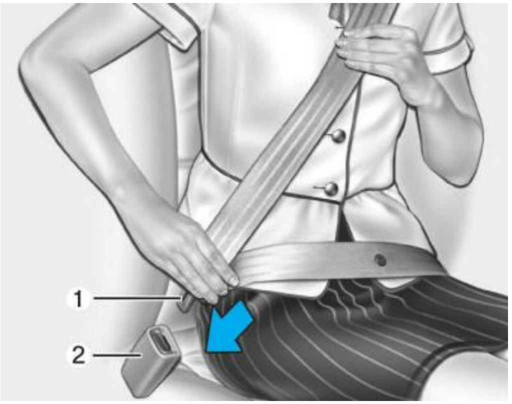
- Seatbelts and safety harnesses must be designed so that:

  1. They are comfortable to wear under normal circumstances

  2. They arrest the body's motion during rapid deceleration (without injury)

- Some common types are depicted below:

2-Point Restraint
- "Lapstrap"
- Common for passenger seats

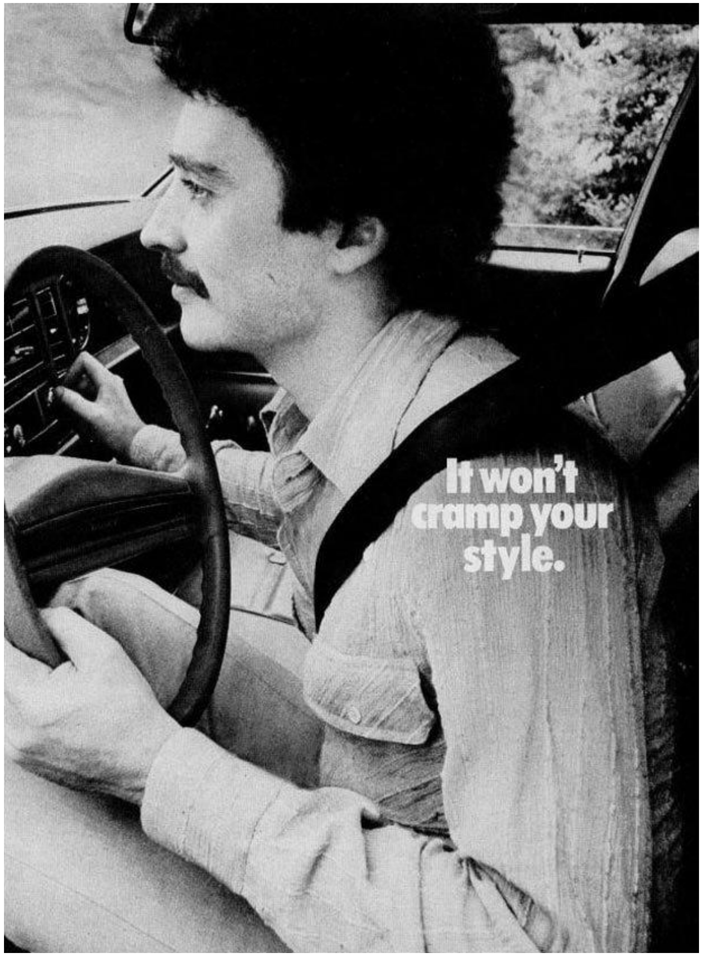


3-Point Restraint
- "Single Sash"
- Common for GA aircraft seats

5-Point Restraint
- Aerobatic harness
- Prevents linear and sideways deceleration

Safety Harnesses

- Seatbelts also commonly have an **inertia reel**
- This allows the pilot to lean forward and reach controls
- However, when a deceleration in excess of 1 G is applied, the inertia reel will lock
- These should be inspected before flight



CONTROLS

Controls

- The earliest designs of aircraft used single **joysticks** for flight control

- This eventually evolved into the **dual control wheels** or **yokes** we see today because:

1. It allows the use of both hands

2. It allows two pilots to assist each other

3. It may have other secondary functions such as radio transmit, autopilot disconnect and electric trim buttons

Controls

- However, some aircraft still use joysticks
- Military aircraft usually have joysticks for the purpose of manoeuvrability
- Others, such as the A380, have sticks to reduce "clutter" inside the cockpit and increase visibility of systems
- These are actually "side sticks"
- The central area is reserved for mutual control of power

Controls

- Any flight controls should have the following properties:

They should operate in the natural sense

- This means if you move the control yoke to the left, the aircraft should turn left
- Or, if you push the right rudder pedal, the aircraft should yaw to the right

They should be balanced

- The controls used most often should require the least effort to manipulate
- The degree of control deflection should mirror the aircraft's response

They should provide feedback

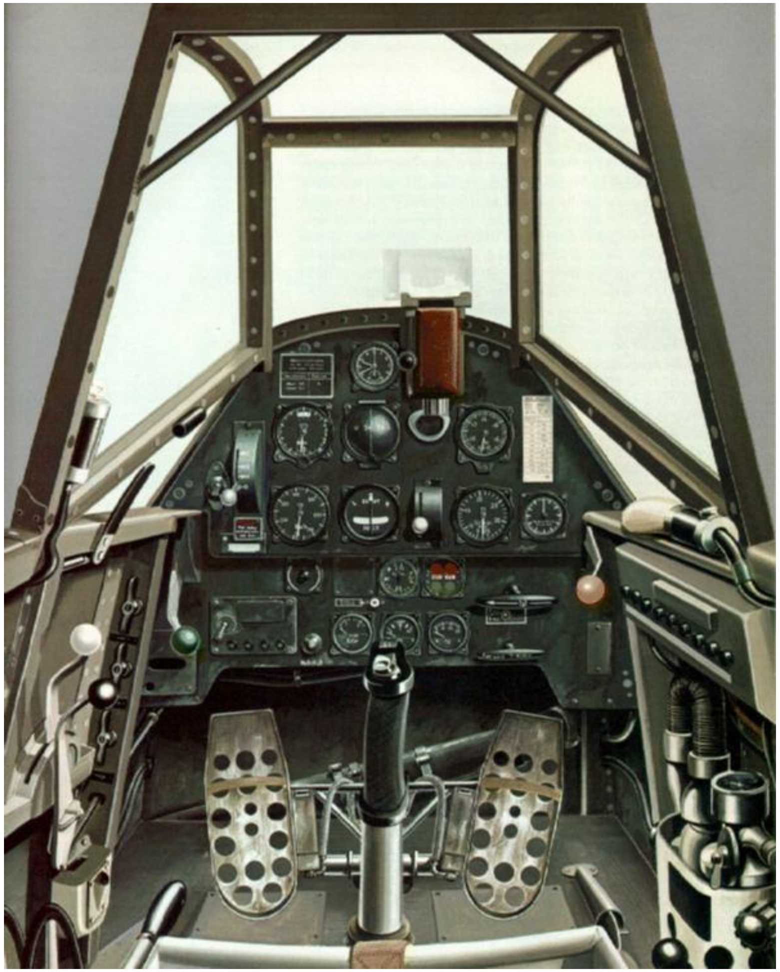
- The pilot should feel a resistance on the controls i.e. FAST = FIRM, SLOW = SLOPPY
- The Sabre has the same control feel at 120kts and 600kts but a vastly different response to control input
- Modern aircraft with hydraulically-actuated controls require "artificial feel"

Controls

- The position of other controls like engine and ancillary controls must also be considered

- In WW2, German aircraft were designed so that the throttle all the way **backwards** was full power

- Controls should:



1. **Work in the natural sense**
2. **Be placed in a position that corresponds to their frequency of use**
3. **Be reachable at all times, preferably by both pilots**

Controls

Vickers Valetta – 1940s era British Military Transport Aircraft

Controls

Boeing B17 Flying Fortress – 1940s era American WW2 Bomber

Controls

Beechcraft Bonanza

Controls

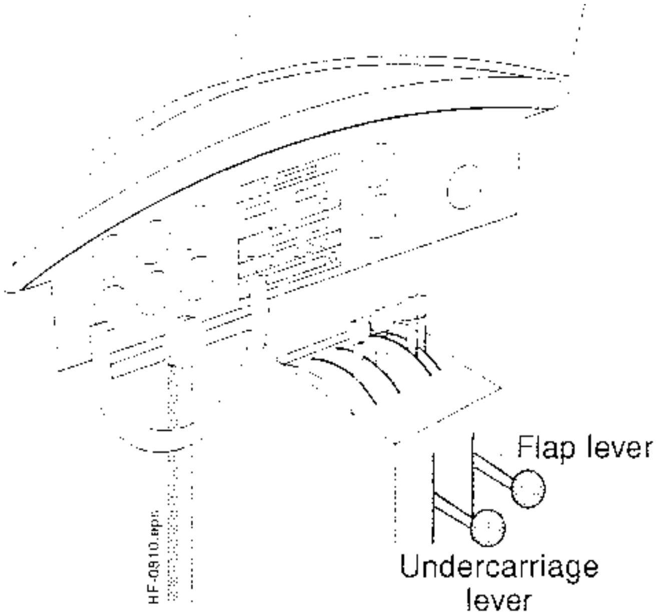
- **Control coding** is also used to prevent inadvertent selection of an incorrect control

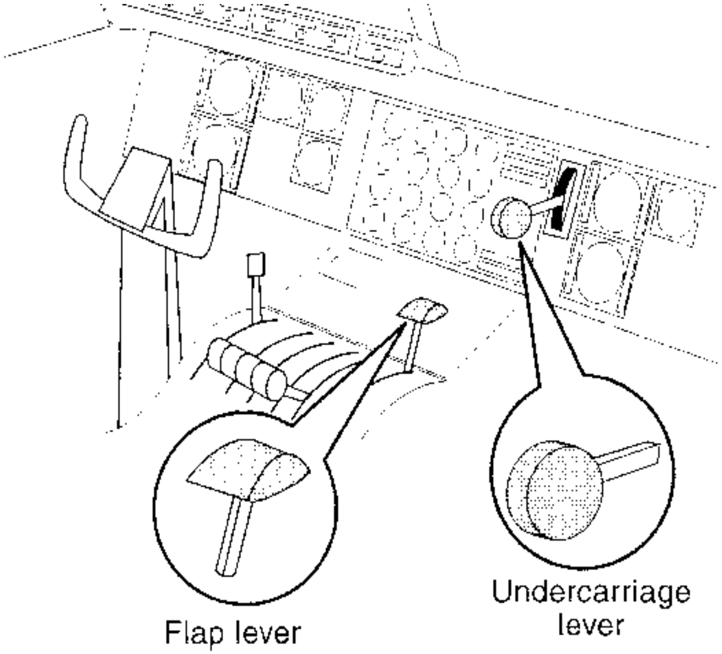
- Specific controls will always have a specific shape and colour:

  Throttle: Black and round

  Pitch: Blue and three bumps

  Mixture: Red and multiple bumps





DISPLAYS

Displays

- A display presents information directly to one of our senses

- For example, on many Boeing aircraft, the approach to stall may be indicated by:

  1. A stick-shaker – sense of touch

  2. A warning horn – sense of hearing

  3. A warning light – sense of sight

- **Visual warnings** are quite common in aviation although they require the pilot's direct gaze

- This means that some important items may be missed whilst the pilot's vision is elsewhere

- This is why **audio warnings** are also incorporated

Displays

- Early audio warning systems were simple “bells” or “alarms” or “horns”
- This would alert the pilot that something was wrong, but would not inform the pilot of the exact nature of the problem
- Modern systems such as Ground Proximity Warning Systems (GPWS) alert the pilot using audible alarms and voice commands to fix the problem

Boeing 737 Alarms, T-CAS and GPWS

https://www.youtube.com/watch?v=W5Z-d1Zx02o

Airbus A380 Alarms, T-CAS and GPWS

https://www.youtube.com/watch?v=GNwd1qXt3RI

Displays

- Heads-Up Displays (HUDs) allow the pilot to concentrate outside and inside simultaneously

Displays

- Most displays however are still visual and are designed based on the following principles:

1. Visibility

2. Ease of Use

3. Frequency of Use

4. Interpretation

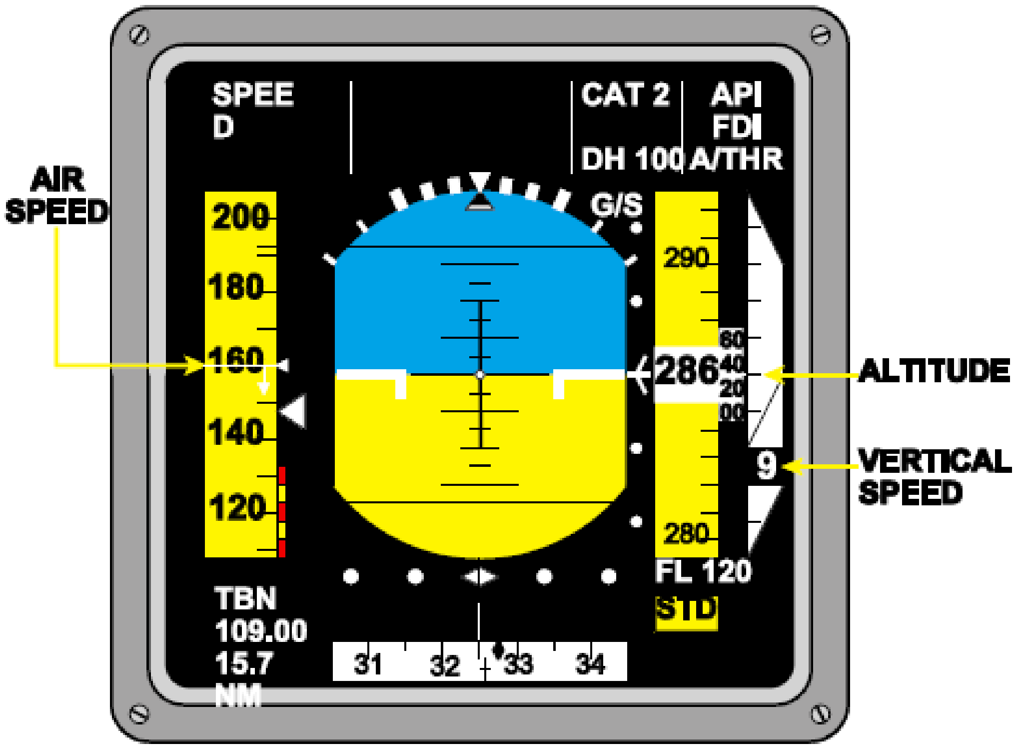
5. Standardisation

Displays – Visibility, Ease & Frequency of Use

- A display must be fully **visible** to the pilot
- The display must be **easy to interpret**
- Displays that are used **more frequently** should be in a location **central to the pilot**
- Displays that are used **less frequently** can be located in a **more obscure position**

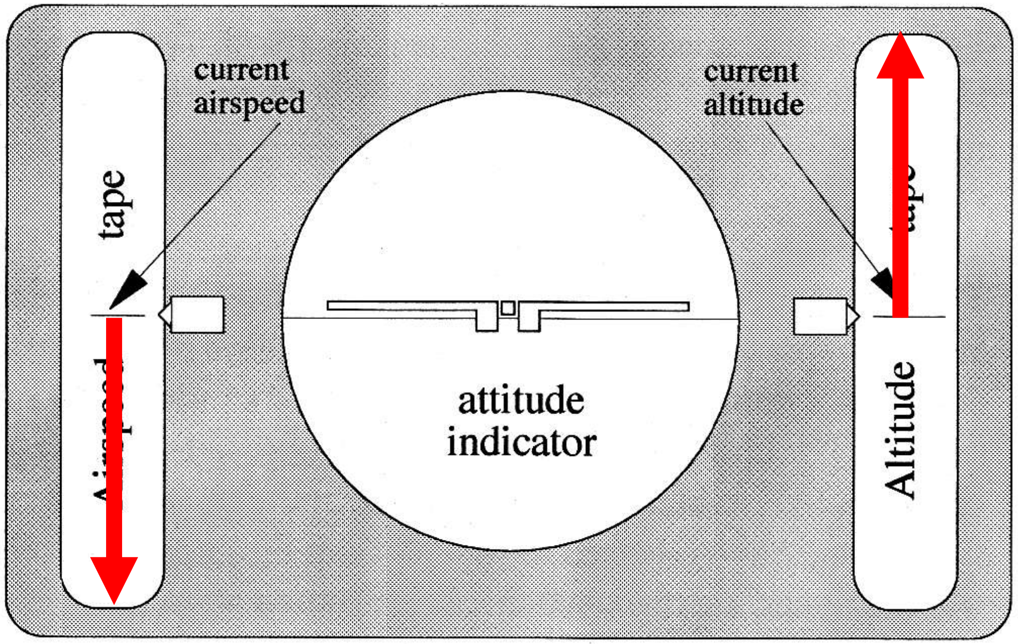
Displays – Interpretation

- A display must also be **difficult to misinterpret**
- This can be a common problem for **linear strip displays** or **“tapes”**



Displays – Interpretation

- Below, we can see a typical set up with linear strip displays either side of an attitude indicator
- If the nose was to pitch up, the ASI value would decrease and the ALT value would increase
- This can produce the **illusion of rolling**



Displays – Standardisation

- Displays that are **standardised** make it easier for pilots to move from aircraft to aircraft without having to re-learn a scan technique

- Most GA analogue type displays have the **6-pack** with **“Standard T”** layout

Displays – Analogue vs. Digital

Analogue

Digital

- Best for qualitative indication
- Easy to get a “rough idea” at a glance
- Best at showing a trend/rate of change
- Multiple needles (ALT) may cause difficulty in reading

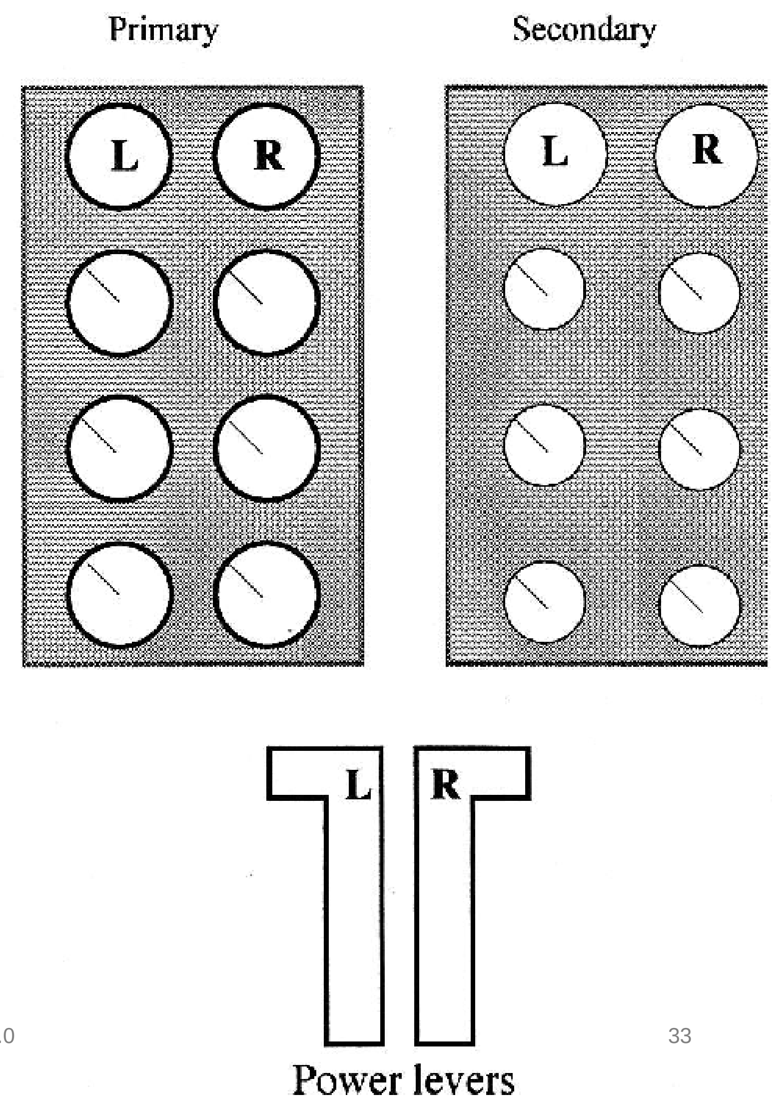
- Best for quantitative indication
- Can read exact values, however this will take more time to read

Displays – Engine Instruments

- For multi-engine aircraft, the set-up of engine instruments is particularly important
- In the diagram on the left, the display is arranged so that:

1. Primary instruments (Manifold Pressure) for both left and right engines are displayed on the left
2. Secondary instruments (RPM) for both left and right engines are displayed on the right

- This makes it easy to notice any disparate indications between the two engines
- In other words, it makes it easy to match the MAP and RPM on both engines



Displays – Engine Instruments

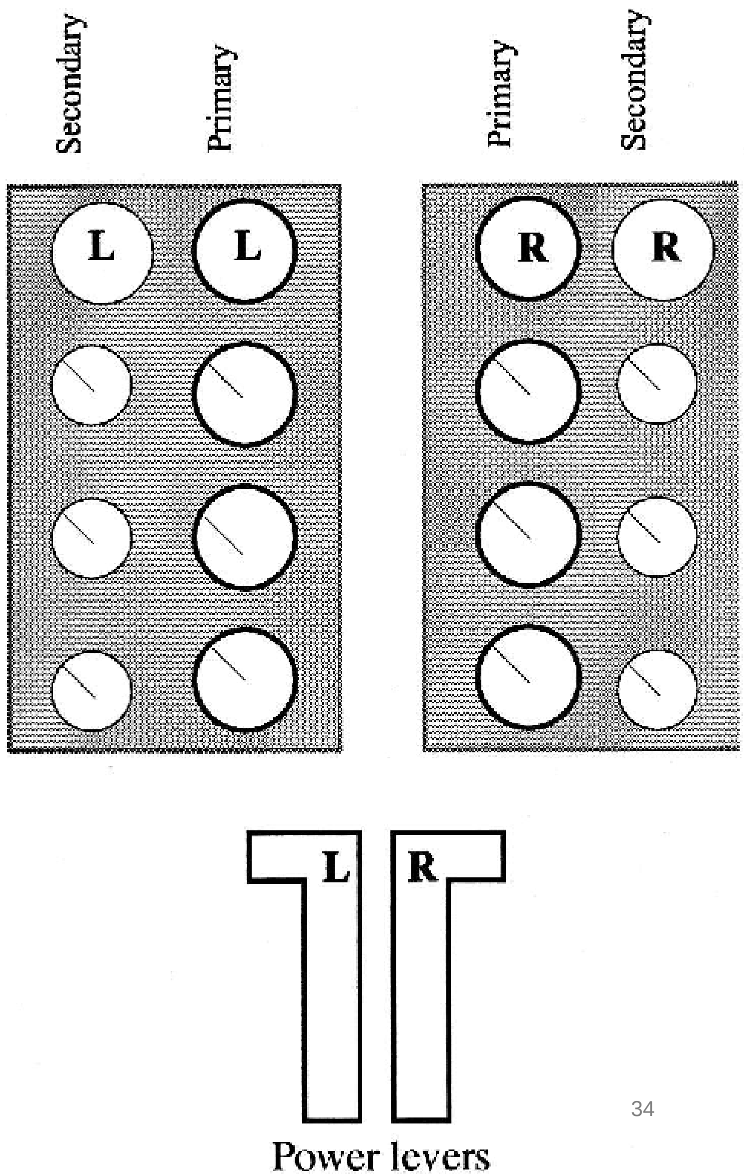
- The other set-up is pictured here

- The display is now arranged so that:

1. Primary instrument (MAP) and secondary instrument (RPM) for the left engine is displayed on the left

2. Primary instrument (MAP) and secondary instrument (RPM) for the right engine is displayed on the right

- This makes it easier to identify a problem in one particular engine



THE GLASS COCKPIT

The Glass Cockpit

- ➢ The **glass cockpit** is becoming increasingly common in modern aircraft and is replacing the conventional **analogue** type displays

- ➢ Glass cockpit aircraft usually possess:

Electronic Flight Instrument Systems (EFIS)

- ➢ Presents attitude, performance and navigation information
- ➢ Additional displays also present information for systems monitoring
- ➢ The G1000 is an EFIS

Flight Management System (FMS)

- ➢ The EFIS is integrated with the FMS which is used for data input and even checklists

The Glass Cockpit – Auto Pilot

Advantages

- Increased efficiency and accuracy
- Does not require motivation
- Does not suffer from human error, fatigue or stress

However, there are also disadvantages…

The 3 most common phrases on the modern flight deck:

1. "What's it doing?"
2. "Why did it do that?"
3. "What's it going to do next!?"

The Glass Cockpit

Disadvantages

- The pilot now becomes a monitor, not a participant
- Therefore, pilot workload isn't actually reduced, but the role of the pilot has changed
- Unfortunately, humans are subject to boredom and complacency and are not suited to the role of a monitor!
- A pilot monitoring the EFIS must maintain **mode awareness**

E.g. Air Inter A320 Strasbourg June 1992 The A320 allows a flight path angle to be entered into its FMS. The crew intended to input an angle of 3.3 degrees. However, the FMS was in Vertical Speed Mode and the FMS registered the input as a 3300 fpm rate of descent. Although the mode was displayed in at least 3 places, the crew failed to check and the aircraft crashed.

The Glass Cockpit

Disadvantages

- There is also an increased tendency (especially in younger pilots) to rely on the EFIS, leading to:

1. **Reduced "hands on" flying time (loss of flying skills)**
2. **Reduced instrument scan**
3. **Reduced situational awareness**