**The circulatory system:**
Blood is pumped around the body by the heart.
Vessels **Away from** the heart are **Arteries.**
**To** the heart = **Veins**.

**Arteries** branch until they become one cell thick to tissue. Arteries carry oxygenated blood. Except the pulmonary artery which carries unoxygenated blood from the heart to the lungs.

**The Heart:**
Main vessel from heart to rest of body runs down the inside of the spine called the **Aorta.**

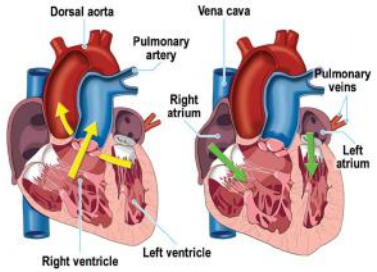
**Vena Cava** = Main vessel back into the heart is called the**.**

**Pulmonary Arteries/Veins =** Vessels going from heart to lungs and back**.**

**Coronary arteries supply blood to the heart.**
**Failure of the coronary arteries** means heart cannot get enough oxygen to work.

Heart has **4 internal** chambers:
- Ventricles
- Left and right Atrium (Atria)

## Circulation




- Major contraction is of the ventricles.
- Blood pumped from right ventricle through pulmonary artery to the lungs.
- Blood returning from the lungs collects in the left atrium where it is injected into the left ventricle.
- Power stroke from left ventricle pumps blood into the dorsal aorta.
- Both ventricles contract together and both atria contract together.

- Pulse rate is approx. 72 beats/min at rest. **Pulse rate controlled by the amount of glucose in the blood, amount of CO2 and hormone adrenaline.**

- Each beat of the ventricle pumps about **70ml of blood (stroke volume)**

- **Cardiac output = Heart rate x stroke volume = approx. 5Litres a min**

**Anaemia →**
**Symptoms:**
- **Tiredness, Weakness, Shortage of breath**
- **Thirst and feeling of pass out, sometimes pale face.**

Arterial blood pressure is sensed by nerves in cavities called **sinuses**.
Known as Carotid Sinus and Aortic Arch Pressoreceptors, collectively known as the arterial pressoreceptors.
**Blood pressure regulated by brain varying amount of hormone secretion.**
**Hormones control artery dilation.**
**Pressoreceptors may also be referred to as baroreceptors.**

**Blood pressure depends on:**
- **The work of the heart**
- **Peripheral resistance (how free is blood flow)**
- **Elasticity of arterial walls**
- **Blood volume viscosity.**

**Systolic blood pressure = Pressure as ventricles CONTRACT**
**Diastolic blood pressure = heart is relaxing between beats.**

**Units [mm Hg]**
**Typical = 120/80 (young adult)**
Rule of thumb = 100 plus persons age is normal.

**Composition of blood:**
- Blood = colourless plasma.
- Red blood cells = Haemoglobin (oxygen carry)
- White blood cells = fight infection

Blood carries 'fuel' = oxygen and sugar.
**Anaemia caused by reduction of haemoglobin, which reduces blood oxygen transportation.**
**Causes of anaemia:**
- **Iron deficiency**
- **Vitamin B12 Deficiency**
- **Folic acid Deficiency**
- **Bone marrow failure due to drugs/cancer.**
- **Blood loss = iron Deficiency**
- **Inadequate secretion of erythropoietin due to kidney failure**
- **Excessive destruction of erythrocytes such as sickle-cell anaemia**

**Hypoxia:**
Also known as Anoxia
**Body SHORT of Haemoglobin oxygen saturation.**
**Hypoxia: 'A reduction in oxygen supply'.**
**Anoxia: 'Total absence of oxygen supply'.**

Amount of Oxyhaemoglobin in blood depends on amount of **OXYGEN IN LUNGS.**

Amount of oxygen in air can be described as its partial pressure in mmHg.
At sea level ATM pressure = 760mmHg
But only 160mmHg is oxygen.

Atmosphere: 78%Nitrogen, 21%Oxygen, 0.9% Argon, 0.1% Carbon Dioxide, Moisture, Solid particles etc.

**At sea level only 14% of air in lungs = oxygen and partial pressure = 103mmHg (Application of Dalton's Law)**

**Hypoxia – Physiological thresholds:**
Effects of Hypoxia split into 3:
**Reaction Thresholds (7000ft):**
Performance of complex tasks may be impaired. Slight increase in breathing/heart

**Disturbance Threshold(10-12,000ft)**
Body defence begin to generate cardiovascular responses. Impaired judgment, memory, and alertness.
Drowsiness.

**Critical Threshold (22,000ft)**
Lapsed mental performance, rapid onset of extreme dizziness and confusion. Total loss of consciousness and complete incapacitation without warning.

## Hypoxia, Hyperventilation, Acceleration:

| Sea Level | Total Pressure mm Hg | Oxygen mm Hg | Nitrogen mm Hg | Water Vapour mm Hg | Carbon Dioxide mm Hg |
|---|---|---|---|---|---|
| Atmosphere | 760 | 160 (21%) | 600 | - | - |
| Alveoli | 760 | 103 (14%) | 570 | 47 | 40 |
| 10 000 ft | | | | | |
| Alveoli | 523 | 55 (10.5%) | 381 | 47 | 40 |

**Do not operate above 10 000 ft cabin height without oxygen**

**Oxygen must be supplied >10,000ft**
**Proportion of oxygen supplied gradually up to 100% between 33,700ft-40,000ft.**

**Above 40,000ft Pressure Breathing.** Oxygen forced into lungs under pressure.

**Hypoxia does not lead to shortage of breath.**

**Hypoxia symptoms:**
Effects **Brain first:**
- **Difficulty concentrating**
- **Impaired judgment, mood changes, euphoria**
- **Drowsiness**
- **Light headedness, dizziness, nausea**
- **Loss of muscular co-ordination**
- **Pallor and Cyanosis, Blueing of extremities (fingertips, earlobes) due to low oxyhaemoglobin**
- **Colour vision failure (>5,000ft)**
- **Unconsciousness, Coma, Death.**

**Hypoxia can be increased by:**
- **Exercise**
- **Cold**
- **Illness, Fatigue, Drugs/Alcohol, Smoking.**

**Smoker can become hypoxic at 6,000ft!**

**Time of Useful Consciousness:**
Cold increases oxygen demand.
Time of Useful Consciousness **(TUC): Time an individual can act with mental and physical efficiency and alert.**
- **Measured from moment exposed to hypoxia**

| | For a person seated (at rest) | For a person moderately active |
|---|---|---|
| 20 000 ft | 30 min | 5 min |
| 30 000 ft | 1-2 min | not required |
| 35 000 ft | 30-90 sec | not required |
| 40 000 ft | 15-20 sec | not required |

Blood donors more susceptible to hypoxia.
**Time of useful consciousness at 25,000ft when moderately active is 2.5mins!**

**Hyperventilation:**
'Unwarranted increase in the rate of breathing can lead to reduction in $CO_2$ in blood, which changes acid balance in plasma.'→ leads to contraction of arteries, resulting in an imbalance of oxygen and $CO_2$, can lead to symptoms like hypoxia.
**Rate and depth of breathing controlled by brain sensing the ACIDITY (amount of $CO_2$ in solution) of blood.**

**Causes:**
**Psychological: Stress/Anxiety**
**Physiological: Reaction to vibration, heat, high acceleration**

**Symptoms:**
- **Dizziness**
- **Tingling of extremities**
- **Visual Disturbance**
- **Hot and Cold flushes**
- **Anxiety**
- **Impaired performance**
- **Loss of consciousness.**

**Hyperventilation continued:**
Prolonged hyperventilation = Can suffer spasms '**Carpopedal Spasms'**
May become fixed contractions **'Tetany'** if person becomes unconscious.

**Hyperventilation is largely self-correcting. I.e.. You lose consciousness and then refresh.**
**If in doubt treat for HYPOXIA.**

- **Hypoxia and hyperventilation are hard to distinguish**
- **Dizziness is an early symptom of hyperventilation**
- **Cyanosis is a symptom of hypoxia but not hyperventilation**
- **Treat for hypoxia if in doubt, select 100% oxygen and descend below 10,000ft.**

**Anaemia:**
Medical condition,
Body has too few red blood cells,
Reduction in diameter of arteries supplying the brain = increase in breathing rate.
Resulting imbalance of oxygen and CO2 = symptoms like hypoxia.
Do not fly after donating blood.

**Anaemic Hypoxia** = lack of oxygen resulting from anaemia.

Circulatory shock is a failure of the blood supply, a heart attack would lead to circulatory shock.

**Decompression Sickness:**
If prolonged periods at high altitude, dissolved gasses in the blood (mostly nitrogen) can emerge in the body as bubbles.
**Application of Henry's Law.**
Can happen even if oxygen supply is good and can show after a flight.

**Symptoms known to divers include:**

- **The Bends (pain in joints)**
- **The Creeps (itching of skin, rash** by Nitrogen in skin)
- **The Chokes (Pains in chest and hacking cough)**
- **Partial loss of vision**
- **Paralysis of limbs**
- **The Staggers (Collapse leading to unconsciousness and death).**

**Unlikely <18,000ft**
**Rare <25,000ft**
**Rare in modern aviation.**

**Airliners fly with cabin pressure of 6,000ft-8,000ft for more unhealthy passengers.**

Pilots are **PROHIBITED** from flying within 24hr of scuba diving or diving below 30ft without air.
**Treatment: compression chamber on 100% oxygen and warm.**

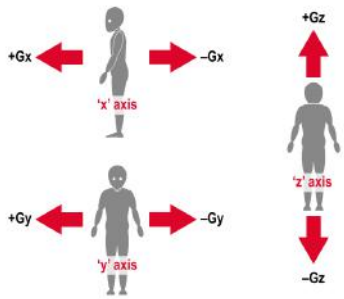
**Immediate actions on loss of pressurisation:**

- **Put on oxygen mask to 100% oxygen**
- **Rapid descent to 10,000ft**
- **Seatbelt and no smoking.**
- **Be on alert for decompression sickness.**

Do not fly for 24hr if experienced a decompression.

**Effects of acceleration:**
**3 types:**
**Linear –** Crashes, and crash landings and buffeting
**Radial –** Turns about a distance axis, e.g., loops or turns.
**angular acceleration –** Rate of rotation changes, e.g., change of roll rate.
**Humans can withstand 7-8G's**

**Acceleration axis based on human spine:**




**Effects of Z-Acceleration (Up/down):**
Body can tolerate short term exposure as much as **25G!** in the vertical.
And **45G in the fore/aft axis!**
+1Gz Drives blood to lower part of body
+3.5Gz = 'Greying out' of vision / loss of vision / peripheral loss / blackout / unconsciousness.

**Clamping the leg and stomach muscles reduce the effect and can delay onset of vision loss to 7/8G.**

**Military pilots use pressure trousers that inflate with bleed air as Gs increase!**

G tolerance is reduced by: Hypoxia, Hyperventilation, Smoking, Low blood sugar, heat, and alcohol.

**Body less okay with negative G's!**
**-3G** will increase blood pressure to head and brain, leading to 'Red out' Vision

Long duration = >1sec
Short duration = <1sec

**-Ve G is rarer and is tolerated less.**
**Short people can tolerate more vertical G.**

# High Altitude Operations (Aeroplanes)

**Intro:**
Altitude of >35,000ft Requires consideration.
High concentration of ozone, cosmic radiations, UV, etc.

Ozone $O_3$:
Present in troposphere, but concentrations rise rapidly above tropopause.
Greatest in winter/spring.
Ozone most concentrated: 50,000ft to 100,000ft.
Risk of ozone greater on Trans-polar flights (Due to reduced troposphere at poles).

Ozone poisoning:
Symptoms:
- Dryness of nose, throat
- Irritation causing coughing

Severe poisoning:
- Difficulties breathing
- Heart strain
- Death

Concentration of ozone more significant than exposure time.

Ozone partly destroyed by high temps created in jet engines.
Cabin air taken from engine bleed downstream of compressor removing ozone.
AC without bleed air require ozone removers.

- **Ozone is a poison**
- **Ozone is potential danger between 40,000-75,000ft.**
- **Ozone is usually destroyed by the pressurisation process.**

**Radiation:**
More serious at higher altitudes.
**4-hour flight above 35,000ft = same radiation as full chest x-ray**

**2 types of cosmic radiation:**
1. **Background radiation from deep space (galactic component):**
2. **Solar radiation:** varies with sun storms and solar flares

We get protection from mag fields, which is less effective near magnetic poles.

**Sun storms:**
High solar activity forecasted using NOTAMs.

**Cosmic radiation Risk:**
Risk of cancers
Radiation doses are measured in milliSieverts (mSv) or microSieverts.
Background radiation dose for general population in Europe is around 2.2milliSv a year.

**Additional dose of radiation at altitude of 26,000ft (8km) is about 3microSv /hr!**
**Less near poles of 1-1.5 microSv/hr**
**At 39,000ft (12km) values are doubled!**

**Mitigating the effect of cosmic radiation:**
Dedicated cosmic radiation monitoring equipment must be carried on AC >49,000ft.

**Blue and UV light:**
**Can't wear polarised glasses for LCD panels.**
But UV light can be damaging and damages the retina.

**Blue and UV light:**
Pilots should wear sunglasses at altitude for protection they should be:
- Impact resistant
- Good optical quality, Class 1
- Luminance transmittance of 10-15%
- Meet filtration standards.

Photochromic sunglasses not permitted.

**Low Humidity:**
Humidity = Amount of water vapour in the air.
**RH in AC cabin is around 10-20% (Very LOW)**
RH in a home is around 50%

Effects of low RH:
- Thirst, Dry eyes, skin, and mucous membranes.

Drinking water, eye drops, and creams helps.

Glasses are better than contact lenses as it can dry eyes.

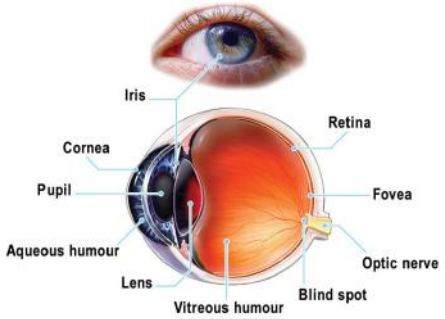
- **Low RH same symptoms as ozone poisoning**
- **Humidity is kept low because of the cost of operating humidifiers.**

**Very Low Temperatures:**
Body heat is generated by metabolism of oxygen with carbs in tissues.
Very low temps require higher than usual levels of metabolism and therefore higher amounts of oxygen.
**Exposure to low temps (Hypothermia) increases the susceptibility to hypoxia.**

# The Eye and Vision

**5 Senses:**
**Sight, Hearing, Smell, Touch and Taste.**

**The Eye:**




**Vitreous and aqueous humour**: watery fluid that fills eye and maintains shape.
**Cornea is transparent.**

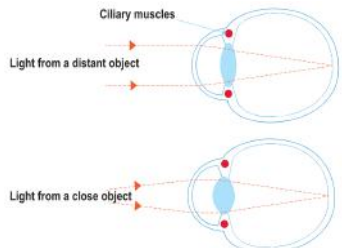
**Iris changes aperture.**

Behind iris, is a lens that can contract and react to control focus.

Light forced by lens to retina (light sensitive membrane) → converted to electrical impulse.

**Fovea**: Most sensitive part of retina

**Accommodation:**
**Most refraction takes place in the cornea,** Shape of lens can be adjusted by small ring of muscle around it, **The Ciliary muscle** to adjust focus.




**Rods and Cones:**
The light sensitive cells on the back of the retina are called **rods and cones** (after their shapes).

**Rods = Low light, not sensitive to colour.**
**Distributed on across large area, used for peripheral vision and low light. Scotopic vision 'Dark-seeing'.**

**Cones = Bright light, colour sensitive.**
**Concentrated at the point that most light falls, give the sharpest vision. Photopic vision 'Light-seeing'.**

**Visual Acuity:**
Comparing sight of a normal person at 20ft. If you are normal your vision is 20/20, meaning you can see at 20ft what a normal person can see at 20ft.
Now expressed in m. so 20/20 is now 6/6 vision.

If ratio expressed is >1 person has better vision than normal. I.e., 6/4 you can distinguish 6m what a normal person only distinguishes at 4m.

Regardless of visual acuity Vision is affected by:
- Amount of light available
- Size and contours of an object
- Distance an object is
- Contrast of an object with surroundings
- Relative motion of object
- Clarity of atmosphere.

**Visual field:**
**120Degrees left to right**
**150degrees up and down.**

**Peripheral vision detects movement but not detail.**

**Depth perception:**
Short-range depth perception is helped at ranges <1m.
- Parallax. Head movements cause distinct objects to move relative to each other.
- Perspective. Converging parallels.
- Relative Size: distant objects are smaller
- Relative motion: closer objects are appeared faster.
- Overlapping contours: objects in front of others must be closer.
- Aerial perspective: aka atmospheric perspective. Scattering of light makes distant objects appear bluer.

**Colour Vision:**
**Detected by cones in retina.**
**3 types of cones – red, blue, green detectors.**
Colour blindness is genetic, prevents distinguishing colours.
Most common = Red/Green.
7% men only 0.1% woman.

**Night Vision:**
**2 ways:**
1. **Dilate pupils, allows more light in.**
2. **Chemical response in rods and cones to adjust to lower light.**

**Cones adapt fast! Fully adapted within 7 mins.**
**Rods take another 30 mins.**

**From Night vision to day vision takes seconds.**

Rods sensitive to shorter wavelengths of lights, means in very low light blue objects are more likely to be seen than red, although neither will be in colour.

**Even mils hypoxia will effect night vision.**
**Vitamin A certainly helps, and B and C are good.**

# The Ear and Hearing

**Hearing:**
**Human Hearing range = 20Hz to 20,000Hz**
**Most sensitive = 750Hz to 4,000Hz**

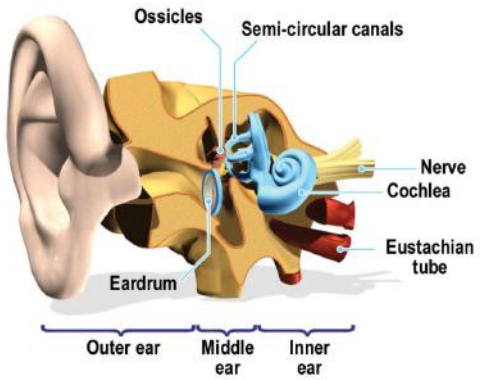
Higher freq range reduces with age.

Eardrum forms junction between the outer and middle ear. Sound waves, which are compression waves in the air are collected by the outer ear and directed into the eardrum which vibrates.

3 small bones: **Malleus, Incus and Stapes** collectively '**ossicles'** pick-up vibrations and relay them to the fluid filled inner eat.
**(Cochlea)**

**Cochlea is** coiled up snail like, fluid filled tube. With nerve cells along the tube that react to diff freq.

**The Ossicles are in the middle ear.**
**The Cochlea is in the inner ear.**




**Hearing continued:**
**The Eustachian tube:** connected to passage of nose and throat to equalise pressure, between mid-ear and outer ear. If eustachian tube is blocked due to infection or cold, there is a risk ear drum will rupture. **Which is why you should not fly with a cold.**

**Sound intensity measured in dB. (Log scale).**
**Rough guide:**

- **0 dB = Soundproof room**
- **50 dB = Avrg office environment**
- **70 dB = normal convo**
- **120 dB = large jet taking off.**

**High levels of noise can lead to temp hearing loss.**
**Called Induced hearing loss (NIHL) and** ringing in the ears **(Tinnitus).**
**Extent of loss depends on the intensity.**

**Prolonged exposure >90 dB = permanent damage.**


**Conductive hearing loss =** Hearing loss caused by failure of the sound conducting elements of the middle ear, eardrum, and ossicles, and can result in infection of mid ear.
**Presbycusis =** General hearing loss with age.

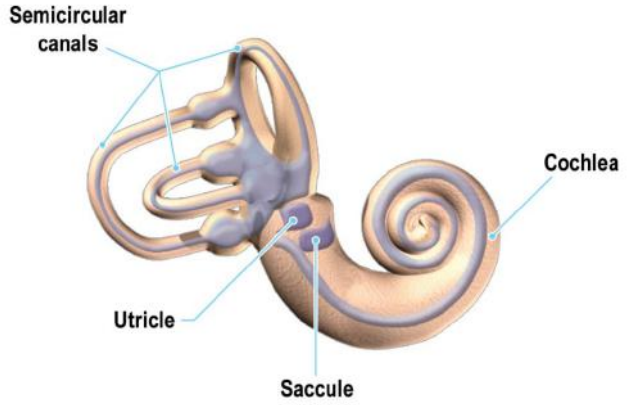
**Balance:**
Sense of balance comes from the vestibular apparatus of the inner ear.

3-semi-circular canals arranged at right angles (orthogonal).
Hairs sense displacement and send signals to brain.

At base of semi-circular canals lie the **utricle and saccule. Called the otolith organs.**
**Sensory hairs with chalky deposits at the free end.**
Chalky deposits are affected by gravity and other linear accelerations, hairs bend and the nerve cells at the base send signal to the brain to interpret orientation.

**The otoliths are the Utricle and the Saccule**

**The Utricle senses horizontal acceleration**
**The Saccule senses vertical acceleration.**



# The Nervous and Endocrine Systems

**Sensory Thresholds:**

**Absolute Threshold:** Threshold at which a receptor reacts to a stimulus.
We rarely notice very small changes.

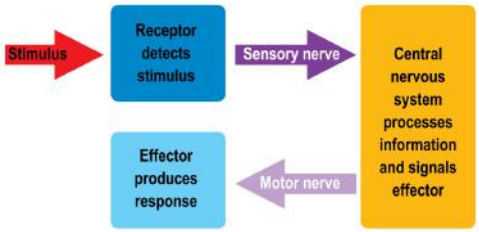
Sensory thresholds differ for each sense.
Differs from person to person.

**Habituation:** A change in sensitivity caused by the body becoming used to the stimulus.

**Adaptation:** I.e., at night when rods become more sensitive the longer, they are away from bright lights. → also used to block out nuisance noises, like a train.

**Just noticeable difference (j.n.d): 'a percentage'.**

**The Nervous and Endocrine System:**




**Receptors are passed along nerves, called sensory nerves to the brain.**

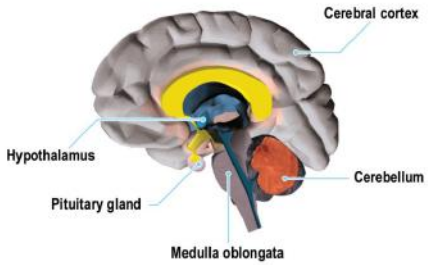
**Nerves made up of Neurons** which use electrochemical signals to transmit information.
**Synapse =** gap in neurons. Where they join.
**Reflex = uncontrolled response to stimuli.**

**The Central Nervous System:**
**(CNS) =** Brain and spine column.
Made up of **White Matter → ends of neurons.**
**Grey Matter** → Cell bodies.
**Cerebrospinal fluid →** Circulating around the CNS.

Most primitive parts of the brain are:

- The **Medulla Oblongata** which controls **automatic activities** such as breathing and heart rate.
- The **Hypothalamus** which controls **water balance and temperature.**
- The **Pituitary Gland** which controls **growth, blood pressure, blood sugar level, the thyroid and adrenal glands and ovaries or testes.**
- The **Cerebellum** which controls **balance and posture**.

**Cerebral cortex** = Memory, imagination, thought, sight, sound, and taste.




**The peripheral Nervous System (PNS):**
Consists of Sensory and motor nerves running to and from the CNS.
12 Cranial nerves from the brain stem connect to sensory organs and muscles of the head and neck.
31 pairs of nerves pass through various gaps in the spinal vertebrae, carrying commands to the muscles and carrying sensory information back to the brain (a two-way highway)

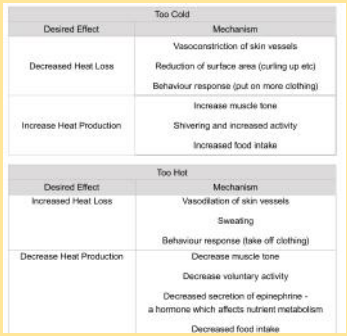
**Nerves can be classed by the tasks that they carry out:**

- The nerves which control the **voluntary** activities of the body, primarily controlled by the cerebral cortex. Sometimes called 'Somatic nervous system'.
- Nerves which control **involuntary** activities are controlled by the **medulla oblongata**. Sometimes called autonomous or vegetative nervous system. Uses hormone release controlled by feedback → **Self-regulated neuro-hormonal system.**

**The Endocrine system:**
Provide self-regulating control of many of the body processes by secreting hormones into the bloodstream in response to chemical and nervous stimuli. The master gland is the pituitary at the base of the brain which controls:

- Metabolism and growth
- Adrenal glands to produce adrenalin
- Pancreas to control blood sugar
- Testes and ovaries to produce sexual hormones.

**Body temperature control:**
**Human body = 35C to 38C, normal = 37C.**
Body adapts to heat better than cold.
**Below 35C shivering will stop, followed by unconsciousness.**
**Similar if >39C**



| Too Cold | |
|---|---|
| Desired Effect | Mechanism |
| Decreased Heat Loss | Vasoconstriction of skin vessels<br>Reduction of surface area (curling up etc)<br>Behaviour response (put on more clothing) |
| Increase Heat Production | Increase muscle tone<br>Shivering and increased activity<br>Increased food intake |

| Too Hot | |
|---|---|
| Desired Effect | Mechanism |
| Increased Heat Loss | Vasodilation of skin vessels<br>Sweating<br>Behaviour response (take off clothing) |
| Decrease Heat Production | Decrease muscle tone<br>Decrease voluntary activity<br>Decreased secretion of epinephrine - a hormone which affects nutrient metabolism<br>Decreased food intake |

**Making Sense of information**
Inputs from the peripheral Nervous system and attempts to make sense out of information.
**Missing information is filled in.**

**Visual Illusions:**
**Illusion:** when the brains mental model of the world differs from the real world.

**Perspective:**
Perspective can cause illusions.

This illusion known as 'Size constancy'
Shape constancy is linked to size constancy.

**Vectional False horizons** can disorientate in flight.
Sloping cloud/terrain that slopes up or down can be misinterpreted for the real horizon.

**Autokinesis:** When star light/AC lights appear to move and wander in different directions.

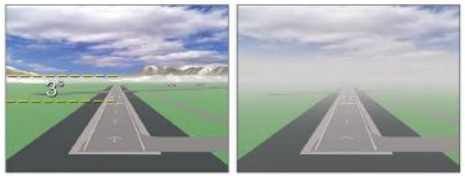
**Visual Cues and Illusions on Landing:**


When Vis is bad, we tend to extend the runway to the vanishing point.

## Integrating the sensory inputs, illusions

**Sloping Runway Illusions:**
Sloping runways can produce incorrect estimates of the location of the horizon and lead to inaccurate judgments of the glide angle.

**Up-sloping runways tend to make you feel higher**
**Down-sloping runways tend to make you feel lower.**

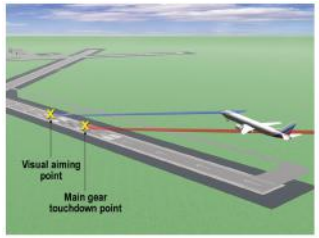



The correct approach angle on a down sloping runway looks too low without the horizon in sight

**Final cues on Landing:**

**Narrow Runway = Illusion of being too high.**
**Wide Runway = Illusion of being lower.**

**The black hole effect and Cockpit Height:**




Occurs during approaches on **Dark Nights** without visual references. **Runway can appear further away than it is (Low approach).**

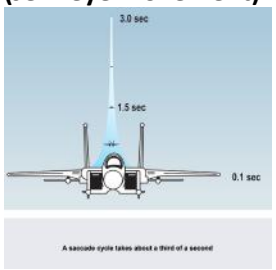
- **Rain can also make pilot feel too high.**
- **When penetrating mist/fog an illusion of pitching up occurs.**
- **Beware that larger AC have landing gear >100ft behind flight deck**

**Mid-Air Collisions - Constant angle:**

**If two AC about to collide, they will maintain a constant relative bearing (assuming constant speed).**

**Mid-Air Collisions – Rapid size increase:**
AC on a head-on collision course will **appear stationary** and **increase in size.**

**A saccade/rest cycle takes 1/3 of a second.**
**(Jerk eye movement).**




A saccade cycle takes about a third of a second

**Empty Field Myopia and lookout techniques:**
When there is nothing to focus on the eye will focus 1-2 meters in front naturally.
Making distance objects more difficult to spot.

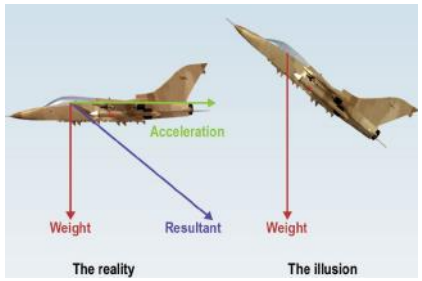
**Avoid resting eye, make as many eye movement as possible.**
**To avoid empty field myopia.**

## Integrating the Sensory Inputs, Spatial Orientation, Vertigo

**Spatial Orientation:**
Vestibular senses not used alone, they are combined with inputs from vision, hearing, memory etc.
**Visual sense relied on most.**
**If not enough visual, brain → memory.**

**Somatogravic Illusion:**
Forces sensed by the subcutaneous pressure receptors, with responses from muscles and joints, gives us a sense of orientation called **proprioception**, aka **Seat-of-the-pants sense.**
**We cannot rely on Seat-of-the-pants sense in an AC as other forces are present.**

**When the AC accelerates, pilot experiences a force pushing backwards.** It produces a resultant force that can produce a feeling of **climbing.**




**Rolling out of a steep turn:**
When rolling out of a steep turn the **reduction in G's** maybe falsely interpreted by the 'seat of the pants' **as a dive.**

**Reduced G force rolling out of a steep turn can make you think you are pitching down.**

**Somatogyral Illusion – The Leans:**
A 2nd Vestibular illusion to do with **roll.**
If pilot turns in coordinated turn and body doesn't sense the turn, when he returns to normal flight and his body feels it, he will feel as if he is banking, **aka the Leans.**
**A pilot recovering from a spin may have a strong sensation of turning in the opposite direction.**

**Spatial Disorientation:**
The ears balancing mechanism can be simulated without any change in the rate of turn of the aircraft. If a person moves their head during a steady turn an illusion can arise from what is referred to as a cross-coupled stimulation (Coriolis) of the Semi-circular canals of the ear. This is also a cause of vertigo.

**Disorientation: when eyes and vestibular do not agree.**
**Conditions predisposing to spatial disorientation are:**
- **From VMC to IMC**
- **Flying VMC with external conditions unreliable**
- **After aerobatics**
- **Moving the head when the AC is turning (Coriolis)**
- **Lack of flying practice / Instrument flying**
- **After formation flying**

**Overcoming Spatial Disorientation:**
**TRUST INTRUMENTS over Senses.**
Don't fly under influence of alcohol.
Avoid rapid head movements in turns
Choose reliable visual ref.

**Motion Sickness:**
Normal reaction to confusing stimuli.
Motion sickness in flight = **air sickness**

- **Mismatch can happen when body is exposed to unfamiliar stimuli.**
- **Visual references do not match up.**

Air sickness can also happen when the head is **vibrated at freq <0.5Hz. Common in turbulence.**

**Motion sickness can cause:**
- **Nausea, Salivation, Vomiting, Hyperventilation, apathy, Drowsiness, Pallor, and cold sweats.** Most people just experience mild Nausea.

**Medication can help but affects performance.**
**Hyoscine is most common drug used.**

**Vertigo:**
Happens on tall buildings, where surroundings appear to whirl dizzily, loss of balance and sometimes nausea and vomiting.

**On a single engine AC, sunlight flashing through prop, can cause 'Flicker vertigo'.**
**Same thing can happen with lights freq 4-20 flash/sec. → avoid by looking away/change rpm.**

**Pilots' vertigo:** Contradictory impulses to the CNS. Caused by flickering light or **ear infection** causing a mismatch.

**Vibration:**
**Apart from causing motion sickness they can:**
- 1-4Hz interfere with breathing
- 4-10Hz Chest and abdominal Pain
- 8-12Hz Backache
- 10-20Hz Headaches, eye strain, pain in throat, speech disturbance…

**Duty of notify:**
Any queries regarding aeromedical fitness should be directed to an **AME (Aeromedical Examiner) or AeMC (Aeromedical Centre)**

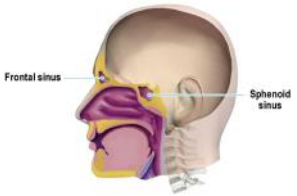
**Colds and Flu:**
Symptoms seriously impair pilot's performance.
Tissue inflammation can block the narrow eustachian tube that connects the middle ear to the environment.

**Barotrauma/ Pressure Trauma (Otic Barotrauma):** Air is let out as AC climbs but not allowed back in, in a decent. Very painful, can lead to **ruptured eardrum.**

If eustachian tube partially blocked, it can help to pinch nose and blow out to equalise pressure.

**A cold can cause barotrauma in the middle ear in a descent.**

Chewing, Yawning, or swallowing can cause the small muscles around the nasal end of the eustachian tube to contract and help it open.




**Blocked sinuses cause barotrauma in the decent.**

**Teeth:**
**Diseased/badly filled teeth** may contain **air pockets.** In flight the air **expands** due to **Boyle's law.** Which can cause pain known as: **aerodontalgia.**

# Health, Common Aliments

**Stomach and Gut:**
When we swallow air is taken in along with food to the stomach.
Due to **Boyle's Law** the air expands and causes **belching/flatulence**.
Sometimes, **air can be trapped in small intestine** which causes pain and can cause **fainting.**
**Barotrauma** in the gut can be minimised by avoiding fizzy, beer, beans, and spicy food before flying.

**Gastritis =** inflammation of stomach lining that may be caused by diet. Good diet needs to be maintained.
Old people may experience Gastritis unrelated to diet.

**Gastro-enteritis is more severe.** Caused by food poising.
Results in: vomiting, cramps, diarrhoea, and nausea.
Subsides within **72 hr.** if persists can be **serious**. Leading to salmonella etc.

**Food poisoning can be reduced by drinking bottled water.**
Be careful with ice, unwashed fruit, ice-cream, and shellfish.

**'Travellers' diarrhoea' subsides within 2-3days**
**Loperamide (Imodium) controls diarrhoea but you are not fit to fly.**

**Visual Defects:**
**Myopia and Hypermetropia:**
**70% of bending of light takes place in the CORNEA**
**30% in the LENS.**
**Myopia =** Short-sightedness **= CONCAVE lens**
**Hypermetropia** = Long-sightedness **= CONVEX lens.**

**Spectacles and contact lenses:**
Pilots can wear glasses subject to:
Read small print at 30cm and to read 6/9 in each eye.
**If specs worn, a spare must be carried.**

- **Normal Vision: image focussed on retina.**
- **Hypermetropia: Long sightedness caused by a short eyeball and corrected with a convex lens.**
- **Myopia: Short sightedness caused by a long eyeball and corrected with a concave lens.**
- **Minimum uncorrected vision must be 6/9 in each eye.**

**Presbyopia:**
With age, eyes become hard to focus 'accommodate'.
Above 45 a form of longsightedness **Presbyopia** develops.
**Weak Convex lens corrects this.**
**Is a long-sightedness caused by lack of elasticity of the middle eyeball with age.**

**Astigmatism:**
Rarer. Lens/Cornea have trouble focusing. Can be compensated by lenses.

**Glaucoma and Cataracts:**
Eye fluid constantly replaced with fresh liquid.
Sometimes it is replaced faster than it is removed. And pressure in eye **increases. = which can lead to loss of vision.**
**Treated with medication.**

**Flash blindness:**
Lightning flashes cause **temp blindness.**
Wearing sunglasses can help.

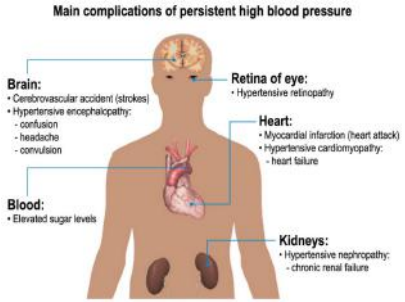
**Hearing Loss:**
**Use of ANR (**Active Noise reduction**) Headphones advised.**
**90dB >8hr is harmful**
**103dB for 30mins is harmful**

**Blood Pressure:**
**100/60 to 160/100 is normal**
**Age + 100.**

**Hypotension =** Too low pressure.
**Hypertension =** Blood pressure too high

**Hypotension:**
**Reduced blood flow to brain can cause death.**
**Most fatal = haemorrhage = blood loss due to accident.**
Fainting after given blood is an **Emotional** reaction. Not due to loosing blood.

**Hypertension:**
More common. More permanent.
Causes can be unknown.
**High blood pressure risks increased stress to heart, increases probability of heart attacks and kidney failure/strokes.**
**REDUCE SALT. Give up Smoking. Exercise.**
**Beta blockers can be used.**




**Coronary Disease:**
Heart depends on **Coronary** arteries.
Failure of blood supply as arteries narrow with age will cause **angina** in times of physical/emotional stress.
Symptoms = **Pain in chest / left arm.**
**Can cause gradual/sudden heart failure.**

Heart attack symptoms = **Nausea, vomiting, swearing, weakness and shortage of breath.**

**Myocardial infraction:** Heart attack / heart muscles would have died due to lack of blood flow.

Risk factors (in order): Family history, Smoking, High blood pressure, High blood cholesterol, lack of exercise and diabetes.

**Angina is an early indication of heart disease.**
**Highest risk factor for heart disease is family history then smoking.**

**Obesity:**

$$BMI = \frac{Weight\ [kg]}{Height^2\ [m^2]}$$

**If BMI > 25 = Overweight**
**If BMI > 30 = Obese.**

Example:

A man is 1.83 metres tall and weighs 82 kg. He is

a) below normal weight
b) normal weight
c) above normal weight
d) obese

Solution:

The BMI

$= 82 \div 1.83^2$
$= 82 \div 3.35$
$= 24.48$

and therefore his weight is in the normal range.

**Example**

**Obesity** reduced the ability to cope with **hypoxia and decompression sickness and withstand G forces.**

**Diseases associated with Obesity: Gout, Hypertension, Diabetes, Osteoarthritis.**

**Back Pain:**
**Pilots prone to: Lower Back Pain (LBP)**
**Or Prolapsed Intervertebral Disc (PID) (Slipped Disc)**

LBP increases if sat in poorly adjusted seat for long. **Taller = more susceptible.**

**Diet:**
Balance of foods.
**Body gets energy from carbs and protein.**

**Low Blood Sugar:**
**Hypoglycaemia (Low blood sugar):** comes from poor diet, causes headache, lack of concentration, nausea, fainting and low G tolerance. **Eating balanced diet should help.**

**Hydration:**
**Body 2/3 water.**
**No water = headaches and fatigue.**
**1.6L for woman**
**2L for men**

# Health in Aviation

## Tropical and Epidemic Diseases

- Drink bottled water.
- Proper prepared food.
- AC sprayed with insecticide to stop spread of malaria.

## Parasitic Worms

- Hookworm, Roundworm, and others.
- AKA **Helminths**
- **Tropical regions in temperate climates.**
- Infections by **Helminths** known as **Helminthiasis.**
- Can exists for **years** inside host.

## Rabies and other Zoonoses

- Rabies = Viral = **inflammation of brain**
- **Survival unlikely**
- 1-3 months incubation.
- Dog foaming = rabies, some animals don't show.

- **Influenza** (another zoonoses)
- Very dangers.

## Malaria

- **Biggest killer.**
- Single cell parasite introduced by a female *Anopheles* mosquito
- **Symptoms =** Flu like. = **Death** if untreated.
- Once infected, malaria **DOSNT go away. Can relapse years later.**
- **Wear long trousers / shirts / net / insect repellent.**
- Drugs include:
- Quinine
- Halfan 'Morning after pill' if symptoms develop.

## Dengue Fever

- AKA. Breakbone fever.
- **Symptoms: Fever, headache, Muscle/Joint pains, skin rash.**
- Can develop to life-threatening dengue haemorrhagic fever = bleeding
- Dengue shock syndrome = low blood pressure occurs.
- No vaccine.
- Limiting exposure to bites.
- Asia-Pacific regions / Africa / south America.

## Yellow Fever, Polio and Typhoid

**Yellow Fever:**
- Insect Borne
- Vaccination available
- Required to enter some countries.

**Polio:**
Viral infectious disease, spread from person to person
Vax available

**Typhoid:**
Bacterial disease by ingestion of contaminated food/water.
Vax available

## Hepatitis

**Inflammation of the liver tissue**
- Hep A = Contracted by eating or drinking water contaminated with human faeces.
- Hep B and C = STDs.
- Hep B = Virus by bodily fluid exchange
- Hep C = Blood exposure
- A and B Vax available
- **Gamma-globulin treats hep A**
- **Hep B and C can come from needles.**

## Cholera, Tetanus, STDs.

**Cholera:**
- **Spread by Dirty water.**
- Vax useless, best action avoid contaminated water.

**Tetanus:**
- **Lockjaw (tetanus) = caused by:** bacterium, clostridium tetani
- **Entering via wound.**
- **Untreated causes muscular spasms/death**
- **Vax available.**

**STD:**
Avoid sexual encounters oversea.

## Diabetes

- **Very common**
- Sugar and starch not used correctly due to insulin deficiency by the pancreas.
- **Insulin = helps body use glucose for energy.**
- **Can be genetic or dietary/lack of exercise.**

**Type 1**
- **Body unable to produce insulin.**
- **Controlled by INJECTIONs**
- **DISQUALIFYING for pilot**

**Type 2**
- **Body can make insulin, but not enough.**
- **May require injections, but can be managed by diet**
- Factors for developing: Obesity, Lack of exercise, Unhealthy diet, >40 years old.
- Ethnicity also plays role.
- **Can be Disqualifying.**

**Effects of diabetes:**
- **Cardiovascular diseases and strokes 5x more likely in type 2 sufferers.**
- Blood clots.
- Neurological problems: **Diabetic Retinopathy** damages retina. → Leads to damage to vision = blindness.
- **Peripheral Neuropathy:** caused by 1 and 2. Peripheral Nervous system becomes damaged. Infections may develop. **Amputations required.**

## Cigarettes, Coffee, Drugs and Alcohol.

**Cigarettes:**

- Reduces resistance to **hypoxia**
- **Reduced G tolerance**
- Badly affects night vision
- 3 components = Nicotine, Tar, CO.

**Coffee:**

- **Caffeine = short term =** feeling of sickness, trembling hands, sleeping issues.
- **Long term = cardiovascular diseases.**
- **Pilots max 200-250mg caffeine daily recommended.**
- In flight coffee = 60-70mg.
- **Rule of thumb = 4 coffees a day max.**

**Alcohol:**

- **Depressant to the CNS.**
- **Relaxes and less prone to worry, decrease in alertness.**
- Visual impairment = 200mg/100ml
- Lose consciousness 400mg/100
- Motion sickness and disorientation.
- **30 units a week are damaging for men**
- **20 units a week are damaging for woman**

15mg/100 ml = half a pint of beer = 1 unit.
Driving limits = 50mg/100 – 80mg/100ml.
**Body breaks down rate: 15mg/100ml per hour.**

**20mg/100ml is MAX to fly**
**Not even a small amount of alcohol may be consumed with 8 hours of duty.**

## Drugs

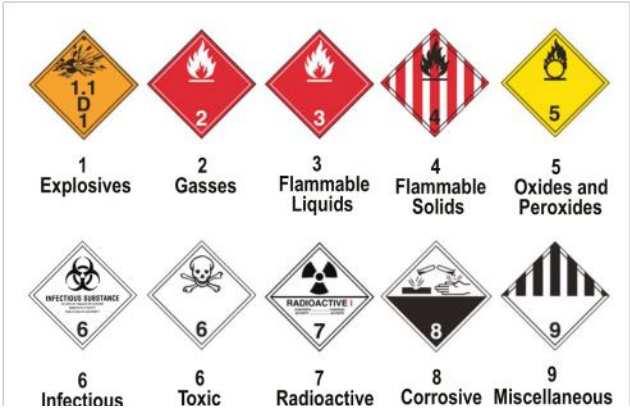
**No no's.**

- **Antihistamine** – used to trat insect bites, rashes, hay fever etc, **can be drowsy.**
- **Do not self-medicate.**
- **Do not fly if unfit.**
- **Seek medical opinion.**
- **Aspirin can cause gastric bleeding**
- **Imodium can cause blurred vision.**

**Anaesthetic:**

- **A pilot should NOT fly within 12hours of local anaesthetic**
- **48 hours of general anaesthetic**

## Toxic Substances and Dangerous Goods




## Incapacitation in Flight

**Reasons for incapacitation:**

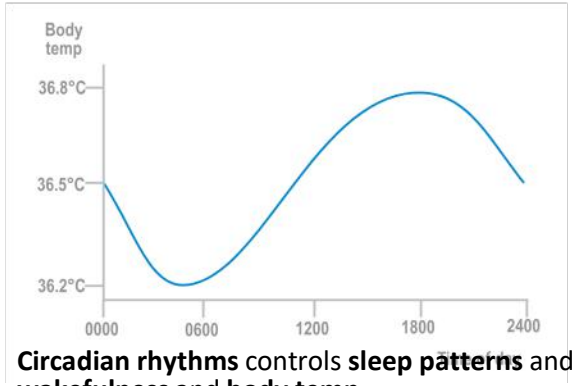
- Gastro-intestinal disorders **(Most common)**
- Physiological stressed by fatigue
- Blocked Sinuses
- Congested eustachian tubes
- CO poison
- Hypoxia
- Bladder Problems/kidney stones
- Heart attack
- Medication side effects
- Epileptic fits.

- **Insidious incapacitation is the most dangerous**

# Sleep

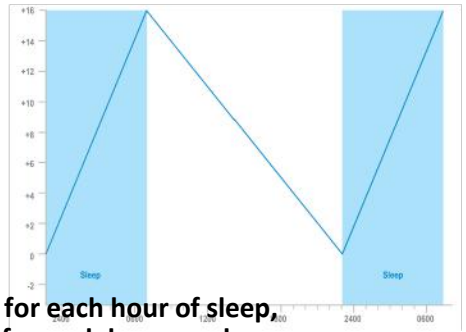
## Circadian Rhythms and Zeirgebers

- Circadian Rhythms = Daily Cycle = **25 hours long**
- **Zeirgebers = external influences =** 'time givers'
- **Body temp lowest at 5am**
- **Body temp highest at 6pm**
- **Endogenous rhythms are synchronised by zeitgebers.**




- **Circadian rhythms** controls **sleep patterns** and **wakefulness** and **body temp.**
- Sleep is easier when body temp is falling.
- **Affects** tasks.
- **Performance of simple tasks is worst at dawn and best in the early evening.**

## Sleep Credits




- **2 points for each hour of sleep,**
- **-1 point for each hour awake**
- **Max 16 points.**

## The stages of sleep

- **5 stages:**

**Slow wave sleep**

- **Stage 1 sleep, Stage 2 sleep, Stage 3 sleep, Stage 4 sleep.**
- **5th stage = REM.**

- Sleep can be measured by **EEG (Electroencephalogram)**
- **Brain activity can be split into, alpha beta and delta.**
- **Alpha = 8-13Hz** (**Relaxed** person eyes closed)
- **Beta** (more agitates and lower amplitude. **Alert/thinking**)
- **Delta** (Slow, high amplitude **deep sleep**.)

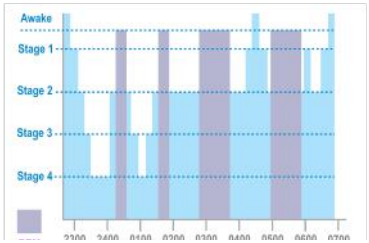
- **Stage 1 sleep is transitional.**
- **Stages 2 – 4 show increasing delta activity.**

## REM Sleep

- Eye Activity measured by **EOG (electrooculogram).**
- Muscle movement measured by **EMG (electromyogram)**

- **REM brain activity = to that of someone awake.**
- **Eyes twitch rapidly**
- **Muscles completely relaxed**
- **REM aka paradoxical sleep** (As if the person is awake)

## Cycles of Sleep




## Cycles of Sleep

- **When woken from slow wave sleep, sensations such as being crushed can be remembered**
- **Paradoxical sleep: strengthens the memory.**
- **Slow wave sleep: is related to body restoration.**

- Most people need **8-9hr** sleep/night
- **Older** sleep **less** and have **less REM.**

- If in **sleep debt**, body requires **half** of the amount missed.

## Jet Lag

- Jet lag = **Circadian Dysrhythmia.**
- Happens when body moved to diff time zones.
- Body **adjusts** at **1 – 1½ hours a day.**
- Body **harder** to acclimatise when travelling **east.**

- Westbound transatlantic flights are easier to cope with than the eastbound 'red-eye'.

## EASA Flight Time Limitations:

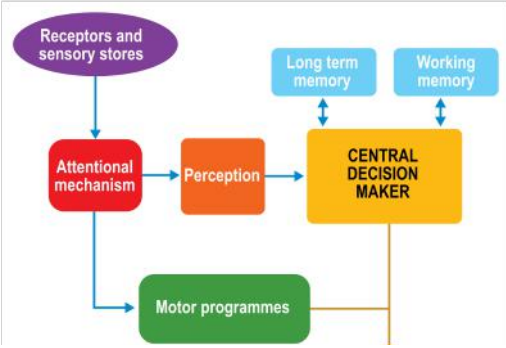
- Flight time limitation (FTL)
- Flight Duty Period (FDP)
- **The timing of sleep is the most critical factor influencing sleep duration. Naps help shift workers.**

## Sleep Disorders

- **Narcolepsy** – Keep falling asleep
- **Sleep Apnea** – Temp stop breathing
- **Insomnia** – Difficulty sleeping
- **Somniloquism** – Sleep talking
- **Somnabulism** – Sleep walkingm

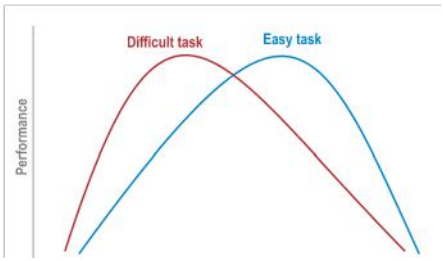
## The information Processing System

- The Central decision maker constitutes a bottleneck in the information processing system.




## Vigilance

- **Performance depends on = alertness** (arousal/vigilance)
- Body uses **adrenalin** to **adapt** to **arouse.**
- **Over arousal is just as bad as under arousal**
- An optimal level is required for best performance




## Over-Arousal and Under-Arousal

**Over-arousal causes:**

- High workload
- Environmental stressors (head and noise)
- Emergencies

**Effects of over-arousal:**

- Reduced ability to perform calculations
- Disproportionate narrowing of attention
- Narrowing visual field
- Tendency to complete tasks faster (less accurate)

**The information Processing Systems**

## Over-Arousal and Under-Arousal

**Under-arousal (<u>Hypovigilance</u>) causes:**

- Sleep deprivation
- Overwork

**Effects of under-arousal:**

- Reduced performance levels
- Behavioural changes
- Inability to prioritise between tasks
- Loss of speed and accuracy

## Over-Arousal and Under-Arousal

**Combatting Under-Arousal**

- Hypovigilance can be restored with sleep.
- Alternating periods of activity and relaxation
- Social conversation
- Physical activity (stretching)
- Naps (not >30-40min) nap recovery = approx. 5mins.

## Attention

- Human brain limited by processing capability
- **Auditory** stimuli can attract **more attention**. (Less accurate response)
- **Selective attention = Cocktail party effect.**

## Decision Maker

- **Divided attention =** ability to monitor more than one channel
- Over arousal **reduces** divided **attention**
- **Brain** rapidly switches between tasks, given illusion of 'multi-tasking'
- **Brain deals with one decision at a time.**

## Coping With Many Tasks

- Multiple tasks coped with by prioritising and rapid switching.
- Attention on secondary tasks can be reduced with **good cockpit design** and **training.**
- **SOPs used** to reduce attention required.

# Perception

## Process of Perception

- **Gestalt** theory deals with our **perception and organisation.**

## Mental Models

- **Brain** uses **pervious** knowledge to interpret the information received by the senses. This is used to construct **mental models** of the world.
- **70%** of information we process comes from **visual**.
- **Perception** is highly **subjective.**

- **Cognitive illusion =** illusion caused by misinterpretation of sensory inputs.

## Bottom-up and Top-down processing

- **Bottom-up** processing **uses sensory information** to start building a mental model
- **Top-Down** processing uses **previous knowledge** to modify the mental model.

## Complexity of perception

- One advantage of using mental model to interpret visual sensory information is our ability to apply **visual constancy.**
- **Process of mental models is Very Dynamic**

## Expectancy

- Mental models = based on experience.
- **Expectancy / perceptual set =** we perceive what we expect to perceive, not what is there.

## Visual Constancy

- **Visual Constancy =** brains ability to perceive an object as the same object throughout a wide variety of viewing conditions. **Recognising familiar objects even in unfamiliar conditions.**
- **Size Constancy =** brain auto scales up and down an image. **(Important on final).**
- **Colour Constancy =** as colours change under lighting, brain accounts.
- **Shape Constancy =** Face shapes may change based on angle, but brain corrects.

## Visual Cues

- Brain uses **Cues** to make inferences.
- Fog/Mist can affect our **depth perception.**
- **Depth perception is driven primarily by size and clarity of an object.**
- **Misty conditions tend to make objects appear further than they are.**
- **Texture flow is an important visual cue used during final.**

## Relative Movement

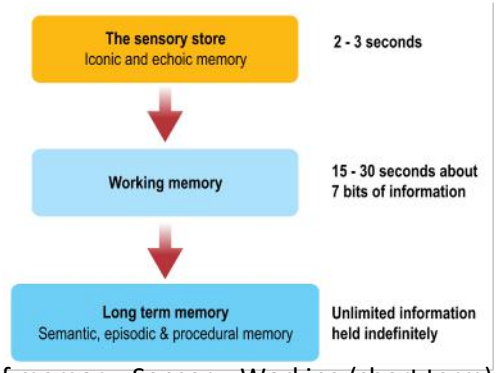
- **When converting to a large AC pilots will tend to taxy too fast.**

## Perceptual Set or Expectancy

- **Expectancy = perceptual set =** a Bias, to perceive features of a stimulus.
- **Expectancy is influenced by the context in which the information is presented**
- **Expectancy has been a contributory factor in fatal AC accidents.**

# Memory, learning, Acquiring Skills

## Structure of Memory




- 3 Types of memory: Sensory, Working (short term) , Long-term.

## The Sensory Store

- Allows for an accurate 'Copy' of sensory information for a brief time, following exposure to stimulus.
- Sensory memory specific to each sense organ.
- Sensory Store for **Vision = Iconic Memory (70%) (0.5 sec storage)**
- Sensory Store for **Audio** = **Echoic Memory ( >8sec)**
- **Less than 1%** of info entering sensory store **makes working memory**

## Working Memory

- **15 – 30 sec.**
- Extended through repetition or rehearsal.
- Holds consciousness.
- **Working memory =** transient store.
- **Spatial info held in visual code (10-20sec)**
- **Verbal info in an acoustic form (10-20sec)**

## Chunking

- **Max items in working memory = 7 chunks of info.**
- **Amount of info can be increased by chunking.**

**Rehearsal**

- Rehearsal / repletion increases time stored in working memory.

## Long Term Memory

- **Permanent store – no limit on capacity.**
- "Cataloguing" information helps brain retrieve info.
- **Long term comprises =**
- **- Episodic Memory** (Autobiographical information, i.e. what you did on holiday) Amnesia only effects episodic.
- **- Semantic Memory** (General Knowledge, meaning of words etc) accurate and long lasting.
- **- Procedural Memory** (AKA **Motor memory** e.g., complex interaction of muscles and balance in riding a bike.)

## Help to remember

- **Methods to help remember:**
- **-Association** (associated with context)
- **-Catch Phrases and Rhymes**
- **-Mnemonics** (such as FREDA)
- **-Over Learning** (repeated tasks holds better)

## Learning

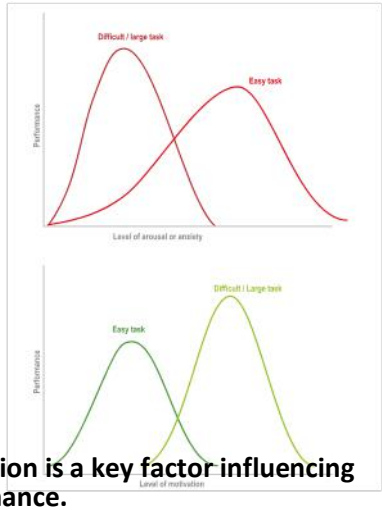
- **Classic Conditioning** (passive learning by association)
- **Operant Conditioning** (Active leaning e.g., 'if I do this then this will happen')
- **Learning by insight** (aha moment)
- **Learning by imitation** (Copying/modelling, used in aviation)

## Factors which affect Leaning

- **Intrinsic Motivation:** Internal rewards, learning enhanced by satisfaction
- **Good mental Health:** Detrimental effect on the learning process.
- **Rehearsals for improvement of memory:** Repetition of information helps store info.
- **Consciousness:** Sentience
- **Vigilance:** Ability to pay attention to an area of a stimulation over a period.

- **Motivation drives learning.**
- **Lack of motivation =** impatience, grievances, unfair treatment.

## Relationship between Arousal and Performance




- **Motivation is a key factor influencing performance.**
- **An optimal level of arousal maximises motivation**
- **Complex tasks require a higher level of motivation than simple ones.**
- **The optimum level of motivation and arousal is proportional to experience.**

## Acquiring Skills

**Phases of learning a skill:**

- Mental preparation helps.
- **Skills are learned in 3-Stage (Andersons Model):**
- **1. Cognitive** (Talking and explaining stage)
- **2. Associative** (Techniques demonstrated, learned, and refined)
- **3. Autonomous** (Performance is perfected or improved and **'internalised'**)

- **Theoretical knowledge is acquired in the cognitive phase**
- **The skill is practiced in the associative phase.**
- **Skill is polished, perfected, and internalised in the autonomous phase.**

## Motor Programmes/Mental Schema

- In the Autonomous stage, actions can be executed without conscious control. Known as **Motor Programmes. Require Little/ no Conscious thought**

- **Skill-Based behaviours =** Motor programmes which can be executed without conscious thought.

- **Mental Schemas =** Rule-based Behaviours, they describe learned sequences of actions and behaviour such as an engine fire drill or a go-around procedure.

## Advantages and disadvantages of Motor Programmes

**Advantages:**

- Relieve load on information processing

**Disadvantages:**

- Vulnerable to types of errors at the **initiation stage.**

**Knowledge-Based Behaviours**

- **Requires evaluation of a new situation using previous knowledge and experience.**

## **Risks** of skill-based, Rule-based and Knowledge-based behaviour

- **Each of the 3 are prone to errors.**
- **Problems** occur when **Central Decision Maker is busy** with other tasks
- **Habit also causes errors** in skill-based behaviour **called Environmental capture.** (Calling 3 greens without checking).
- **Distraction major cause of error**
- **Rule-based behaviour** e.g., SOPs, Checklists etc help to **Improve** safety.
- **Rule-Based behaviour** subject to same errors as those with long-term memory
- **Rule-Based behaviour** is abandoned in favour of **knowledge-based behaviour** when rules are identified as unsuitable.

# Human Error, Error generation

## The unreliability of Human Behaviour

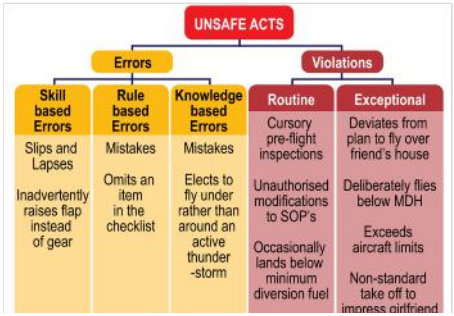
- **Error =** '*is an occasion where a planned sequence of mental or physical actives fails to achieve its intended outcome, and where these failures cannot be attributed to random external intervention'.*
- Error is the concept of **intention.**
- **Human behaviour invariably results in error.**
- **Human error rate = 1in100 to 1in1000 for complex tasks.**

## The Theory and Model of Human Error

- **James Reason's Error Model 4 main categories:**
- **-Slips** (Actions which don't go to plan, Dialling wrong freq into radio)
- **-Mistakes** (Plan itself is faulty. Person making a mistake believes he is correct)
- **-Lapses** ('Forgetting', i.e., forgetting to lower gear)
- **-Violation** (Deliberately carrying out wrongdoings)

- Errors mirror the main 3 types of skills.
- **According to Rasmussen model error occurs at the:**
- **-Skill-based Behaviour level** (routine errors)
- **-Rule-based Behaviour level**
- **-Knowledge-based Behaviour level**

## Deviation and Violation




## Error Chain

- **Error chain =** A sequence of related errors.

## Active and Latent Errors

- **Latent Errors:** Consequences may lie dormant in the system for some time.
- **Active Errors:** Consequences of the error are felt immediately.
- **Murphy's law =** '*if it can go wrong, it will'*

## Internal Error Generation

- **Sensing Errors:** Errors in physical sensing.
- **Perceptual Errors:** Interpretation of stimuli is faulty.
- **Action Slips:** When wrong sequence of action (Motor programme) is implemented.
  **'Action not as planned ANAP' –** 2 types:
  Goal-Directed with an improper element inserted into it or an action misdirected to the wrong goal.
- **Decision-Making:** Made in decision making.
- **False-Hypothesis:** Easy to adopt, hard to relinquish. *Most insidious and dangerous*
- **Distraction:** When attention is diverted it is switched from the current info processing task to another.
- **Motivation and arousal:** Unmotivated/unaroused are more likely to commit errors. '**End deterioration effect' –** complacency towards the end of a task.

## External Error Generation

- **3 Main factors:**
- **Ergonomics,**
- **Economics**
- **Social Environment.**

## SHELL Model


**Liveware-Hardware:**
- Interface between liveware and hardware. I.e., 3 needle altimeter

**Liveware-Software:**
- Issues with: Checklists, Operational manuals poorly written
- **Mode errors:** Features of some automated systems, that allow user to switch mode

**Liveware-Environment:**
- Physical and psychological stressors
- Noise, Vibration, Temp, Work pattern/shifts, poor working environments.

**Liveware-Liveware:**
- Heavy focus on MCC and CRM.
- Poor relationships with captain.

## Strategies for coping with human error

- **Human errors are inevitable.**

**Error Management Programmes:**

- **Zero Defect Programme:** Attempts are made to eradicate errors by encouraging high levels of motivation and imposing a rigid regime of training and checking. **FLAWED to think human error can be eradicated.**
  Result of zero defect = reduction in **reported** errors.

- **Error Cause Removal (ECR):** Less radical. Reducing errors.

## Reducing the Causes and Consequences of Errors

Include:

- **Reversible Errors:** Scratch pad allows to check before committing to the FMC
- **Error Prevention:** Weight on wheel switches, physically prevent errors.
- **Cross-Monitoring:** Cross checking between 2+crew.
- **Machine Monitoring Systems:** GPWS, TCAS.

**Tolerant error =** When a system is set up so that the consequences of an error will not jeopardise safety.
**Vulnerable to error =** A system where a single error can cause a disaster.

## Threat and Error Management (TEM)

3 components =

- **Threats**
- **Errors**
- **Undesired aircraft states.**


# Strategies for coping with Human Error

## Threats

- **Threats =** *'Events that occur beyond the influences of the flight crew'.*
- **Can be anticipated** (weather TS)
- **Unexpected** (Sudden failure)
- **Latent** (Not directly obvious)

Threats can be:

- **Environmental** (Weather, ATC, Terrain, Aerodrome)
- **Organisational** (Delays, AC, Cabin, Ground, Dispatch)

## Errors

- **Error =** *'An action or inaction by an operational person that leads to deviations from the organisational or the operational persons intentions or expectations.'*
- **Unmanaged errors often lead to undesired AC states.**
- **Can be spontaneous, no link to threats**

3 categories of errors in the TEM:

- **AC handling errors** (Incorrect flight control positions, Automation errors, System errors, Ground navigation errors)
- **Procedural Errors** (SOP, Checklist, Briefing, Documentation)
- **Communication Errors** (Crew to external, Internal (pilot to pilot))

## Undesired Aircraft state

- **Undesired AC state:** *The possible outcome of ineffective threat and/or error management is an undesired AC state.*
- **Defined as –** flight crew induced, (reduced safety)
- **Can be broken into 3 categories:**
- **- AC handling**
- **- Ground Navigation**
- **- Incorrect AC config.**

## Flight Deck Ergonomics

- **Built to reduce error.**
- **Static Anthropometry =** Measures limb lengths
- **Dynamic Anthropometry =** Measures reach and clearances.

**Static and dynamic anthropometry of a specific sample of the population is used.**

**Seat Design:**

- Fully adjustable, include lumbar support**.**

**Design Eye Point:**

- Good view of both controls and outside world.
- Eye should be at the design eye point the whole flight.

**Instrument and Display Design:**

- Analogue better suited to show qualitative information (numbers), to show changes.
- Digital will show a blur if constantly changing. (Best combine both)
- Ideally all cockpit layouts stay the same.

## Instrument Design Faults

Poor design, like the 3-point altimeter. Multipoint altimeters are slower to read and more likely to be read in error than digital and pointer altimeter.

- Now instruments look different for different operation.
- On switches always up.

## Poor standardisation

- Issues may arise
- Pilot may be 'used to' a certain layout.
- Example of **'Habit reversion' (negative habit transfer)**

## Design of Checklists and Documentation

**Important principles:**

- **Typeface:** Uppercase may show importance, but too much reduces readability. **Checklists should use upper- and lower-case font.**
- **Colour:** Colour can show importance, but maybe incompatible with flight deck lighting.
- **Indexing and Layout:** Page and paragraph number easier to recognise than lettering.
- **Diagrams and Charts:** Complex info better represented in diagrams

## Warning Systems

- **Attention getting** without being startling.
- **2 main functions: Alert and Inform.**

## Summary of Design Principles

- **Human-Machine Interface (HMI)** is goal orientated.
- **Main goals = Productivity, Safety, Humanisation, and environmental compatibility.**

- **Positioning and Sequencing:** Important = easy reach.
- **Identification of Controls:** Controls look and feel different.
- **Spatial Relationships:** Throttle of left engine on left side.
- **Display Colour/Symbology:** Colours standardised, i.e., Red = danger, critical.
- **Guards and Interlocks:** Critical controls are often guarded.
- **Standardisation:** positions are standard where possible from AC to AC.

## Decision Making

- **KNOWLEDGE-BASED BEHAVIOUR.**

**Decision Making Concepts**

- *A decision is where a choice I actively made between one or more courses of action.*

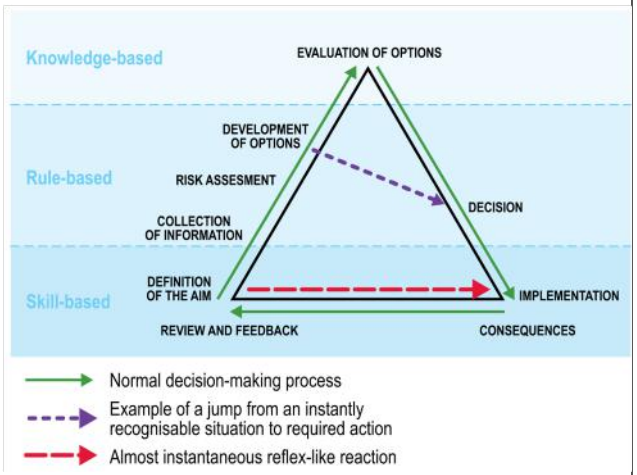
**Typical Decision-making process has 9 stages:**

1. Definition of the aim
2. Collection of information
3. Risk assessment
4. Development of options
5. Evaluation of options
6. Decision
7. Implementation
8. Consequences
9. Review and feedback

## Decision Making Concepts

- **Gary Klein (1993), identified 3 sources of error:**
  1. Lack of experience
  2. Lack of information
  3. Inadequate simulation. (What ifs)

- **Habits** and routine **bias** decision making.




## Conditions Which Make Errors More Likely

- **Decision-Making errors are made more likely by:**
  Stress, Time pressure, Distraction, Peer pressure, Economic pressure, Self-imposed Pressure.

- Errors are more likely when the decision make is:
- **Under physiological or psychological stress**
- **Under pressure to make the decision quick**
- **Distracted**
- **Unduly influenced by peers**
- **Under operational/economic pressure**
- **Under self-imposed pressure**

# Cockpit and Crew Management

## Situational Awareness

- **Situational Awareness SA** – Best defence against error.
- **Accurate mental model** Conscious effort.

**Situationally aware pilot will:**

- Gather information, from variety of sources
- Take time to make decision
- Consider all interpretations
- Maintain 3D plot of other AC
- Test hypotheses

## Loss of Situational Awareness

- Breakdown of SA = False hypotheses, Poor/inappropriate actions
- If SA is lost, try off-loading some pressures.

## The Multi-Crew Concept

- Fundamental elements = **Cooperation** and **Communication**
- **Standard Operating Procedures (SOPs) =** Effective method to mitigate errors and manage threats = + safety. Supported by briefings and checklists.

## Crew Briefing

- Refresh Memories.

**The Briefing formalises and re-states:**

- Responsibilities between crew
- Planned events
- Routine factors
- Actions in case of emergency
- Weather terrain etc
- They are MANDATORY for UK crew.

## Checklists

- Essential discipline.
- Reduce risk of forgetting
- **Correct sequence**
- Schedule checks for low workload.
- Intuitive and ergonomic (Left to right around the cockpit)
- Encourage cooperation and cross checking.
- **Checklists are an example of 'Rule-based behaviour' so common error = forgetting/missing items.**

## Group Dynamics

**Cooperation and communication**

- Group = 2+ individuals shared goals.
- **Synergy =** High degree of cooperation between members.
- **Groups likely to arrive at better decisions than individuals.**

- **Groupthink =** Adopt a false consensus. When individual members display extreme conformity to a group for the sake of conformity alone.

- **Groupthink marked by 5 features:**
- -Group making the decision is very cohesive
- -Group insulated from external info
- -Decision-Makers fail to examine all
- -Group under pressure
- -Group always dominated by directive leader.

- **Risky Shift =** Group tendency to arrive at a riskier decision

- **Conformity =** Urge to Conform to group norms.
- **Compliance =** likelihood of individual to comply with a request.
- **Self-centred =** crew do their job independently.
- **Coaction =** form of cooperation working in parallel towards a common goal.

## Communication

- **Communication model of Claude Shannon and Warren Weaver:** 4 basic components of interpersonal communication.
- **-Sender, The message, the channel, the receiver.**
- Communication serves **4 main functions:**
- **- Instrumental:** 'Pass me the salt'
- **- Informative:** 'Discovery/explanation: need to ask for a better approach'
- **- Ritual:** 'Ceremony or cultural habit: good morning capt.'
- **- Persuasive:** 'Changing an attitude/behaviour"
- **Nonverbal communication = 70% of communication** (eye contact etc)
- **Metacommunication =** communicating about the communication.
- **Inter-personal conflict =** Conflict between crew.

- **Good communication =** Inquiry, Active listening, Advocacy, Feedback, Metacommunication, Negotiation, Arbitration.

- **Factors that affect communication=** Intelligibility, Ambiguity, Uniqueness, amount of info, Using a mix of languages.

## Teamwork, Team Leadership and Team memb

- **Cohesion within a group is a measure of the team spirit.**
- **Factors that affect behaviour:**
- **Persuasion:**
- **Conformity:** Changing behaviour
- **Compliance:** Responding favourably to an explicit or implicit request offered by others.
- **Obedience:** Social influence that derives from an authority figure.

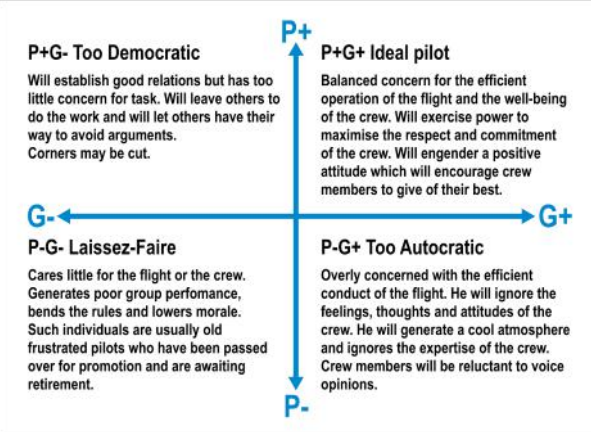
- **Implicit** communication = focuses on the ambiguous areas of gestures vocal tones etc.
- **Explicit** communication = deals with what a person writes/says directly.

## Teamwork, Team Leadership and Team memb

- **The authoritarian leader** = Tends to be **dogmatic, assertive, and unreceptive to criticism.**
- **The Paternalistic leader** = is highly **conscious of his status. He will praise unquestioning obedience but will not brook dissent.**

- **Laissez-Faire =** Leave me alone/ do no interfere type leader.

**G(Goal) factor**
**P(Person) factor**




## Ability Status and Role

- Members will place a greater/lesser value according to perceived: **Ability, Status and Role.**
- **Cockpit authority gradient =** Differences in status

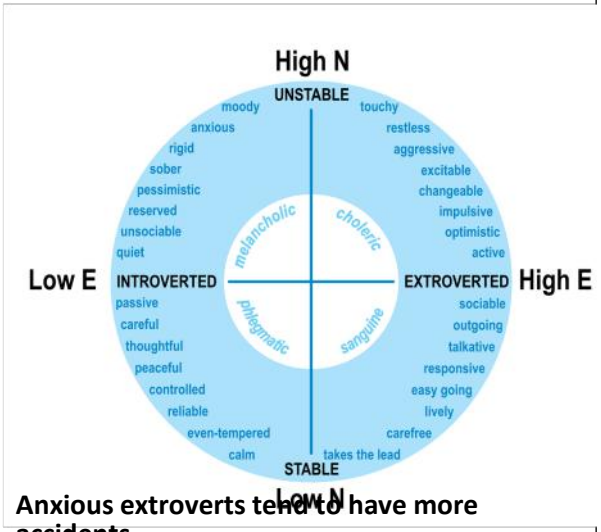
Qualities of a good leader:
- **Good judgment**
- **Intelligence**
- **Responsibility**
- **Demonstrated achievements**
- **Cooperative and understanding**

**Good leader will:**
- **Motivate the team**
- **Reinforce good behaviour with praise**
- **Demonstrate appropriate performance standards**
- **Strive to maintain group cohesion**
- **Manage resources**

# Personality

## Personality and Attitudes

- ***Personality:*** *'The stable behavioural characteristics associated with an individual'. Characteristics known as* ***traits*** *or* ***factors.***
- ***Attitudes:*** *'A Predisposition to behave in a certain way towards certain events'*
- 
- **Eysneck:** Proposed 2dimensional models where personality could be defined as resting somewhere on 2 spectra: Stable-Unstable, Introverted-Extroverted.
- **E = Extroversion, N = Neuroticism**




- **Anxious extroverts tend to have more accidents**
- **Ideal Pilot is a stable extrovert**
- **Psychotic tendencies are incompatible with flying**

- Nowadays 5 Fundamental factors to describe personality:
  -Extroversion, -Agreeableness, -Conscientiousness, -Neuroticism, Openness to Experience.

## The Humanist Approach to Personality:

- The most efficient and adaptable individuals are those who have little gap between how they are and how they would like to be.

## Motivation, Performance and Self-Discipline

- **Motivation =** The difference between what a person can do and what a person will do.

## Maslow's Hierarchy of Needs

- **Motivation levels vary over time**
- **The Least motivated pilot is likely to be a passed-over F/O awaiting retirement**


## Herzberg's 2-Factor Theory

- Classical model of motivation, describes 2 fundamental components:
- **1. Motivation Factors:** Associated with job satisfaction.
- **2. Hygiene Factors:** Associated with job dissatisfaction (staff relationship etc)

## Motivation

- **Motivation is determined by the goals an individual sets herself and the ethos of the company in which they work.**

## Hazardous Behaviours and Attitudes

- **6 Behavioural traits found to be hazardous in aviation:**
- **1. Anti-Authoritarianism:**
- **2. Impulsiveness**
- **3. Sense of invulnerability**
- **4. Excessive self-esteem (Aka Macho)**
- **5. Resignation**
- **6. Complacency**

# Human Overload and Underload

## Human Overload and Underload


- **An Extremely** aroused/anxious pilot will perform **significantly less** well than one who is optimally aroused.
- **Arousal** is a physiological **response to stress**
- The **Sympathetic nervous system** is responsible for **increasing arousal.**
- The **parasympathetic nervous system** is responsible for **reducing arousal.**

## The Autonomic Nervous System ANS

- Arousal mechanism is part of the **Autonomic Nervous System (ANS)**
- **ANS** controls involuntary activates such as **heartbeat**
- **2 Sub systems:**
- **1. Sympathetic 2. Parasympathetic**
- E.g., Sympathetic increases heart rate
- Parasympathetic reduces heart rate
- **Homeostasis.**
- **Fight or flight = General adaption syndrome = from the ANS.**

## Resistance and Exhaustion

- If Source of Stress did not remove the body enters **resistance.**
- **Parasympathetic** helps **recover** the body.

- If Source of stress remains, final stage = **Exhaustion.**
- Hypertension, Heart disease, Asthma, and ulcer.

3 Phases of response to stress aka **General adaption syndrome GAS**:

1. Alarm reaction
2. Resistance
3. Exhaustion

**Correct level of stress**

- **Underload –** complete absence of stress. (Bored sick)
- **A strong physiological response to an immediate physical threat is highly desirable**
- **Complete absence of stress is usually undesirable**

## Overstress

- Too high stress = anxiety and a reduction in performance, and physical problems.
- Prolonged exposure to stress can cause physical illness. Anxiety affects judgement, attention, memory, and concentration

## Stress and the causes of Stress

- **Stress =** Heightened state of arousal caused by stressors in the environment.
- **Stressors =** Any event or situation that induces stress.
- Main stress to airline pilot = lack of control and disruption to their lives
- **Environmental stress lowers an individual's tolerance to other forms of stress.**

## Anxiety, Obsessive and Phobic Disorders

- **Anxiety =** Sufferers live in constant tension and worry, for no rational reason.
- **Obsessive-Compulsive =** Individuals obsessed with something
- **Phobia =** Fear of something.
- **Individuals respond to stress in different ways.**

## Effects of stress and Stress Overload

- **Acute and Chronic.**

**Potential Effects of stress classified under 4 areas:**

1. **Physiological** (short term acute, +heart rate)
2. **Behavioural**
3. **Cognitive**
4. **Personality**

- Chronic Stress can result in physical illness
- Stress is cumulative. Domestic stress can lead to a decrease in professional performance – affecting concentration and decision making

## Strategies for Coping with Stress

Coping strategies can be divided into 3 categories:

1. **Action Coping:** Individual takes positive action to cope (removing oneself from the problem, addressing or altering) **Actual demand**
2. **Cognitive Coping:** Reducing the **Perceived demand,** 'Yes I CAN do this'
3. **Symptom Directed Coping:** Treating symptoms rather than the cause of stress.

- **Absenteeism =** extreme form of action coping

## Stress Management

- Fitness Programmes
- Relaxation Techniques
- Counselling

- **Chronic fatigue is a cumulative process caused by extended periods of high workload and inadequate rest. Stress management programmes centre on developing appropriate coping strategies.**

## Fatigue and Fatigue Management

- **Fatigue =** Mental state of **exhaustion**
- **4 main causes:**
    1. **Inadequate rest**
    2. **Disruption of circadian Rhythm**
    3. **Excessive muscular activity**
    4. **Excessive cognitive work**

- Fatigue can be **Chronic** or **Acute.**

## Fatigue Management

- For pilots sleep loss is major cause of fatigue
- Significant performance decreases for up to **20 mins** after a **nap.**

## Fatigue Risk Management System (FRMS)

- Like Safety Management System (SMS)
- FRMS looks to find balance between costs productivity and safety in aviation.
- FRMS = '***Data-Driven means of continuously monitoring and manging fatigue-related safety risks, based on scientific principles and knowledge as well as operational experience that aims to ensure relevant personnel are performing at adequate levels of alertness'***

**Advanced Cockpit Automation**

## Airbus and Boeing Automation

- **Airbus:** (Fly-by-wire) Pilot limited by automation
- **Boeing:** Pilot not limited. 'Soft' envelope protection

## Advantages and Disadvantages

- **Advantages:**
  - **Safe extension of the operational envelope**
  - **Economic benefits**
  - **Workload Reduction**
- **Disadvantages:**
  - **Computers not intelligent**
  - **Reduced Vigilance:** Excessive automation can lead to pilots being out the loop.

## Reduced Situation Awareness SA

- More automation can lead to **Confusion** about what the display is telling them and can cause **Blinkered concentration** as pilot struggles to interpret information due to **reduced SA.**
- **Reduced Workload** can = **Reduced Performance.**

## Automation complacency

- **Automation complacency =** Pilot puts too much faith in automation

Factors in automation complacency:

- **Passive monitoring:** Faith in system makes crew watch rather than analyse/check.
- **Blinkered concentration:** Narrowing concentration in highly automated cockpit.
- **Confusion:** Breakdown in SA due to over-reliance on auto systems.
- **Mode Awareness:** Crew need to be aware of mode selected.