Human Performance

Edition 1.1

Human Factors/Flight Safety and TEM

HUMAN FACTORS/FLIGHT SAFETY

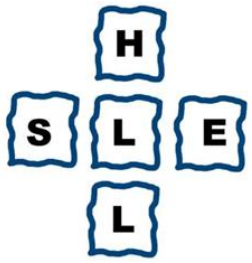
ACCIDENT STATISTICS

- Currently **1 accident per million** movements
- This makes aviation the safest mode of transport
- **GPWS** has been the biggest contributor to safety so far
- **Pilot error** makes up **70%** of accidents through **lack of good judgement**
- **1 in 1000 times** is a good human error rate

THE COMPETENT PILOT

- Has the correct **Knowledge, Skills and Attitudes (KSA)**
- **Everyone** is responsible for safety as **individuals**, not just pilots

SHELL MODEL



- **Software –** Non-physical aspects like checklists/SOPs
- **Hardware –** All solid objects around the liveware like the aircraft
- **Environment –** The varying factors through which the aircraft is operated
- **Liveware –** The pilot and other people (x2)

FAULT VS SLIP

- **Fault – Good Action, Wrong Intention**
- **Slip – Wrong Action, Good Intention**
- **Omission –** Forgetting to do something
- **Commission –** Doing something you shouldn't
- **Substitution –** Similar to a slip

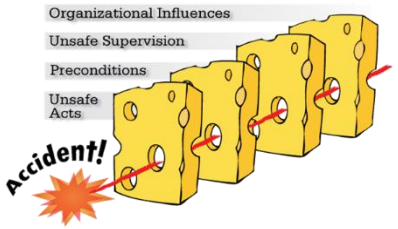
GOOD SAFETY CULTURE

- Is a **subset** of **national culture**
- **Just -** Genuine mistakes are not punished
- **Reporting –** Mistakes are reported
- **Informed –** Mistake reports are assessed
- **Learning –** Action is taken on gathered data
- **Flexible –** Must be flexible in implementing solutions

OPEN VS CLOSED CULTURE

- **Open Culture –** People can share their knowledge/thoughts
- **Closed Culture –** No incentive/fear towards sharing

SWISS CHEESE MODEL



- For an accident to happen, **multiple active** and **latent failures** must line-up such that **layers** of safety barriers (the cheese slices) are **ineffective**

ACTIVE VS LATENT FAILURES

- **Active –** Errors with ***immediate consequence***
- **Latent –** Caused by **circumstance** or **surroundings** and ***not directly obvious***

THREAT & ERROR MANAGEMENT (TEM)

TEM

Threats → Errors → UAS

- **Threat – External** factor beyond flight crew influence
- **Error – Internal** factors (**action/inaction**)
- **Undesired Aircraft State – Unintended** situation causing reduced **safety margins**

TYPES OF THREATS

- **Environmental –** Weather, ATC...
- **Organizational –** Operational Pressures, Manual Error...

TYPES OF ERRORS

- **Communication –** Missed ATC call...
- **Aircraft Handling –** Incorrect Config...
- **Procedural –** Missed SOP/Wrong Callout...

TYPES OF UAS

- **Ground Navigation –** Wrong Taxiway...
- **Aircraft Handling –** Unstable Approach, Outside Limits...
- **Incorrect Config –** Flight Controls, Mass and Balance...

COUNTERMEASURES

- **Hard –** Already in place
- **Soft –** Utilizes the **KSA** of the flight crew

Atmosphere

COMPOSITION

- **78% Nitrogen**, **21% Oxygen** and **1% Rare Gases** (**0.03% Carbon Dioxide**)
- Proportions constant until **100km**

PRESSURE

Key Pressures:

- **760 mmHg** at **Sea Level**
- **380 mmHg** at **½ Pressure** (18,000ft)
- **190 mmHg** at ¼ Pressure (34,000ft)

Key Lapse Rates:

- **27ft/hPa** up to **18,000ft**
- **50ft/hPa** above this

TEMPERATURE

- **2°C per 1,000ft** up to **36,000ft** (-56.5°C)
- **Isothermal** above this

ATMOSPHERIC ZONES

- **MSL-10,000ft –** Physiological Zone
- **10-60,000ft –** Physiological Deficient Zone
- **60,000ft+ -** Space Equivalent Zone

GAS LAWS

- **Charles** Law – **Volume ∝ Temperature** (**Constant Pressure**)
- **Boyles** Law – **Pressure ∝ 1/Temperature** (**Constant Temperature**)
- **General** Gas Law - $^{PV}/_{T}$ = **Constant**
- **Daltons** Law – In a mixture, **total pressure** is the **sum** of the **partial pressures**
- **Ficks** Law – Rate of diffusion depends on **Surface Area**, **Differential Pressure** and **Membrane Thickness**
- **Henrys** Law – **Quantity** of gas dissolved into liquid is proportional to the **partial pressure**

TRAPPED GAS DISORDERS

- **Pain** will result from trapped gas – **'Dysbarism'**
- Occurs in the **stomach**, **ears**, **sinuses** and **teeth**
- Caused by **Boyles Law**

GASTROINTESTINAL

- Occurs in the **stomach**
- **Severe pain** possible above **25,000ft**
- Relieved by **belching**, **passing flatus** (farting) and **descending**

OTIC BAROTRAUMA

- Occurs in the **ear**
- **Eustachian tube** balances pressure
- **Harder** to equalise pressure in the **descent**
- Relieved by **yawning**, **swallowing**, **Valsalva** or **Frenzel manoeuvre**
- Can result in **ear drum rupture**

SINUS BAROTRAUMA

- Can be **blocked** by **infection/cold**
- Prevents air equalization
- **Climbing** means the pressure **can't escape**
- **Descending** creates a **vacuum**
- This ***cannot be relieved***

AERODONTALGIA

- Occurs in the **teeth**
- Trapped gas **expands** when **climbing**
- Relieved by **descending**

DECOMPRESSION SICKNESS (DCS)

1. Nitrogen absorbed into blood
2. Pressure reduces
3. **Nitrogen bubbles form**
4. This creates **blockages** potentially leading to **tissue death**

- Caused by **Henrys Law**

BLOCKAGE TYPES

- **Joints** – "**Bends**" – Deep pain in large joints
  - This is the **primary symptom**
- **Skin Capillaries** – "**Creeps**" – Intense itching
- **Lungs** – "**Chokes**" – Chest pain
- **Brain** – "**Staggers**" – Neurological problems
- *These symptoms may not be immediate*

REQUIRED CONDITIONS

- **Unlikely** below **14,000ft**
- **Most likely** above **18,000ft** (unpressurised)
- **Significant increase in risk** above **25,000ft**
- *Scuba diving, obesity and age are risk factors*

SCUBA DIVING

- **Shallow Dive – 12 Hour** Flight Ban
- **>30ft – 24 Hour** Flight Ban
- **Snorkeling** presents **no problem**
- ***Doing exercise does not prevent DCS***

Respiration and Circulation

BLOOD

FUNCTION

- Transports O_2
- Removes CO_2
- Fights **infection** and **produces clots**

COMPOSITION

- Made up of **red/white blood cells**, **platelets** and **plasmas**
- **55% plasma** and **45% cells**
- Produced in the **bone marrow**
- Lifespan of **140 days**
- Red blood cells contain **haemoglobin** that **carries oxygen**
- **Insufficient haemoglobin** causes **anaemia**

ARTERIES AND VEINS

- **Arteries – Away** from the heart
- **Veins – Back** to the heart
- **Pulmonary Veins/Arteries –** Connects **heart** and **lungs**
  - Only **de-oxygenated artery** in the body
- **Systemic Veins/Arteries –** Connects **heart** and **tissues**

CIRCULATORY SHOCK

- **Inadequate circulation** of blood
- Leads to **tissue death**
- Caused by **mass bleeding**, **heart problems**, **blockage** or **anaphylactic shock**

STROKE

- **Blood supply** to the **brain** is **cut-off**
- Caused by ***clotted/blocked/ruptured*** *vessels*
- *Not to be confused with* ***fainting*** *or a* ***fit***

DEEP VEIN THROMBOSIS (DVT)

- Caused by a **blood clot** in a **deep vein**
- Causes **painful aching**
- Risk factors include **old age**, **inactivity** and **obesity**

HEART

STRUCTURE

- **4 Chambers** (**2 Atria** and **2 Ventricles**)
- **4 Valves**

HEART RATE (HR)

- Measured by counting the pressure waves
- Affected by **exercise**, **body temperature**, **eating**, **drugs** and **stress**
- Cardiac Output = HR x Stroke Output
- 70bpm x 75ml = **5.2 liters/minute** (typical)

BLOOD PRESSURE

- Force exerted by **blood** on the **artery walls**
- **Systolic** (*Contraction*) – Blood **leaves** ventricle
  - **120 mmHg** (typical)
- **Diastolic** (*Relaxation*) – Blood **enters** atrium
  - **80 mmHg** (typical)
- Influenced by **work**, **peripheral resistance**, **elasticity** and **blood viscosity**
- Measured in the body by **pressoreceptors**

DISORDERS

HYPERTENSION

- **High Blood Pressure** (**>140/90**)
- Caused by **stress**, **age**, too much **salt**, **hereditary** or **obesity**
- The high pressure causes a **tear**, **fat** builds up on the tear and a **blood clot** forms
- Treated with **medication**, **diet** and **exercise**
- Can be **disqualifying**

HYPOTENSION

- **Low Blood Pressure**
- Can cause **dizziness/fainting**
- Can also be **disqualifying**

ANGINA

- Temporary situation where demand > supply
- Caused by **coronary artery narrowing**
- Symptoms are **tiredness**, **breathlessness** and **crushing pain**
- Treated with **rest** and **medication**

HEART ATTACK

- **Myocardial Infarction**
- Caused by a **blocked coronary artery**
- Can cause **tissue death**
- **Family history** is the **biggest risk factor**
- Most **common** cause of death for **men >40**
- ECGs can detect anomalies in advance

CARDIAC ARREST

- **Ventricular Fibrillation**
- Caused by **breakdown** in the **electrical stimulus** (heart suddenly stops)
- Triggered by a **heart attack**, **electrocution** or **trauma**

RESPIRATION

FUNCTIONS

- **Energy Production**
- **Temperature** and **Chemical Regulation**
  - This is known as **homeostasis**
  - Body must remain between **7.2-7.6 pH**
- Achieved by breathing **16-18 times per minute**
- Regulated by amount of **CO2**

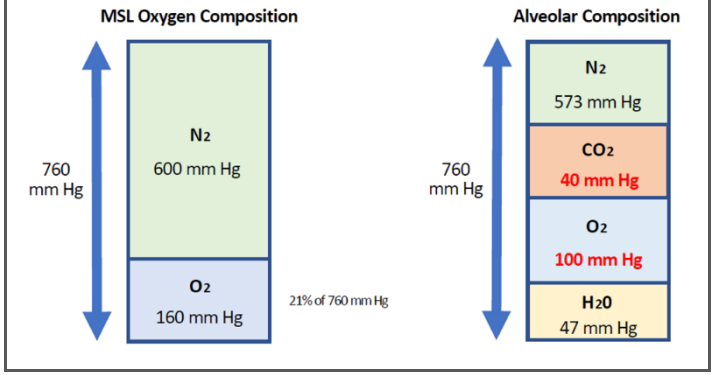
METABOLIC PROCESS

- O2 + Food = CO2, Energy + Water
- Respiration allows O_2 in and CO_2 out

LUNG VOLUME AND CAPACITY

- **Tidal** Volume (Normal Breath) **– 500ml**
- **Expiratory Reserve** (Extra Air Out) **– 1,000ml**
- **Inspiratory Reserve** (Extra Air In) **– 3,300ml**
- **Residual – 1,200ml**
- **Total – 6 litres** (male), **4.2 litres** (female)

AIR COMPOSITION



INTERNAL VS EXTERNAL RESPIRATION

- **Internal –** O_2 and CO_2 exchanged in **cells**
- **External –** O_2 and CO_2 exchanged in **lungs**

Hypoxia and Hyperventilation

BASICS

- **>10,000ft – Hypoxia** (O_2 Related)
- **<10,000ft – Hyperventilation** (CO_2 Related)
- **Hypoxia –** Condition of **insufficient** O_2 in the blood
- **Hyperventilation – Excessive rate** and **depth** of **respiration**

HYPOXIC HYPOXIA

- **Inadequate diffusion** of O_2 into the blood
- Caused by **altitude** (**Dalton's Law**)
  - *"Henry's sick (DCS), Dalton's hypoxic"*
- **<55mmHg** partial pressure of O_2 there is a **significant decrease** in mental function
- This occurs at **10,000ft** (normal and healthy individuals)
- **33,700ft – 100%** O_2 simulates **sea level**
  - Only effective up to **40,000ft** where **positive pressure** is required

HYPAEMIC HYPOXIA

- **Reduced carrying capacity** of the blood
- Caused by **Anemia**, **CO Poisoning** and **Smoking**

STAGNANT HYPOXIA

- **Inadequate circulation** of blood
- Caused by **heart attacks** or **positive G**

HISTOTOXIC HYPOXIA

- **Cells can't use O_2 effectively**
- Caused by **cell poisoning** (alcohol or drugs)

CARBON MONOXIDE POISONING

- **200x greater affinity** than O_2
- **Prevents haemoglobin** from **absorbing O_2**
- Colourless, odourless and tasteless gas
- Caused by **incomplete combustion**
- Can take **several days** to recover from

SIGNS AND SYMPTOMS

- **Signs –** Perceptible to others
- **Symptoms –** Experienced by the individual
- **Main Sign – Cyanosis** (**Blue** Skin)
  - **Impaired judgement** is the **most dangerous** sign
  - Also **impaired mental ability**, **muscle in-coordination** and **hyperventilation**
- **Main Symptom – Euphoria**
  - Also **tingling**, **reduced visual acuity** and **shortness of breath**
  - *Joint pain/suffocation feelings are NOT symptoms*

RISK FACTORS

- Tobacco
- Alcohol (1 ounce raises altitude by 2,000ft)
- Temperature
- Physical & Mental Activity

PREVENTION

- Avoid unpressurised flight >10,000ft
- Never fly >14,000ft without O_2
- Avoid risk factors

STAGES OF HYPOXIA

- **Indifferent Stage – 0-10,000ft**
  - **Night Vision** affected from **5,000ft**
- **Compensatory Stage – 10-15,000ft**
  - Hypoxic effects after *10-15 mins*
  - **Short-term memory** affected from **12,000ft**
- **Disturbance Stage – 15-20,000ft**
  - Body can ***no longer compensate***
- **Critical Stage – 20,000ft+**

TIME OF USEFUL CONSCIOUSNESS (TUC)

- Time from **interruption** of O_2 supply to **loss of ability** to take corrective action

Altitude	TUC
20,000ft	30 Minutes
25,000ft	2-3 Minutes
30,000ft	1-2 Minutes
35,000ft	30-90 Seconds
40,000ft	15-20 Seconds

- Times **reduced** with **moderate activity**

HYPERVENTILATION

- Causes **CO_2** levels to **decrease**
- Body becomes **too alkaline**
- **O_2**'s affinity to haemoglobin **increases**
- **O_2** then **doesn't diffuse** into cells

SIGNS AND SYMPTOMS

- Symptoms include **tingling**, **poor co-ordination**, **shortness of breath** and **deteriorated vision**
- Signs are like hypoxia **EXCEPT** cyanosis

High Altitude Environment

RADIATION

- May be **Terrestrial**, **Artificial** or **Cosmic** (including **Galactic** + **Solar**)
- Becomes a **risk above 49,000ft**
- Risk factors include **exposure time**, **high altitude** and **high latitude** (*in that order*)

RADIATION DOSAGE

- Flight crew are within **recommended dose** of **20 millisieverts** per year
- **Cumulative** and **total instantaneous dose** must be **recorded**

OZONE

- **Toxic** to humans
- **Radiation** causes **O_2** to form **Ozone** (O_3)
- This creates a **UV protective layer** in the atmosphere
- **UV-A –** Causes tanning (95% that reaches Earth)
- **UV-B –** Causes **skin cancer** (filtered better)
- **Negligible <40,000ft**
- **Peak** at **115,000ft**
- **Reduced >140,000ft**
- **UV concentration** is **higher** in **Winter**
- **Ozone converters** remove it from the cabin

HUMIDITY

- **Absolute Humidity –** Amount of **actual water vapour** in the air in **g/m^3**
- **Relative Humidity - %** of water vapour in the air vs maximum (saturated)
- Kept low on aircraft to avoid corrosion
- **Cabin – 10%**
- **Ideal Minimum – 20%**
- **Optimum – 40-60%**

PRESSURISATION

- **Cabin altitude** usually **6-8,000ft**
- In event of a **depressurization**, **oxygen mask** on **FIRST!**
- Then descend to **10,000ft/MSA**

Miscellaneous Problems

DRUGS

- **Antibiotics – Infections**
- **Antihistamines – Allergies**
  - Side effects include drowsiness, dry mouth, headaches and nausea
- **Analgesics – Pain Killers**
- **Nose sprays** contract blood vessels to ease congestion but this may **destroy mucus membrane**, cause **bleeding** & **drowziness**
- **Excessive aspirin** use can cause **gastric bleeding**
- **Packaging guidance cannot** be relied on for **pilots**

ANAESTHETICS

- **Local –** Wait **12** hours
- **General –** Wait **48** hours

ALCOHOL

- **Central Nervous System** (CNS) **Depressant**
- Degrades **judgement**, **G tolerance** and **sleep quality**, gives **spatial disorientation** and **blurry vision**
- Also **intensifies** effects of drugs (**synergistic**)
- **1 unit = 15mg/100ml** *(½ pint or glass of wine)*
- Damaging threshold is 28 units/week (male) or 21 units/week (female)
- **20mg/100ml** is the **limit for flying** but you should ***never fly under the influence of alcohol***
- '8 Hours Bottle to Throttle'
- Body removes **1 unit per hour** (**0.015%**)
- **Alcohol Abuse – Excessive** alcohol use that damages **physical**, **mental** or **social** life
- **Alcoholism – Dependency** on alcohol

SMOKING

- **Nicotine – Addictive**
- **Tar – Carcinogen**
- 20 per day (1 pack) **raises physiological altitude** to **4-5,000ft** and **reduces oxygen capacity** by **5-8%**
- This is due to **Carbon Monoxide** poisoning

CAFFEINE

- **CNS Stimulant** and **Vasodilator**
- Improves **alertness**, **thought** and **muscle co-ordination**
- **Performance** affected **>250mg**
- This causes **muscle tremors**, **rapid heart rate**, **excessive urination** and **irritability**

TOXIC MATERIALS

- On contact with skin, wash with **copious amounts of water**
- Should not initially use soap (except fuel)
- **Mercury** is **prohibited** on aircraft as it is **highly reactive**

HEALTHY DIET

- **Breakfast** provides **25% of daily caloric intake**
- **Hypoglycemia –** Low Blood Sugar
  - Can cause dizziness/fainting
  - Avoided by a balanced diet and small snacks between meals

DISEASES

Disease	Source
Malaria	Mosquitos (World's Biggest Killer)
Yellow Fever	Mosquitos
Dengue Fever	Mosquitos (By **Day**)
Hepatitis B/C	Contaminated Needles/Sex
Tetanus	Open Wounds
Tuberculosis	Coughs and Sneezes
Rabies	Animals (**120 Day Incubation** Period)
Cholera	Contaminated Food & Water
Typhoid	
Dysentery	
Hepatitis A	

- If symptoms exceed 72 hours, seek help!
- Cabins may be sprayed with insecticide **30 minutes** before landing

COLDS/FLU

- Can **block** the **Eustachian tube**
- *See Atmosphere (Otic/Sinus Barotrauma)*
- Other middle ear problems include **pressure vertigo**, **ringing** in the ears and **temporary hearing loss**

INCAPACITATION

- **Gastrointestinal** is the most common cause
- **Subtle** (**Insidious**) **–** Appears OK **externally**
  - **Most dangerous** type
- **Obvious –** Spotted **immediately**
- A partially incapacitated pilot *should not fly*
- If possible, crew should eat different meals

Miscellaneous Problems

OBESITY

- **BMI = $\frac{\text{Weight (kg)}}{\text{Height (m)}^2}$**
  For females, subtract 1
- **<18.5 – Underweight**
- **18.5-25 – Normal**
- **25-30 – Overweight**
- **30+ - Obese**
- Caused by **high caloric intake**
- **High fat levels** cause **poor circulation** and subsequent **coronary heart problems**, **reduced hypoxia/DCS tolerance**, **low G tolerance** and **type 2 diabetes**
- Extra weight also causes **arthritis**
- Prevented by **reduced caloric intake** mainly, **exercise** can also help

EXERCISE

- Should **double** the **heartrate** for **20 minutes**, **3 times a week**
- Could cause **muscle** and **abdominal cramps** caused by dehydration in high temps

DIABETES

- **Insulin –** Hormone that enables cells to absorb **glucose**
- **Type 1 – "Insulin Dependent"**
  - **Not enough insulin** is produced
  - Requires an **epi-pen**
  - **Disqualifying** for pilots
- **Type 2 – "Non-Insulin Dependent"**
  - **Cells do not respond** properly
  - **Obesity** is the **biggest cause**
  - Causes **high blood sugar** (hyperglycemia)
  - **Usually disqualifying**

FIT VS FAINT

- **Fit – Electrical disturbance** in the brain
  - a.k.a **Seizure**
  - Usually detected by an EEG
- **Faint – Reduction in blood sugar** to part of the brain
  - a.k.a **Syncope**

BACK PROBLEMS

- Tension/Fatigue of Lower Back Muscles
- Slipped Disc
- Different Lengths of Lower Extremities
- **Lumbar support** can prevent back pains by allowing the spine to curve properly

Visual System

PURPOSE

- Takes in light rays
- Focus rays on the **retina**
- Convert light into **electrical signals**
- Used for **70-80%** of **knowledge acquisition**

PARTS OF THE EYE

- **Cornea**
  - **Protects** the eye
  - **70%** of the **focusing**
  - **Fixed**
- **Lens**
  - **30%** of the **focusing** (***16-30*** *diopters*)
  - **Adjustable**
- **Pupil –** Controls **amount of light** entering
- **Iris –** Controls the **size** of the **pupil**
  - Contained in the **uvea**
- **Retina –** Converts light to **electrical signals**
  - Consists of **rods** and **cones**
- **Optic Nerve –** Sends signals to the brain
- **Vitreous Humour –** Tissue filling the eyeball

RODS

- Used for **greyscale** vision
- **Scotopic** Vision
- Provide vision in **dim light**
- Found round the **edges** of the eye

CONES

- Used for **colour** vision and **visual acuity**
- **Red**, **green** and **blue**
- **Colour-blindness** caused by **imperfections**
- **Photopic** Vision
- Provide vision in **bright light** (daytime)
- Found in the **centre** of the retina (**fovea**)

VISUAL ACUITY

- Measure of clarity of vision
- **Best acuity = 2-3°** from the fovea
- Reduces **rapidly** toward the **periphery**
- **Normal** vision = **20/20**
- Can discriminate between 2 different points under an angle of 1 arc minute from 20ft

ADAPTATION

- **Pupil widening –** controlled by **iris**
  - Pupil is **wide** in **dark** environments
- **Rhodopsin** (***Visual Purple***) aids **night vision**
  - Takes **30-45 mins** for **rods** to adapt
  - **White light bleaches** it
  - **Vitamin A produces** it
- **Hypoxia** reduces night vision from **5,000ft**
  - **Rods** are therefore **most susceptible**
  - **Hypaemic hypoxia** also causes this as a result of **smoking**
- **10 secs** needed to adapt to **bright light**

ACCOMODATION

- **Lens bending –** effected by **ciliary** muscles
  - Lens goes **flat** for **distant** objects

BLUE/UV LIGHT

- May **damage** the **lens** or **retina**
- **Higher energy** than other light

BLIND SPOTS

- **Day – No rods/nerves** on the **optic nerve**
  - **Binocular vision/moving head** fixes this
- **Night – Inactive fovea** due to low light
  - **5-10° blindspot**
  - Therefore look to the **sides** of an object

EMPTY FIELD MYOPIA

- Eye naturally focuses to **1.5-2m away**
- Makes it hard to detect traffic
- Try and focus on an objects **beyond 6m**

SACCADIC EYE MOVEMENT

- **Cones don't function** when the eye is moving (**a saccade**)
- When scanning, wait **3-5 seconds** to adjust

HIGH LIGHT LEVELS

- **Flash Blindness –** From lightning/strobes
- **Flicker Vertigo –** From propellers/helicopter rotors

SUNGLASSES

- **Polarized** sunglasses **not used** for flying
- **Photochromatic** sunglasses are **useless** as flight deck windows block the UV they need

BINOCULAR VISION

- Uses **both eyes** for **distance** and **depth**
- **Stereoscopic –** Images are added together
- **Convergence –** Eye swivel gives cues

MONOCULAR VISION

Vision with 1 eye achieved by:

- **Size of retinal image –** prior experience
- **Obscuration**
- **Motion parallax –** Close objects move faster
- **Texture –** Close objects have more detail
- **Atmospheric Perspective -** Distant objects appear hazy
- **Linear Perspective –** Parallel lines converge

MYOPIA

- "**Shortsightedness**"
- Can only see **close** objects
- Image forms in **front** of retina
- Corrected with a **concave** lens
- Caused by long eyeball/too much bending

HYPERMETROPIA

- "**Farsightedness**"
- Can only see **distant** objects
- Image forms **beyond** retina
- Corrected with a **convex** lens
- Caused by short eyeball/not enough bending

ASTIGMATISM

- **Unequal curvature** of the **cornea/lens**
- **Cannot focus** on **2 planes** at the same time
- Corrected with a **cylindrical** lens

PRESBYOPIA

- **Hardening** of the lens with **age**
- A form of **hypermetropia**
- Usually occurs when **older than 40**
- Pre-existing conditions may **delay** (***myopia***) or **accelerate** (***hypermetropia***) onset

GLAUCOMA

- **Rise** of the **internal pressure** of the eye
- Causes **visual field narrowing**, **pain** & eventually **blindness**
- **Insidious** onset (initially undetected)

CATARACTS

- **Clouding** of the lens
- Leads to **vision loss** unless lens replaced

RUNWAY WIDTH ILLUSIONS

- **Wide Runway = Looks Low**
  - **High, Steep Approach**
  - **Early Flare**
- **Narrow Runway = Looks High**
  - **Low, Flat Approach**
  - **Late Flare**

RUNWAY SLOPE ILLUSIONS

- **Downslope = Looks Low**
  - Causes an **approach** that is **too high**
- **Upslope = Looks High**
  - Causes an **approach** that is **too shallow**

APPROACH TERRAIN

- **Upsloping** terrain makes you feel **high**
  - Causes an **approach** that is **too shallow**
- **Downsloping** terrain makes you feel **low**
  - Causes an **approach** that is **too high**

TAXI ILLUSIONS

- Being **high up** makes you **feel slower**
- **Other moving aircraft** nearby will make you **feel like you are moving**

BLACK HOLE EFFECT

- Causes a temptation to fly a **low approach**

WHITE OUT

- **Snowy ground** & **white clouds merge** and the horizon is **obscured**
- May cause **Controlled Flight into Terrain** (**CFIT**)

LIGHT INTENSITY

- **Bright** Lights appear **Closer** = **Low** Approach
- **Dim** Lights appear **Further** = **High** Approach

RAIN, HAZE AND MIST

- **Rain** on the **windshield** causes light to refract making you appear **high**
- **Rain/haze/mist** has the same effect and lights feel **dimmer** (**higher approach**)
- **Shallow** fog layers may make you think you are **high** as **distant lights disappear**

AUTOKINETIC ILLUSION

- **Static** lights appear to **move** when stared at

SPECTACLES

- **Half-Moon –** Aid near vision only
- **Bifocal –** Corrects near and far vision
- **Varifocal –** Not advised due to peripheral distortion

Hearing and Noise & Acceleration and Balance

HEARING AND NOISE

INTENSITY

- Hearing range is **20Hz – 20kHz**
- Intensity measured in **decibels** (dB)
- **Pain threshold** is **140dB**
- Uses a **logarithmic** scale

DURATION

- Effects depends on **loudness**, **length of exposure** and **frequency**
- **Steady State – Continuous** noise
- **Impulse – Sudden** noise

ANATOMY

- **Outer Ear – Auricle** (*Pinna*), **Auditory Canal** and **Ear Drum** (***Tympanic Membrane***)
- **Middle Ear – Ossicles** (*tiny bones*)
- **Inner Ear – Cochlea** and **Eustachian Tube** and **Semi-Circular Canals**

RATES

- **Listening Rate – 500 words** per minute
- **Speaking Rate – 125 words** per minute

HEARING LOSS

- **Conductive Hearing Loss –** Sound does not reach **inner ear**
- **Sensorineural Hearing Loss –** Due to **cochlea damage** (*sensory hairs/nerve fibres*)
  - Treat with surgery, hearing aids & meds
- **Noise Induced Hearing Loss** (**NIHL**) results from **damage** to the **cochlea hair cells**
  - **No pain** occurs
  - From **high intensity** or **long duration**
- **Acoustic Trauma – Sudden** exposure to loud noise (>140 dB)
- **Gradual NIHL – Repeated** exposure (>90dB) and usually **insidious**
- **Presbycusis –** Hearing loss with **age**
  - Causes loss of **high** tones **first**
  - Either **conductive** or **NIHL**

ACCELERATION AND BALANCE

TYPES OF ACCELERATION

- **Linear –** In a **straight** line
  - e.g Take Off/Crashes
- **Angular –** Changes in **angular velocity**
  - e.g Aircraft Spin
- **Radial –** Toward the **center** of a circle
  - e.g Loop

AXES OF ACCELERATION

- **+Gz – Positive G** (**Radial**)
  - e.g Loops/Spiral Dive Recoveries
  - ***Most significant*** for pilots
- **-Gz – Negative G** (**Radial**)
  - e.g Pushovers
- **+Gx – Transverse Forwards**
  - e.g Take-Off
- **-Gx – Transverse Backwards**
  - e.g Braking
- **Gy – Lateral** (*Rare in flight*)

SHORT DURATION ACCELERATIONS

- Acts for **less than 1 second**
- **Maximum +25G Vertical (Gz)**
- **Maximum ±45G Transverse (Gx)**

LONG DURATION ACCELERATIONS

- Acts for **more than 1 second**
- **3.5G – Tunnel Vision/Grey Out**
- **4.5G – Black Out**
- **Negative G** is **not well tolerated**

TOLERANCE FACTORS

- Experience/Training
- Anti-G Suit
- Duration of Exposure
- General Health
- Seating Position (**Supine**)
  - Best tolerance when **distance** between **heart** and **brain** is **minimized**

HARNESS TYPES

- **4 Point** Harness – **Danger** of **submarining**
- **5 Point** Harness – **Prevents submarining**

SPATIAL ORIENTATION

VESTIBULAR APPARTUS

- **3x Semi-circular Canals** and **2x Otoliths**
- Located within the **inner ear**

SEMI-CIRCULAR CANALS

- Senses **angular acceleration** (**pitch/yaw/roll**)
- If angular velocity is **constant**, **no acceleration** is sensed

OLIOTH ORGANS

- Senses **linear acceleration** and **gravity**
- **Horizontal** Plane – **Utricles**
- **Vertical** Plane – **Saccules**
- **Chalk like crystals** that sit on top of a **jelly**
- Acceleration causes them to move

SOMATOSENSORY SYSTEM

- Senses the **seat of the pants** feeling
- **Subcutaneous receptors** sense **pressure** on the **skin**
- **Proprioceptors** sense **relative motion** and **position of body parts**
- **Only useful** flying in **VMC**

SPATIAL DISORIENTATION

SOMATOGYRAL ILLUSIONS

- **3D Illusions**
- Within the **semi-circular canals**
- Includes the **leans**, **graveyard spin** and the **Coriolis illusion** (**vertigo**)
- **Leans –** Perceiving the aircraft **attitude** as being **different from reality**
  - Caused by a movement **below sensory threshold**
- **Graveyard Spin – Spin recovery** that results in **spin in original direction**
- **Graveyard Spiral – Normal rollout** that results in a **tightening turn**
- **Coriolis** (**Vertigo**) **– Head tilted** upwards/downwards (***especially whilst turning***) giving a **tumbling sensation**

SOMATOGRAVIC ILLUSIONS

- **2D Illusions** (Take-Off and Landing)
- Within the **otolith organs**
- Includes **pitch up/down illusion**, **elevator illusion** and **inversion illusion**
- **Pitch up illusion – acceleration** feels like a **climb**
- **Pitch down illusion – deceleration** feels like a **descent**
- These may also cause an **oculogravic illusion** – apparent upward/downward movement and displacement of object
- **Elevator illusion** is caused by **turbulence** when…
  - Aircraft goes **up – climb** is felt
  - Aircraft goes **down – descent** is felt
  - Temptation is then to **overcorrect** this
- **Inversion illusion –** Abrupt change from climb to straight and level creates the illusion of **tumbling backwards**

PROPRIOCEPTIVE ILLUSIONS

- **Entering turn** is sensed as a **climb**
- **Exiting a turn** is sensed as a **descent**

MANAGING ILLUSIONS

- **ALWAYS TRUST YOUR INSTRUMENTS!**

MOTION SICKNESS

- Caused by **disagreement** between the **visual** and **vestibular system**
- **Vibration** of **1-100Hz** can **cause resonance** in the **vestibular system**
- Symptoms include **restlessness**, **increased saliva**, **cold sweat**, **dizziness**, **nausea** and **headache**
- Treated by **minimizing head movements** and **fixing gaze on a stable horizon** (or **rest head on back of seat** with **eyes closed**)
- **Supplemental Oxygen**, **opening air vents** and **loosening clothing** also helps
- Prevented with **avoiding medication** and **alcohol** and **continued exposure**

SENSING VS PERCEPTION

- We sense **stimuli** as just **raw data**
- Perception involves **interpreting** **raw data** to give it **meaning**
- Based on our **mental models** (past experiences and learning)
- Stimuli stored in **sensory memory**
  - **Iconic** Memory – **Sight** – **0.5-1 second**
  - **Echoic** Memory – **Hearing** – **2-8 seconds**
- **Gestalt Laws –** govern how objects are **mentally organized/perceived**

TYPES OF PERCEPTION

- **Bottom Up –** From **sensory information**
- **Top Down –** From **experience**/**expectation**
- Means perception varies between individuals

PERCEPTION ILLUSIONS

- When there is a **difference** between what is **perceived** and what is **reality**
- **Individuals** and **Groups** are affected
- Treated as **threats** that **should be managed**

ATTENTION

- **Concentrating** on a **stimuli/thought**
- **Wickens' Theory –** Information perceived by **multiple** **senses** more likely to get attention
- Guided by the **level of autonomy**, **expectations** and **salience** of information

TYPES OF ATTENTION

- **Goal driven –** Directed to what we feel is most appropriate
- **Stimulus driven –** Physical properties of stimuli attract attention
- **Divided Attention –** Execute **several activities** at the same time
- **Selective Attention –** Focusing on **1 stimulus** due to **limited** **capacity**
- **Blinkered Attention –** Concentrating on 1 specific thing
- ***Can't*** *do* ***2 attentional tasks*** ***simultaneously***

VIGILANCE

- Giving **sustained** **attention** to something to notice a non-ordinary event
- Affected by **task**, **motivation**, **physiological** and **environmental factors**
- We naturally divert our attention as relief
- **Hypovigilance** **–** **Reduction** in vigilance
- Brought about by **monotony**, **lack of stimulation** and **fatigue**
- Managed by **aircraft interactions** and **in-flight rest**

SHORT-TERM MEMORY

- a.k.a "**Working Memory**"
- Involved in the **decision-making process**
- **Finite** capacity of **5 items ± 2**
- Will be **forgotten** after **10-20 seconds**
- **Sensitive** to **disturbances**
- Requires **attention**
- **Improved** by **chunking/mnemonics**

LONG-TERM MEMORY

- **Infinite capacity** and **permanent**
- **Does not** require **attention**
- **Influenced** by **suggestion/expectation**
- **Degrades** if information **not** **regularly** **retrieved** or **few** **associations**

TYPES OF LONG-TERM MEMORY

- **Episodic** Memory – Specific Lifetime **Events**
  - **Easily** **influenced**
- **Semantic** Memory – **Facts**
  - **Lasts** **longer** than episodic memory
- **Procedural** Memory – **Actions/Skills**
  - Includes **motor programmes**

MOTOR PROGRAMMES

- a.k.a **"Mental Schemes"**
- **Stored routines** completed **automatically**
- Learnt by **repetition** in **cognitive**, **associative** and **automatic** **phases**
- **Errors** include **action slip** and **environmental capture**

AUTOMATIC VS CONSCIOUS PROCESSING

Conscious Processing

- **Working memory** used to make **decisions**
- **Requires** **attentional resources**

Automatic Processing

- A **motor program** from **long-term memory**
- a.k.a "**Behavioural Sub-routine**"
- **Does** **not** require **attentional resources**

SITUATIONAL AWARENESS

- When **perception = reality**
- **Levels of awareness** include **Monitor**, **Evaluate**, **Anticipate**
- Used in **TEM** as **countermeasures**

Personality and Behaviour

PERSONALITY VS BEHAVIOUR

- **Personality – Who We Are**
  - **Stable** characteristics
  - **Fixed** by **age 7**
- **Behaviour – What We Do**
  - **Modifiable**
  - **Controllable** **display** of **personality**
  - **More important** than **personality**

MEASURING PERSONALITY

- **Projective tests**, **handwriting analysis** and **interviews** all accepted methods
- **Best** **method** is **personality tests**

PERSONALITY CATEGORIES

- **Introvert** or **Extrovert**
- **Stable** or **Unstable** (Anxious)
- **Average Pilot** is **stable** and **extroverted**

INFLUENCES ON BEHAVIOUR

- **Personality + Attitudes = Behaviour**
- Influenced by **social norms**, **faith** & **culture**

SELF CONCEPT

- ***"The way we see ourselves"***
- **Ideal Self –** how we **want** to see ourselves
- **Motivation –** From a **difference** between **self-concept** and **ideal self**
- **Anxiety – Ideal self** seems **unattainable**
- **Under-confidence** leads to **aggression**/**assertiveness**

SELF DISCIPLINE

- Ability to control our own behaviour

RASMUSSEN TYPES OF BEHAVIOUR

- **Skill Based –** Use of **motor programmes**
  - Prone to **action slips** and **environmental capture**
- **Rule Based –** Following learnt **procedures**
  - **Errors** may be in the **rule itself**, the **application** (error in ***technical knowledge***) or using the **wrong rule**
  - Used if **automated** behaviour unsuitable
- **Knowledge Based – Knowledge** and **experience** used to determine action
  - Associated with problem solving
  - Used if **rule-based** behaviour unsuitable

OTHER TYPES OF BEHAVIOUR

- **Passive –** Putting needs of **others** first
- **Assertive –** Active listening, assured manner
- **Aggressive –** Putting **own** needs first
- **Invulnerability –** Accidents happen to others
- **Macho –** Trying to prove they're the best
- Other hazardous attitudes include **anti-authority**, **impulsivity** and **resignation**

LEADERSHIP

- Psychologists measure styles as either **task** or **relationship** **oriented**
- **Ideal** leaders are **both**
- **Paternalistic –** Acts as a **father** figure

COMMUNICATION

- Depends **heavily** on the **sender**
- Influenced by **workload**, **noise** and **voice**
- **Feedback –** *Measured/corrected* for meaning

VERBAL COMMUNICATION

- The **words** that are **said**/**written**
- **95%** of the communication on the flight deck

NON-VERBAL COMMUNICATION

- **Body Language –** Facial Expressions, Gestures and Posture
- **Paralanguage –** Pitch, Tone and Pauses

EXPLICIT VS IMPLICIT

- **Explicit – Clear** and unambiguous
- **Implicit –** Potentially **ambiguous**
- **Metacommunication –** Communication about communication
- Makes up **80%** of communication
- **Professional** **language** with **precise** words and **simplified grammar** used in aviation

CONFLICT

- **Intrapersonal –** Conflict within **one's self**
- **Interpersonal –** Conflict between **2+ people**
- **Levels of Interpersonal Conflict:**
  1. Positive Resolution
  2. Difference of Opinion
  3. Confrontation
  4. Fight/Flight
  5. Combat

GOOD COMMUNICATION SKILLS

- **Inquiry**, **Active Listening**, **Advocacy** and **Metacommunication**
- **Open** **questions** are preferred
- **Higher** **level conflict** dealt with through **negotiation** and **arbitration**

Stress

NERVOUS SYSTEM

OVERVIEW

- **Central Nervous System** (**CNS**) – **Brain** and **Spinal Cord**
- **Peripheral Nervous System** (**PNS**) – **Connects** everything to **CNS**

COMPONENTS

- **Neurons –** Conducting elements
- **Synapse –** Connection between neurons
- **Visual Cortex –** Where vision information is processed in the brain
- **Cerebellum –** Reflex center of co-ordination
- Signals travel **electrically** (*charged molecules*) along the **axon** and **chemically** across the **synaptic gap**

AUTOMATIC NERVOUS SYSTEM (ANS)

- Part of the **PNS**
- **Unconsciously** regulates bodily functions
- **Homeostasis** – Body's state of **equilibrium**
- Maintained through the **ANS**

STRESS

CLASSIFICATIONS

- **Eustress – Good** stress giving increased energy and ability to deal with it
- **Distress – Bad** stress giving a feeling of being out of control and unable to cope
- **Acute – Short** term as a result of a sudden unexpected event
- **Chronic – Long** term caused by something continuing for a long period

STRESSORS

- **External**/**internal stimulus** causing **stress**
- Dependent on an individual's **subjective evaluation** of a situation & **ability to cope**

PHYSICAL (ENVIRONMENTAL) STRESSORS

- **Comfortable** environment ≈ **20°C**
- **30°C+ - Uncomfortable**
- **Adaptation** to a hot country takes **14 days**
- **Noise**, **low humidity**, **vibrations** and **UV radiation** are also factors

BODY TEMPERATURE

- **39°C+ – Impaired mental/physical** performance
- **37°C - Normal** core temperature
- *Below this,* ***reasoning problems*** *start*
- **35°C - Hypothermia** starts
- **32°C - Shivering stops** and **apathy starts**
- **Apathy** is the **most dangerous** symptom!

TEMPERATURE REGULATION

- **High Temperatures – Vasodilation** and **Sweating**
- **Low Temperatures – Vasoconstriction** and **Shivering**

PHYSIOLOGICAL (LIFE) STRESSORS

- Events in **everyday life**
  1. Death of a Spouse
  2. Divorce
  3. Death of a Close Family Member
- In order of the **worst effects**

REACTIVE STRESSORS

- Body's reaction to **specific events**
- Often trigger fight/flight response

ORGANIZATIONAL STRESSORS

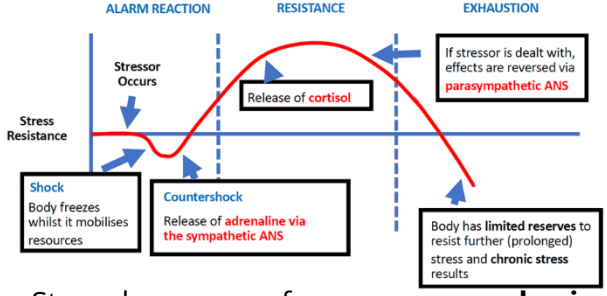
- Stress arising from **company**/**organization**
- *e.g Career Development, Management etc.*

PHYSIOLOGICAL STRESS MODEL

- Stress occurs when **perceived demand outweighs perceived ability**

GENERAL ADAPTATION SYNDROME (GAS)

- Model of the body's **ANS** response to stress



- Stress has **more** of a response on **physical** than **mental** performance
- **Adrenaline -** Causes **glucose** to be released
- **Cortisol -** Converts **fat** to **sugar**

CHRONIC STRESS

Effects include….

- **Somatic** (**Physiological**) including frequent illness, muscle tension and appetite changes
- **Psychosomatic** – **Somatic** (physiological) or **Psychosomatic** (psychological stress)
- **Psychological –** Depression, anxiety etc.
- Overcome with **counselling**, **fitness** and **relaxation techniques**

Stress & Decision Making

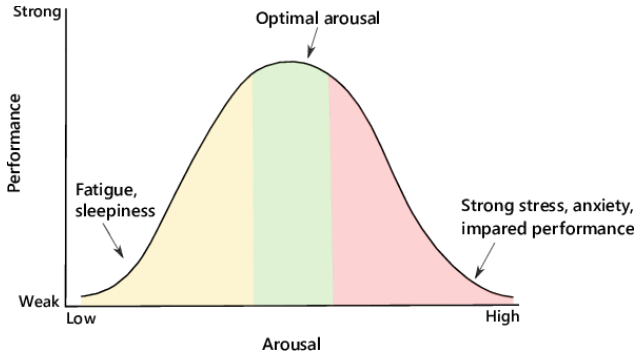
ANXIETY

- Feeling of **unease** (from **mild** to **severe**)
- May cause stress but is **never** **healthy**
- **Physiological** effects include **sweating**, **dry mouth** and **fast breathing**

AROUSAL

- State of being **alert/ready for action**
- Influenced by **fatigue**, **workload**, **stress**, **motivation** and **vigilance**

Inverted U Curve (Yerkes Dodson)



- **Breakpoint –** Where **further** arousal will **decrease** **performance**
- **Optimum** **Arousal –** **Ideal** level of arousal that gives the **best** **performance**

OVERLOAD

- **Excessive** arousal levels that **reduce** **performance**
- Symptoms include **increased errors**, **task fixation**, **rushed actions** and **communication reduction**
- **Significant** **overload** symptoms are of **aggression**, **withdrawal** & **reversion to type**

DECISION MAKING

BIASES

- **Confirmation Bias –** Seeking out info that **confirms** what we **already think**
- **Satisficing –** Picking the **first good enough** option rather than the best
- **Recency Bias –** More weight is given to **recent information**
- **Expectation Bias –** Believing that something is happening based on an expectation that it would be

DECIDE MODEL

- **Detect –** Recognize change has occurred
  - Susceptible to **confirmation bias**
- **Estimate –** Estimating the need to react
- **Choose –** Choosing a desired outcome
- **Identify –** Identifying solutions to achieve the objective
  - Susceptible to **satisficing**
- **Do –** Doing what needs to be done
  - Must ensure someone is flying!
- **Evaluate –** See if the decision that was made was correct

GROUP TYPES

- **Primary** **Group –** Close-knit and intimate (e.g family)
- **Secondary** **Group –** Impersonal and temporary (e.g cockpit crew)

ROLE VS STATUS

- **Role –** Associated functions and behaviours
- **Status –** Hierarchical position

GROUP DECISION MAKING

- Group performance is **better** than the average individual
- Benefit from each-others **KSA**
- **Cooperation –** Working together towards a common goal
- **Cohesion –** Team bond (*team spirit*)
- **Co-action –** Motivated by the presence of others to perform better

Affected by….

- Group Think (Members agree with a leader)
- Ability
- Status and Role
- Persuasion and Conformity
- Obedience (compliance without question)
- Risky Shift (groups make riskier choices)
- Group Norms

IMPROVED DECISION MAKING

- **Assertiveness** is considered the **most important** **attribute**
- Other attributes include **explaining decisions**, using **open questions** and **asking others** first

Automation & Fatigue and Sleep

AUTOMATION

ADVANTAGES

- **Reduces workload**
- **Improves minima**
- **Improves accuracy**
- **Saves fuel**

DISADVANTAGES

- **Reduced Situational Awareness**
- **Loss** of **Basic Flying Skills**
- **Hard** to make **Last Minute Changes**
- **Mode Awareness** - Knowing what systems are doing and what they should be doing

COMPLACENCY

- **Passive Monitoring – Watching** the autopilot but **not thinking** about it
- Prevented by regarding the autopilot as an **additional crew member**

IRONY OF AUTOMATION

- Automation requires an **increased** amount of monitoring

AUTOMATION AND COMMUNICATION

- **Aural/visual** alerts **reduce** communication
- Still just as important!

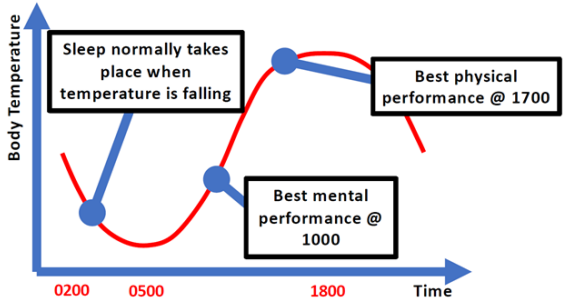
FATIGUE AND SLEEP

FATIGUE

- **Physiological state** of **reduced mental/physical** performance
- Caused by **sleep loss**, **physical exercise**, **duty time**, **poor health** and **jet lag**
- **Acute** (short-term) or **Chronic** (long-term)
- **Chronic fatigue** is the **most dangerous**
- Symptoms include mood swings, slow reactions, more errors, short term memory problems and tunnel vision
- Prevented by good quality/quantity of sleep, exercise, balanced diet and stress control

CIRCADIAN RHYTHM

- Cycle that **regulates physiological processes** ("Body Clock")
- Triggered mainly by **daylight/darkness**
- The "**free-running**" rhythm (no triggers) is closer to **25 hours**
- Also serves to **regulate body temperature**



- **Lowest Body Temp – 5am**
- **Window of Circadian Low (WOCL) – 2-5am**

SLEEP STAGES

- **5 Stages** – Stages 1-4 and REM Stage
- Cycles through all the stages in **90 mins**
- **Stages 1-4 – Orthodox** (Body Restoration)
  - **Stage 2 – 50%** of sleep
  - **Stage 3-4 – Slow Wave**
- **Rapid Eye Movement (REM) Stage – Paradoxical** (Memory Organization)
  - Responsible for dreams
  - Gets **longer** with each cycle
  - **4-5 REM periods** each night
  - **Degraded** with alcohol

SLEEP CREDIT SYSTEM

- **1hr sleep - +2 points**
- **1hr awake - -1 point**
- **Maximum credits = 16**

JET LAG

- **Circadian Dysrhythmia/Trans-meridian Desynchronization**
- Caused when **body clock** is **out of sync**
- Body synchronizes **1-1.5hrs per day**
- For **stopovers <24hrs, stay on home time**
- **Eastbound – Harder to adjust**
- **Westbound – Easier to adjust**

Fatigue and Sleep & Learning

SLEEP MANAGEMENT

- No flying within **12hrs** of taking **melatonin**
- **Alcohol reduces** sleep **quality**
- **Optimum nap length** is **20 mins**
- **Nap recovery** is **up to 20 mins**
- **Microsleep – Uncontrolled** nodding-off
- Does **not** increase **sleep credit**

DISORDERS

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

LEARNING

TYPES OF LEARNING

- **Operant Conditioning –** Connection between behaviour and the consequence
- **Classical Conditioning –** Stimulus triggers a behavioural response
- These are **behaviouristic** approaches
- **Observation/Imitation –** Learning behaviour through **watching others**
  - A **modelling** approach
- **Insight – Seeing and understanding**
  - A **cognitive** approach

MOTIVATION

- **Most important factor** on ability to **learn**
- **Maslow's Hierarchy of Needs** describes that to reach full potential basic needs (**safety** and **security**) must first be met
- **Herzberg's Theory** says motivation is based on proper **hygiene needs** being met and proper **motivators** being in place
- **Job satisfaction** may be achieved by **enlargement** (more roles/responsibilities) or **enrichment** (involvement in decision making)

LEARNING A SKILL (ANDERSON MODEL)

1. **Cognitive Phase –** Understanding the theory
   - "Declarative Knowledge"
2. **Associative Phase –** Practicing the skill
   - "Knowledge Compilation"
3. **Automatic Phase –** No conscious thought
   - "Procedural Knowledge"