HUMAN PERFORMANCE

MEDICAL

DISPOSITION

- Fit / Unfit / Referred

SEEK AME ADVICE

- Hospital > 12 Hrs
- Surgical Operation / Invasive Procedure
- Regular use of medication
- Regular use of correcting lenses

MUST ADVISE AUTHORITY IN WRITING

- Significant Personal Injury
- Illness > 21 Days
- Pregnant

DONATION & NO FLY

- Blood = 24 Hrs
  - Increases susceptibility to hypoxia
- Bone = 48 Hrs

ERRORS

FACTS

- GPWS is the main contributor to aviation safety in recent years.
- 70% of accidents have some human factors involved.

SAFETY CULTURE

- Safety culture is a **subset (influenced) by national culture.**

ERROR TOLERANCE

- When no **single error** can cause a failure.

ERROR CLASSIFICATION SYSTEMS

1. DESIGN & OPERATOR INDUCED

- **Design** – EG/ Poor Cockpit Ergonomics
- **Operator** – Inadequate performance from an individual
- Both can be further sub-divided into **active** (immediate effect) or **latent errors** (inherent within the system)

2. FAULTS AND SLIPS

- **Fault**
  - Intention - Wrong but satisfied
  - EG/ Incorrectly identifying the bad engine and shutting it down.
- **Slip**
  - Intention – Correct but not satisfied
  - EG/ Selecting flap lever instead of landing gear lever

3. OMISSION, COMMISSION & SUBSTITUTION

- **Error of omission**
  - Missing item on checklist
- **Error of commission**
  - Wrong decision
  - EG/ Takeoff without clearance
- **Error of substitution**
  - Wrong action taken instead
  - EG/ Slip

HUMAN PERFORMANCE

4. RASMUSSEN & REASON'S

- **Accidental**
- **Anticipation**
- **Compensation**
- **Transposition**

- **Sporadic Error** (Outlier)
- **Random Error**
- **Systematic Error**

ERROR MODELS

ERROR CHAIN

- **4 -> 7** links typically lead to an accident.

1. SWISS CHEESE

- Successive layers protect against those hazards which have slipped through previous levels.

2. SHEL(L) MODEL

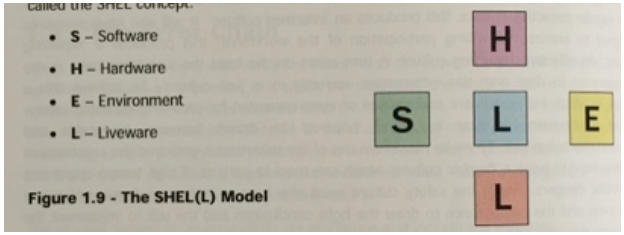


Figure 1.9 - The SHEL(L) Model

TEM

THREATS / ERRORS

- **Threats –** External, beyond the influence of the flight crew.

- **Error** – Actions / intentions by the flight crew.

↓

UAS

- **Undesired Aircraft State**

↓

COUNTERMEASURE

- **Hard** – Part of system which is present before the crew report for duty.

- **Soft** – Human contribution during flight.

ATMOSPHERE

COMPOSITION

- Nitrogen – 78%
- Oxygen – 21%
- Other Gases – 0.95%
- Carbon Dioxide – 0.03%

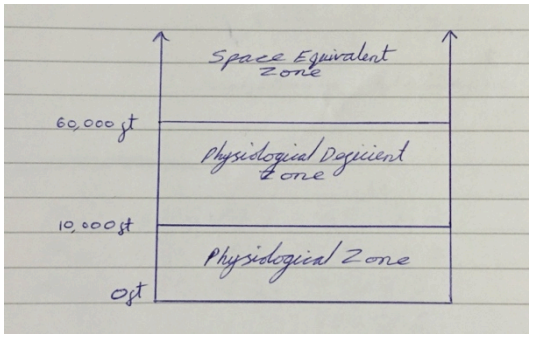
Altitude	Pressure	PP O_2
MSL	760 mmHg	103 mmHg
10,000 ft	500 mmHg	55 mmHg
18,000 ft	380 mmHg	-
33,700 ft	190 mmHg	103 mmHg *
40,000 ft	140 mmHg	55 mmHg *

* Obtained by breathing 100% O_2
> 40,000 ft O_2 required under +ve pressure

HUMAN PERFORMANCE

ZONES OF THE ATMOSPHERE

- **Physiological Zone**
  - 0 – 10,000 ft
  - Oxygen level sufficient
- **Physiological Deficient Zone**
  - 10,000 ft – 60,000 ft
  - Oxygen deficiencies begin
- **Space Equivalent Zone**
  - 60,000 ft +
  - 100% O_2 under pressure no longer sufficient
  - Oxygen deficiencies begin



GAS LAWS

- **Boyles Law** (Trapped gas expansion)
  - P X V = C
- **Charles Law**
  - V / T = C
- **Henry** – Gas under pressure | DCS
- **Dalton** – Partial Pressure | Hypoxia

TRAPPED GAS DISORDERS

TRAPPED GAS DISORDER

- Known as **Dsybarism**
- Prominent above 25,000 ft
- Occurs within:
  - Sinus's
  - Joints
  - Abdomen
  - Teeth
  - Ears

EUSTACHIAN TUBE

- Allows middle ear to equalise with ambient pressure during descent.

EVLOVED GAS DISORDERS - DCS

CAUSE

- Nitrogen released too quickly during rapid ascent and body becomes super saturated.

DCS EFFECTS

- Effects can occur upto **12 Hrs** after decompression
- **Bends** – Nitrogen bubbles in skin
- **Creeps** – Gas bubbles under skin
- **Chokes –** Shortness of breath
- **Staggers** – Bubbles affecting nervous system

DIVING

- **Snorkeling:** No Wait
- **Up to 30 ft:** 12 Hrs – 18 Hrs (multiple dives)
- **More than 30 ft:** At least 24 Hrs

TREATMENT

- Urgent medical advice
- Breathe 100% Oxygen
- Hyperbaric chamber

HUMAN PERFORMANCE

RESPIRATORY

BREATHING RATE

- Breathing is regulated by **amount of CO_2** in the blood.
- Too much CO_2 = Increased breathing
- Too little CO_2 = Decreased breathing

LUNG VOLUME

- **Average Male** – 5.5 Litres
- **Average Female** – 4.5 Litres

BREATING RATE

- **16 - 18 times per min**

LUNG VOLUME COMPONENTS

- **TV – Tidal Volume**
  - Air breathed in / out (~ 500 ml)
- **IRV – Inspiratory Reserve Volume**
  - Amount that be forcefully inhaled
- **ERV – External Reserve Volume**
  - Amount that be forcefully exhaled
- **RV – Residual Volume** (~ 1200 ml)

Total Volume = TV + IRV + ERV + RV

HEAT BALANCE

- Optimum 36.9^{0}C

BODY CHEMICAL BALANCE

- 7.2 → 7.6 pH
- Changes are sensed by respiratory centre of the brain

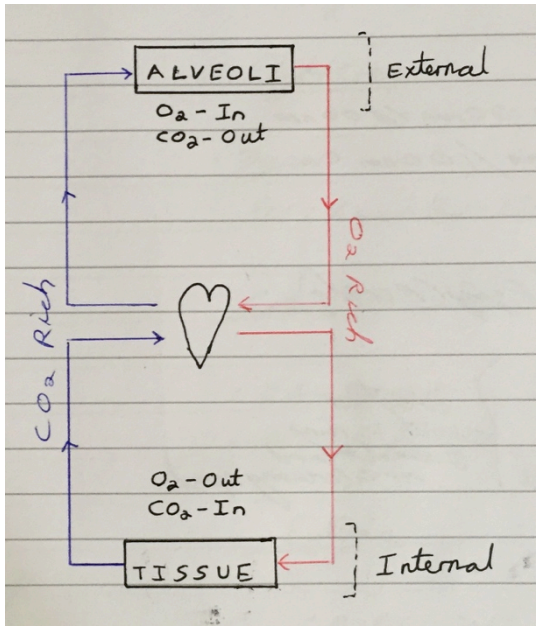
RESPIRATORY COMPONENTS

- **Nose** – Moistens, filters and warms
- **Larynx** – Voice box
- **Pharynx** – Back of the throat, humidifies air
- **Trachea** – Windpipe
- **Bronchi**
- **Alveoli**

FICKS LAW

- Rate of diffusion across a permeable membrane is directly proportional to the difference in partial pressures of the gas.

INTERNAL VS EXTERNAL



PULMONARY ALVEOLI

- **Alveoli** are tiny air sacks within the lungs
- Where the exchange of O_2 and CO_2 take place in external respiration.
- Within the alveoli, partial pressures are:
  - **Water Vapour:** 47 mmHg
  - **Oxygen**: 102 mmHg
  - **CO_2 :** 40 mmHg

HUMAN PERFORMANCE

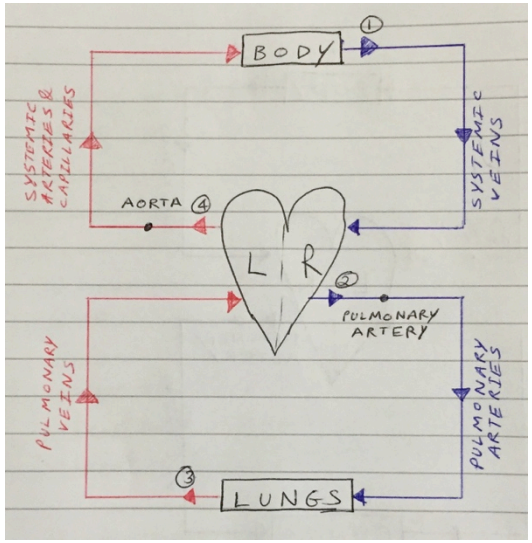
CIRCULATORY SYSTEM

CIRCULATORY SYSTEM

- **Veins** – Carry blood TO heart.
- **Arteries** - Carry blood FROM heart.

- Oxygen deficient blood from heart is transported to right side of heart via veins.
- Then pumped to the lungs via arteries where it picks up oxygen.
- Transported back to left side of heart via veins.
- Pumped from left side of heart to body via arteries.

- **Coronary Arteries** supply blood to the heart to keep it functioning.



COMPONENTS OF BLOOD

- **Plasma**
  - Transports CO_2, nutrients, hormones and waste products.

- **Red Blood Cells**
  - Carry oxygen

- **White Blood Cells**
  - Fight infections

- **Platelets**
  - Clot blood

HEART

CARDIAC OUTPUT

Cardiac Output = Stroke Volume x Heart Rate

- Stroke Volume = 70 ml
- Heart Rate = 70 times/min
- Average Output = 4.9 litres / min

BLOOD PRESSURE RATIO

- **Systolic Pressure** – Highest pressure obtained when the heart beats.

- **Diastolic Pressure** – Lowest pressure obtained when the heart rests.

- **Average Ratio = 120/80 mm Hg**

CIRCULATORY DISORDERS

- **Hypertension**
  - High blood pressure
  - Increases heart attack risk

- **Hypotension**
  - Low blood pressure

- **Angina**
  - Narrowing of the coronary artery
  - Results in reduced oxygen supply to some part of the heart muscle.

- **Infarct**
  - Blockage of the coronary artery
  - Normally leads to heart attack

- **Heart Attack**
  - Sudden inability of the heart to function

- **Anemia**
  - Reduction in number of red blood cells / haemoglobin

- **Faint / Syncope**
  - Reduction in supply of blood to the brain

- **Stroke**
  - Blood supply to part of the brain is cut off.
  - Ischemic – Blockage
  - Hemorrhagic – Burst blood vessel

- **Fit**

HUMAN PERFORMANCE

PRESSORECEPTORS

- Essentially a **blood pressure sensor**
- Located in the carotid and aortic arterial vessels
- When blood pressure is too low it:
  - Constricts vessels
  - Increase heart rate
  - Increase cardiac output

HYPOXIA

TYPES OF HYPOXIA

- **Hypoxic**
  - Not enough oxygen
- **Hypaemic**
  - Reduced oxygen carrying capacity of blood (can be caused by smoking)
- **Stagnant**
  - Inadequate blood circulation
- **Histotoxic**
  - Body not able to use oxygen effectively

STAGES

- **Indifferent –** SFC to 10,000 ft
  - Night vision deteriorates above 4000'
  - Cognitive deteriorates above 8000'
- **Compensating** – 10,000 ft to 15,000 ft
- **Disturbance** – 15,000 ft to 20,000 ft
- **Critical** – 20,000 ft to 25,000 ft

TUC

- **25,000 ft:** 2 -3 mins
- **30,000 ft**: 1 – 2 mins
- **35,000 ft:** 30 – 90 seconds
- **40,000 ft:** 15 – 20 seconds

SIGNS & SYMPTOMS

- **Sign –** Can be seen by others
- **Symptoms** – Felt by individual

- Bad things!
- Not aches / pains (DCS)
- Hyperventilation
- Cyanosis (Blue skin)

CO POISONING

- Haemoglobin within red blood cells normally carries oxygen around the body.
- Haemoglobin has a greater affinity to CO over Oxygen by **200 times.**

HYPERVENTILATION

CAUSE

- Breathing **too rapid**
- **Exhale too much CO_2**
- Blood PH rises and becomes **too alkaline**
- **Less oxygen can be diffused** into cells and they don't get the required level of oxygen

SIGNS & SYMPTOMS

- Similar to hypoxia however…
  - Tingling sensation in extremities
  - Clamy skin rather than blue with hypoxia
- Below 10,000 ft suspect hyperventilation rather than hypoxia.

TREATMENT

- Steady breathing
- Breathe into paper bag

HUMAN PERFORMANCE

RADIATION

TYPES

- **1. Galactic**
  - Majority of radiation
  - Steady with little variation
- **2. Solar**

- Crew receive roughly double amount of background radiation over a year.

CHANGES WITH ALTITUDE

- Both **increase with altitude**
- Records kept operating above **49,000 ft**

GEOMAGNETIC SHIELDING

- **Weakest at poles** as flux lines point straight downwards rather than parallel to surface.

OZONE

COMPOSITION

- **High concentrations of O_3**
- **Highly toxic** gas
- Created by action of **UV light on O_2** which then protects us from UV
- **Negligible below 40,000 ft**
- **Peak level 115,000 ft – 140,000 ft**

ABSORBPTION

- Absorbs 99% of UV light which is potentially damaging to life on earth.

- Absorbs UV-B better than UV-A (not as harmful)

DESTROYING OZONE

- Destroyed by heat
- Total destruction at 400^0C

REALATIVE HUMIDITY

VALUES

- **Optimum: 50%**
- **Minimum: 20%**
- **Certification: 30%**

- Cockpit can be as low **5 – 15%**

MEDICINE

DRUG TYPES

- **Antibiotics** – Fight bacterial infections
- **Antihistamines** – Fight allergies
- **Anti-hypertensives** – High Blood Pressure
- **Analgesics –** Pain Killers

ANASTHETICS

- **Local:** 12 Hrs No-Fly
- **General:** 48 Hrs No-Fly

ALCOHOL

LIMITS

- **Pilots: 20 mg / 100 ml**
- **Weekly Max: 28 Units (M) / 21 Units (F)**
- **Absolute Min:** 8 Hrs bottle to throttle

- 1 ounce = physiological altitude of 2,000 ft

- 1 unit (15 mg/100ml) processed each hour by the liver

PROCESS

- Absorbed through stomach wall into bloodstream
- Brain / CNS initially affected
- Speech / muscular activity affected next
- **0.05%** blood alcohol = Lack of coordination

SMOKING

SMOKING

- **Tar** → Cancer & Heart Disease
- **Nicotine** → Addictive
- 1 pack a day = **5 – 8%** O_2 capacity reduction

HUMAN PERFORMANCE

CAFFEINE

LIMITS

- **250 – 300 mg/day (Aircrew)**
- As little as 200 mg may reduce performance
- 1 cup ~ 75 mg

INCAPACITATION

TYPES

- **Obvious**
  - Silent
  - Overt
- **Insidious (Subtle)**

INCAPACITATION

- **Incidious** most dangerous
- **Takeover if:**
  - 2 failures to respond
  - 1 failure to respond with SOP deviation

GENERAL HEALTH

DIET

- **Carbohydrates** – Energy
- **Protein** – Muscle (Energy)
- **Fats –** Energy storage
  - ADEK – Fat soluble - Stored
  - BC – Water soluble – needed every day
- **Vitamins**
- **Minerals**
- Vegetables produce gas in the body

DIABETES

- **Insulin Dependent** - Permanent
- **Non-Insulin Dependent** - Temporary

BMI

$$BMI = \frac{Weight\ (kg)}{Height^2\ (m)}$$

- **Underweight**: < 18.5
- **Normal**: 18.5 – 25
- **Overweight**: 25 – 30
- **Obese**: > 30

STROKE VS FIT VS FAINT

- **Stroke** – Interruption of blood supply to brain
- **Fit** –Electrical disturbance in brain
- **Faint** – Reduced oxygen supply to brain (caused by too low blood pressure)

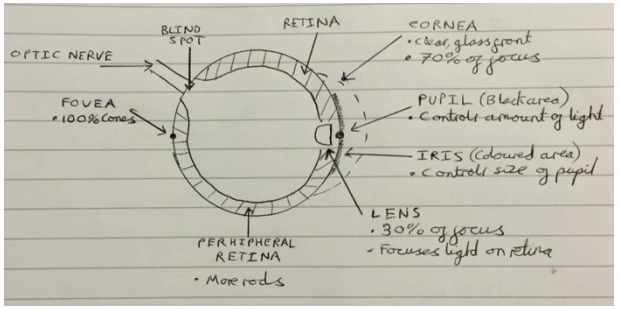
EXERCISE

- Double resting heart rate for 20 mins, 3 times a week

HUMAN PERFORMANCE

VISION

PARTS OF THE EYE



RODS VS CONES

- **Rods** – Peripheral & Monochrome - Scotopic
- **Cones** – Visual Acuity & Colour - Photopic
  - Best acuity therefore 2 – 3^0 of fovea
  - Decrease rapidly towards periphery
  - 3 classes - Red, Green, Blue
- **Day** – Rods & Cones
- **Night** - Rods

ADAPTATION

- Bright Light – 10 seconds
- Night Vision – 30 minutes
  - Allows visual purple to build up (bleached by bright light)

NIGHT VISION ADAPTATION

- Rods – 40 Mins
- Cones – 7 Mins

ACCOMODATION

- Ability of lens to change shape
- Focus on **near object**
  - Iris – Narrows
  - Lens – Fattens (More spherical)
- Focus on **far away object**
  - Iris – Widens
  - Lens – Flattens (Less spherical)

VISION PROBLEMS

DAY BLIND SPOT

- Due to blind spot at optic nerve
- Occurs when **one eye is covered**
- Can be caused by a pillar

NIGHT BLIND SPOT

- Cones which are not good for night vision are mainly present within 5 – 10^0
- **Look to the sides** to make use of rods

EMPTY FIELD MYOPIA

- Without an object to focus on, the eye relaxes and focuses 1.5 – 2 metres ahead.
- During lookout, pick an object **6m or more away** to focus on. Beyond this distance, the eye focuses on infinity.

SACCADIC EYE MOVEMENT

- Eye essentially switches off whilst it's moving
- Saccade lasts 0.3 seconds
- Lookout requires keeping the head and eye still for a second in each lookout segment.

CONSTANT BEARING

- Aircraft on a collision course appear as a constant bearing

HUMAN PERFORMANCE

DISTANCE / DEPTH PERCEPTION

BINOCULAR METHODS (CLOSE / MEDIUM)

- **Stereoscopic Vision**
  - Two picture produce 3D image
- **Convergence**
  - Angle of 'eye swivel'

MONOCULAR METHODS

- **Geometric Perspective**
  - Shape of object depends on distance
- **Motion Parallax**
  - Relative motion of objects
- **Known size of objects**
- **Terrestrial Association**
  - Comparison of objects

VISUAL DEFECTS

HIGH LIGHT LEVELS

- **Flicker Vertigo** – Propellers & Strobe Lights
- **Flash Blindness** - Lightning

MYOPIA

- **Short sighted** (image in front of retina)
- Due to **long eyeball**
- Corrected with **concave lens**

HYPERMETROPIA

- **Long sighted** (image behind retina)
- Due to **short eyeball**
- Corrected with **convex lens**

PRESBYOPIA

- **Gradual hardening** of the lens with age
- **Decreases accommodation**
- Results in **long sightedness**

RETINAL RIVALRY

- Dominant eye overrides other eye
- Some visual items may be missed
- Can also result in eye pain

HYPOGLYCAEMIA

- Vitamin A deficiency
- Required to produce visual purple
- Impairs night vision

GLAUCOMA

- Rise in internal pressure of eye
- Severe pain and ultimately blindness
- Tested with the puff test

CATARACTS

- Clouding in the lens
- Obstructs passage of light

ASTIGMATISM

- Unequal curvature of cornea / lens
- Difficultly focusing on vertical and horizontal at the same time

HUMAN PERFORMANCE

VISUAL CORRECTIONS

CONTACTS & SPECTACLES

- **Spectacles**
  - Bifocal
  - Trifocal
  - Varifocal not recommended
- **Contacts**
  - Bifocal
  - Trifocal
- Reactolite not allowed in either

VISUAL ILLUSIONS

APPEAR TOO HIGH

- Narrow runway
- Upslope

APPEARS TOO LOW

- Wide runway
- Downslope

SHALLOW FOG

- Creates a **pitch up illusion**
- **Tendency to pitch down** results

RAIN

- **Between aircraft and runway (+ FOG)**
  - Lights appear dimmer
  - Appears further away
  - Pilots makes too high an approach
- **Rain on windshield**
  - Runway appears magnified
  - Appears closer

BLACK HOLE EFFECT

- Landing into a runway at night with no cultural lighting around
- Tendency to **think you are too high** and are likely to fly below the glideslope

AUTOKINESIS

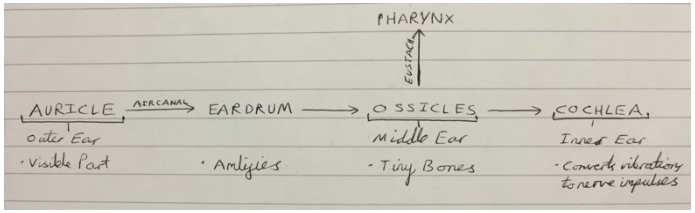
- Static light (EG/ Runway light) appears to move when stared at during night.

COUNTERMEASURES

- PAPIs
- ILS

HUMAN PERFORMANCE

THE EAR



HEARING RANGE

- 20 Hz – 20 kHz

NOISE

- **Pain** – 140 dB

HEARING LOSS

PRESBYCUSIS

- Loss of hearing with age
- Usually occurs first in the higher frequencies

CONDUCTIVE HEARING LOSS

- Blockage between outer and inner ear
- Does not include damage of the auditory nerve

NERVOUS SYSTEM

CNS

- Central Nervous System
- Brain + Spinal Cord
- Deals with the reception of stimuli and activation of muscles mechanisms

PNS

- Peripheral Nervous System
- Nervous structures that do not lie in CNS
- Contains receptors that feed CNS

ANS

- Automatic Nervous System
- Occurs sub-consciously
- Controls respiration, sweating, general adaptation syndrome etc

BRAIN

- Centre of the nervous system
- Cerebrum – Memory, perception etc
- Cerebellum – Coordination of movement

NEURONS

- Electrically excitable cells in the nervous system
- Process and transmit information
- Communicate via synapses

HUMAN PERFORMANCE

VESTIBULAR SYSTEM

VESTIBULAR SYSTEM (INNER EAR)

- **Otoliths**
  - Gravity & Linear Accelerations
  - Small sacs in the vestibule
- **Semicircular Canals**
  - 3 in total
  - Angular accelerations

METHOD OF OPERATION

- Senses **rate of change** rather than sustained change.

LEANS

- Caused by sudden return to level flight after an **undetected** gradual turn.
- Leveling of wings is interpreted as entering a turn and pilot may enter a turn in the original direction.

GRAVEYARD SPIN

- Vestibular system gets used to spin
- Corrective action is sensed as entering another spin
- Pilot likely to re-enter the original spin direction

GRAVEYARD SPIRAL

- Like leans but follows an intentional prolonged banked turn.

CORIOLIS ILLUSION

- Caused by sudden head movement during a turn
- Stimulation of multiple semicircular canals at the same time
- Most dangerous of vestibular illusions

VERTIGO

- Mismatch between information from visual and vestibular system

ACCELERATIONS

G-LOADING

- **G_Z : Up / Down Acceleration**
  - **Grey-out:** + 3 Gs
  - **Black-out:** +4.5 Gs
  - **G-LOC:** + 5 Gs
- **G_X : Linear Acceleration**
  - Create sensory illusions
- **G_Y : Lateral / Transverse Acceleration**
  - Not normally present

HEAD-UP ILLUSION

- Result of sudden linear acceleration
- Can result in pilot pitching down

HEAD-DOWN ILLUSION

- Result of sudden linear deceleration
- Can result in pilot pitching up

HUMAN PERFORMANCE

VIBRATIONS

AFFECTED RANGE

- **1 – 100 Hz**

RESONANT FREQUENCIES

- **Vestibular** – 0.1 to 2 Hz
- **Respiratory** – 1 to 4 Hz
- **Spine & Abdomen** – 4 to 10 Hz
- **Heart** – 7 Hz
- **Head** – 10 to 30 Hz

SLEEP

CREDIT / DEBIT SYSTEM

- Each hour of sleep = 2 credits (hours)
- Max 16 credits

NATURAL CIRCADIAN RHYTHM

- **25 Hours**

ACCLIMATISATION

- **Westbound** - 1 day / 1.5 Hrs time shift
- **Eastbound** – 1 day / 1 Hr time shift

SLEEP STAGES

1. Light Sleep
2. Sleep Spindles
3. Transition to deep sleep
4. Deep sleep
5. REM (Paradoxical)

- Stages 1 – 4: Refresh Body
- Stage 5 – Refreshes Mind

ALCOHOL

- Degrades REM sleep

BODY TEMPERATURE

- Lowest – 0500
- Highest - 1800

DISEASES

- **Hepatitis A & Cholera** - Contaminated food / water
- **Tetanus** – Puncture in skin
- **Yellow Fever** - Mosquito

BODY TEMPERATURE

HYPERTHERMIA

- **37 – 35^{0}C :** Mild to strong shivering | Apathy
- **35 – 32^{0}C :** Violent shivering | Paleness
- **32 – 24^{0}C :** Shivering stops | Amnesia

HUMAN PERFORMANCE

PHYSCHOLOGY

OPERATION MODES

- **Skill Based**
- **Rule Based**
- **Knowledge Based**