

Basics:

Latent threat: Cockpit design error

Conceptual aspects of systems mismatch: **Liveware – software**

James reason: Gathering **information** from accidents & investigations is **informed**

Atmosphere:

Heart muscles: Blood supply from **coronary arteries**

Blood: Is lacking in oxygen & rich on CO₂

Pressoreceptors: Located in **carotid & aortic arterial vessels**

Angina: Symptom of reduced oxygen to **heart muscle**, caused by narrowing/obstruction of **coronary artery**

Circulation: O₂ & CO₂ transportation

Gas exchange: Partial pressure of CO₂ in the **alveoli is lower than in the blood**

Respiratory system: Oral nasal passage, pharynx, larynx, trachea, bronchi & alveoli

Anaemia: Not enough functioning haemoglobin

Hypoxia:

- **Histotoxic hypoxia:** Alcohol increases physiological altitude, 1 ounce 2000ft
- **Hypoxic hypoxia:** Short term memory impairment starts at **12000ft**
- **Hypaemic hypoxia:** Smoking
- **Stagnant hypoxia:** **Excessive G-forces**
- **Can be experienced at 6000ft**
- **Night vision reduced at compensatory stage**
- **Dalton's death**

Hyperventilation:

- Causes CO₂ to be **removed from the blood**
- **Lack/shortage of CO₂ in the blood**
- **Blood circulation to brain slowed down**
- **Jogging does NOT cause hyperventilation**
- Running is **voluntary hyperventilation**

Decompression sickness:

- Primary symptom: **The bends**
- **Nitrogen gas bubbles released**
- **Wait 12 hours before next flight**
- **Henry's hole**

Rate of depth of breathing:

- Controlled by **pressure of CO₂ in the blood**
- Increased rate = **high level of waste CO₂ in the lungs**
- Increased CO₂ causes shortness of breath
- Controlled by **receptor cells in the brain**

Respiratory control centre: **Sensitive to carbon dioxide**

Hypertension: **Physiological** condition involving increased pressure on the arterial walls

Hypothermia: **Demand for oxygen initially increased**

Low blood pressure:

- **Arterioles constrict, cardiac output increase, heart rate rises**
- **Increased risk of low blood pressure when donating blood due to loss of blood volume**

General gas law: **Volume** of a gas multiplied by **pressure** divide by its **absolute temperature** is constant

Law of diffusion:

- Transfer of CO₂ to the **alveoli**
- **Adjacent gases** of different concentration **mix** until concentration is **balanced**

Charles' law: Volume of gas at constant pressure is proportional to **absolute temperature**

Boyle's law: Volume of a gas is **inversely proportional** to its **pressure** with **temperature constant**

Henry's law: Quantity of gas **dissolved in a liquid** is proportional to the **partial pressure** of the gas

Dalton's law:

- Partial pressure of gas is proportional to its **fractional concentration** in a gas mixture
- **Total pressure = sum of partial pressures** of the gas in the mixture

G-forces:

- Factors: Low blood sugar, obesity & hypoxia
- +Gz: Blood flow to brain decrease

Heart attack:

- Common for people above 40
- Total blockage **of a coronary artery leading to the death of a piece of heart muscle**

Random knowledge:

Alpha radiation: Absorbed by thin sheet of paper or 0.2cm of water

Cosmic radiation: Increases at higher **latitudes**

Temperature increase RH decrease

Ozone absorbs UVB better than UVA

Man environment & sensory systems

Eye:

Iris: Control the size/diameter of pupils

Pupil: **Controls** amount of **light** that strikes the **eye**

Accommodation:

- Controlled by **ciliary muscle** around the lens
- Ability of the lens to change its shape

Optic system: Cornea, lens, vitreous humour

3 coats of the eye: **Sclera, uvea, retina**

Crystalline lens: Enables a clear image to be obtained

Cornea: Part of the eye that bends the light the most

Cornea & crystalline lens: Causes the convergence of light rays onto the retina

Central vision: Enables details & colours to be seen, represents a zone where **150 000 cones/mm** are located to give high resolution capacity

Fovea: Area of **best day vision & no night vision** at all

Foveal area is the only area where **resolution is good enough** to see clearly

Retina: Rods in peripheral zone

Central zone: Cones

Optic nerve: Has no rods & cones

Vibrations cause blurred vision due to resonance of **eyeballs**

When **focusing** shape of lens gets **more spherical**

Glaucoma: **Increase in pressure** of the liquid within eye

Eyes move in short jerky movements called **saccades**; smooth vision is achieved in **visual cortex**

Reading alphanumeric information limited to **foveal area of the retina**

Refractive power: Variable from 16 – 30D

Monocular depth cue: Linear perspective

Sunglasses: Can have disadvantages

Visual acuity: **1 minute of arc**

Visual acuity affected by: **hypoxia, age & angular distance from the fovea**

Presbyopia:

- **Far sightedness** due to **age**
- Common over the age of 50
- Decrease of **accommodation**

Short or near sightedness/myopia:

- Defective vision in the form of optical image in front of the retina
- Person will start experiencing problems at a later age with **presbyopia** than usual

Astigmatism: **Misshaped cornea**

Accelerations:

- Forward linear acceleration: **Somatogravic/oculogravic**
- Forward acceleration: Illusion of **backward tilt** it results in **backward displacement** of the otolithic membranes

Sound:

Threshold for pain: **140db**

Presbycusis: Gradual loss of **hearing with age**

13% of knowledge acquired through hearing

Conductive hearing loss: **Not** caused by damage of auditory nerve

Sound waves transferred from outer ear to inner ear by **ossicles**

NIHL: Governed by intensity & duration of noise in excess of 90db

Cochlea: Responsible for sound

Vibrations:

Cochlea: Transfers **vibrations** to nerve impulses in the **ear**

Vibrations upset the vestibular apparatus

Nervous systems:

Connection between **neurons: Synapse**

Neuronal signals travel **electrically** along the axon & **chemically** along synaptic gap

Reflex centre for co-ordination of **equilibrium: Cerebellum**

Neurons: Conducting elements of the nervous system cell

Seat of the pants:

- Muscles, tendons & joints sensitive to the position & movement of body parts
- **Proprioceptors** inform of **relative motion & relative position** of his body parts

Spatial orientation:

- Measuring linear & radial accelerations in **inner ear**
- Sacculus & utricle: Gravity & linear acceleration
- Semi-circular canals: Angular accelerations, during a **roll**, **hair in canals** senses fluid motion by roll, vestibular nerve is stimulated & **nerve impulses transmitted to brain. (Roll, pitch & yaw)**

Illusions:

- Dangerous: Somatogravic, somatogyral, neurological & colour illusion
- Somatogyral/leans caused by **reducing bank following a prolonged turn**
- Coriolis effect: Simultaneous stimulation of several **semi-circular canals**
- **Graveyard spin:** Pilot on recovery tends to re-enter spin due to **somatogyral illusion**
- **Bottom up:** Flying over tall trees then suddenly seeing short trees
- **Top - down:** Smaller objects perceived as further away than larger objects
- **Top – down:** Reduced visibility such as dust/haze objects of equal size & distance may be perceived as **larger/smaller**

Fog/mist: Objects appear **further away**, lead to **steep approaches & long landings**

Runways:

Upsloping: Believes/feels to be **high**, approaches **steeper**, **landing short**

Downsloping: Approach **higher** than normal, may result in **long landing**

Narrow:

- Believes to be **high**, tendency to land **short**
- **Flatter than normal approach with tendency to undershoot**
- **Low approach with undershoot**
- **Initiate flare too late**

Larger/wider:

- Believes to be **low**, **you think you are low**
- **high approach with overshoot**
- Early or high “round-out” **flare**

Approaches at night with **no** landing aids: Pilot thinks he is **higher than actual** & risks **landing short**

Black hole effect:

- Flying over water at night on the approach to an airfield creating an **illusion** that the aircraft is at a **higher** altitude than it is, leading to a **low approach being flown**
- **Being too high & too far away, dropping low & landing short**

Motion sickness:

- Systems involved: Vestibular, vision, proprioceptive & gastro-intestinal

Health & hygiene

Sleep:

- Orthodox – Deep sleep, physical recovery, refreshes body
- Paradox (REM) – Increases during night, regenerate mental functions (4-5 cycles)
- Time zone adjustment: 3-4 zones with 24 hour layover – keep in swing/rhythm of departure country as long as possible, maintain regular living patterns
- **Duration** depends on **the point within your circadian rhythm at which you try to sleep**

Barotrauma:

- Reduction of hearing ability & feeling of increased pressure
- Affects facial sinuses, middle ear & dental cavities
- Pressure differentials between gases in hollow cavities of the body & the ambient pressure
- Causes pressure pains & flatulence

Dysbarism:

- Refers to various medical problems caused by gas expansion induced by **decreased barometric pressure**

Aerodontalgia/barodontalgia:

- Doesn't occur at desert
- Arises especially with irritation of the sensitive tissues close to the root of a tooth

Smoking:

- Lifts smoker physiological altitude
- Flying at 10000ft, oxygen content in blood equal to altitude above 10000ft
- Causes **hypaemic** hypoxia

Alcohol:

- No alcohol should be consumed 8 hours prior for flight duty period or period of standby
- Does **not** promote barotrauma
- Degrades paradoxical sleep

Hypoglycaemia/low blood pressure:

- Headache & lack of concentration

Eustachian tube:

- Blocked = equalization of pressure is limited

Cold:

- Pain & damage can occur to ear drum, particularly during fast descents
- Increased risk of barotrauma during climbs & descents

Metabolic cell waste:

- **Water & carbon dioxide**

Diabetes:

- Type 2: Caused by genetics & obesity (**Low** physical activity?)

Hyperthermia:

- Adjustment to hot country takes 14 days

Tetanus:

- Bacteria in the form of spores via **punctures**

Others:

Rasmussen's model:

- Errors in rule-based control mode are **errors of technical knowledge**
- Skill, rule & knowledge based models are associated with **problem solving**

Anderson model:

- Cognitive, associative & automatic

Rule allows situation to be resolved: **Actions return to automatic mode**

Attention:

- Detecting relevant information which is not presented in an actively monitored input channel = **Attention**
- Depends on **level of automation of behaviour, salience of information, expectations**

1st stage of information process = **sensory stimulation**

Long term memory:

- Affected by expectation & **suggestion**, where **motor programs** are kept
- It is helpful to **mentally rehearse information before it is needed**

Short term memory: 20 seconds

Mental training, rehearsal & cognitive pre- training is most important to **acquire complex motor skills**

Working memory: 5 – 9 items without rehearsing (About 7 maximum)

Experience & repetition may be beneficial & negative

Environmental capture:

Tendency of a skill to be executed in an environment in which it is frequently exercised

Tendency for a skill acquired in another aircraft executed in a new aircraft type even if it is inappropriate

Errors:

- Error tolerance: Error tolerance means minimizing the effects of errors by making a system as **tolerant as possible towards errors**
- Error results in cognitive sequence which makes it possible to modify behaviour with a **view to adaptation**
- **Humans are fallible** & system & procedures should be designed to **minimize human error**
- **Error of commission: Taxiing to wrong runway**

Decision making:

- **Assertiveness makes crew decision making most effective**
- Amount of time available has a large influence on analysis of the situation
- Pilot should take as much time as he needs & is available to make up his mind
- Intention of **being integrated**, to be recognized as leader or avoid conflicts: **Attempt to agree on decisions made by other crew members**

Time constraints: **Preparation of the action & the prioritisation of tasks**

Confirmation bias:

- Tendency to look for information that confirms the validity of the decision
- To avoid: Search for information that will falsify hypothesis

Groupthink: More or less **unconscious** support of a solution from group members

Professional language:

- Uses **limited vocabulary & context provides meaning**
- **Quick comprehension & simplified grammar**

Communications:

- Relies heavily on the sender
- TO make effective: Send information in line with receivers decoding abilities
- Loss of words & packaging more important as: **Body language is lost**

Information: **Intended to reduce uncertainty, measured in bits**

Coordination: Allows **synergy between pilot & co-pilot**, in this **mode** has the function of **synchronizing actions & distributing responsibilities**

Very high ambition & need for achievement disturbs climate of co-operation

Paralanguage: Pilots speak to a person which is outside aircraft

Democratic & co-operative style: **Trying to clarify reasons & causes of the conflict with all persons involved**

Co-action: Working parallel to achieve one common objective

CRM: Improves quality of crew performance

Invulnerability:

- **Accidents can only happen to others**
- **"It will not happen to me"**

"Personality": Refers to unique psychological characteristics

Stress:

- **Non-specific response of the body to every demand placed on a person**
- **Increases vigilance but may focus attention inappropriately**
- **Psychosomatic: Mental in nature (Not physical)**
- **Physical stress: Strains on HOMEOSTATIC mechanisms on the body**
- **Stressor: External/internal stimulus which is interpreted by an individual as being stressful**
- **Acute stress: Mobilization of resources required to cope with the stressor**
- **Chronic stress: Address the physical causes of stress**

Acute fatigue: Does NOT have psychological roots

Stress reactions:

- **Alarm phase: Increased arousal, release of glucose, decrease in stress resistance**
- **Resistance phase: Allows fats to be converted into sugars prolonging the mobilization of energy in the body, appearance of psychosomatic disorders when lasting over a prolonged period**

High levels of arousal narrows span of attention

Automation errors: Capture of a poor subprogram, an action mode error

Complacency: Unjustified self confidence

Reliability & good detectability: Sum of automatic monitoring, detection & warning facilities, alerting capabilities of the man-machine interface

Automation: Attention of cockpit crew will become reduced with the consequence of being out of the loop

Figures:

Human factors causes **70 – 80%** of accidents

Rate of accidents: **1 accident per million** airport movements

Healthy adult:

- **Pulse: 60 – 80 beats/min**
- **Breathing rate: 10 -15 breaths/min**
- **Breathing rate: 16 cycles/min**
- **Breathing rate at rest: 12 – 20 cycles/min**
- **Arterial blood pressure: 120/80 mmHg**
- **Cardiac output (Blood quantity /min): 5 litres/min**

Proportion of atmosphere constant up to **100km** (Oxygen 21%, Nitrogen 78% ...)

18000ft – ½

27000ft – 1/3

34000ft – ¼

45000ft – 1/8

Oxygen breathing:

- Percentage of **oxygen breathing** at 25000ft: **62%**
- **100% at 33700ft: Equivalent to SEA LEVEL**
- **100% at 38000ft: Equivalent to 8000ft**
- **100% at 40000ft: Equivalent to 10000ft**

100% oxygen physiological altitude: 40000ft

Exhaled air contains: **15% oxygen & 4% carbon dioxide**

Barometric pressure difference (decrease of pressure) greatest at **0ft – 5000ft**

Cardiac output = Volume pumped x beats per minute

Blood: Contains 45% blood cells & 55% plasma

Blood oxygen saturation affects pilot >10000ft

Above 10000ft partial pressure is **below critical** value of **55mmHg**

Partial pressure in alveoli: 40 CO₂, 47 H₂O, 100 O₂ (mmHg_{pp})

Carbon monoxide affinity to haemoglobin: **210 – 250 times**

Breathing cycle volume (Tidal volume): **500ml of air**

Inspiratory volume: 3300ml

Expiratory volume: 1000ml

Residual volume: 1200ml

TUC:

- 25000ft: 3 – 5 minutes
- 30000ft: 45 seconds to 1 min 30 seconds
- 35000ft: 30 – 60 seconds (45 seconds)
- 43000ft: 30 – 45 seconds

Reaction threshold/compensatory reactions: 7000ft (Human organism starts remarkable measures)

Disturbance threshold: 10000 – 12000ft

Critical threshold: 22000ft (Non-pressurized 20000ft)

Hypoxia:

- Does not occur below 3000m
- Occurs at 38000 – 40000ft 100% oxygen **without pressure**
- **Affects night vision at approximately 5000ft**

Records of radiation kept above **29000ft**

After **scuba diving wait 24 hours**

Sight:

70 - 75% of knowledge from sight, 13% hearing

Night vision: Degradation of night vision occurs from 1500m (5000ft)

Visual acuity: Best within **2-3 degrees** of the fovea & **reduces rapidly** towards periphery vision

Hearing:

Frequencies: 20 – 20000Hz

Hear/listen to **500** & speak **125**

Alcohol:

Slight lack of coordination starts at **0.05%** blood alcohol

No alcohol **8 hours** before

EASA blood/alcohol limit: **20 mg per 100mm of blood**

Rate of metabolism or digestion of alcohol: **0.01 – 0.015g/100g per hour (15mg/100ml/hour)**

Smoking:

One pack of cigarettes gives away **5 – 8%** of total oxygen transportation

Time zone:

Resynchronization time at a rate of **1 – 1.5 hours** a day

Sleep:

5 stages of sleep

REM sleep 4-5 bouts in 8 hours,

Free running circadian rhythms: 25 hours

Credit/debit system: **12 hours**

Normal sleep cycle every **90 minutes**

Human adults require **8 hours** of sleep per night

BMI:

- $\text{Mass} \div \text{Height}^2$
- Normal 18 to 25 (Females just -1)
- Obese >30/29

Breakfast = 25%

Caffeine in excess of 250mg/day is a problem

Errors:

Simple **repetitive tasks** occur about **1 in 100 times**

Good & realistic error rates: 1 in 1000 times

Communications:

80% of communications is **metacommunications**