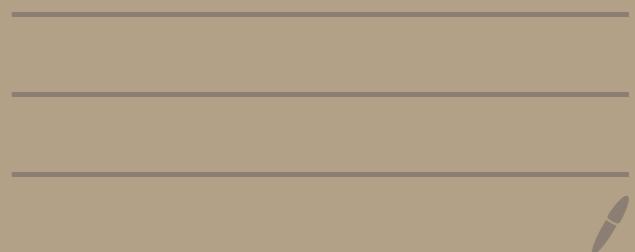


Human Performance and Limitation



01 Human Factors: Basic concepts

Human factors in aviation

- initially: competent but low confidence

Competence:

- Knowledge
- Skill
- Attitude
- Situational Awareness

- Communication
- leadership and teamwork
- application of procedures

Flight Safety Concepts

TEM model

- Undesired Aircraft State (UAS)
 - reduction in margin
 - Fuel shortage
 - higher approach speed than cleared by ATC

- organizational threats (in aviation structures)
 - expired charts

- Environmental threats
 - contaminated runway

- Latent threat
 - Cockpit design error
 - not obvious

- Errors:
 - Handling
 - Procedural
 - Communication

Hard countermeasure → ACAS

- GPWS and SOPs are systematic based
hardware-based countermeasures



Safety Culture

Safety Management System (SMS)

- Safety policy (and objectives)
- " risk management
- " assurance
- " promotion

Safety culture is a subset of national culture

Closed culture
→ Captain yells

Reporting culture

Informed culture → safety risk management more effective

Good safety culture:

- Responsibility = individuals
- Accountability = Management

02 Basics of Aviation Psychology and Health Maintenance

Basics of flight physiology

The Atmosphere

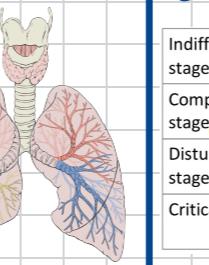
78% Nitrogen, 21% O₂, 0.03% CO₂, 0.92% Rare gas

8000 ft	3/4 of sea level pressure
18000 ft	1/2 of sea level pressure
27000 ft	1/3 of sea level pressure
36000 ft	1/4 of sea level pressure

Respiratory and Circulatory System

External respiration

- Total volume of lungs is not usable
- Average volume is 5-6 liters
- Gas exchange through passive diffusion (alveoli)
- Normal: 10-16 cycles per minute
- Tidal volume = 0.5L
- Residual volume = 1.2L



Internal respiration

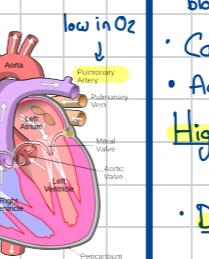
- Gradient of diffusion affects diffusion of O₂ between blood and body cells
- Pulmonary artery: high in CO₂, low in O₂ (low saturation)
- Fick's law: oxygen absorption in blood
- Cardiac output: stroke volume × heart rate ≈ 5L/min

The circulatory system

- Anaemia → not enough haemoglobin

Blood pressure

- Normal: 120/80 mmHg
- Measured at same height as the heart



- Hypertension starts at 140/90
 - increased pressure on the artery walls
 - increase risk of heart attack and stroke

Hypotension

- caused by clinical shock
- medication against hypertension
- Systolic pressure: force of heart
- Diastolic pressure: static pressure

Blocked coronary artery: heart infarction

- Stroke: blood supply to brain is cut off
- Myocardial infarction or heart stroke → total blockage of coronary artery / death part of a muscle
- Plasma: blood without cells

Hypoxia

- Explained by Dalton's law
- Anemic hypoxia → smoking
- Hypoxic hypoxia → reduced partial oxygen pressure

Stages of hypoxia

Indifferent stage	0 to 6000 ft	7000 ft
Compensatory stage / reaction	Night vision reduced	6000 to 15000 ft
Disturbance stage		15000 to 20000 ft
Critical stage		20000 to 23000 ft

10'000 → short-term memory impairment
12'000
22'000

Altitude ft	Equivalent altitude with 100% O ₂
34000	Sea level
38000	8000
40000	10000
45000	20000

Altitude ft	Oxygen
Sea-level - 10'000	Outside air
10'000 - 34'000	Mixture
34'000 - 40'000	Pure O ₂
> 40'000	Pure O ₂ with positive pressure

Humidity

- lowest humidity: cold outside aircraft
warm inside

Ozone → should be below defined limits
(ozone remover)

Time of Useful Consciousness (TUC)

Altitude ft	TUC
20'000	30 min
25'000	2-3 min
30'000	1-2 min
35'000	30-90 sec
40'000	15-20 sec

People and the environment: the sensory system

Senses

- Proprioceptors: sense joint position

Central, peripheral and autonomic nervous system

Vision

Functional Anatomy

- Pupil controls amount of light to retina
- Cornea: clear portion of the eye where light passes through

Retina: contains photoreceptors for vision
- acquisition of visual signal and coding of physiological data

- Rod, periphery, night, moving object
- Rhodopsin (visual purple) for night vision
- Needs Vitamin A
- Scotopic vision

Cones
- 2-3° of fovea, decreases rapidly
- photopic vision

Accommodation

- Change of shape of lens
- Controlled by ciliary muscles

Hearing

- Fit oval window, vibrating chain of ossicles induce pressure waves in endolymph

Sound: fluid-filled portion of the cochlea

Presbycusis: hearing loss of high tones through aging

Equilibrium

- Vestibular apparatus
 - 3 semi-circular canals: rotation and angular acceleration
 - Otolith organ (utricle and saccule): gravity and linear acceleration

Motion sickness
→ Hyperventilation, Euphoria

Illusions

Most critical: Visual (blind spot), Kinaesthetic (leans) and auditory (missed radio call) illusion

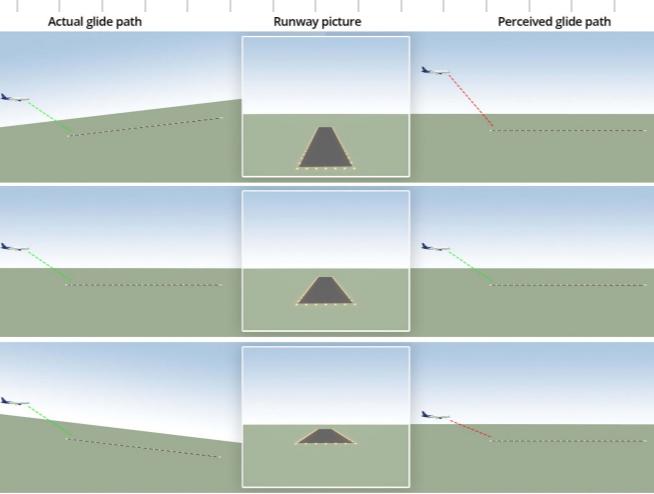
Black hole effect
- illusion that aircraft is too high
- flying above water
- leads to low approach

Haze: objects seems further away than in reality

Vestibular illusion

Somatogravitational

Somatogravitational: linear acceleration, otoliths
Acceleration: head up illusion



Fovea and peripheral vision

Night Vision

Binocular and Monocular vision

Monocular depth cue: linear perspective
- obscuration, texture, atmospheric perspective



Defective vision

Astigmatism: irregular misshapen cornea

Presbyopia
- loss of elasticity due to aging (common over 50s)
- Decrease of accommodation

Astigmatism
- cornea not even shaped

Glaucoma

increase in pressure of the eye liquid

Contact lenses

Acceptable only if short-sighted (must see instruments)

Damage to cornea due to low humidity and hypoxia

Health and hygiene

Body Rhythm and sleep

Sleep Cycle

- Each cycle ~90 min
- Stage 3 and 4 → physical recovery
- REM 90-120 min in 5 to 6 phases
↑ Paradoxical sleep phases get longer
- Credit/Debit
 - 2 points per 1h sleep
- Free running circadian rhythm = 25h

Problem Areas for Pilots

Barotrauma

- When descending rapidly

Barodontalgia

- sensitive tissue close to the root of tooth

Eustachian tube

- equalize pressure btw middle ear and environment

Obesity and diabetes

- Type I (birth)
- Type II (obesity) → unexplained weight loss
- $BMI > 30$ = obesity
- Sleep apnoea / Diabetes / Coronary disease

Tropical climates

- Disinsecting at least 30 min before landing
- Dengue fever / Cholera and dysentery
- Can kill in a short time
- Nasal spray 7-12 µm

Basic of Aviation Psychology

Human error processing

Short term memory

- Information stored for 20 sec
- 7 bits

Long term memory

- episodic: influenced by suggestions (events)
- Semantic: meaning of words and general knowledge
- unlimited storage

Mental schemes

- Memorised procedures

Modelling

→ learning a task by imitation

Top-down

- In reduced visibility, objects are perceived as larger or smaller
- Compare brain data to new info
→ critically disqualifying inconsistent details

Anderson model of skill learning

- Cognitive
- Associative
- Automatic/Autonomous

Captain / FO

Rasmussen model

Skill-based behaviour

- routine errors

Rule-based behaviour

- approach or divert decision
- checklist
- sound alert

Weather

Knowledge based

Gestalt laws

- how objects are mentally organized and perceived

Error of a motor program

- Action slip (wrong check list)
- Environmental capture (habituation)

- skill executed in environment where frequently exercised
- skill from old aircraft type used in new aircraft

Human error and reliability

Violation: not using the checklist

Error rate:

Simple: 1-100

Complex: 1-1000

Decision making

- Detet
- Estimate
- Choose
- Identify
- Do
- Evaluate

Avoiding and managing errors: cockpit management

Type of authority

- Autocratic → overloaded
- Laissez-faire
- Synergistic

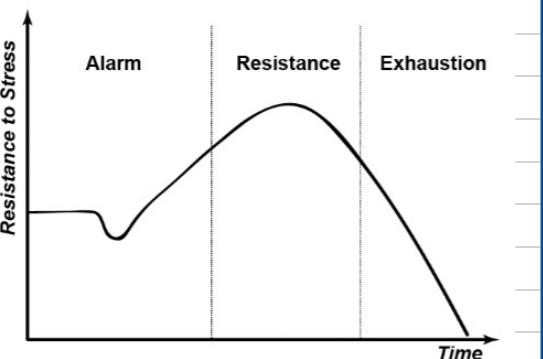
- Paralanguage: tone of voice, break in sentence
- Metacommunication 80%.

Human behaviour

- Self-concept: complete set of attitude
- New captain might be aggressive
- Invulnerability: "it will not happen to me"
- Anti-authority: "Don't tell me what to do"
- Resignation: hard taking difficult decision

Human overload and underload

① Alarm reaction



② Resistance

- fat transformed in sugar
- psychosomatic disorder

③ Exhaustion

- Stress promotes physical capability (more than mental)

• Dry mouth

• Homeostatic mechanism

• Environmental stress

• Economical stress

• Social stress

- General Adaption Syndrome GAS
 - connected to the ANS Automatic Nervous System

Fatigue

- Acute (short term)
- Chronic (long term)

Advanced cockpit automation