IPAS
MISSION CREW
COURSE TEXTBOOK

IPAS .com.au MISSION CREW

GROUP 1 – INTRODUCTORY CONTEXT

The Element/s in this Group relate to an Introduction to CRM and the Organisation

ELEMENT 1 – Introduction

Contents:

Module 1.1

1.1 **Introduction to this Course and Facility.** This module is designed primarily to assist facilitators in opening a CRM course, describing the format of this CRM course and describing the key areas covered in a CRM course. In this module, the course will be introduced and the required information relating to the facility will be given.

Section

1.1.1 **Welcome and opening remarks.** The facilitator will commence the course by welcoming the attendees. This should also be the time when attendance is taken. The attendance sign-in sheet is a record of who attends each day and is also the nominal roll for a head count in the event of an emergency. All attendees should sign in and return the sheet to the facilitator.

1.1.2 **Actions in the event of an emergency and WHS.** The facilitator will provide guidance on actions in the event of an emergency, in particular:

- What the fire alarm sounds like, evacuation routes and assembly areas and if any assistance will be given to the managers and staff of the facility if the course is being run externally.
- The location of first aid kits and AEDs and other medical devices.
- The manner in which a roll call will be conducted and who will be responsible for taking the nominal roll if applicable.

1.1.3 **Timings for the Key Events.** The facilitator will outline the timetable for the day's activities, when breaks will occur, and when catering will be supplied. Any other activities that are relevant will be included here.

1.1.4 **Amenities.** The facilitator will outline the amenities of the facility, including the location of kitchens, tea and coffee making facilities, bathrooms, and other relevant facilities. He or she will also discuss the air-conditioning and heating if necessary. The layout of the classroom or facility may also be addressed here, and any shortcomings or special considerations will be considered and discussed if required.

1.1.5 **Course Courtesy and Confidentiality.** Course courtesy will include such things as:

- Punctuality - attendees are encouraged to be punctual after breaks. Tardiness is inconsiderate to the other attendees and results in the course running over time or the facilitator being made to rush through the material. It is imperative that the attendees and the facilitator understand that punctuality is extremely important in order to get through the course material and to show respect for other members on the course. The facilitator, when commencing a break, should confirm the current time and then give a time to reconvene so that everyone is aware of the expectations on punctuality.
- Disruptive behaviour - the facilitator will request that the attendees are respectful to other members on the course by refraining from talking amongst themselves, making inappropriate comments that do not complement discussion, making rude, sexist, racist or otherwise inappropriate remarks that a reasonable person would find offensive or other such behaviour that will disrupt the course.

- Mobile phones - the facilitator will request that all mobile phones be switched to silent and that attendees will refrain from using them, either to speak or text, whilst in the course so as not to disturb the other attendees.

- Confidentiality - CRM courses are an excellent venue for learning from other people's mistakes and violations. As a result, it is important that confidentiality be maintained. This will encourage people to be more open about their own experiences without fear. Only in this way will people feel comfortable. This concept is very important. Violations are never reported and so people do not learn from violators. By maintaining confidentiality, people are more likely to admit to their own violations and thus allow others to learn from their mistakes. The facilitator must be aware that in some cases senior members of the organisation may be present within the course, and this may stifle the free exchange of comments and ideas.

1.1.6 **Course work, assessments, etc.** The facilitator will outline any coursework, reading, or assessments that may be carried out or required during the conduct of the course.

Module 1.2

1.2 **Introduction to CRM and Regulatory Requirement.** In this module, we will discuss the concept of CRM, its history and its growth and what requirements there are by the regulator.

Section

1.2.1 **Defining CRM.** Defining CRM is somewhat more difficult than it sounds. The actual acronym, Crew Resource Management, suggests that it relates only to aircrew. This is not the case. Probably a more accurate term would be Team Resource Management, or Group Interaction in a High Risk Environment. This latter term has been used in university studies in the methodology of assessing what is sometimes seen as a very subjective activity.

1.2.1.1 Non-Technical Skills (NTS) is the term used in the European aviation environment to describe those skills that are not directly related to the task at hand – usually flying skills - but rather skills that are complementary. NTS is another way of referring to CRM. In both cases the main concern is on the complementary skills of the individuals and the team rather than their technical skills. What are these complimentary skills? These can be such things as the ability to communicate effectively, the ability to make good decisions, the ability to resolve conflicts, the ability to identify threats and to manage errors. All these non-technical skills complement the technical skills that any team might use in any high risk environment. So in essence, CRM can be defined as:

> *"… a management system which makes optimum use of all available resources – equipment, procedures, people – to promote safety and enhance the efficiency of [flight] operations."*

Note the brackets around the word "flight?" This is because CRM (or TRM or NTS or whatever you want to call it), has applications that are not just centred around aircrew and flight.

1.2.2 **History and growth of CRM.** CRM has been around in one way or another for the last 30 years. It has been known by other acronyms such as Cockpit Leadership Resource, Aircrew Team Training, Cockpit Resource Management, and other variations. And even though it has gone by many names, the concept of this non-technical skills training has been to identify ways to improve safety in a team environment. Initially it was led by the airlines, with United Airlines in conjunction with NASA really getting the ball rolling in the late 70s and early 80s. Initially, it was modelled on a form of training called the Managerial Grid and concentrated heavily on psychological testing and general concepts such as leadership.[1] These days CRM/NTS is used in many high-risk environments such as the emergency services, surgical teams, the power industry, the military, and many others.

1.2.2.1 Over the last 30 years, CRM courses have changed somewhat in the manner in which they are run. In the first generations, the concern was mainly with adjusting behaviour by attempting to compensate for personality differences. Later iterations of CRM courses moved away from defining personality differences and concentrated more on how individual organisations identify threats to good working relationships and also to safety and how they eradicated or mitigated those threats.

[1] Helmrich, et al, *The Evolution of Crew Resource Management Training in Commercial Aviation,* Dept of Psychology, University of Texas, date unk

1.2.2.2 CRM has also moved away from just the aviation environment. Group Interaction in a High Risk Environment is a very good term to use for CRM in general. CRM, or TRM (Team Resource Management) and other terms for the concept, are being taught in many high risk areas, such as firefighting, emergency services, surgical teams, maritime operations, rail networks or anywhere where individuals and teams can benefit from greater safety and efficiency when working in high risk areas.

Figure 1.1 A rappelling crew working in the US Forestry Department. CRM has found its way from purely an aviation-centric training philosophy to a valuable tool in many other high risk fields.

1.2.3 **Requirements of the Regulator.** Because CRM has its origins in aviation, regulations surrounding CRM and its implementation have been more entrenched in that industry, however more and more it is becoming widespread in other high risk industries. The Civil Aviation Safety Authority (CASA) is the governing regulatory body in Australia for civil aviation.

1.2.3.1 CASA's Notice of Proposed Rule Making[2] that required Safety Management Systems (SMS) be introduced into Regular Public Transport (RPT) airline operations, cited four accidents where Human Factors (CRM) were contributory factors. The Australian Transport Safety Bureau's (ATSB) accident reports made recommendations to CASA that operators implement an SMS. These recommendations can be found on the ATSB website at www.atsb.gov.au, but two accidents are worth noting:

- R20020194 – A Cessna 310 operated by the WA Police crashed whilst conducting a NVFR flight due to fuel starvation. The investigation found poor planning, poor systems knowledge, inexperience, poor managerial oversight, perceived operational stress and a conflict of interest between CASA and the AOC holder all contributed to the accident.
  .
- R20070002 and R20070003 – A Fairchild SA227 Metro 23 conducting an RNAV GNSS approach to Lockhart River suffered CFIT. The investigation cited a very

[2] CASA, *Notice of Final Rule Making – Implementation of Safety Management System (SMS) and introduction of Human Factors (HF) Training and Non-Technical Skills (NTS) Assessment,* NFRM 0803OS – Canberra, Jan 2009.

steep cockpit gradient (ie a very experienced or overbearing captain and a relatively inexperienced or submissive co-pilot), poor CRM capabilities demonstrated by the individuals previously, poor weather conditions, complicated approach design, violation of the regulations (co-pilot not authorised to fly RNAV approaches), violation of the operations manual, descent below appropriate altitude during the approach and inappropriate route checks contributed to the accident.

1.2.3.2 Despite objections as to the necessity for prescriptive measures, it was decided that government action was needed to ensure instigation of SMS throughout the industry to, as the RIS says: "…overcome limitations of the exclusive use of technical and operational standards in a rapidly expanding industry with global interconnectedness."[3]

1.2.3.3 The objectives of the instigation by CASA of the SMS requirements were to:[4]

- Assist operators to meet the ICAO SMS requirements through increased guidance and advisory material (quoted verbatim)
- Minimise compliance burden
- Keep associated costs low.

1.2.3.4 The SMS would consist of a number of key elements outlined by the ICAO Doc 9859 which is cited in the RIS, and are:

- Establishing safety policy at the company's management level
- Collecting safety information
- Identifying safety hazards
- Analyzing safety risks
- Performing safety investigations
- Developing corrective actions
- Providing safety training
- Monitoring safety performance
- Creating a continuous improvement environment
- Safety communication.

In the words of CASA, the regulator would establish the objective and the operator would determine how they would meet the objective.

[3] NFRM 0803OS Regulation Impact Statement, p16, op.cit. CASA
[4] Ibid.

Module 1.3

1.3 **Subjects of a CRM course and this CRM Course.** In this module, the subjects that are recommended to be covered in a CRM course are discussed. It also discusses the IPAS CRM course content and associated content.

Figure 1.2 CRM Courses can cover many areas in team environments with the most important aspect being able to learn from others.

1.**3**.1 **What Areas are Covered in a CRM Course?** The regulator is reluctant to prescribe exactly what should be covered in a CRM course, but provides overarching guidance and allows the user to determine what is best for its own operations. When compared to the suggestions of other regulators around the world, a number of similar subjects are deemed to be relevant. The suggested syllabi from the regulators of the United States, the United Kingdom, Europe, and Australia were compared by IPAS side-by-side to ascertain where commonalities lay. Insofar as the theory is concerned, the helicopter Air Transport Pilot's Licence (ATPL-H) course syllabus issued by CASA was the most comprehensive. The IPAS CRM course uses all the topics covered in that syllabus, and where it was deficient when compared with other syllabi, those deficiencies were rectified by including the missing topics. The result is a very thorough and wide-ranging syllabus that covers all the suggested topics as recommended by the regulator and provides a basis for further study.

1.3.2 **This CRM course and the GEMS Structure used by IPAS.** This CRM course has reviewed various CRM course formats and found that the format used by the Australian Defence Force (ADF) is very efficient and logical. The manner in which the ADF teaches the

various topics is a very logical progression for CRM theory. But where the ADF has 12 topics, the IPAS course has been reduced to nine, with some topics combined or relocated. The various topics and subjects were then categorised and put into a new format called the 'GEMS format.' It is appropriate to discuss the GEMS structure at this point.

1.3.2.1 **GEMS.** The acronym GEMS stands for Group, Element, Module, and Section. All the areas covered in the IPAS CRM course, the IPAS CRM Facilitator Training Course, and all the elective modules have been organised into Groups. Within these Groups are individual Elements that contain Modules made up of Sections. By organising the course in this format, it allows for greater flexibility and expansion of the course. Depending on the requirements of the training, individual elements, modules, and sections can be omitted or replaced depending on the needs of the client organisation. This allows for more specific training, more relevant training, more flexible training, and more thorough training. For example, a single pilot Rotary Wing cattle mustering operation may not require the CRM element on automation to be taught in its CRM course. The elective element on low-level flying would not be applicable to an RPT organisation. In these cases, these organisations can substitute individual elements to suit their own needs when using the IPAS CRM course.

1.3.2.2 **Referencing.** All references are shown as footnotes with the relevant part of the manual's text shown as a superscript number like this.[5] Even though footnotes are not normally used in technical texts, this method is more pleasing to the eye, more convenient and allows for more rapid acquisition of information. Footnotes are also used to expand upon information. With regard to paragraph numbering, the following system is used (see Figure 1.2 for a diagrammatical example):

- The first number is always the Element – in the case of this paragraph, Element number one is **Introduction.**
- The second number is the Module – in the case of this paragraph, Module number three is **Subjects of a CRM course and this CRM Course.**
- The third number is the Section (if used) – in the case of this paragraph, number two is **This CRM course and the GEMS Structure used by IPAS.**
- The fourth number (if necessary) relates to the Paragraph – in this case Paragraph number 2, is **Referencing.**

Not all numbers denoting parts of the manual and its elements, modules, sections and paragraphs may be used. Some references may be only two numbers or three numbers, but in all cases, the first number will be the Element; the second number will be the Module, etc

[5] This is the reference line used to provide information relevant to the part in the text denoted by the superscript numeral 5 in paragraph 1.3.2.2. It is laid out in 8pt Arial.

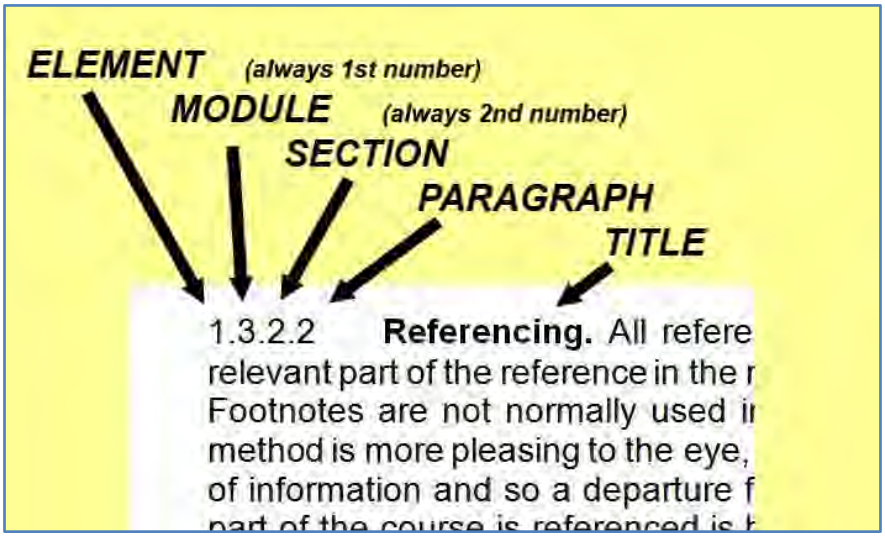


Figure 1.3 The numbering format used in this course.

Figure 1.4 Referencing to this manual also occurs on audio visual slides and handouts. Note the Element/Module/Section/Paragraph number 1.3.2.3 in the bottom right hand corner of this slide indicating that this slide relates to the paragraph on Groups and their Elements which can be found in Element 1, Module 3, Section 2 and is Paragraph 3.

1.3.2.3 **Groups and their Elements.** The major classification of the IPAS CRM components is called a Group. It contains a collection of elements that are related to each other or that form a logical step in the training regime. Just as a baby will first crawl then walk

then run, the CRM course uses the same methodology and places the elements and modules into a context. The term context is used to describe the group. The main groups are as follows:

- **GROUP 1 - THE INTRODUCTORY CONTEXT.** In this group all the introductions to the CRM training are contained. These introductions are such things as;
    - Introduction to the facility - the fire and safety brief, the workplace health and safety brief, and the location of amenities.
        - Introduction to the course and course courtesy - the expectations of the facilitator with regards to punctuality, disruptive behaviour, and confidentiality.
    - **Element 1: Introduction to CRM** - defining what CRM means and a brief history on the subject as well as requirements of the regulator, what areas are covered and how it is arranged in the course and any activities or assessments.
        - An introduction to CRM within the organisation - the safety culture of the organisation, management perspective, methods of reporting, and the safety management system within the organisation, and anything else that is pertinent and relevant to the organisation that is related to safety.
- **GROUP 2 - THE HUMAN CONTEXT.** In this group all the elements relating to the human are contained. These elements are such things as;
    - **Element 2: The Human Mind** - CRM concepts that are related to human psychology such as motivation, behaviour, attitudes, and personalities.
    - **Element 3: The Human Body** - CRM concepts that are related to human physiology and human performance limitations such as stress, fatigue, information processing, the senses, hearing, vision, hypoxia, etc.
    - **Element 4: Human Error and Threat Management** - CRM concepts that are related to the errors committed by humans and how to manage them as well as identifying threats to the mission and how to mitigate against them. In aviation, this is the same as TEM (Threat and Error Management).
- **GROUP 3 - THE INTERACTIVE CONTEXT.** In this group all the elements relating to how humans interact with each other, with the environment and with machines. It includes:
    - **Element 5: Communication and Assertiveness** - CRM concepts that are related to how humans communicate with each other in a team environment and how assertiveness is used to ensure the team goals are met.
    - **Element 6: The Group Dynamic** - in this element the course explores how humans work in team environments using concepts such as teamwork, leadership and followership and the barriers to these.

- **Element 7: Situational Awareness** - situation awareness is how a human interacts with his or her environment, how (s)he detects information from it, processes and understands and information, and then determines how it will affect the mission.

- **GROUP 4 - THE OPERATIONAL CONTEXT.** In this group all the elements relating to how the elements of CRM are used operationally are explored, and include such things as:

  - **Element 8: Judgement and Decision Making** - this element includes defining what decision-making is, various decision-making models and barriers to effective decision-making.

  - **Element 9: Planning, Briefing and Debriefing** - this element combines planning, briefing and debriefing. It follows from the concept of decision-making and how decisions can be made prior to the mission based on information received and the experience of the individual in order to facilitate the mission and then how to pass on information and elicit information.

- **GROUP 5 - ELECTIVES.** This group includes all the elements that are elective and are not normally part of a standard CRM course but which have applications within many organisations. The organisation can elect to include a number of these electives as part of its CRM training regime.

  - **Element 10: Low Flying and Its Hazards** – the basis of this element is to highlight the various hazards associated with flying below 500'. It covers wires and identifying wires and their associated hardware, rules surrounding low flying, weather, flying in close terrain, animal hazards, etc.

  - **Element 11: Basic Aerodynamics for Non-Aviators** – in many organisations there is a requirement for members to be conversant with aerodynamics. For example, Mission Commanders such as Air Observers, Air Attack Supervisors, Air Base Managers, Aviation Ops Personnel.

  - **Element 12: Introduction to Risk Management** - risk management refers to the process of identifying the task at hand, placing it into context, identifying threats, identifying negative consequences, and identifying controls to minimise or eradicate negative consequences from threats and thus ensure mission success. The risk management process can be virtually standardised and forms part of a well-rounded safety management system. This element introduces the concept of risk management to an organisation that is endeavouring to increase productivity and efficiency by establishing safe procedures and systems. Part of this element can be included into Element 4 - Human Error, Threats and Management.

  - **Element 13: Introduction to Night Vision** - night vision devices are no longer the domain of the military. Many civilian organisations are now using night vision devices which have their own set of the CRM implications. This element introduces the concept of night vision devices, their theory of operation, specific CRM issues related to them, and effective use.

- **Element 14: Mission Command vs Aircraft Command** - Mission command refers to the command, management, and coordination of a mission which may include managing the activities of the pilot so that mission aims can be achieved. Mission command **does not** remove the responsibility of the PIC to operate the aircraft safely and legally and if safety or legality becomes an issue, the PIC has ultimate authority. As a result, a mission may have two persons in authority - one for the mission and one for the aircraft - which may, at times, lead to confusion or conflict. This element aims to clarify and delineate the roles of each person.

Figure 1.5 Mission Command is the situation where there is a person aboard the aircraft who is responsible for running the mission and achieving mission aims but who is not the aircraft commander (PIC). Organisations such as the NSW State Emergency Service have Air Observers who are Mission Commanders but not pilots.

- **Element 15: Automation** - the increasing use of automation brings with it its own set of CRM issues such as mode confusion, automation complacency, monitoring fatigue, and the heightened training liability. This element looks at the problems with automation which are only going to increase as it becomes more affordable and more widespread. It also looks at the change in the way training occurs and the change in the culture of new entrants into the industry.

- **Element 16: Aircraft Safety and Emergencies** - this element is useful for organisations that use aircraft but who do not operate their own. In many cases, the personnel of these organisations are expected to be able to operate safely around aircraft even though it is not their core business. This element provides an overview of aircraft safety, operating in their vicinity, and provides an understanding of emergencies related to aviation which helps to build confidence amongst these personnel. Subjects covered include crash positions, entering and exiting the danger areas, safety equipment, weight and balance, loading, dangerous goods, engine failures, and other related subjects.

- **Element 17: Navigation and Map Reading** - This element looks at methods of navigation and map reading, especially from aircraft. It covers such things as map scales, map types, projections, use of GPS and its theory, navigation, and other related subjects. It meets the needs of navigation for the emergency services.

- **Element 18: Unmanned Aerial Systems** - the operation of UAVs has brought with it its own CRM considerations. Along with automation, UAV operations are becoming significant components of future aviation. This element explores some of the key issues surrounding UAV operations, including those found in a military environment.

- **GROUP 6 – TRAINING DESIGN AND DEVELOPMENT.** This group is centred around the manner in which CRM courses are designed, developed and executed.

  - **Element 20: Facilitation** - Facilitation is different from instructing. With facilitation, the trainees are expected already to be familiar with the subject matter. To this end, a facilitator needs to be able to direct the training as opposed to give instruction and requires specific skill sets. This element discusses what facilitation is and how it should be performed.

  - **Element 21: Trainees and Adult Learning** - with facilitated courses, the attendees are normally adults. As a result, the method in which instruction is given must take this into account. This is element looks at the unique needs of adult learners and how a facilitator can maximise the benefits of teaching and facilitating adults.

  - **Element 22: Presentation Techniques** - presentation techniques deals with how a person presents him/herself as well as the material. It is a fact of nature that a message will be received in a particular way depending on the way it is presented. This can have significant effects on training.

  - **Element 23: Audio Visual and Printed Matter** - just like in Element 22: Presentation Techniques, this element looks at the manner in which material is presented on the screen and in print. And just like in element 22, information can be received differently depending on the manner in which it is presented. This element provides guidance on the best way to present information in audio/visual and printed formats.

  - **Element 24: Referencing and Copyright** - this element explores the concept and requirements of referencing and copyright. This is an often overlooked element of intellectual property and course design.

  - **Element 25: Case Studies** - Case studies are an excellent method of teaching. It reinforces subjects being explored and puts them into context. It is interesting to note that case studies are a recommended method of CRM instruction as listed in the suggested syllabi from overseas regulators. This element explores the methods in which case studies can be generated and how best to do so; sources, referencing and A/V.

Figure 1.6 Case Studies are great vehicles for proving points in CRM, such as the Palm 90 disaster where an Air Florida 737 crashed into the Potomac River

- **Element 26: Assessment of Knowledge and Skills** - CRM is often considered to be a subjective subject. Therefore, assessing it can sometimes be difficult. This element looks at methods of assessing CRM and provides guidance to organisations to do so.

Module 1.4

1.4 **CRM and The Organisation.** CRM can be used by any organisation where individuals are required to work with others, or where individuals and teams are expected to cooperate and achieve mission objectives. This is particularly important in high-risk environments. This module allows for the organisation to discuss its view on CRM, risk management, and how it would achieve organisational aims safely and efficiently.

Section

1.4.1 **The Organisation's Safety Culture.** Different organisations look at safety in different ways. In many cases, a substandard safety culture may be due to financial constraints, apathy by management, or lack of understanding or education. The box below contains a very good explanation on safety as part of an organisation's culture. An explanation of the concept of culture can be found in Element 2 on Human Behaviour. Perhaps one of the best indicators of what culture means to an organisation or group is the saying: "Who and what we are, what we find important, and how we go about doing things 'round here."[6] This implies that actions and activities are done regardless of who may be watching and assessing. It is the way of doing business.

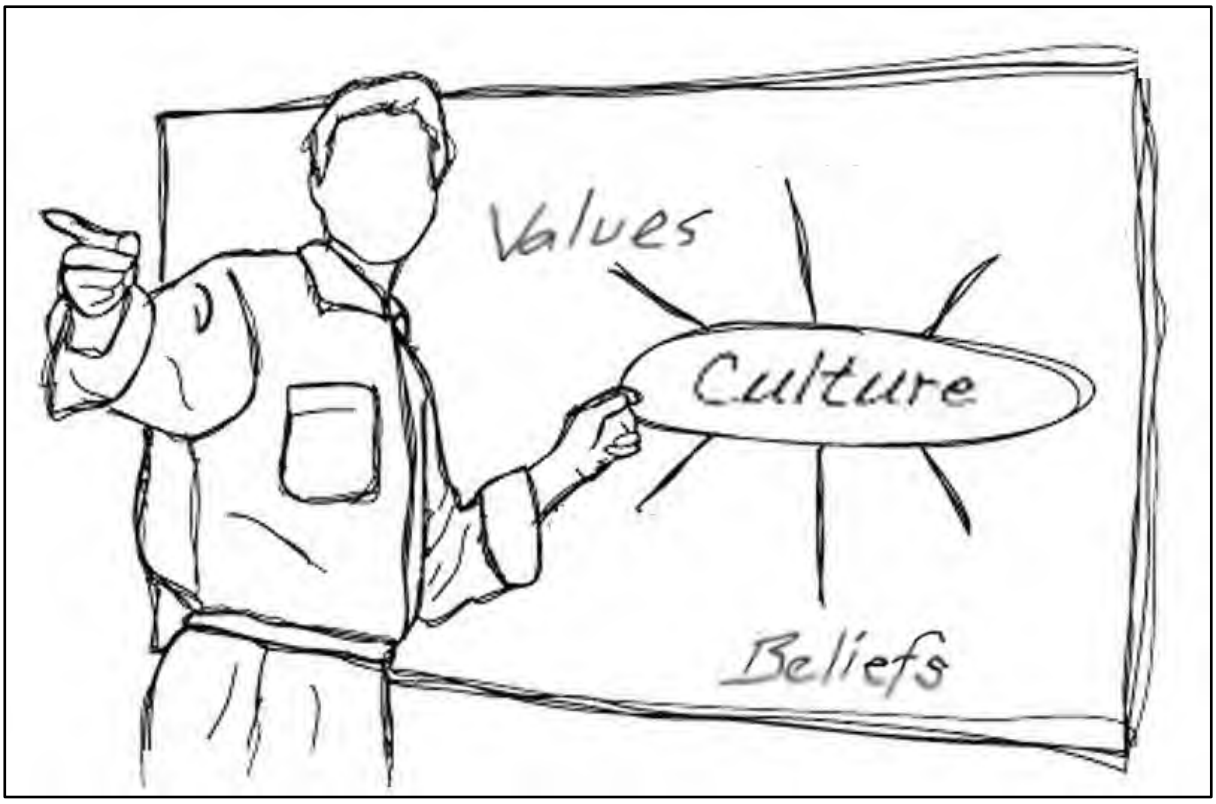
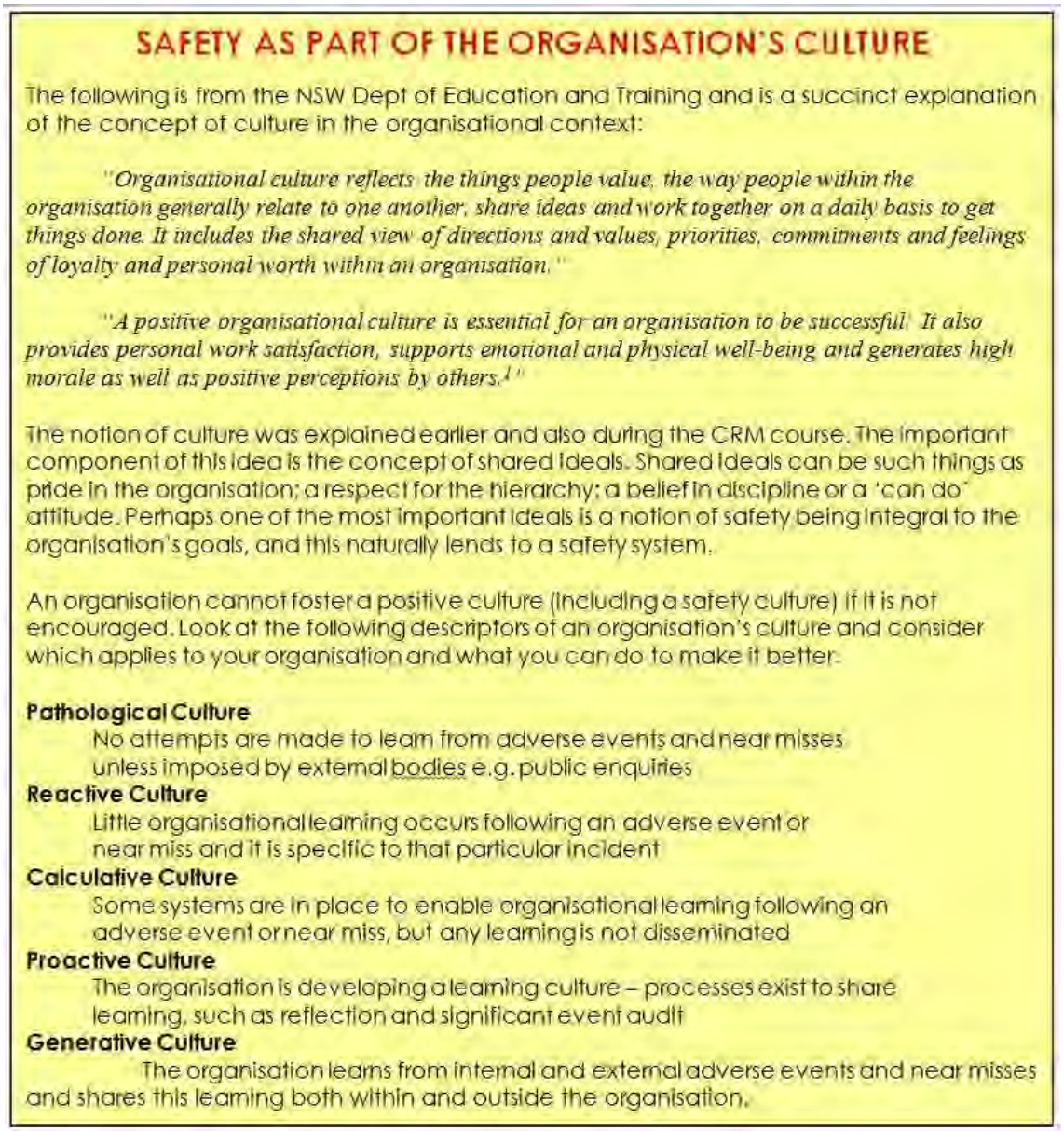


Figure 1.7 Understanding the organisation's safety systems and the way it does business is key to the safety culture within it.

[6] Hudson, P., *Safety Culture – Theory and Practice.* http://ftp.rta.nato.int/public//PubFulltext/RTO/MP/RTO-MP-032///MP-032-08.pdf accessed 12 Jan 2009



SAFETY AS PART OF THE ORGANISATION'S CULTURE

The following is from the NSW Dept of Education and Training and is a succinct explanation of the concept of culture in the organisational context:

"Organisational culture reflects the things people value, the way people within the organisation generally relate to one another, share ideas and work together on a daily basis to get things done. It includes the shared view of directions and values, priorities, commitments and feelings of loyalty and personal worth within an organisation."

"A positive organisational culture is essential for an organisation to be successful. It also provides personal work satisfaction, supports emotional and physical well-being and generates high morale as well as positive perceptions by others."

The notion of culture was explained earlier and also during the CRM course. The important component of this idea is the concept of shared ideals. Shared ideals can be such things as pride in the organisation; a respect for the hierarchy; a belief in discipline or a 'can do' attitude. Perhaps one of the most important ideals is a notion of safety being integral to the organisation's goals, and this naturally lends to a safety system.

An organisation cannot foster a positive culture (including a safety culture) if it is not encouraged. Look at the following descriptors of an organisation's culture and consider which applies to your organisation and what you can do to make it better.

Pathological Culture
No attempts are made to learn from adverse events and near misses unless imposed by external bodies e.g. public enquiries

Reactive Culture
Little organisational learning occurs following an adverse event or near miss and it is specific to that particular incident

Calculative Culture
Some systems are in place to enable organisational learning following an adverse event or near miss, but any learning is not disseminated

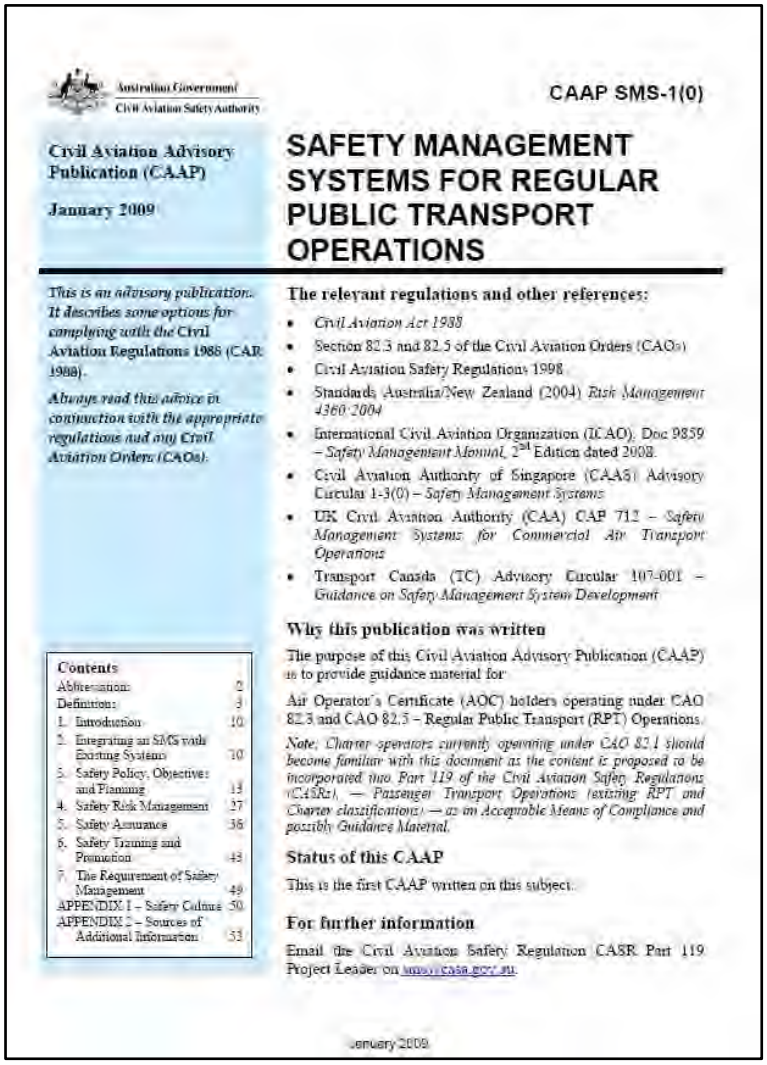
Proactive Culture
The organisation is developing a learning culture – processes exist to share learning, such as reflection and significant event audit

Generative Culture
The organisation learns from internal and external adverse events and near misses and shares this learning both within and outside the organisation.

Figure 1.8 Safety as part of an Organisation's Culture. [7]

1.4.2 **The Organisation's Safety Management System.** A Safety Management System is an integrated method of managing, overseeing, and improving safety within an organisation. It includes such things as management mission statements for safety, the methodology in which safety issues can be reported, the reporting chain, safety managers and the like. In a CRM course, this would be the opportunity for the organisation to reinforce the qualities and attributes and methodologies of its Safety Management System.

[7] https://www.det.nsw.edu.au/reviews/futuresproject/issuespapers/orgculture.htm accessed 09 Feb 09



Australian Government
Civil Aviation Safety Authority

CAAP SMS-1(0)

Civil Aviation Advisory Publication (CAAP)

January 2009

SAFETY MANAGEMENT SYSTEMS FOR REGULAR PUBLIC TRANSPORT OPERATIONS

This is an advisory publication. It describes some options for complying with the Civil Aviation Regulations 1988 (CAR 1988).

Always read this advice in conjunction with the appropriate regulations and any Civil Aviation Orders (CAOs).

Contents

The relevant regulations and other references:

- *Civil Aviation Act 1988*
- Section 82.3 and 82.5 of the Civil Aviation Orders (CAOs)
- Civil Aviation Safety Regulations 1998
- Standards Australia/New Zealand (2004) *Risk Management 4360:2004*
- International Civil Aviation Organization (ICAO), Doc 9859 – *Safety Management Manual*, 2nd Edition dated 2008.
- Civil Aviation Authority of Singapore (CAAS) Advisory Circular 1-3(0) – *Safety Management Systems*
- UK Civil Aviation Authority (CAA) CAP 712 – *Safety Management Systems for Commercial Air Transport Operations*
- Transport Canada (TC) Advisory Circular 107-001 – *Guidance on Safety Management System Development*

Why this publication was written

The purpose of this Civil Aviation Advisory Publication (CAAP) is to provide guidance material for:

Air Operator's Certificate (AOC) holders operating under CAO 82.3 and CAO 82.5 – Regular Public Transport (RPT) Operations.

Note: Charter operators currently operating under CAO 82.1 should become familiar with this document as the content is proposed to be incorporated into Part 119 of the Civil Aviation Safety Regulations (CASRs) — Passenger Transport Operations (existing RPT and Charter classifications) — as an Acceptable Means of Compliance and possibly Guidance Material.

Status of this CAAP

This is the first CAAP written on this subject.

For further information

Email the Civil Aviation Safety Regulation CASR Part 119 Project Leader on www.casa.gov.au.

January 2009

Figure 1.9 CASA's CAAP on SMS for RPT operations outlines the components of a Safety Management System and provides a good basis for the establishment of one within an aviation organisation.

1.4.2.1 **The Required Components of an SMS.** CASA has outlined the requirements for an SMS for aviation operations which is, in turn, based on the ICAO SMS requirements.[8] The first real guidance was primarily for RPT operators, and it is not overly prescriptive leaving much of the creation of the SMS to the individual organisations. The framework is useful as a guide to the components of any organisation's SMS. They consist of four key areas:

- (1) Safety Policy, Objectives and Planning – this includes:
  - A commitment by and accountability of managers
  - Appointment of key safety personnel
  - SMS implementation plans

[8] CASA, *CAAP SMS-1(0): Safety Management Systems for Regular Public Transport Operations,* Jan 2009, Canberra.

- Emergency Response plans and
- Documentation.

- (2) Safety Risk Management – a means by which the risk of threats that could adversely affect the organisation's goals by threatening safety and efficiency are identified, quantified and controls put in place. (See the reference for further information and also refer to Element 4 on Human Error and Threat and Error Management for information on Risk Management).

- (3) Safety Assurance – an integrated system that has features including, but not limited to:
  - An organisation-wide system for the capture of written safety events/issue reports
  - A safety audit review system
  - A published system for the conduct of internal safety investigations
  - A means to analyse safety data as part of risk management
  - Periodic review of the effectiveness of the safety system

- (4) Safety Training and Promotion – the key function of safety training is to create awareness of the SMS and the importance of a positive safety culture. The training should be based on an analysis of the organisation's needs and should be directed at:
  - Safety management awareness for all staff
  - Training aimed at management's safety responsibilities
  - Specific and targeted training for operational staff (flight/ops/maint)
  - Specific and targeted training for safety specialists (Safety Managers, Safety Reps, etc).

1.4.3 **Management Perspective.** CRM courses are perfect venues for management to address members of the organisation and reinforce management perspectives on safety and efficiency. CRM facilitators are encouraged to organise such events, especially as part of CRM awareness training or safety stand downs or other safety-oriented training.

CONCLUSION

CRM is a multifaceted process of understanding how we work by ourselves and with other people and with man-made devices. It can be used in almost any activity where humans need to cooperate with each other to achieve aims or where humans need to interact in high risk environments.

NOTES:

GROUP 2 – THE HUMAN CONTEXT

The Element/s in this Group relate to the Human Being and how (s)he works.

ELEMENT 2 – The Human Mind

Contents:

Module 2.1

2.1 **Personality.** Personality, according to the Encyclopaedia of Psychology, has been defined thus:

> *"…refers to individual differences in characteristic patterns of thinking, feeling and behaving. The study of personality focuses on two broad areas: One is understanding individual differences in particular personality characteristics, such as sociability or irritability. The other is understanding how the various parts of a person come together as a whole."*[9]

The important items from the above definition are "individual" and "patterns of thinking and behaving". There are many theories surrounding how a personality develops, two of which that are particularly relevant to CRM are:

- Personality Development – the concept that personality is affected by various sources such as environment (culture, upbringing, socialisation, etc); and
- Personality Genetics – the scientific field that examines the relationship between personality and inherited characteristics.

In summary, personality is a collection of emotional **thought** and **behavioural** patterns **unique** to a person that is more or less **consistent** over a period of time.[10]

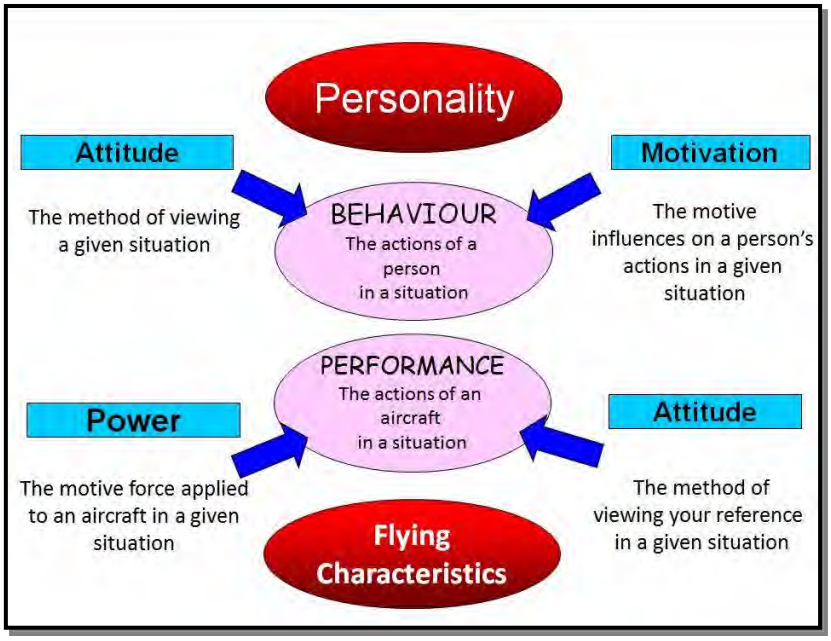


Figure 2.1 The influences on personality can be likened to the classic influences on the performance of an aircraft which would be known to most pilots – a particular attitude coupled with motive power results in a certain performance – or behaviour – of the aircraft. This is the aviation catch cry of 'Power plus Attitude equals Performance' and is merely another way of saying "Motivation plus Attitude will result in a Behaviour".

[9] Kazdin, A.E., PhD, (Editor in Chief), *Encyclopaedia of Psychology*¸ Oxford University Press, NY, as cited in <http://www.apa.org/topics/personality/index.aspx> accessed 01 Jun 2012.
[10] http://en.wikipedia.org/wiki/Personality accessed 28 Jul 06

Section

2.1.1 **Nature vs Nurture and Personality Types.** The above concepts are usually argued in what are known as 'nature versus nurture' theories where theorists argue that personalities are derived from natural (genetic) influences or nurturing (environmental) influences. There are many theories surrounding the creation of personalities and many types of classifications. One of the key classifications within the aviation industry uses the four components listed below:

- **Assertive Personalities** are differentiated with aggressive personalities in that assertive people try and shape the psychological environment by use of cooperative methods. This may be by using a set of rules or it may be by actively engaging and influencing other team members in the decision-making process so that the team goals become personalised and desirable by all the team members, not just the team leader. Assertive behaviour can be utilised by any member of the team.

- **Submissive Personalities** are those personalities that demonstrate either low self-esteem or a lack of confidence in that person's ability, position or opinion due to the social context or other factors. Submissive personalities are more likely to acquiesce to the will of a more dominant team member, not just the team leader. In some instances, a team leader may demonstrate submissive characteristics and allow other members of the team to dominate the team's activities and leadership.

- **Supportive Personalities** are those personalities that demonstrate a nurturing manner and supportive behaviour to other members in the team. This behaviour may be a function of the team leader in his/her effort to build the team or it may be demonstrated by a subordinate team member in support of his/her peers, subordinates or superior team members. (Note: When discussing personality types, Supportive Personalities are not normally included – however it is considered appropriate to include this subset because as a typology, it is valid).

- **Aggressive Personalities** are fundamentally at war with anything that stands in the way of their unrestrained pursuit of their desires,[11] according to Dr George Simon. He also goes on to say that those people with aggressive personalities "…are individuals whose overall 'style' of interacting involves considerable, persistent, maladaptive aggression."

2.1.1.1 Some aggressive personalities are not as overt in their aggression but are more subtle. This is known as passive aggression. (See section on aggression below). Aggressive behaviour is characterised by:

- Anger and frustration

- Aggressive postures & actions threatening a person's personal space
- Raised voice

- Arrogant/aggressive comments.

[11] Simon, Dr G., *Understanding Aggressive Personalities*, http://counsellingresource.com/features/2008/11/03/aggressive-personalities/ accessed 16 Jul 12.

Section

2.1.2 **Characteristics and Traits.** There are certain traits that accompany the theory of personality typologies. Where the above personality types provide wide categories, the following traits can be overlaid on them. They are known as 'the Big Five', and are:

- Openness – outgoing, interested in new things
- Conscientiousness – orderly, responsible, dependable
- Extraversion or Surgency – talkative, assertive, energetic, gregarious
- Agreeableness – good-natured, cooperative, trustful
- Neuroticism – emotionally unstable, moody, easily stressed.[12]

(Note: The last trait is often known as Emotional Stability, however the negative aspect of this trait was chosen by various sources in order to create a mnemonic – OCEAN).

The Big Five personality characteristics are often used by employers as a measure of likely performance outcomes. By rating a person against the five factors (ie agrees or disagrees with the adjectives used above), an overall personality profile can be established, usually by way of several (usually over 100) questions that aim to assess the individual against the traits. The basis of the test is that certain key characteristics of desirable or undesirable persons can be seen across many respondents with some consistency. For example, people who are 'natural' leaders display certain common traits. This may be a quality that employers are seeking and so the Big Five personality test is one tool for employers to use to try and find persons who display those characteristics in the hope that they will be leaders within the organisation.

2.1.2.1 **Individual Differences.** Within the study of personality differences comes the study of individual differences. Individual differences is a field of study that looked at how people are different from each other as opposed to how they may be the same. It looks at such influences as genetics and environment, but in the same way that behaviour does.

2.1.2.2 Part of the study of individual differences is that of Personality and Ability. Personality has already been defined, whereas ability is determined to be the best one person can do on a particular measure in a particular time.[13] The study of individual differences seems to mirror the concept of characteristics, or more accurately enhances this concept. The broadest categories to describe individual differences are introversion and extraversion and emotional stability and neuroticism. Coming close behind these are agreeableness, conscientiousness and intellectual openness.[14] Note how these individual differences mirror the Big 5 categories.

[12] AllPsych ONLINE, *Personality Synopsis,* http://allpsych.com/personalitysynopsis/trait_application.html, accessed 17 Jul 2012.
[13] Revelle, W., *Individual Differences,* Dept of Psychology, NorthWestern Universigy, Evanston IL, http://www.personality-project.org/revelle/publications/ids.html accessed 17 Jul 2012.
[14] Ibid.

Section

2.1.3 **The Concept of Self**. The Self-Concept is a psychological term to describe how a person perceives him/herself. McLeod[15] cites Lewis[16] who suggested this concept has two aspects:

- The Existential Self – the sense of being separate and distinct from others which can commence from the age of as young as two or three months.

- The Categorical Self – once Existential Self is established, the individual then realises that s/he is also an object of the world and can be categorised. For example, a person can describe him/herself as male or female, of a specific age, as being short or tall, etc. As a person matures, the categories begin to change from objective descriptions like those listed above to more subjective descriptions such as psychological traits (eg shy, extroverted) or with comparisons to others (eg more handsome than…, less attractive than…).

The above concepts can be considered to be relatively objective. One can describe one's self as existing as a separate person and can then describe him/herself as short or tall, fat or thin, male or female, blonde or brunette, etc. McLeod then cites Rogers[17] who suggests that there is a third category of the Self Concept:

- The Self Image (The view you have of yourself). The Self Image is subjective and may not reflect reality (ie an individual may view him/herself completely differently from how others view him/her). (See also Self Esteem and Self Worth).

2.1.3.1 **Self Esteem and Self Worth.** The extent to which one values one's self is a measure of one's self esteem and is a subjective view on how we perceive ourselves and how we think we are perceived by others. The two key areas are:

- High Self Esteem – where an individual has a positive view of him/herself and is usually characterised by such things as confidence in one's own abilities, a good acceptance of one's self as an individual including a sense of pride in one's individuality. Such a person often cares little about the opinion of others in relation to how they judge him/her and an overarching optimism.

- Low Self Esteem – where an individual has a negative view of him/herself. Shows as a lack of confidence, a desire to be or to look like someone else. A constant worrier about what others think of him or her and an overall pessimism.

2.1.4 **Personality Types and Behaviour.** As part of the nature vs nurture debate, behaviour is associated also with personality types. Behaviour, as will be seen in the next module, can be modified by training and the environment, but a certain degree of it is related to personality which is innate. The figure and table below shows behavioural patterns listed against personality types using another view. Note how there are similarities between all.

[15] McLeod, S, 2008, *The Self Concept in Psychology,* viewed 17 Jul 2012 < http://www.simplypsychology.org/self-concept.html>.
[16] Lewis, M. (1990). Self-knowledge and social development in early life. In L. A. Pervin (Ed.), *Handbook of personality* (pp. 277-300). New York: Guilford.
[17] Rogers, C. (1959). A Theory of Therapy, Personality and Interpersonal Relationships as Developed in the Client-centered Framework. In (ed.) S. Koch, *Psychology: A Study of a Science. Vol. 3: Formulations of the Person and the Social Context*. New York: McGraw Hill.

EHAVIOURAL PATTERNS	STRENGTHS	WEAKNESSES
NURTURING	Caring, Trusting, Optimistic, Loyal, Idealistic, Helpful, Modest, Devoted, **Supportive**, Accepting, Polite, Understanding	Smothering, Gullible, Impractical, Slavish, Wishful, Self-denying, Self-Effacing, Self-Sacrificing, **Submissive**, Passive, Deferential, Masochistic
AUTONOMOUS	Reserved, Cautious, Practical, Economical, Methodical, Analytical, Principled, Orderly, Fair, Persevering, Conserving	Cold, Suspicious, Unimaginative, Stingy, Rigid, Nit-Picking, Unbending, Compulsive, Unfeeling, Stubborn, Possessive
AGGRESSIVE	Ambitious, Self-Confident, Enterprising, Organizing, Persuasive, Forceful, Quick to Act, Imaginative, Competitive, Proud, Bold, Risk-taking	Ruthless, Arrogant, Opportunistic, Controlling, Pressuring, Dictatorial, Rash, Dreamer, Combative, Conceited, Brash, Gambler.
ASSERTIVE	**?**	

Figure 2.2 and Table 2.1. Another view of personality types and their behavioural patterns listed as strengths and weaknesses. See how it mirrors the four key types discussed above. Note how Submissive and Supportive adjectives are found as both strengths and weaknesses?[18] What strengths does assertiveness bring to a team environment?

[18] Derived from Behavioural Patterns - http://www.crm-devel.org/resources/misc/transcan/transcan4.htm. accessed 17 Jul 12.

Module 2.2

2.2 **Behaviour and Skills.** Behaviour is the way a person will act in a given situation. Skills describe the capabilities of an individual or group. Within the context of this element, they can be exclusive or interdependent. For example, the ability to perform a particular skill may result in a particular behaviour. On the other hand a particular type of behaviour may demonstrate a lack of mastery of a particular skill, such as when a person tries to show off and fails.

Section

2.2.1 **Drives (aka Motivations).** According to the theory of 'Attitude Behaviour Consistency'[19] ; there are two ways to change a person's behaviour, Direct Control which can be considered external control and Attitudinal Control which can be considered to be internal control. Basically:

- Direct Control – Forcing a certain behaviour upon another by force or threat of force whereby the force may be physical or psychological. This type of behaviour control is only effective if there is constant monitoring and whilst the potential force is available.

- Attitudinal Control – By changing a person's subjective view on a behaviour such that it is favourable will make that behaviour self-policing with the promise of some sort of benefit to the subject.

2.2.1.1 **A Quick Word on Attitude.** Attitude is covered later in this workbook, but basically an attitude is a person's positive or negative view on something. In order to change attitude (so as to change behaviour), then there are also two ways to achieve that:

- Attitude Availability - Does the subject have a positive or negative view on an object? A person with a neutral view of an object will not be inclined to be motivated to act in a certain way. An attitude has to be 'activated' in the subject. (An example of a neutral attitude is one where the subject could answer: 'I don't care one way or the other.')

- Attitude Relevance – Is the attitude in question relevant to the situation at hand? For example, an attitude towards the colour blue has no relevance to CRM, but it does have relevance to choosing a shirt.

2.2.2 **Cognitive Dissonance Theory**. Cognition, in general psychology, can mean Information Processing, especially in relation to understanding individual psychological functions, but in social psychology it infers an understanding of attitudes and group dynamics[20]. Dissonance means incongruence or disharmony. In this instance, Cognitive Dissonance refers to disharmony in a person's attitudes and beliefs.

2.2.2.1 **Elements of Cognitive Dissonance**. Cognitive Dissonance has some critical components to it which will influence an individual's behaviour. The theory states that if CD exists, then the subject will experience an unpleasant state of physical or psychological arousal. For example, a person may understand that smoking is unhealthy but because that person is addicted and needs to smoke (and believes s/he is not able to quit) then a state of

[19] *Attitude Drives Behaviour,* http://www.as.wvu.edu/~sbb/comm221/chapters/abc.htm 01 Sep 04

[20] http://en.wikipedia.org/wiki/Cognition accessed 12 Jul 2012

disharmony exists between what s/he knows is bad and his/her need to do it. That person will try and restore consonance (harmony) which is a human trait of trying to make order out of the disorderly. This harmony may be achieved by the individual trying to add new cognitions or changing existing ones. For example, s/he may justify the need to smoke by such things as fatalism ('I'll let fate decide if it's going to kill me'), or acceptance ('we all have to die sometime'), or denial ('All the warnings are just a media beat up'), or some other means of justifying the behaviour by adding new cognitions or changing existing ones.

Section

2.2.3 **Motivation and Behaviour.** Central to our behaviour are the concepts of attitude and motivation. Motivation is the driving force towards a particular behaviour. This section discusses motivation and where it fits within the CRM context.

2.2.3.1 **Motivation** is the psychological or physiological impetus for an organism to react in a certain way. Its two extremes are Fear and Desire. All human behaviour is due to motivation which is made up of a component or components of these two extremes. One component will outweigh the other in most circumstances and in turn will be influenced by attitude and culture and personality.

2.2.3.2 **Maslow's Heirarchy of Needs.** Abraham Maslow noticed that in primates (initially in monkeys and then in humans) that there was an order of precedence in how the subject solved its needs. He developed a pyramidal hierarchy of needs which influences the way we look at our motivations.

Figure 2.3 Maslow's Hierarchy of Needs suggested that all human needs and wants are satisfied in a particular order, starting at the bottom and working up.

- Physiological Needs are those needs that are required for life; air, water, food, shelter, sex. These needs must be satisfied first before others.

- Safety and Security Needs includes stability, structure and limits.

- Belonging and Affection Needs are natural tendencies for humans to associate with other humans and to achieve a sense of inclusion.

- Self-Esteem needs include two versions; lower needs and higher needs.

    - Lower needs include the respect of others, need for status, fame, glory, recognition.

    - Higher needs include the need for self-respect, confidence, competence, independence, freedom etc.

- Self-Actualisation needs are those needs where the person achieves those aims that are important to him/her and becomes what he/she wants, independent of the opinions of others. At this stage, most humans are willing to give of themselves to others.

2.2.4 **Aggressive Behaviours and their influences.** There are a number of different motivations for aggressive behaviour, some of which are innate and others which are cognitive. Here are a number of different types of aggression:

- **Aggressive typologies:**

    - Predatory Aggression
        - A psychological attraction to aggressive acts in order to dominate or to satisfy a pathology

    - Inter-male Aggression
        - Perceived ego threat or competition for resources. Hormonal influences play a part in its manifestation

    - Fear-induced Aggression
        - Lashing out due to a perceived threat to one's safety

    - Territorial Aggression
        - Aggressive behaviour when protecting one's territory or submissive behaviour when encroaching on another's

    - Maternal Agression
        - Innate protective instinct of a mother for her children

    - Irritable Agression
        - Tendency to lash out when irritated

    - Sex-related Aggression
        - The same stimuli that evoke sexual behaviour can evoke aggressive behaviour
        - Misogynistic behaviour
        - Jealousy-related behaviour
        - Pathological behaviour where sex and aggression are inter-woven in the psychological make-up of a person

- Instrumental Aggression
  - A successful outcome related to aggressive behaviour pre-disposes a person to repeat the act, eg robbery, rape, intimidation where aggression is used as the instrument to obtain the end state

Figure 2.4 Aggression between a football fan and a member of the police. A combination of inter-male aggression and territorial aggression and fuelled by mob mentality.

Common characteristics amongst aggressive personalities include:[21]

- Actively seeking the superior or dominant position in any relationship
- They abhor submission to anyone or any rules or procedures but will do so if it meets their goals in the short term
- Can be ruthlessly self-advancing especially at the expense of others (whereas the narcissistic personality cares only for him/herself and not for the rights or needs of others, such a person will not necessarily violate the rights/needs of others… however an aggressive personality will)
- They have a disdain for the truth, especially if violating it will help them achieve their goals
- They exercise little control over their impulses if they are seeking a goal

[21] Simon, Dr G., op. cit.

Module 2.3

2.3 **Attitude Development.** Attitude, as Philip Zimbardo describes it, is a psychological concept that describes a person's positive, negative or neutral view of an "attitude object" such as another person, object or event.[22] The reason why attitudes are important is that they may have a direct effect on a person's behaviour. The American Psychological Association's definition states that attitudes are 'learned and relatively stable tendencies.'[23] This is important to us because it tells us that attitudes are influenced by environmental (learned) influences such as culture and training as well as personality.

Section

2.3.1 **Origins and Components to Attitude**. There are many factors that will influence attitude and often disagreement about the strength of those influencing factors. Some common concepts as to the **origin of a person's attitudes**, according to the University of Notre Dame, [24] are:

- **Functionalist Theory**
    - Where attitudes are held by the individual because it serves a purpose in achieving a goal. For example, an attitude towards a particular political party may be due to the belief that if elected, their policy will benefit the individual in a particular way such as increasing funding on a particular project in which the individual is involved
    - Functionalist theory also believes that attitudes will change depending on phases of life or status or other environmental stimuli. As a person matures, their attitude towards décor may change from pop culture to more conservative which befits that person's stage of life and the image s/he wishes to project, which is a goal oriented stimuli.
- **Learning Theory** consists of three parts:
    - **Classical Conditioning** – when two stimuli are repeatedly associated, the subject learns to respond to them with a similar emotional reaction. (Repetition and Consistency result in reaction)
    - **Instrumental/operant Conditioning** – when a behaviour or attitude is followed by a positive consequence. Training a dog with treats is an example of Instrumental Conditioning where the treats are the reward. In so far as attitudes are concerned, if a person holds an attitude, and other people in the person's peer group (or other influential group) agree with that attitude, then that is a form of reward and constitutes Instrumental Conditioning of an attitude. (A positive response results in a reaction).
    - **Observational Learning** – the subject observes the behaviour and attitudes of people around him/her and imitates it. Racist attitudes can be handed down from generation to generation based on the attitudes of the

[22] Zimbardo, P.G., 1999, et al, *Psychology(3rd Edn),* Addison, Wesley Longman, Boston.
[23] American Psychological Association Glossary of Terms, http://www.apa.org/research/action/glossary.aspx accessed 20 Jan 2008.
[24] Liska et al, (date unk) *Lecture 2 – Social Psych – Attitudes*, University of Notre Dame, Indiana, http://www.nd.edu/~rwilliam/xsoc530/attitudes.html accessed 12 Jun 2012.

parents. (The subject discerns the environment and takes an attitude from that environment. (See the section on Culture, below).

Figure 2.5 Kids in Belfast play a game based on their life experiences in their environment. The normalisation of this behaviour is a classic case of conditioning and would be alien in an environment in a country like Australia.

Section

2.3.2 **Attitude, Beliefs and Opinions**. **Attitude** has already been defined in para 2.3 as being a person's view on another thing or event. A **Belief** has a different concept in that a belief is a form of an attitude but in this case, the subject holds that a certain proposition or premise is true[25]. For example, a person can see a coffee cup on a work desk and believe that it is on the desk, however that person may have a negative attitude towards it being there (because s/he has the attitude that it should not be on the desk but should be in the kitchen). Having a belief does not mean that the person holding the belief has first-hand experience in the subject being considered. Faith in a God is an example of a belief that is not founded on actual experience, but of faith, yet the subject still holds that the premise that a God exists to be true. An **Opinion** is an evaluation, impression or estimation of the value or worth of an object or concept. To encapsulate all three, a person can have an attitude, a belief and an opinion about war. For example, a person can have a negative attitude towards war; a belief that war will always exist and an opinion that war is a necessary evil. In the first instance, there is no reason to doubt his/her attitude if s/he says that that is what it is and so arguing against that would be moot. In the second instance, his/her belief can be argued against because belief is subjective and not based on fact. In the third instance, the opinion is based on personal cognitive processes and is held by the subject and arguing against it may persuade the subject to change it.

[25] Schwitzgebel, Eric, "Belief", *The Stanford Encyclopedia of Philosophy (Winter 2011 Edition)*, Edward N. Zalta (ed.), URL = <http://plato.stanford.edu/archives/win2011/entries/belief/>.

2.3.2.1 **Resistance to change**. Change, in any manifestation, can be difficult to accept. Whether it be a change in working conditions; a change in family life or a change in relationship status – either personal or professional – a person may object to the change and try and justify that objection. Some reasons for objecting to change and resisting it are:[26]

- Established within a position/place and too comfortable (or lazy) to move
- Needs are met in the current situation
- Unfinished business (perceived or real) prevents moving on
- Lack of understanding of the proposed change
- The new end state does not seem to hold any advantages over current situation
- A clear and defined path is not provided
- The change goes against preferences or beliefs
- A lack of confidence in the people instigating the change
- Little or no negative consequences in not changing, therefore there is no incentive to make the change
- Lack of senior support for change.

In order to try and make a change, finding logical reasons to counter the above examples of resistance will assist in facilitating the change, in particular point five: the end state does not seem to hold any advantage over the current situation.

2.3.2.2 **Primacy of learning/information.** Also known as the Law of Primacy, it states that students retain information they learn for the first time longer than subsequent information, especially information that must be re-learnt due to incorrect teaching. In other words, bad habits are harder to break than teaching new habits.[27] The same also applies somewhat to those lessons learnt as part of growing up in a particular environment.

2.3.2.3 **Effect of training.** Because of the Law of Primacy, effective training in the early stages will affect the behaviour and attitudes of the individual for some time thereafter. Provided the training is correct and appropriate, a new participant can be moulded and shaped into the type of person needed and who possesses the required behaviour which is borne out by the attitude instilled.

[26] Changing Minds.Org, *Rationale for Resistance,* auth unkn, http://changingminds.org/disciplines/change_management/resistance_change/rationale_resistance.htm accessed 29 Aug 12.

[27] US Navy, *The Laws of Learning,* Navy Instructor Manual – Military Manual for teaching in the military, Integrated Publishing, http://navyadministration.tpub.com/134t/css/134t_11.htm accessed 29 Aug 12.

Figure 2.6 Children in a Madrassa learning about religious beliefs will keep those beliefs and their attitudes into their adulthood.

Section

2.3.3 **Effect on safety and managing risk.** Changing attitudes and thus behaviour can be brought about not only by environment, but by training as well. This has been proven by the changes within Australian Army aviation. Since the mid-1990s, after an horrific mid-air collision between two Army Black Hawk helicopters, the concept of Aviation Risk Management has been part and parcel of Army Aviation business, so much so that all activities are conducted within a pre-determined risk profile for standard type missions or, if a mission is not standard, then a risk management plan is created specifically for the new mission. At first, these requirements were met with a great deal of scepticism and criticism, but at time of writing it is an accepted part of Army Aviation business because it is integrated into the training regime. Eventually, new members will replace the old and the thought of conducting operations without a risk management plan or a risk profile will seem totally alien and incongruous. This section looks at attitudes and how they affect risk management and therefore safety.

2.3.3.1 **Effect on risk acceptance due to culture/gender/group dynamic.** (See paragraph on Culture below) When determining risk acceptance within a cultural group, the group's ideals and beliefs need to be closely scrutinised. Take, for example, safety cultures within an industrial and affluent country such as Australia and compare it to the safety culture within a third world country. One may hazard an opinion that the value of life is looked upon differently in one cultural context as compared to the other, and therefore safety is weighted differently because of that. Another argument is that religious beliefs as a part of a culture also change the outlook on certain activities and that has a flow on effect in how risk is managed. Risk acceptance as a part of industrial cultures can also differ. Look at the example cited in the paragraph above and use the aviation industry as the example and then compare it to the rock fishing culture within Australia: the same national culture; different industrial culture.

Figure 2.7 Electricity line workers in India. Safety standards in third world cultures differ markedly from those in first world nations due to differences in resources and possibly due to the difference in the value of life. [28]

2.3.3.2 **Risk acceptance due to gender.** Outwardly, it would seem obvious that men are more likely to take risks than women, purely based on general experience. There have been a number of studies into this phenomenon, with one in particular looking at five specific areas where risks are taken and the associated risk assessment conducted by men versus women. These five domains were financial, health and safety, recreational, ethical, and social.[29] The study found that males were more likely to undertake risky activities than females, and were more likely to do so if they considered the enjoyment of the risk taking activity was going to be significant which, in most cases, they did. Unfortunately, this study's sample had a mean age of 18.5 years. This shows a marked lack of life experience and so is based purely on the limited life experience of the sample group. Another study found similar results but related it to evolutionary theory in which young males are more willing to take risks in an effort to attract a mate and that risk-taking is a form of display designed to attract a mate just as a bird might effect a display of bright plumage to do similar.[30]

[28] Rajesh Kumar Singh / AP

[29] Harris, C.R., and Jenkins, M., and Glaser, D., *Gender Differences in Risk Assessment: Why do Women Take Fewer Risks than Men?* Judgment and Decision Making, Vol.1, July 2006, pp 48 – 63.

[30] Pawlowski, B., Rajinder, A., Dunbar, R.I.M., *Sex Differences in Everyday Risk-Taking Behaviour in Humans*, Evolutionary Psychology, www.epjournal.net – 2008.6(1): 29 – 42.

Module 2.4

2.4 **Cognitive Biases.** Cognitive bias is a phenomenon whereby our ability to rationally consider a situation (by cognitive processes) is skewed by some form of bias or prejudice. Many are irrational but are extremely common.

2.4.1 **Common Biases.** 12 common Cognitive Biases are[31]:

- Confirmation Bias – Individuals tend towards people or sources of information that agree with them (eg like-minded people; websites with whose views they sympathise)

- In-Group Bias – Individuals will tend towards favouring what their group thinks at the expense of those outside the group. It is a form of tribalism

- Gambler's Fallacy / Expectation Bias – The expectation that because a previous event or series of events has occurred, then that will influence the likelihood of the next event occurring in a particular way (eg tossing a coin and getting four heads in a row may make the gambler think that the chances of a tail occurring next is higher, when in fact it is the same odds, ie 50/50). See later for Expectation Bias.

- Post-Purchase Rationalisation – Trying to rationalise an irrational purchase so that the individual feels more at ease with his/her decision. This applies to all situations where a choice has been made, not just in purchasing items.

- Neglecting Probability – The inability to understand likelihood and risk properly due to some preconceived notion or skewed perspective. For example, dying in a car accident is more likely than dying in a aeroplane accident, yet some people fear flying moreso than driving.

- Observational Selection Bias – The phenomenon of noticing something moreso than one has done before after experiencing a relevant event. For example, when purchasing a new car and then noticing how popular that car is on the roads; or learning a new word for the first time and then hearing that word more often than one has noticed it before.

- Status Quo Bias – Reluctance to change because of fear of the unknown. A phenomenon known well in business and in politics, especially at election time.

- Negativity Bias – Humans pay more attention to bad news/events than to good ones. It has been suggested that this is an evolutionary after effect whereby survival depended on knowing what items or actions had negative consequences.

- Bandwagon Effect – Similar to In-Group Bias, Bandwagon Effect is the propensity for people to 'join the crowd' and to enter into a group mentality rather than maintain individual standards.

- Projection Bias – This cognitive bias is where people project their own ideas and ideals into others where there is no reason to. An example of where a person or group of persons believe that their view of the world is shared by others outside their group.

[31] Dvorksy, G, *The 12 Cognitive Biases that Prevent you from being rational,* http://io9.com/i-disagree-entirely-with-the-example-stated-in-neglecti-264007832 accessed 28 Oct 13

- The Current Moment Bias – Where humans are more prone to delay inconvenient or uncomfortable situations in preference for being comfortable or satisfied in the current moment. Economists often relate to the lack of saving and the propensity for credit card use as a form of Current Moment Bias.

- Anchoring Effect – False comparisons to justify a choice. An example is an item on sale that is not worth as much as its sale price and definitely not worth as much as its normal retail price. A consumer may look at the value of the saving rather than the value of the item and make a choice based on the apparent saving. For example, a nice pen is marked down from $100 to $50. A consumer may see a $50 saving but in actuality, the pen may only be worth $10 if s/he considers its real value so, in essence, if s/he bought it, then they would be wasting $40 rather than saving $50.

2.4.1.1 **In-Group Bias and Risk Acceptance.** Arguably the two most common phenomena in this area are Risky Shift and the Abilene Paradox, both of which are forms of *Groupthink*, a term first coined by William Whyte in 1952 (and later cited by Irving Janis), that described the way in which a group of people may rationalise their decisions even though, upon closer inspection or consideration, those decisions may be faulty.

Figure 2.8 The Space Shuttle Challenger exploded soon after launch when a faulty seal in the solid rocket booster caused a catastrophic failure. The contractor/manufacturer of the part had advised NASA that due to the cold weather being experienced at the time of launch, it could not guarantee the integrity of the part and recommended a delay until the weather became warmer. Upon pressure from NASA, the management at the contractor decided that perhaps the risk was acceptable and gave the go-ahead even though later they would admit that the recommendation was probably not appropriate. The image above shows black smoke emanating from the faulty seal during the launch sequence.

2.4.2 **Risky Shift** is a form of group polarisation. In essence, the risk acceptance of an individual will shift more towards the average of the group in which the individual is in. In other words, if most of the people group are very cautious, then the individual may find that his or her risk acceptance becomes more cautious. This is often called *cautious shift.* In the opposite case, an individual might be more inclined to take greater risk when the average of the group would accept greater risk.

2.4.2.1 There have been a number of studies surrounding this phenomenon with various explanations, some of which include the following:[32]

- because of the perceived diffusion of responsibility, greater risks might be chosen by the individual, especially when the individual shares some sort of emotional bond with other members of the group
- high risk takers are often more confident and therefore more persuasive and may be more likely to convince a more cautious person to take risks
- within a group scenario, potential actions may often be made more familiar during discussion and debate. With this increasing familiarity, cautious people might be more inclined to take risks associated with that activity.

2.4.3 **The Abilene Paradox** was named after a town in Texas. The story goes that a family in the town of Coleman, 53 miles from Abilene, decided to take a hot and dusty drive into Abilene for a meal which was very disappointing. Upon return, they discovered that no one in the group actually wanted to make the journey for the meal, but when it was suggested in the first place they had all agreed that it would be a good idea to make the trip even though individually they did not. This is another form of group polarisation where individuals will take a course of action in order to conform with what they perceive are the desires of the group even though the desires of the group are actually not as that they perceive them to be. This paradox happens in those organisations where strong cohesion exists and where individuals do not feel empowered to speak up in opposition to the group.

[32] Changing Minds, *Risky Shift Phenomenon,* http://changingminds.org/explanations/theories/risky_shift.htm accessed 12 Aug 12.

Section

2.4.4 **Putting it all together.** The diagram below is a flow chart of decision making and is a good start at putting some of the concepts together that have been discussed above. It is derived from the work of Dr Icek Aizen of the University of Massachusetts – Amherst whose work on the Theory of Planned Behaviour aims to shed light on how and why we behave in certain ways. His model of planned behaviour – illustrated below – is what we shall use to combine the concepts discussed above.

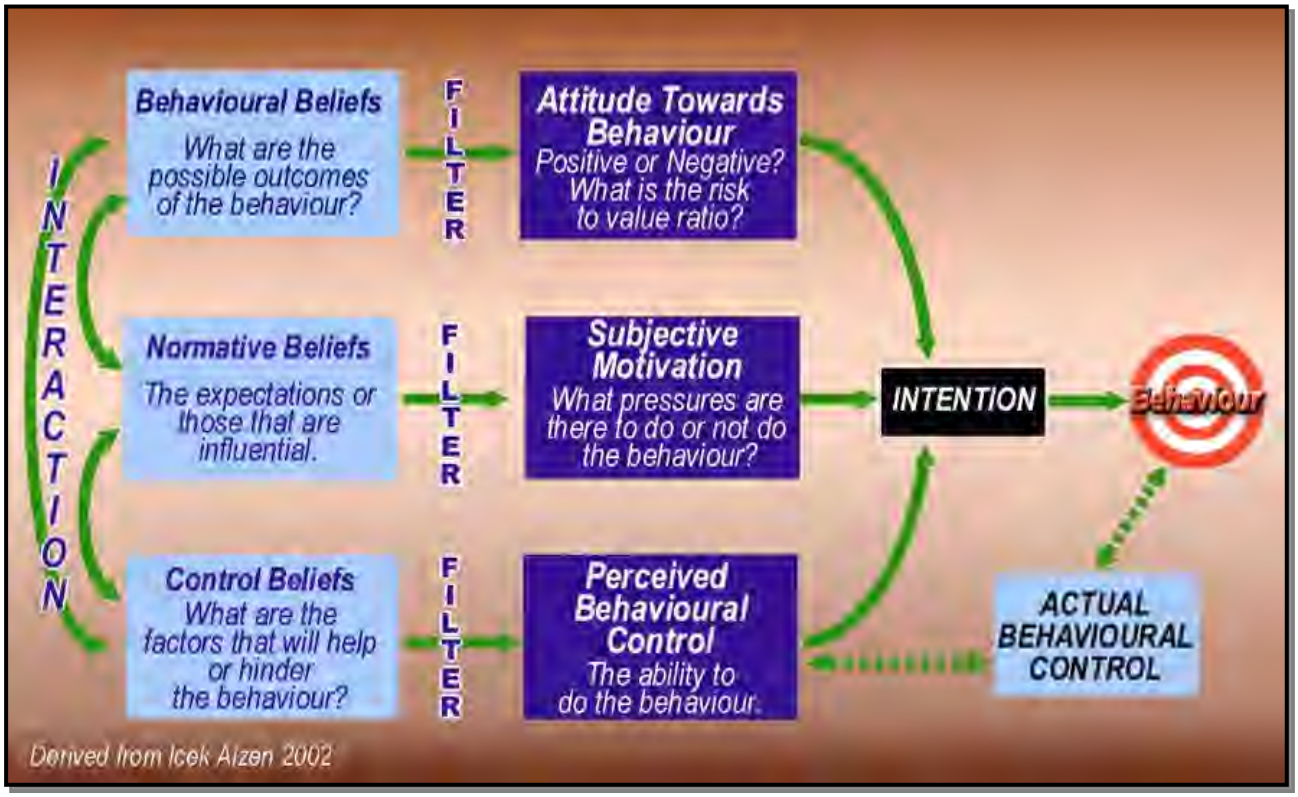


Figure 2.9 This diagram, derived from the work of Icek Aizen, shows the flow of decision making towards a behaviour as filtered through a belief and attitude system and is representative of his theory of planned behaviour.

2.4.4.1 A person decides to commit a risky behaviour, say drag racing from a set of traffic lights in the company car. The thought processes go thus:

- **Behavioural Beliefs** – the individual considers what are the possible outcomes: thrill (positive) vs crash (negative). Filters this train of thought through his experience base and weighs up his **Attitude towards the Behaviour** vs the risk of the possible outcomes. His decision is influenced by his attitude towards both outcomes (which is a result of his experience, his training, his upbringing and his culture) and whether the risk of a negative outcome is outweighed by the risk of the positive outcome. This acceptance of risk can be influenced by group dynamics (Risky Shift).

- **Normative Beliefs –** the individual considers those people that are influential to him: his parents… do they have an influence on this situation? His boss… does he have an influence on this situation? His peers… do they have an influence on this situation? The Police… do they have an influence on this situation? These

beliefs are filtered through his beliefs of their expectations which leads to **Subjective Motivations.** What pressures are there for him to do or not do the intended action? His parents would probably not want him to do it, nor would his boss. The Police would not either, but what about his peers? His peers may be with him in the car and may actually be encouraging him to do the action.

- **Control Beliefs** – what factors will help or hinder the individual? Are there any police around? Will the boss find out? How much traffic is there? He weighs up these factors and assesses them through his filter of experience and assumptions and then considers his ability to do the action, the **Perceived Behavioural Control**. He figures out whether it is possible for him to do the action with regard to his skill level and with regard to the environmental conditions.

2.4.4.2 The end result is that the individual comes up with his intention to either do or not do the action (ie drag racing) and then what he does is the behaviour. It is at this point that behavioural control can intercede and change the behavioural intent and outcome of the individual. That behavioural control may be a conscious decision to not do the action based on factors that he considers more important. Perhaps his attitude towards street racing has been influenced by the death of a friend in a similar situation, or due to driver education. In our experience, we can say that an acceptance of the principles of CRM is the behavioural control.

Figure 2.10 [33] Normative beliefs in some groups can significantly change attitudes towards acceptable behaviour. Football and other sporting clubs are such groups where members can experience overt or subtle pressure to conform to their group norms, even if they are contrary to accepted social mores.

[33] CC-BY-SA-3.0 http://en.wikipedia.org/wiki/Canterbury-Bankstown_Bulldogs

Module 2.5

2.5 **Culture.** The manner in which we view events, objects and situations can be highly influenced by the culture in which we exist. Culture is an abstract concept but perhaps one of the better definitions is from the Arizona State University:

> *Culture is shared beliefs, values, behaviors, [rules] and material objects among members of a group or society. Culture is learned, shared and taken-for-granted.*[34]

Culture is not merely based on ethnic or national backgrounds, although this is perhaps the most prevalent understanding of the concept of culture, it can also be applied to subsets within ethnic cultures. Look at the Australian culture: we can divide Australian culture into those who follow NRL and those who follow AFL; or Queenslanders vs Tasmanians. Culture can also be applied to industries and other organised groups. The aviation industry is a cross border culture. A football culture; a beer culture; popular culture are all legitimate expressions of the concept. Each subset has its own cultural norms and components. Because culture can influence daily lives so deeply, it is worth discussing some basic components of culture when discussing attitudes and beliefs.

Section

2.5.1 **Components of Culture**. There are a number of different components to culture. Some classifications include:

- Material Culture – physical artefacts such as equipment or decorations that are peculiar to a culture and which are tangible (ie can be touched and seen);
    - Flags – A manifestation of symbolism as applied to material culture (see below also on symbol systems).
    - Architecture – For example, the design of cathedrals in catholic countries with their tall spires and buttressed walls as compared to mosques in muslim countries with their minarets adorned with crescent moons.
    - Fashion and costumes. National costumes are a demonstration of culture for nations. Young people may wish to dress as gothics as part of the 'emo' or 'goth' culture.
    - Relics. In religion, parts of the bones of a saint or other venerated person are of great significance within the cultural belief system. Other relics may be related to archaeology such as the Forum in Rome or the Coliseum.
- Non-Material Culture – knowledge, beliefs, norms, customs, values, language and other abstract concepts that have come to exist within a culture and which are accepted and taken for granted as being the norm.
- .
    - Knowledge/Beliefs – what people know to be true or believe to be true irrespective of concrete proof. (eg religion)
    - Values – A shared standard of judgement about what is right and what is wrong; what is good and what is bad; what is beautiful and what is ugly.

[34] http://www.public.asu.edu/~zeyno217/301/culture.html accessed 02 Sep 04

- Norms – Customs, shared rules and expectations and normalise behaviour. In a structured culture, those norms that are codified and enforced are rules and laws. Others that are not codified, are considered to be customs and or traditions. Some can be very strong, especially in highly cohesive groups.

- Symbol Systems – Images and language are examples of cultural components of a non-material nature. The image of a flag is a symbol and can be made tangible by the creation of a flag out of cloth or similar. The stars and stripes are a common theme in the US and are used often. (The flag is considered sacred in that country and laws exist about the manner in which it is to be respected). Symbols are very significant in religious cultures (the Star of David, the Crescent, the Cross). Language is a system of symbols where words signify meaning when written and the sounds that accompany them (speech) signify meaning also.

Figure 2.11 A southern cross tattoo on the chest of a young adult. This symbol has been a part of Australian culture for over 150 years but has recently taken on a new meaning among young males who adorn their property – including their bodies – with the symbol.

Section

2.5.2 **Culture as a medium for Attitudes.** As can be seen in the section above on non-material culture, the values and norms of a society or group will influence the way in which a person will identify that which is right and that which is wrong and that which is expected. This can happen at an organisational level with things like safety cultures. Another common example in Australia is the sporting culture, say, of football teams. On a national/ethnic level, it can be more pronounced and ingrained. An example of how this can change attitudes is in the collectivist versus individualist cultures. Collectivist cultures emphasise family and societal goals above the desires or needs of the individual whereas

individualist cultures emphasize and commend personal achievement rather than group achievement in society in general. There are exceptions, such as on the sporting ground. The table below compares the collectivist culture of China against the individualist culture of the United States. [35]

	CHINESE	AMERICANS
Conception Of the Self	Collectivist: Higher value placed on group cooperation and individual modesty.	Individualist: Higher value placed on self-reliance. Self-promotion is more accepted. High value placed on "freedom" from externally imposed constraints.
Social Relationships	Formal, hierarchical. People most comfortable in the presence of a hierarchy in which they know their position and the customs/rules for behaviour in the situation.	Informal, egalitarian. People most comfortable with their social equals; importance of social rankings minimized.
Friendship	Small number of close, lifelong friends who feel deeply obligated to give each other whatever help might seem required.	Large collection of "friends" and acquaintances which changes over time and involves only limited mutual obligations.
Obligation	Relationships with other people involve reciprocal obligations.	People avoid interdependent relationships and situations that might entail long-term obligations.
Task vs. Relationship Orientation	Relationship-oriented: Maintaining a harmonious relationship has priority over accomplishing tasks.	Task-oriented. Relationships are less important than getting the work done.
Harmony vs. "Truth"	Avoid direct confrontation, open criticism, and controversial topics. Concern maintaining harmony and with "face."	Willing to confront directly, criticize, discuss controversial topics, press personal opinions about what they consider "the truth. Little concern with "face."
Role of laws, rules, and regulations	More faith in personal relationships than in written rules and procedures for structuring interactions.	Written rules presumably apply to everyone and are assumed to produce fair, reasonable procedures and decisions.
Time Consciousness	Relatively more attention to the past and to the longer-term future.	Less interested in the past; eye on near-term future.
Ascribed vs. Achieved Status	Traditionally, a person's status in the society was based importantly on inherited characteristics such as age, gender, and family. This is changing.	People's status is based mainly on their own achievements, including education obtained and level of success realized in their line of work

Table 2.2 Some cultural differences between a collectivist culture like that of the Chinese and the individualist culture like that of America. These cultural differences can cause confusion, embarrassment and even friction amongst people.

[35] http://china-nafsa.aief-usa.org/culture/differences.htm

Figure 2.12 A small child in Gaza behaving as his culture has programmed him.

2.5.2.1 Power Distance Index, Individualism and Uncertainty Avoidance. Geert Hofstede is a Dutch researcher whose work into organisational culture and cultural management created a framework for assessing and differentiating national cultures. His findings show that cultural groups based on national or geographical lines can influence the behaviour of individuals, groups and organisations within those national/geographical lines. This is not surprising to anyone who has travelled overseas and has witnessed 'the way they do things' over there. His work used certain classifications to describe these cultural attributes. His website also provides a means of comparing various cultures against each other using responses from 88,000 individuals from 40 countries. Three of the key classifications are:

- Power Distance – the relationship between subordinates and superiors and can be expressed in the way hierarchies work or societies maintain their government styles. It is the extent to which the less powerful expect and accept that power is distributed unequally.[36]

- Uncertainty Avoidance – the way that different cultures deal with uncertainty, such as fatalism, strong beliefs in higher powers, or by having strict guidelines and rules to follow to remove uncertainty, etc

- Individualism vs Collectivism – whether a culture holds the individual and his/her capabilities in more esteem than the needs and wants of the society or organisation.

[36] Engle, M., *Culture in the Cockpit – CRM in a Multicultural World*, Journal of Air Transportation World Wide, Vol. 5, No. 1 – 2000.

Engle claims that the aspects of national culture listed above have a strong effect on the level and nature of communication and the manner in which team members will interact with each other. This is the bedrock of CRM so cultural differences and their associated behaviour need to be taken into account when discussing culture, behaviour and CRM.

2.5.2.2 **Collectivist Cultures and Power Distance in a Team Environment.** Some aspects of a collectivist culture can cause breakdowns in team synergy, especially when individuals do not question authority figures or persons holding higher rank in an hierarchical system. This unwillingness to question authority can lead to a breakdown in safety and can be especially noted in those ethnic cultures where authority is held in higher regard than in others, especially where the Power Distance Index is high. There are a number of aviation accidents that can be attributed to the manner in which team members interact. For example:

Figure 2.13. Avianca Flight 52, a Boeing 707, crashed on Long Island near New York whilst attempting an approach to JFK. The crew did not assert themselves within their team environment and to ATC when it was apparent that they did not have the fuel to make a go around and return for landing under ATC instructions. (Photo origin unkn)

- Avianca Flight 52 which crashed in New York in 1990 is an example of inappropriate deference to authority in two areas: firstly, the crew were not assertive with the NY Air Traffic Controllers when they were running out of fuel during the approach. This has been attributed to a cultural issue where the aircrew were overly cautious to try and be assertive due to their poorer command of English. Secondly, the First Officer did not communicate precisely the situation to the captain even though he was in communication with ATC. The captain repeatedly told him to declare an emergency but the First Officer did not use the actual word ‘Emergency’ or ‘Mayday’ or any other conventional words to indicate

the emergency. Instead, he said that they were 'running out of fuel' which is a subjective assessment and could be interpreted in many different ways.[37]

- Gulf Air 072 crashed at Bahrain in August 2000. During the approach, the Captain made several errors and was consistently fast on the approach, however the First Officer made no significant attempts to bring the errors to the Captain's attention or to take control. The Arab collectivist culture was likely a contributing factor to the First Officer's reluctance to point out the errors of the Captain, which ultimately cost 143 people their lives. (This accident was also caused by a number of other factors, one of the most significant being autogyral illusion and human performance limitations brought about by late night approach to a runway and then a go around over the ocean with no visual lights as reference. See Element 3 on The Human Body for an explanation of autogyral illusion).

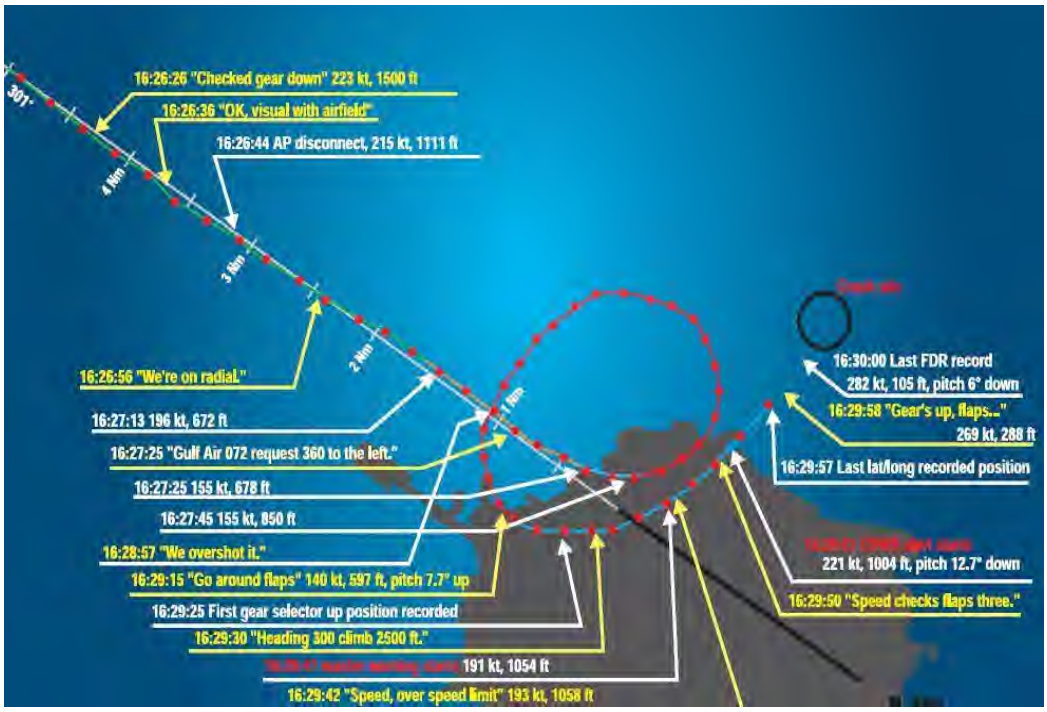
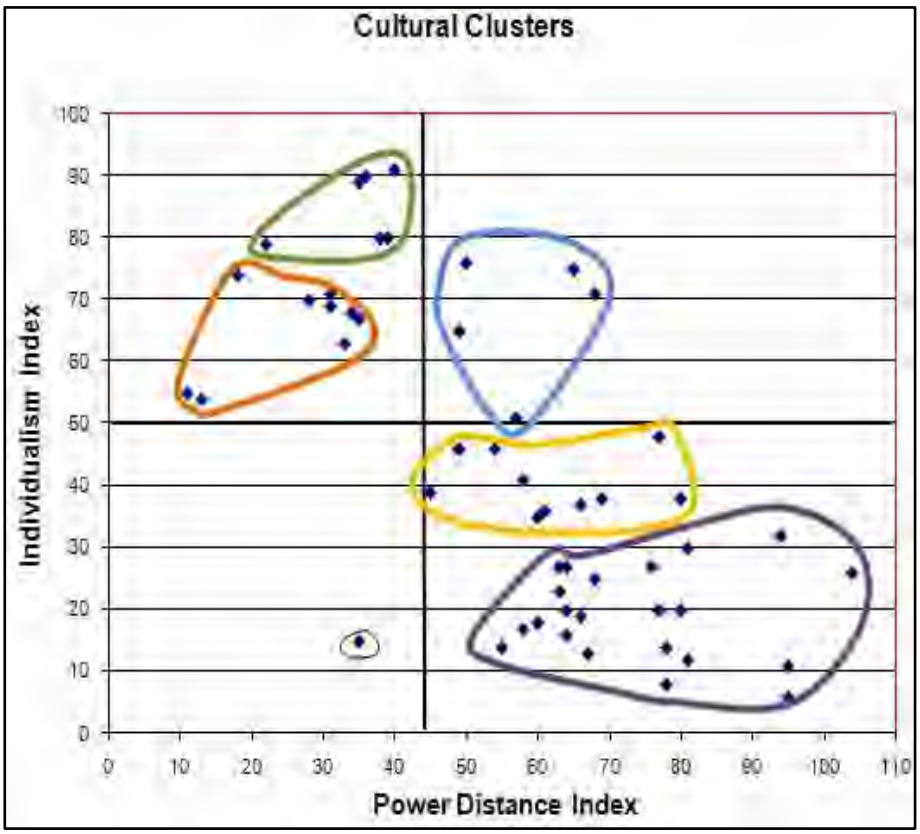


Figure 2.14 [38] The final flight path of Gulf Air 072. A combination of human performance limitations, specifically autogyral illusion, as well as poor communication between the first officer and the captain – possibly due to cultural expectations, led to the crash of this aircraft as it tried to attempt a second approach to the runway after aborting the first approach.

2.5.2.3 **Cultural Clusters.** Part of Geert Hofstede's research lends itself to grouping various nations into cultural clusters based on Power Distance Index and Individualism vs Collectivism. The low PDI countries with high individualism are grouped together and for an Australian, it is no surprise that the other members of that group include the USA, the UK, New Zealand, Canada and the Netherlands; all cultures that prize individuality and hold authority with a certain amount of suspicion.

[37] NTSB Aircraft Accident Investigation Report AAR-91/04 adopted 30 Apr 1991.
[38] Derived from *Flight Safety Magazine's* rendition of the BEA report. *Flight Safety Australia, Nov-Dec 2003* and BEA report a40-ek000823a dated 10 Jul 2002.



	INDIV	
USA	40	91
Australia	36	90
Great Britain	35	89
Netherlands	38	80
Canada	39	80
New Zealand	22	79
Italy	50	76
Belgium	65	75
Denmark	18	74
Sweden	31	71
France	68	71
Ireland	28	70
Norway	31	69
Switzerland	34	68
Germany	35	67
South Africa	49	65
Finland	33	63
Austria	11	55
Israel	13	54
Spain	57	51
India	77	48
Argentina	49	46
Japan	54	46
Iran	58	41
Jamaica	45	39
Brazil	69	38
Arab	80	38
Turkey	66	37
Uruguay	61	36
Greece	60	35
Phillipines	94	32
Mexico	81	30
Portugal	63	27
East Africa	64	27
Yugoslavia	76	27
Malaysia	104	26
Hong Kong	68	25
Chile	63	23
Thailand	64	20
West Africa	77	20
Singapore	80	20
El Salvador	66	19
Korea	60	18
Taiwan	58	17
Peru	64	16
Costa Rica	35	15
Pakistan	55	14
Indonesia	78	14
Columbia	67	13
Venezuela	81	12
Panama	95	11
Equador	78	8
Guatemala	95	6

Figure 2.15 Above and **Table 2.3** Right. Power Distance Index and Individualism as measured amongst various countries around the world. Figure 2.15 above groups the countries into cultural clusters. The top left quadrant contains those cultures where individualism is highest and the Power Distance Index is lowest (below 44). The top right quadrant contains those cultures where individualism is high, but the Power Distance is also high. The bottom right quadrant contains those cultures where the Power Distance is high and the Individualism is low. Note how highly individualist cultures with western democracies are grouped together in the high individualism/low Power Distance cluster.

Traits of Collectivism

- Each person is encouraged to be an active player in society, to do what is best for society as a whole rather than themselves.
- The rights of families, communities, and the collective supersede those of the individual.
- Rules promote unity, brotherhood, and selflessness.
- Working with others and cooperating is the norm; everyone supports each other. as a community, family or nation more than as an individual.

Traits of Individualism

- "I" identity
- Promotes individual goals, initiative and achievement
- Individual rights are seen as being the most important. Rules attempt to ensure self-importance and individualism
- Independence is valued; there is much less of a drive to help other citizens or communities than in collectivism
- Relying or being dependent on others is frequently seen as shameful
- People are encouraged to do things on their own; to rely on themselves.

CONCLUSION

The human mind develops through natural and nurturing influences which then dictate human behaviour. Adjusting behaviour can be achieved by adjusting the nurturing influences such as education, training and experiences.

NOTES:

GROUP 2 – THE HUMAN CONTEXT

The Element/s in this Group relate to the Human Being and how his/her body works.

ELEMENT 3 – The Human Body

Contents:

Module 3.7 The Ear and Hearing
Section 3.7.1 The Ear and its Anatomy
Section 3.7.2 Audition and the Physiology of the Ear
Section 3.7.3 Hearing Loss
Module 3.8 The Inner Ear and Balance
Section 3.8.1 The Inner Ear and its Anatomy
Section 3.8.2 The Semi Circular Canals and Detecting Acceleration
Section 3.8.3 The Subjective Vertical
Module 3.9 Sensory Inputs and Spacial Disorientation
Section 3.9.1 Categories and Types of Disorientation
Section 3.9.2 Vertigo – Medical, Flicker, Pressure and Coriolis Effect
Section 3.9.3 Vestibular Equilibrioception
Section 3.9.4 Motion Sickness
Module 3.10 Information Processing and Memory
Section 3.10.1 The Central and Peripheral Nervous Systems
Section 3.10.2 Mental Set
Section 3.10.3 Channel Capacity and Filtering
Section 3.10.4 Task Saturation, Task Interference and Multitasking
Section 3.10.5 Mechanics of Perception, Constancy and Selective Perception
Section 3.10.6 Memory
Module 3.11 Stress
Section 3.11.1 Types and Definitions of Psychological Stress
Section 3.11.2 Life Stress Scoring
Section 3.11.3 Anxiety
Section 3.11.4 Temporal Stress
Section 3.11.5 Physiological Responses to Psychological Stress
Section 3.11.6 Physiological Stress – Dehydration and Fatigue
Section 3.11.7 Circadian Rhythm, Dysrhythmia and Sleep

Module 3.1

3.1 **Evolution and the Human Body.** As the human body has evolved, it has developed into an organism that is most at ease within certain environmental parameters. If the body or mind are outside these parameters, it will experience a certain degree of stress.

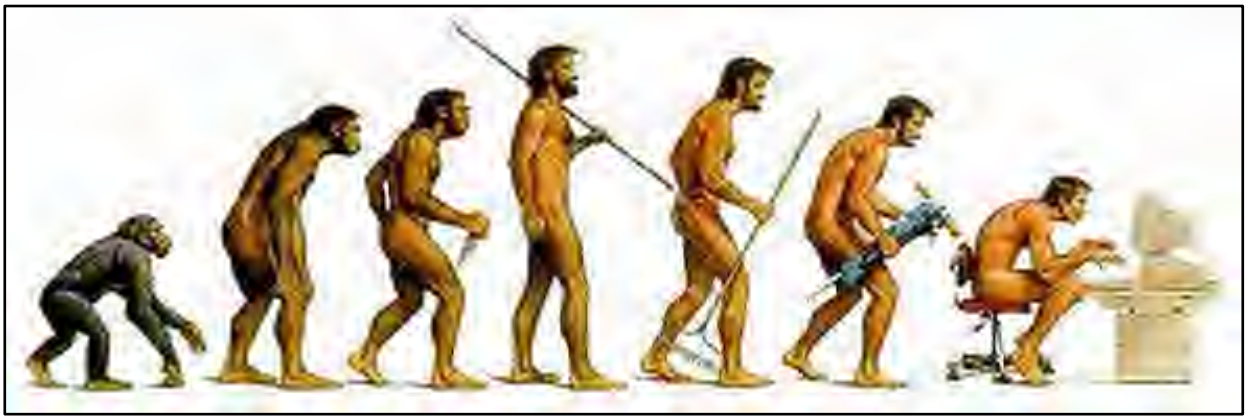


Figure 3.1 A humorous depiction of the evolution of man from a hunched creature to a hunched creature. Our lifestyles may have removed much of the physical stress, but that has been replaced by more psychological stress.

Section

3.1.1 **The Parameters of Comfort.** Every person is different when it comes to preference for comfort and so it is difficult to provide one set of numbers that would apply to all people. Factors such as gender, body shape and surface area, acclimatisation, age, individual fitness, genetic differences, race, etc all influence acceptable comfort levels. The following list is a guide to the parameters of comfort for humans.

- Temperature[39] - approximately 24 to 28 degrees with little or no clothing in the shade not undertaking physical labour.
- Atmospheric Pressure – Sea Level up to no higher than 18,000' for permanent habitation.
- Atmospheric Humidity – Relative Humidity of approximately 50%
- Gravity – 9.8m/s^2 acting downwards.
- Noise – Noise levels lower than 75 db(A) for periods greater than 24 hrs

[39] CAN/CSA Z412-00 (R2005) - "Office Ergonomics" as cited in http://www.ccohs.ca/oshanswers/phys_agents/thermal_comfort.html accessed 01 Aug 12.

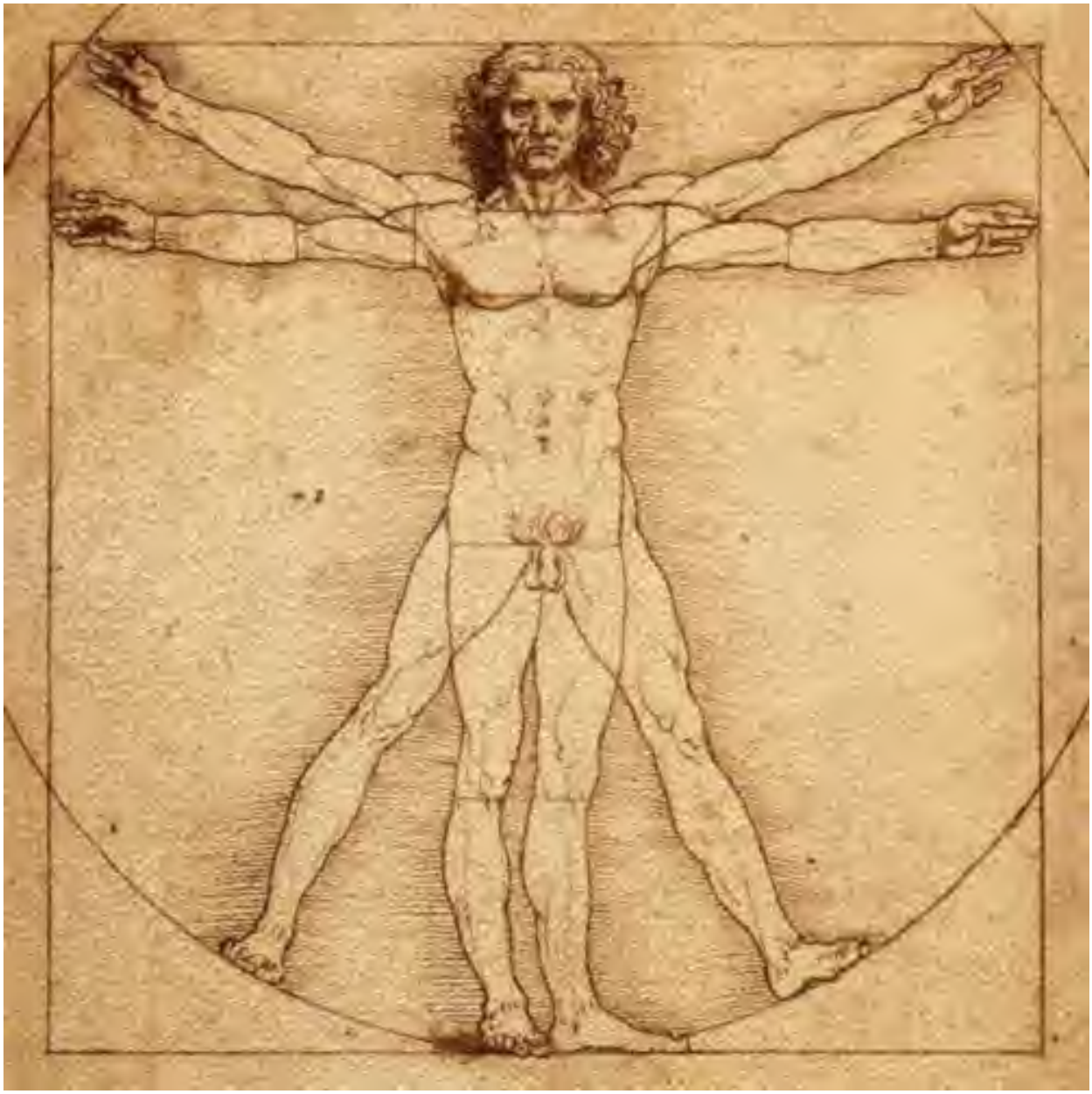


Figure 3.2 Leonardo da Vinci's Vitruvian Man. Da Vinci's drawing is a reference to the Roman architect Vitruvio who calculated that a man had certain set parameters and proportions which could be related to architecture. Where he discussed physical proportions, here we discuss physiological parameters.

Module 3.2

3.2. **<u>The Atmosphere, its Gases and Humans</u>.** The Atmosphere is the term used to describe a layer of gases surrounding a body and held in place by that gravity's body mass.

Figure 3.3 The space shuttle Endeavour sits in low Earth orbit above the atmosphere of the Earth. Space is said to begin at approximately 100,000m or 328,000 feet where the atmosphere starts to become noticeable.[40]

Whilst the Earth's atmosphere is constituted of numerous gases, the most important to life on this planet is, of course, oxygen. The first production of oxygen was said to have occurred during the Great Oxygenation Event or the Oxygen Catastrophe, where cyanobacteria – also known as blue-green algae – began producing oxygen as a by-product of photosynthesis.

Figure 3.4 Blue Green Algal bloom. This cyanobacteria is the origin of oxygen on Earth.

This release of free oxygen caused the extinction of all life on the planet because free oxygen is toxic to living organisms. Fortunately, the life that was made extinct was anaerobic

[40] NASA image in the public domain. http://en.wikipedia.org/wiki/Atmosphere_of_Earth

organisms, small microbes that do not require oxygen to exist and that find oxygen toxic. The human body requires oxygen to have a particular pressure for effective respiration. This is achieved by mixing it with a higher proportion of an inert gas, namely Nitrogen. The Earth's atmosphere has some key aspects:

- The composition is approximately 78.08% Nitrogen, 20.95% Oxygen, with the balance made up of water vapour, argon, carbon dioxide, and some hydrogen and helium.

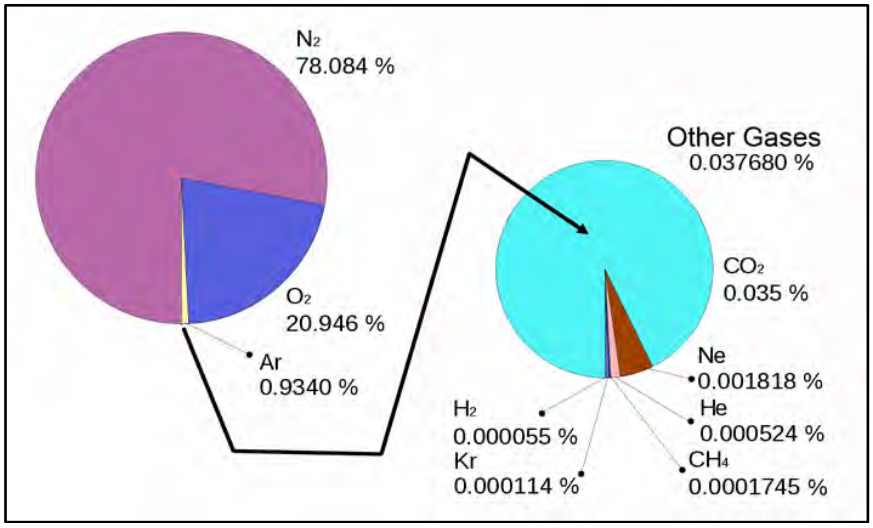


Figure 3.5 The Atmosphere's Gases[41]

- The atmosphere is/can be divided into four layers based on temperature – the troposphere, stratosphere, mesosphere and thermosphere.

- Humans occupy and operate in the troposphere and are affected by weather systems which are predominantly found and active within this layer. The weather systems follow a rough pattern based on cells of high and low pressure and directional flow of air.

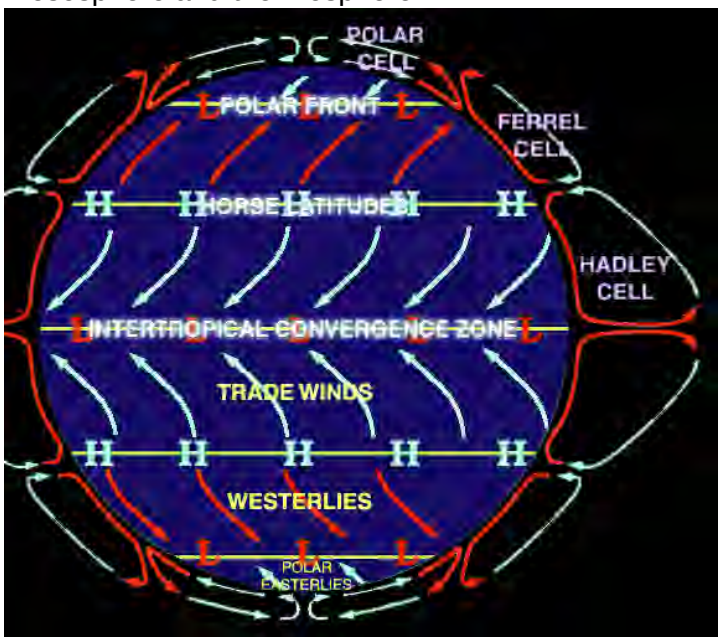
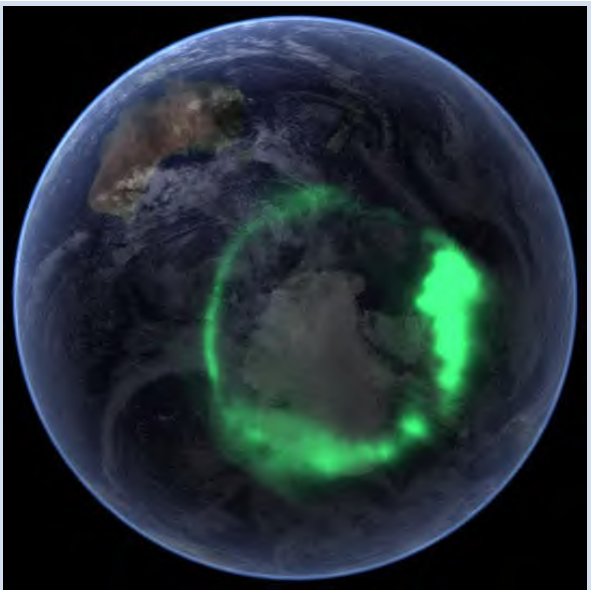


Figure 3.6 The directional flow of air and the key pressure cells of the atmosphere

[41] Image in the public domain. http://en.wikipedia.org/wiki/Atmosphere_of_Earth

ALTITUDE LEVELS OF THE EARTH

Alt (m)	Alt (ft)	Remarks
10,000,000	32,808,399	Exosphere – the extreme limits of gaseous atmosphere. Primarily helium and hydrogen atoms that move in and out of Earth's gravitational influence and are so isolated that they rarely collide with each other and thus no longer have the properties of a fluid.
690,000	2,263,778	Thermosphere's Ceiling – that region of the atmosphere from the Thermopause up to the Exobase. Within this region, temperature remains constant. This is also the region where the International Space Station orbits.
100,000	328,084	The Karman Line – the accepted boundary between Earth's atmosphere and outer space. About 120,000m is where Earth's atmosphere becomes noticeable to spacecraft and may be referred to as 'the Re-Entry Line". At 100,000m, the Aurora phenomena in the polar regions occurs such as the Aurora Australis over Antarctica (right). 
85,000	278,871	Mesosphere's Ceiling – Layer of atmosphere that causes meteors to burn up. Temperature decreases with altitude.
51,000	167,322	Stratosphere's Ceiling – In this layer, the atmospheric temperature begins to increase due to the absorption of UV light with Ozone.
31,000	101,706	99% line – a calculated line whereby 99% of the Earth's atmosphere is below this altitude.
20,000	65,616	Troposphere's Ceiling – The troposphere is that layer of the atmosphere that extends from the Earth's surface up to the tropopause. Because temperature decreases with altitude, this allows for upwards mixing of air and thus weather. Virtually all of the Earth's weather's effects occur in the troposphere.
19,000	62,335	Armstrong Line – The altitude at which fluids boil at the same temperature as the human body due to the rarity of the atmosphere. As such, humans cannot survive above this altitude in unpressurised environments.
11,000	36,089	Pressure Suit Line – Pressure suit required for the human body.
8,360	27,427	Constant Density Altitude Line – if atmospheric pressure at sea level was used as a constant, then for a theoretical column of air 1m square, extending from the Earth's surface upwards using ISA conditions, then 8360m would be the height of the air in that column. ie if the Earth's atmosphere had a constant density, at this altitude the atmosphere would abruptly end and space would begin.
8,000	26,246	Death Zone – A term used in mountaineering to refer to

		altitudes/elevations where the oxygen content in the atmosphere is not high enough to sustain human life.[42]
5,950	19,520	Limit of Temporary Human Habitation – Chilean miners inhabited a camp at this elevation for two years
5,100	16,732	Highest Permanent Human Habitation – La Rinconada in southern Peru is a mining town with the highest elevation in the world of a permanent human population.

Table 3.1 The Altitude Levels of the Earth

Figure 3.7 Felix Baumgartner steps from his capsule at 128,097 ft (39,044m)

ALTITUDE RELATIONSHIPS

metres	feet	Hpa	mm HG	PO_2 mm HG	PAO_2 mm HG	°C
SL	**SL**	1013.25	760	159.6	112.6	15
400	**1 312**	966.59	725	152.25	105.25	12.4
600	**1 968**	942.59	707	148.47	101.47	11.1
800	**2 625**	921.26	691	145.11	98.11	9.8
1 000	**3 281**	898.59	674	141.54	94.54	8.5
1 500	**4 921**	845.26	634	133.14	86.14	5.3
2 000	**6 562**	794.60	596	125.16	78.16	2
2 500	**8 202**	746.61	560	117.6	70.6	-1.2
3 000	**9 842**	701.28	526	110.46	63.46	-4.5
3 500	**11 483**	657.28	493	103.53	56.53	-7.7
4 000	**13 123**	615.95	462	97.02	50.02	-11
4 500	**14 764**	577.29	433	90.93	43.93	-14.2
5 000	**16 404**	539.96	405	85.05	38.05	-17.5
5 500	**18 044**	**505.29**	**379**	**79.59**	**32.59**	**-20.7**
6 000	**19 685**	471.96	354	74.34	27.34	-24
6 500	**21 325**	441.30	331	69.51	22.51	-27.2
7 000	**22 966**	410.63	308	64.68	17.68	-30.5

[42] http://en.wikipedia.org/wiki/Effects_of_high_altitude_on_humans accessed 01 Aug 12.

7 500	**24 606**	382.64	287	60.27	13.27	-33.7
8 000	**26 246**	355.97	267	56.07	9.07	-36.9
10 000	**32 808**	265.31	199	41.79	-5.21	-49.9
12 000	**39 370**	194.65	146	30.66	-16.34	-56.5
14 000	**45 931**	141.32	106	22.26	-24.74	-56.5
16 000	**52 493**	103.99	78	16.38	-30.62	-56.5
18 000	**59 054**	75.99	57	11.97	-35.03	-56.5
20 000	**65 616**	54.66	41	8.61	-38.39	-56.5
25 000	**82 020**	25.33	19	3.99	-43.01	-51.6
30 000	**98 424**	12.00	9	1.89	-45.11	-46.6

Table 3.2 Altitude Relationships with atmospheric and biological pressure and temperature. (HPa – Hectopascals, mmHG – millimetres of mercury, PO2 – Partial Pressure of Oxygen, PAO2 – Partial Pressure of Oxygen in the trachea based on water vapour pressure of 47mmHG for a 37 degree environment) The altitude highlighted in bold roughly equates to the limit of permanent human habitation where PAO2 is about half that at sea level.)

Section

3.2.1 **Oxygen Requirements of the Body.** Cellular respiration requires oxygen (O_2). The human body requires oxygen in the breathing process which, in turn, supplies oxygen to tissues and cells for regeneration and also to assist with metabolism which creates energy and heat for the sustainment of the body. The process of oxygen transfer requires a pressure differential and a means through which the gases pass into the body. These are explained as the Gas Laws and the Metabolism and Respiratory System shown below.

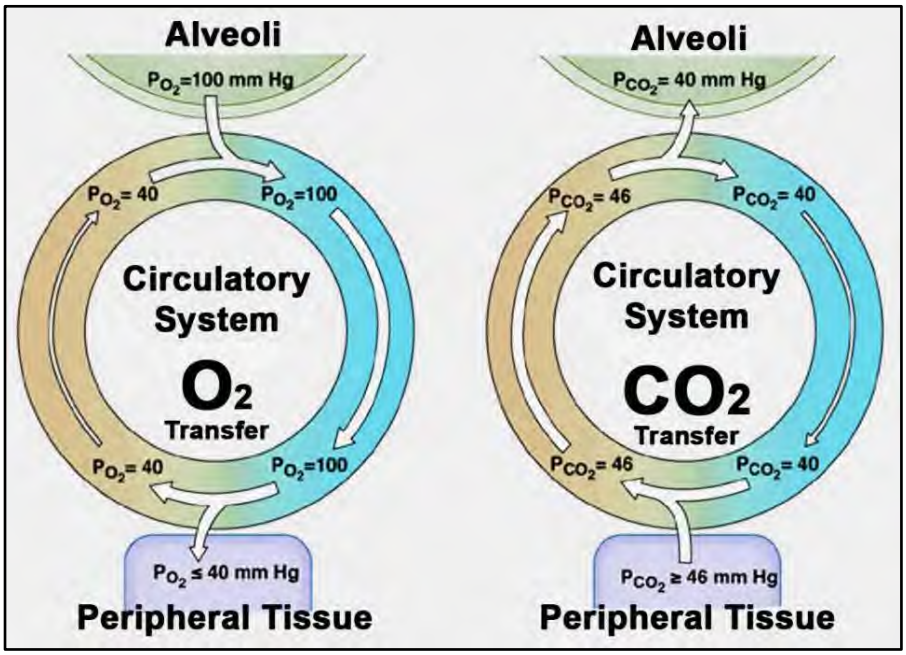


Figure 3.8 Partial pressure differentials allow for the transfer of O2 and CO2 into and out of the body.

Section

3.2.2 **Gas Laws.** There are a number of laws related to gases, but of interest to us in the aviation industry and allied industries are three key laws[43]:

- Boyle's Law – *For a fixed amount of an ideal gas at a given temperature, the pressure and the volume of the gas are inversely proportional.* The formula can be written as P1V1 = P2V2 or PV = k (where p is the pressure of the gas and V is

[43] http://en.wikipedia.org/wiki/Gas_laws accessed 15 Mar 12.

the volume of the gas and k is the constant). Basically, what this means is that if the volume increases, then pressure must decrease so as to remain in constant proportions to each other. The opposite also occurs where if pressure increases, then volume must decrease. This law is important in aviation because it says that if we take a gas up to altitude, and that gas' volume remains constant, then it will try and equalise with the surrounding lower pressure of the atmosphere by expanding. For a gas that's trapped inside the human body, this can have a significant and damaging effect on the body and can cause debilitating pain.

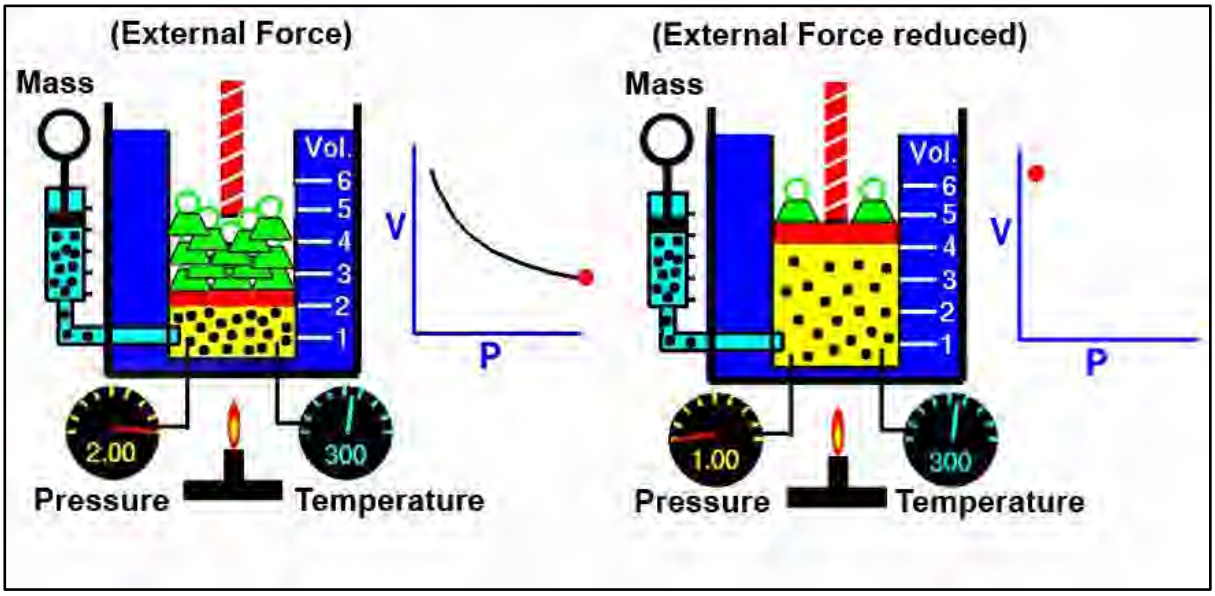


Figure 3.9 Boyle's Law states that the volume of a gas will change when the pressure changes; if one goes up, the other comes down and vice versa. This has implications for us if operating in situations where environmental pressure changes such as SCUBA diving or flying at altitude, especially in unpressurised aircraft. Any gas trapped in the human body will expand or contract depending on the external pressure unless the trapped gas can be released. This can cause discomfort, serious injury or death. In this diagram, the image at left shows pressure of 2 units and a corresponding volume of 2 units. Decrease the pressure on the gas to 1 unit and the volume expands to 4 units. (See decompression below) [44]

- Dalton's Law – *The pressure of a mixture of gases is the sum of all the partial pressures of the individual components.* What this means is that each component of a gas (which may include water vapour) will have an individual pressure. If all the pressures are added together, the total will be equal to the pressure of the gas mixture. For example, if we take a parcel of dry air at 1000 HPa, then the 21% of the gas that is made up of oxygen, will have a partial pressure of 210 HPa – 21% of the total pressure of the dry air. This is important because it explains how oxygen, as a component of total gas, has its own pressure which becomes the driving force for the oxygen to pass through barriers such as lung tissue. This law has to be read in conjunction with Henry's Law (below).

[44] Image derived from an image by NASA and is in the public domain. http://en.wikipedia.org/wiki/Boyle%27s_law

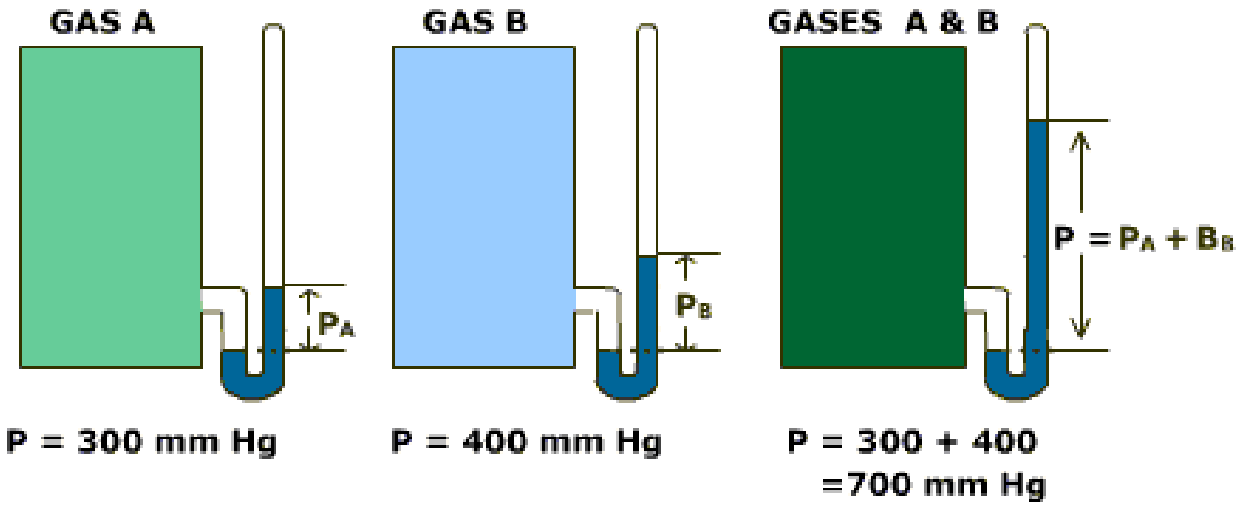


Figure 3.10 An example of Dalton's Law where Gas A with a pressure of 300 mm HG and Gas B with a pressure of 400 mm HG are mixed together. The total pressure will be 700 mm HG but the partial pressure of each constituent gas remains the same at 300 and 400 mm HG respectively.

- Henry's Law – *At a constant temperature, the amount of gas that is able to be dissolved in to a volume of liquid is directly proportional to the partial pressure of that gas if it is equilibrium with that liquid.* This is important to us because it explains how gases can be 'absorbed' into the blood such as oxygen (which is good for us) and nitrogen (which is not so good). It also explains why if there is not enough oxygen in the atmosphere, the blood cannot 'collect' more oxygen molecules.

Section

3.2.3 **Metabolism and the Respiratory System.** Metabolism describes the physical and chemical processes that occur within living tissue of aerobic organisms. These processes create new tissue, replace old tissue, convert chemicals found in food to energy, dispose waste materials and reproduction.

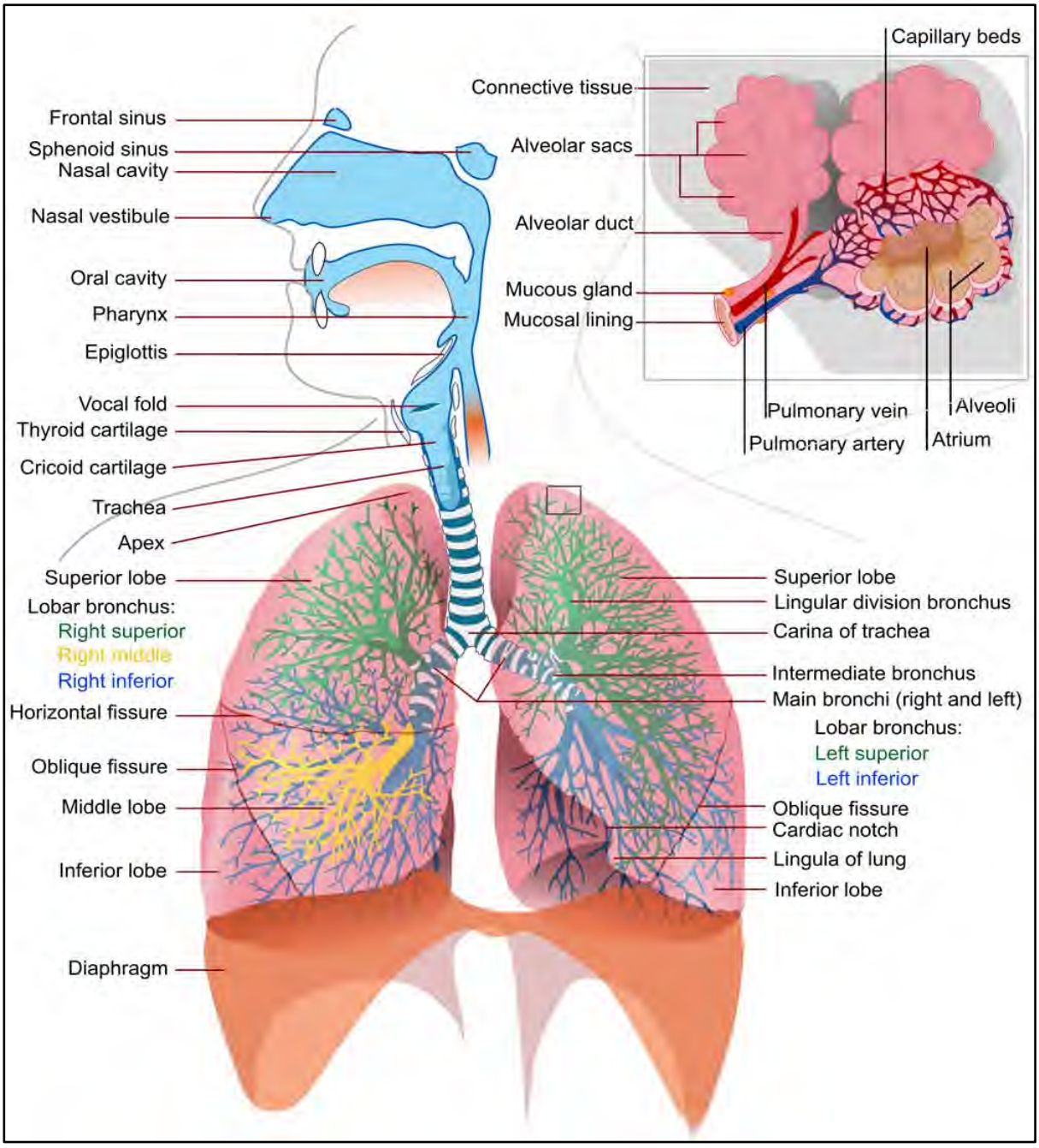


Figure 3.11 The Respiratory System of the Human Body.[45]

[45] From http://en.wikipedia.org/wiki/File:Respiratory_system_complete_en.svg used as required by Wikimedia Commons.

3.2.3.1 **The Respiration Process.** Respiration is the transport of oxygen from air to tissue cells and the removal of carbon dioxide. About 82 to 85% of the oxygen breathed in is replaced by carbon dioxide. There are four stages to human respiration[46]:

- Ventilation – the movement of air to the alveoli of the lung
- Pulmonary gas exchange – where gas moves from the alveoli into the pulmonary capillaries through diffusion
- Gas Transport – where gas is transported from the pulmonary capillaries via the circulation system to the peripheral capillaries in the organs
- Peripheral gas exchange - from the tissue capillaries into the cells and mitochondria

The main function of respiration is gas exchange. As this occurs, the chemical balance of the blood changes which changes the alkalinity of the blood and the amount of carbon dioxide in the blood, both of which, in turn, trigger further respiration.

Section

3.2.4 **Hypoxia and Decompression.** The lack of oxygen in the circulatory system is hypoxia and can be caused by a physical absence of oxygen in the air (hypoxic hypoxia), inability of the blood to carry oxygen because of a toxin which displaces oxygen eg carbon monoxide (histotoxic hypoxia), a loss of blood volume (hypemic hypoxia) and poor oxygen carrying ability of the blood (anaemic hypoxia). Some of the causes of hypoxia listed above may be as follows:

- **Histotoxic Hypoxia** – toxins in the blood may displace oxygen (such as nicotine which has a higher propensity for binding with haemoglobin than oxygen does) thus reducing the useable amount of oxygen for the tissues.
- **Ischemic (Hypemic) Hypoxia** – in order for oxygen to be carried, the flow of blood needs to be constant. Heart failure, stagnation of the blood flow or other conditions may prevent the movement of blood and therefore the movement of oxygen. Ensuring blood flows by exercise and hydration can help counter mild cases of this, such as when seated for a long period of time.
- **Anaemic Hypoxia** – when the oxygen carrying capacity of the blood is reduced. Because iron is vital to haemoglobin's oxygen carrying capacity, a lack of iron will cause a reduction in the ability of blood to transport oxygen.
- **Hypoxemic Hypoxia** – The lack of oxygen due to deficiency in the body (lung disease) or hypoventilation. One of the reasons for hypoxemic hypoxia could be due to the lack of oxygen at altitude. Apart from deliberately ascending to height (eg mountain climbing), the most likely cause of inadvertent hypoxic hypoxia will be due to decompression of a pressurised aircraft. Anoxia is the complete loss of oxygen in a given volume.

Symptoms of hypoxia vary between individuals, but the most common are:

[46] http://www.oxygen-review.com/respiration.html accessed 20 Jul 12

- Headaches
- Decreased reaction times
- Impaired judgement
- Incoherence or inability to formulate cogent thoughts
- Drowsiness and perhaps euphoria
- Cyanosis in extreme cases (blueness of the fingernails and lips).

3.2.4.1 **Decompression (air) and Time of Useful Consciousness.** Aircraft involved in high altitude operations will normally have a capability to keep the cabin pressurised at pressures suitable to sustain human function. This pressurisation is accomplished by a cabin pressurisation system. In a typical system, the cockpit, cabin and cargo holds are incorporated into a sealed unit which is able to maintain an air pressure higher than that outside the aircraft – the ambient pressure. Pressurised air is pumped into the sealed unit by cabin superchargers which deliver constant volumes of air. Air is released from the sealed unit by an outflow valve. It is this valve that can control the pressure within the cabin; increase the outflow and the cabin pressure decreases and vice versa.[47] The pressure in the cabin is referred to using the equivalent pressure in the atmosphere. In most commercial systems, the pressure in the cabin is equivalent to that found at around 8000'. This is known as 'cabin pressure altitude'. The role of pressurisation is to prevent hypoxia, decompression sickness and the effects of cold. The loss of pressurisation within an aircraft cabin – decompression – has significant ramifications if it is unexpected, the most critical of which is hypoxia resulting in loss of consciousness. Hypoxic Hypoxia is the result of a lack of available oxygen to transport to the tissues which could be due to lung disease or other physical factors, but is most common in regimes where there if physically not enough oxygen in the air, such as at altitude.

3.2.4.2 According to an ATSB Report, in an 11-year period ending in March 2006, there were 517 pressurisation failure events in Australia, two of which led to accidents resulting in 10 deaths from the ensuing crashes, four hypoxia incidents and four ear barotrauma incidents due to the emergency descents.[48] The primary cause of pressurisation failures leading to unexpected decompression were failures of the system (44%), or door problems resulting in the next highest percentage of failures (12%) then system failures (8%). Human error induced failures constituted 5% of failures either by the operator (aircrew) or maintenance personnel committing errors.[49]

[47] http://www.faatest.com/books/flt/chapter16/pressurizedairplanes.htm accessed 15 Apr 12.
[48] Newman, Dr D.G., *Depressurisation Accidents and Incidents Involving Australian Civil Aircraft – 1 January 1975 to 31 March 2006, B2006/0142 Final,* Australian Transport Safety Bureau, Commonwealth of Australia, 2006.
[49] Ibid.

ALTITUDE	TIME OF USEFUL CONSCIOUSNESS
45,000 'AMSL	9 to 15 seconds
40,000 'AMSL	15 to 20 seconds
35,000 'AMSL	30 to 60 seconds
30,000 'AMSL	1 to 2 minutes
28,000 'AMSL	2.5 to 3 minutes
25,000 'AMSL	3 to 5 minutes
22,000 'AMSL	5 to 10 minutes
20,000 'AMSL	30 minutes or more

Table 3.3[50] Time of Useful Consciousness at various altitudes.

3.2.4.2 **Decompression Sickness and effects on flying.** Decompression Sickness (DCS) is normally associated with the human body moving from high pressure environment to a lower pressure environment. Cases of DCS occurring due to flight are known, but usually only involve flight in unpressurised aircraft above 25,000'. DCS is due to Henry's Law (see above) and relates to inert gases (usually Nitrogen in most cases due to its partial pressure in normal atmosphere) being dissolved in the blood at high pressure and then being released as bubbles of gas when the pressure reduces. An example of this is the opening of a soft drink bottle. Carbon Dioxide is dissolved into the liquid under pressure during production. The gas remains dissolved whilst the liquid is under pressure. When that pressure is released, such as opening the bottle, the CO2 becomes visible as small bubbles in the liquid. The same effect can occur in the aviation environment. This effect would occur usually only above 25,000' for a person who has not been subjected to air at greater pressure than that found at sea level. In other words, if the person has not been breathing compressed air, then s/he is unlikely to experience DCS at altitudes below 25,000'. SCUBA diving requires breathing compressed air, and so DCS is most common in SCUBA divers and the effects are exacerbated when a SCUBA diver experiences reduced pressure such as during flight or ascending high terrain (eg mountain climbing or crossing high mountains).

Figure 3.12 [51] US Sailors in a decompression chamber. DCS requires treatment in a decompression chamber for extended periods to return the patient to the pressure at which the effect took place and then slowly returning him/her to normal atmospheric pressure.

3.2.4.3 For SCUBA divers, the breathing of compressed air at depth means that close attention needs to be paid to the amount of time spent underwater. Calculated times, known as 'Dive Tables' are used by divers to ensure that they are aware of any pauses in the ascent to the surface that are required. These pauses are known as 'Decompression Stops', or 'Deco Stops' (pr DEE-co) and allows the normal respiration to expel the nitrogen being released into the respiratory system. If a diver requires decompression stops and does not execute them, or cuts them short, then s/he may suffer

[50] Wolff, M., *Cabin Decompression and Hypoxia*, PIA Air Safety Publication (date unk) as cited on http://www.theairlinepilots.com/medical/decompressionandhypoxia.htm, 06 Jan 2006, accessed 14 Apr 12.
[51] http://en.wikipedia.org/wiki/File:Decompression_chamber.jpg image in the Public Domain

from DCS which is commonly referred to as 'The Bends' due to the fact that the symptoms often manifest as pain at the elbow or knees or other 'bends' in the body where the bubbles in the blood will often coalesce causing pain. The table below describes the types of DCS, where the bubbles will most commonly form in the body and the signs and symptoms.

3.2.4.4 The Federal Aviation Administration's Civil Aviation Medical Institute discusses at length the effects of DCS[52].

DCS Type	Bubble Location	Signs & Symptoms (Clinical Manifestations)
BENDS	Mostly large joints of the body (elbows, shoulders, hip, wrists, knees, ankles)	• Localized deep pain, ranging from mild (a "niggle") to excruciating. Sometimes a dull ache, but rarely a sharp pain. • Active and passive motion of the joint aggravates the pain. • Pain can occur at altitude, during the descent, or many hours later.
NEUROLOGIC	Brain	• Confusion or memory loss and Headaches • Spots in visual field (scotoma), tunnel vision, double vision (diplopia), or blurry vision • Unexplained extreme fatigue or behaviour changes • Seizures, dizziness, vertigo, nausea, vomiting and unconsciousness may occur
	Spinal Cord	• Abnormal sensations such as burning, stinging, and tingling around the lower chest and back • Symptoms may spread from the feet up and may be accompanied by ascending weakness or paralysis • Girdling abdominal or chest pain
	Peripheral Nerves	• Urinary and rectal incontinence • Abnormal sensations, such as numbness, burning, stinging and tingling (paraesthesia) • Muscle weakness for twitching
CHOKES	Lungs	• Burning deep chest pain (under the sternum) • Pain is aggravated by breathing • Shortness of breath (dyspnoea) • Dry constant cough
SKIN BENDS	Skin	• Itching usually around the ears, face, neck arms, and upper torso • Sensation of tiny insects crawling ove the skin • Mottled or marbled skin usually around the shoulders, upper chest and abdomen, accompanied by itching • Swelling of the skin, accompanied by tiny scar-like skin depressions (pitting oedema)

Table 3.4 Decompression Sickness and the effects of bubble location on the human body.

[52] *Altitude-Induced Decompression Sickness* http://www.cami.jccbi.gov/aam-400A/Brochures/400altitude.html accessed 03 Sep 04

3.2.5 **Trapped Gases and Barotrauma**. Barotrauma refers to injuries caused by pressure, in particular, changes of pressure. Key barotraumas that affects the aviation environment are:

- Trapped gases in the
  - middle ear
  - sinuses
  - dental work and surgical wounds.
- Dissolved gases in the blood (as previously discussed)

3.2.5.1 The middle ear contains the auditory organs and the vestibular organs. The air inside this area is vented to the outside atmosphere via the Eustachian tube. The Eustachian tube is about 4cm long and connects the middle ear to the back of the nasopharynx at about nostril level. It is normally closed but its capabilities vary greatly between individuals. Most people will have no real problems with manipulating the tube's opening whilst others will. As the environmental pressure changes (by climbing to altitude or diving to depth), the pressure in the middle ear needs to change to match it. This is called equalization. If the Eustachian tube is not blocked, this may happen naturally or may be assisted by stretching the muscles in the back of the throat (yawning or using the Valsalva or Frenzel techniques). If the tube is blocked by a deformity or by mucous from a cold, then the equalization may not occur. The result will be a stretching of the eardrum as the pressure changes. This stretching, known as distension, will cause significant pain.

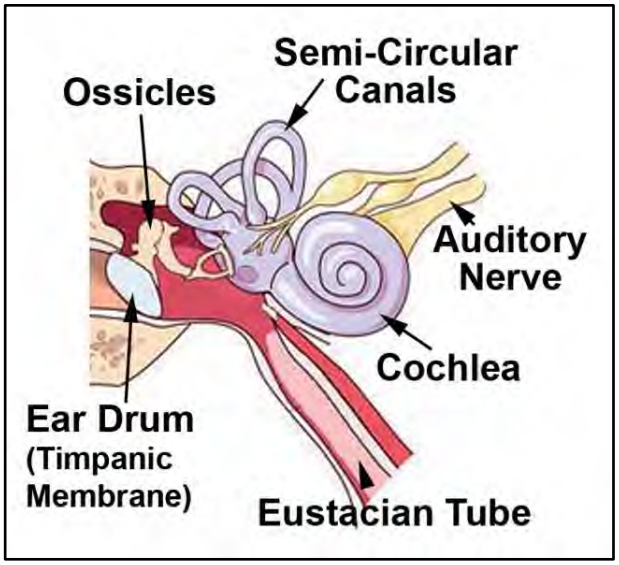


Figure 3.13 The Middle Ear is vented to the outside atmosphere through the Eustachian tube. It is filled with liquid and air. If the Eustachian tube is blocked and air cannot escape, and the outside atmospheric pressure changes (such as during flight), then the trapped gas may expand or contract, causing stress against the tissue, especially the ear drum, causing pain.

3.2.5.2 The sinuses and trapped air in dental work are further considerations. The sinuses vent into the nasal passages and can become blocked with mucous, especially during times of illness. This trapped air can be affected by Boyle's Law (see above) such that even the minor changes in atmospheric pressure from day to day can cause a pressure build up and result in headaches and discomfort. Large changes in pressure, such as SCUBA diving or flying may result in significant discomfort and trauma. Some medications aim to dry out the sinuses and thus relieve this pressure, however many medications have side effects which may adversely affect a person's ability to operate at his/her optimum (See section on drugs later in this element).

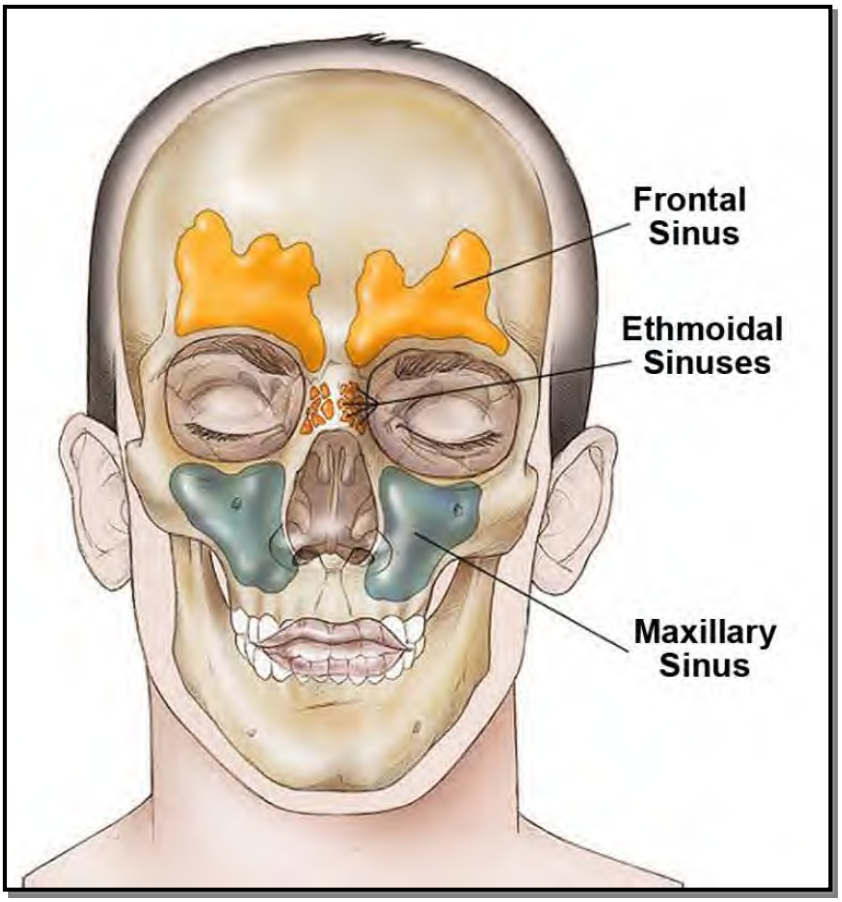


Figure 3.14[53] The facial sinuses which can suffer as a result of trapped gases.

Section

3.2.6 **Hyperventilation – types, factors, symptoms, treatment.** Hyperventilation is rapid or deep breathing in excess of what is considered normal for a person of a similar age and sex such that the partial pressure of CO2 in the alveoli becomes deficient.[54] Sources disagree on what constitutes rapid breathing, but 10L/min of inhaled air is considered to be the upper limit of normal air intake.

3.2.6.1 **Types of Hyperventilation** can be classified as chronic or acute. Chronic may be due to lung disease, diabetes, etc whereas acute may be due to an anxiety attack causing rapid, shallow breathing. Hyperventilation syndrome[55] is a form of overbreathing due to a psychological trigger like stress or panic or anger whereas hyperventilation due to illness or injury is a physiological reaction to a physiological event.

3.2.6.2 **Factors of Hyperventilation** are such things as anxiety or panic (most common), lung or heart disease, drugs, ketoacidosis, severe pain, pregnancy and stress.

3.2.6.3 **Symptoms and Treatment** are many and varied. Symptoms can include:

[53] Derived from an image created by Robert Morreale of Visual Explorations.
[54] Rahkimov, A., *Definition of Hyperventilation and CO2*, http://www.normalbreathing.com/hyperventilation.php. accessed 13 Jul 12.
[55] Vorvick, Dr L., MD, *Hyperventilation Overview,* University of Maryland Medical Center, http://www.umm.edu/ency/article/003071.htm accessed 13 Jul 12.

- a feeling of bloating and belching.
- chest pain.
- confusion.
- dizziness.
- dry mouth.
- muscle spasms or numbness in the extremities.
- heart palpitations.
- shortness of breath.
- sleep disturbances.

Treatment for psychologically induced hyperventilation syndrome can include:

- Consciously trying to control your breathing rate.
- Reducing O2 intake and increasing CO2 intake by reducing the openings to the respiratory system (blocking a nostril and closing the mouth so as to breathe through one nostril).
- Using the paper bag method whereby breathing into a paper bag increases the uptake of CO2 thus balancing the CO2 levels in the blood expelled by rapid breathing.
- If the hyperventilation is anxiety or stress induced, having the assistance from a friend of family member by way of reassurance is very helpful to bring down a person's breathing rate.

Module 3.3

3.3 **The Circulatory System.** The Circulatory System consists of two key areas; the circulatory system which transports blood and the lymphatic system which transports lymph. The blood transports oxygen and nutrients to the organs and tissues and the movement of skeletal muscles helps to pump lymph, which contains lymphocytes, a form of white blood cell important in fighting infection.

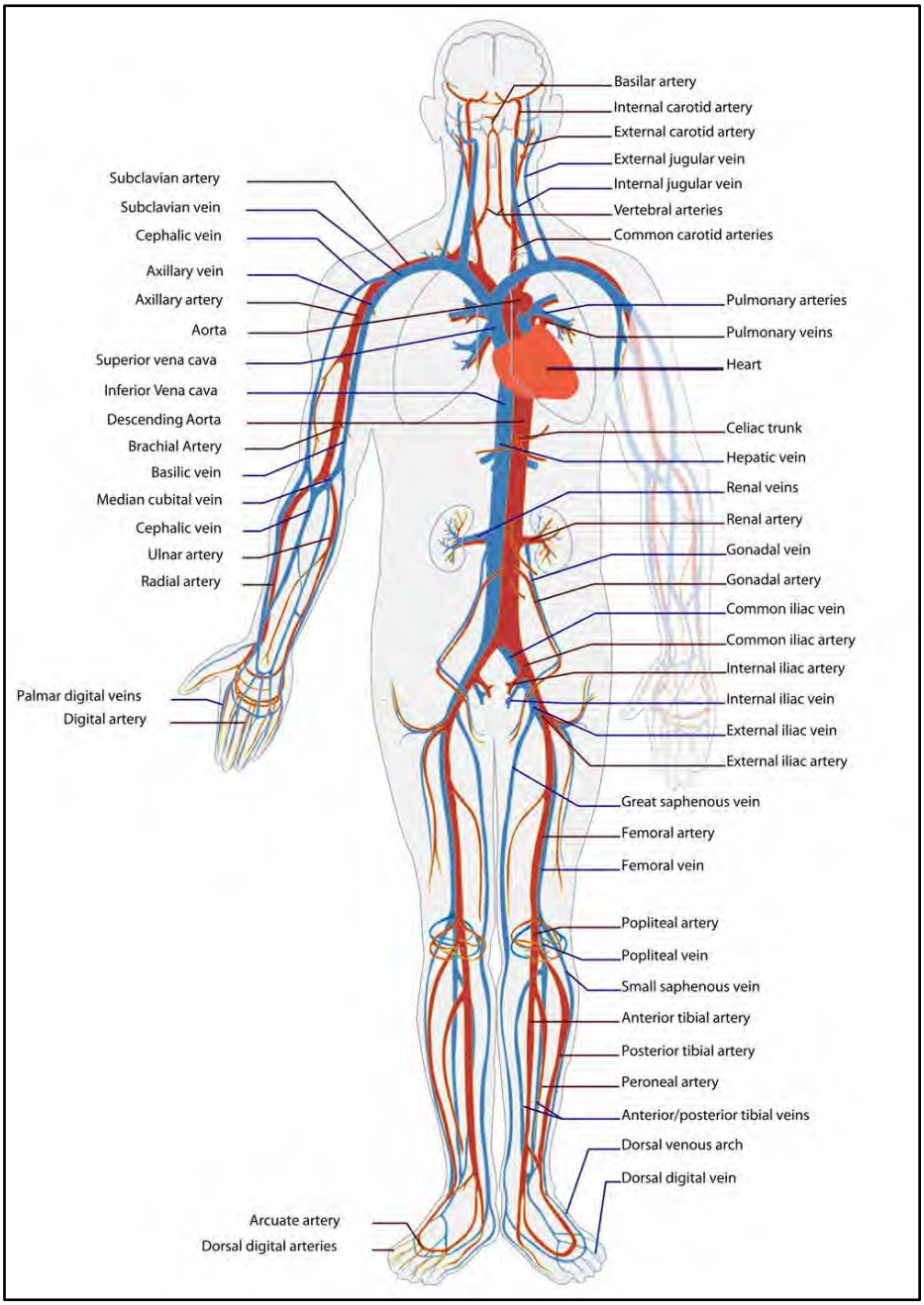


Figure 3.15 The Human Circulatory System.[56]

Section

[56] From http://en.wikipedia.org/wiki/File:Circulatory_System_en.svg and used as required by Wikimedia Commons.

3.3.1 **The Heart**. The heart is a hollow and muscular organ designed to pump blood through the body. It is located directly behind the sternum tending slightly to the left. The heart can be considered to be a dual pump; each half the pump has two chambers, an upper atrium and the lower ventricle. The right side of the heart pumps blood that is low in oxygen from the body into the lungs. The left side of the heart pumps blood from the lungs, which is high in oxygen, to the rest of the body. In both cases it is the atrium of each side of the heart that receives the blood flow, where it pushes it into the ventricle through the tricuspid valve on the right side and via the mitral valve on the left side through an initial contraction. The ventricles receive the blood through one phase of the heart beat called the diastole. The diastole is a relaxation of the ventricle and it is this relaxation that causes low blood pressure within the chamber causing the outlet valve to close and the inlet valve (tricuspid or mitral) to open. The ventricles then push the blood out of the heart and into the circulatory system through a second contraction via the outlet valves; the pulmonary valve for blood travelling to the lungs or the aortic valve for blood travelling to the body. Because the ventricles have to do the bulk of the work, they are particularly strong with the thickest walls (i.e. muscle tissue). Both of these contractions cause changes in the relative pressures within the chambers as the blood flows causing their respective valves to shut with an audible sound. The sounds can be heard through a stethoscope. The forcing of the blood out of the left ventricle causes the blood vessels to expand with the increased pressure. This can be felt as the pulse.

3.3.1.1 **Heartbeat.** The contraction of the heart which constitute the heartbeat do not happen simultaneously. Rather they happen in stages, or like a wave, first with the atria (plural of atrium) contracting and then the ventricles contracting from the bottom up thus forcing the blood through the outlet valves into the pulmonary artery to the lungs or the aorta to the body. The delay between the initial contractions in the second contractions is about .2 of a second giving time for the chambers to fill. For humans the resting heart rate of between 60 to 80 bpm is considered average. During strenuous activity this can rise to as many as 200 bpm with the average being around 150.

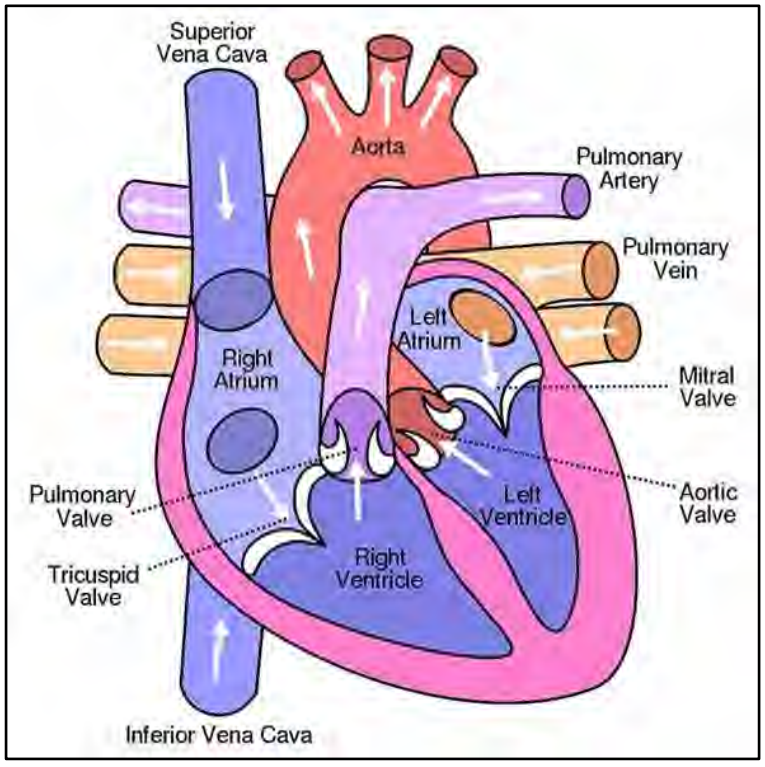


Figure 3.16 The Human Heart[57]

[57] Diagram of the Human Heart by Wapcaplet in Sodipodi as cropped by Yaddah. Used under CC-BY-SA-3.0 accessed through http://commons.wikimedia.org/wiki/File:Diagram_of_the_human_heart_(cropped).svg 13 Jul 12.

Section

3.3.2 **Circulation, Blood and Respiration.** The most important function of blood flow is the transportation of oxygen. In order for this to occur, the blood needs to flow through the body in a continuous motion. This is called the circulation. The blood vessels that carry the blood are one-way vessels allowing blood to flow in one direction due to the shape of the inner layer of the vessels. The pathway of circulation goes as follows:

- **(from the) heart** – in particular the ventricles that pump the blood, to
- **arteries** – that carry blood from the heart, to
- **arterioles** – smaller arteries that can control the flow of blood to organs, to
- **capillaries** – small vessels with a very large surface area and very thin walls, to
- **organs** – that take the nutrients and discard waste products, to
- **venules and veins** - that returned the blood back to the heart. But to 3.3.2.1

3.3.2.1 **Arteries** are the major blood vessels that carry blood from the heart to the lungs or from the heart to the organs. With thick walls, they are able to withstand the high pressure of blood as it is pumped by the heart. The elasticity of the walls causes them to spring back in after the blood pressure reduces during the diastolic phase of a heartbeat. This recoil action helps to propel the blood - along with the action of the heart - and is part of the secondary circulation feature of blood circulation which helps to off-load the work of the heart. All arteries carry bright red oxygenated blood except for the pulmonary artery which carries blood from the heart to the lungs after it has returned from the other organs. The aorta which carries blood from the left ventricle to the body has the largest diameter of about 25 mm and can withstand the highest pressure.

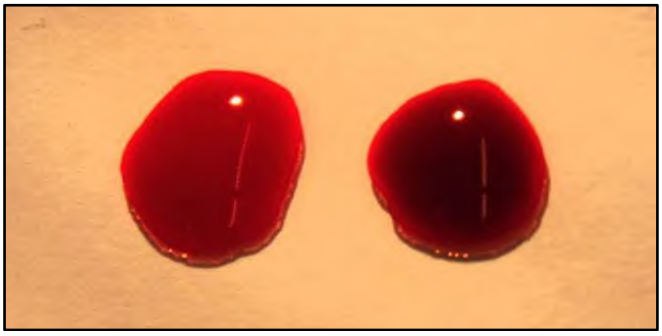


Figure 3.17 Two drops of blood. The droplet on the left that is brightly coloured red is heavily oxygenated blood whilst the one on the right is de-oxygenated.[58]

3.3.2.2 **Arterioles** are smaller arteries. They carry blood from the arteries and deliver it to the capillaries in the tissues. The arterioles are able to constrict or dilate depending on demand. For example, during the activity of running, the tissues of the muscles in the legs may require extra blood. The arterioles can direct more blood to those muscles by restricting

[58] Drops of Blood – author unkn – from http://www.biophotonicsworld.org/uploads/43 as shown on http://en.wikipedia.org/wiki/Red_blood_cells and used as per CC-BY-3.0 Copyright.

the blood flow to other areas of the body. This is necessary because the volume of blood remains the same and therefore apportioning blood must be done depending on which part of the body has the higher demand. The brain and the kidneys always have the same blood flow but other organs can have varied blood flow, for example the gut, especially between meals, muscles that are at rest, and the skin when it is cold.

3.3.2.3 **Capillaries** are a network of very small and narrow blood vessels with a large surface area arranged in what is called a capillary bed. They also have very thin walls that are only one cell thick. In many cases blood cells must flow in single file, that is how narrow these vessels are. The thinness of the walls allows for the exchange of nutrients and waste by way of pressure differentials between the blood and the tissue. Because capillaries are so thin that often collect tissue fluid which is explained below.

3.3.2.4 **Venules and Veins** are relatively large vessels that transport blood from the organs and capillaries back to the atria in the heart. They are thinner than arteries but are more flexible and they tend to run between the muscle blocks and closer to the surface of the skin. Because they run between the muscle blocks, and with the help of one-way valves within the vessels, the contraction of the skeletal muscles helps with pushing the blood flow along in one direction. As in the arteries, this is part of the secondary circulation to assist the heart.

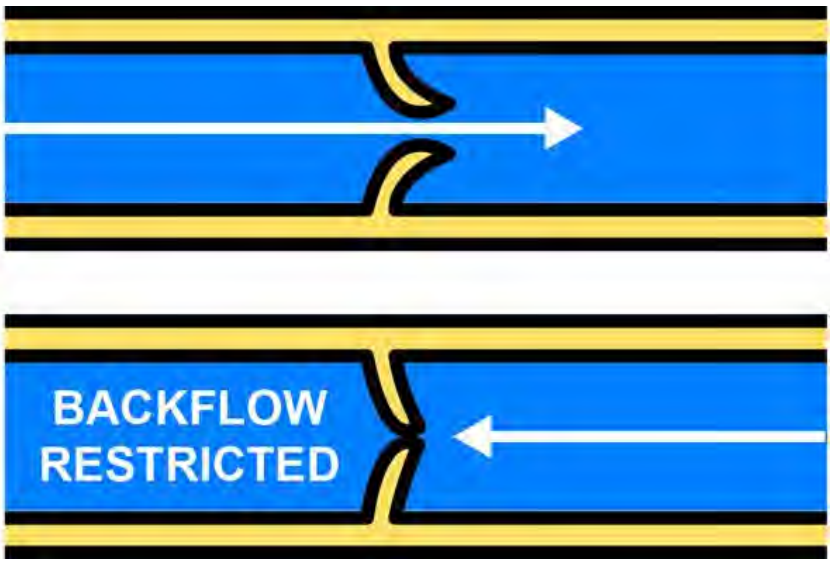


Figure 3.18 One way valves in veins, along with the contraction of muscles, help blood to flow in only one direction.

3.3.2.5 **Pulmonary and Systemic Circuits** are two components of the blood circulatory system worth mentioning. The pulmonary circuit, as the name suggests, relates to the lungs (*pulmo* – Latin for 'lung'). This is the circuit of the blood going from the right ventricle through the capillaries around the lungs and back via the pulmonary vein to the left atrium. The systemic circuit start of the left ventricle and passes through the organs of the body before returning to the right atrium. There are three areas of the systemic circulation that are worthy of mentioning; coronary circulation which is the supply of blood to the heart via the coronary arteries; renal circulation, the supply of blood to the kidneys via the renal artery which takes about 25% of the blood flowing out of the heart and delivers it to the kidneys for filtration; and the hepatic portal circulation, where nutrients picked up by blood in the small intestines are taken to the liver and where access nutrients are stored. The liver also receives about 30% of its blood directly from the aorta via the hepatic artery.

3.3.2.6 **Blood and its Components.** Within the adult human body there is approximately 5 L of blood. Its function is primarily to transport nutrients and O2 and hormones to the tissues and to carry CO2, urea and other wastes away from them. It also plays a role in the transference of heat and also in the fight against disease. Blood is composed of plasma, (which is a liquid and constitutes about 55% of blood), and blood cells, which are mainly red blood cells.

3.3.2.7 **Plasma** consists of water and dissolved molecules. Albumin is a plasma protein that helps to regulate the water and thus is able to help maintain normal volume and pressure. Immunoglobins along with white blood cells form the immune system. White blood cells attack infected or foreign cells. Fibrinogen is a protein that enables the blood to clot.

3.3.2.8 **Red Blood Cells** are the most common types of blood cells and are biconcave in shape giving them a greater surface area and greater flexibility thus allowing them to pass through small capillaries. These cells are produced from stem cells in the bone marrow and are full of haemoglobin which allows them to carry respiratory gases. They live for about 120 days in the circulatory system before they are removed by the liver and spleen.

3.3.2.9 **White Blood Cells** constitute only 0.2% of blood cells. Like red blood cells they are formed in the bone marrow, but unlike red blood cells they have a nucleus but no haemoglobin. Most white blood cells only live a few days, however others can live for months or years and it is this longevity that provides us with immunity from repeat infections.

3.3.2.10 **Platelets** are tiny fragments of other cells that form in bone marrow and assist with blood clotting by adhering to a wound and releasing certain clotting factors. These factors then release other chemicals such as fibrinogen which stops the bleeding by producing a plot. If one of the factors, Factor VII, is malformed in a genetic abnormality, the condition of haemophilia exists and clotting does not occur. This occurs only in males and is potentially fatal. Sometimes the clotting of blood within blood vessels is unwanted. Such clotting can block the flow of blood and is called thrombosis. If this occurs in the coronary artery it may cause the death of heart cells which is known as the coronary thrombosis. It occurs in the brain, then a stroke may in ensue.[59]

3.3.2.11 **Blood Types** are a categorisation system related to the antigens found on the surface of red blood cells. An antigen is a type of carbohydrate that helps the body recognise foreign substances. There are four main categories with each category being either positive or negative. Blood typing means to identify the antigens in a blood sample and thus placing the blood into the classification system. This system is known as the ABO system and is based on the type A and type B antigens as well is the antibodies within the plasma. The red blood cells can carry the A antigen, the B antigen, both A and B antigens, or no antigens at all resulting in type A, type B, type AB, and type O blood types respectively. The type of blood will determine what blood can be donated or received by an individual based on the antigens on the red blood cells and the antibodies in the plasma. The antibodies will repel certain blood types if present.

[59] White, I, *AS Biology Module 1, Chap 6 – The Circulatory System*, http://www.biologymad.com/master.html?http://www.biologymad.com/resources.htm accessed 13 Jul 12.

Blood Type	Can donate to	Can receive from
A	A, AB	A, O
B	B, AB	B, O
AB (universal recipient)	AB	A, B, O
O (universal donor) one	A, B, AB, O	O

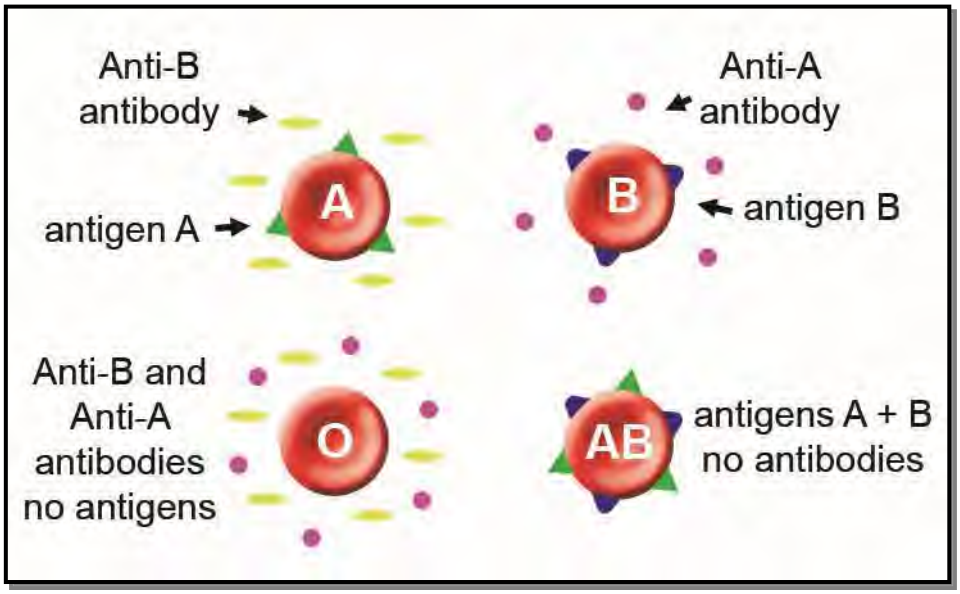


Table 3.5 and **Figure 3.19** showing the comparisons between blood types, donor and recipient. The type and ability to donate are dependent on the antigens and the anti-bodies present. Here each red blood cell has the antigen molecule on its surface and the antibodies in the plasma surrounding it.

3.3.2.12 **Haemoglobin** is a component of red blood cells and is responsible for the carriage of oxygen. The ability of haemoglobin to carry oxygen is largely dependent on the amount of iron available in the body during the creation of haemoglobin. The amount of oxygen able to be carried by one haemoglobin molecule can be up to 4 oxygen molecules.[60] Oxyhaemoglobin is the product formed during respiration as oxygen binds to the haemoglobin. The ability of haemoglobin to bind with oxygen is due to the two forms of haemoglobin, the taut form and the relaxed form. If the blood has a low pH level and a high concentration of CO_2 at the tissues, then these conditions favour the taut form which has a low affinity for oxygen and will release it. As can be seen by the situation high CO_2 indicates that the tissues and organs have metabolised, releasing CO_2 and searching for oxygen. If the haemoglobin molecule has released its oxygen molecule, then it is free to carry another gaseous molecule such as CO_2 which will bind to it and be taken away to the lungs to be exhaled. If the tissues and organs have not metabolised, then there will exist a higher level of

[60] Wikipedia, *Hemoglobin,* http://en.wikipedia.org/wiki/Hemoglobin accessed 22 Jul 12. In

O2 and a lower pH level and it is this situation that favours the relaxed form of haemoglobin which binds to oxygen more readily.

3.3.2.13 **Haemoglobin's Adhesion Properties** are what makes it vital to human metabolism. But these properties which permit the transport oxygen allowance also bind with other gases that are toxic to humans. Carbon monoxide competes with oxygen and has an affinity for binding with haemoglobin which is 250 times greater than oxygen. Because carbon monoxide is a colourless and odourless gas, the effects of carbon monoxide poisoning may not be readily identifiable.

3.3.2.14 **Low Iron Levels** in the body have an effect on the production of haemoglobin. Haemoglobin is what is known as metalloprotein, meaning that it is a protein that contains a metal, in this case iron. Iron is absorbed into the body through the foods that are eaten. In particular such foods as oysters, leafy greens, meat, certain nuts such as cashews, eggs, prune juice and even licorice. There are two forms of iron: heme and non-heme. Non-heme iron is found in vegetables and fruits and other plant sources. Heme iron can only be found in animal flesh. Heme iron is readily absorbed into the body but non-heme iron is not. In order to increase the uptake of non-heme iron, foods rich in vitamin C should be included in the diet. But these foods must be eaten at the same time as the non-heme iron in order for the uptake to occur. Another way of increasing non-heme iron uptake is to include meat with the meal such that both heme iron and non-heme iron are absorbed simultaneously. Vegetarians are particularly prone to iron deficiency due to this inability of the body to readily absorb non-heme iron. Coffee and tea consumed at the same meal will also decrease iron absorption by up to 60%. Where vitamin C helped with the uptake of iron, vitamin A helps with the release of iron stored in the body. In many cases the use of vitamin A and iron supplements may help relieve iron deficiency more than iron alone.[61] Iron is used for various functions in the body and in the creation of haemoglobin in bone marrow. Excess iron is stored in the body for later use. Deficiencies in iron can be due to poor diet, blood loss, increased demand, excessive exertion, or a physiological inability to absorb iron. Women are particularly prone to iron deficiency due to loss of blood through menstruation or during pregnancy. A lack of iron can be manifested by lethargy and fatigue, usually due to the resultant lack of oxygen supplied to the organs through the lack of iron.[62]

Section

3.3.3 **Blood Pressure, Diabetes and Other Blood Issues.** Blood pressure, also known as arterial blood pressure, is a measure of the pressure of blood during the contraction of the heart (a heartbeat) and the pressure of blood when the heart is at rest (between heartbeats). It is measured as a ratio and written as a fraction with the first number being the systolic pressure, from the Greek word systole meaning *to contract* and the second being the diastolic pressure from the Greek word diastole meaning *to separate.* The method of measuring blood pressure is by use of a sphygmomanometer, where the inflatable cuff is wrapped around the upper arm and inflated until blood flow ceases. Through a stethoscope, as the pressure is released, the recommencement of blood flow can be heard and this corresponds to the maximum blood pressure exerted by the contracting heart. This systolic pressure is measured in millimetres of Mercury. As the cuff continues to deflate, the sounds of the blood being forced through the vessels under pressure can be heard. When the sound ceases between heartbeats the corresponding pressure can be read and this equates to the diastolic pressure.[63]

[61] Colorado State University, *Iron: An Essential Nutrient,* http://www.ext.colostate.edu/pubs/foodnut/09356.html accessed 22 July 12.,
[62] Ibid.
[63] High Blood Pressure Research Centre of Australia website, *High Blood Pressure,* http://www.hbprca.com.au/high-blood-pressure/ accessed 22 Jul 12.

3.3.3.1 Hypertension is excessively high blood pressure and is said to be present if the systolic and diastolic pressure readings are greater than 140 and/or 90 respectively. The hypertension can be classed as primary or secondary where primary has no underlying medical cause (e.g. kidney or heart problems). Hypertension is a prime contributing factor to such conditions as heart attack, stroke, aneurysms, arterial disease and kidney disease and is associated with a reduction in longevity.

3.3.3.2 Hypotension is unusually or excessively low blood pressure below 90/60 mmHg. Hypotension is not often diagnosed based purely on blood pressure readings unless there are noticeable symptoms present. In people who are particularly fit, low blood pressure is a byproduct of their fitness, but in others it could be a sign of loss of blood, shock or some other underlying medical condition such as an endocrine or neurological disorder. Low blood pressure may also be accompanied by dizziness and fainting.

3.3.3.3 **Heart Disease** associated with hypertension is due to the excessive stress put on the walls of the arteries. This can be coupled with the build-up of fatty deposits due to an inadequate diet. The stress on the arteries can weaken them and the fatty deposits can break off and form a clot. A heart attack occurs when the muscle of the heart fails or is damaged due to the loss of blood flow to the heart and the subsequent loss of oxygen. A person with high blood pressure risks arterial damage, blocked arteries, blood clots in the arteries and weakened arterial walls which, over time, become narrower. Atherosclerosis – the narrowing of the arteries from such things as poor diet, high cholesterol, genetic disorders, etc, will significantly contribute to the risk of stroke, heart attack and other events.

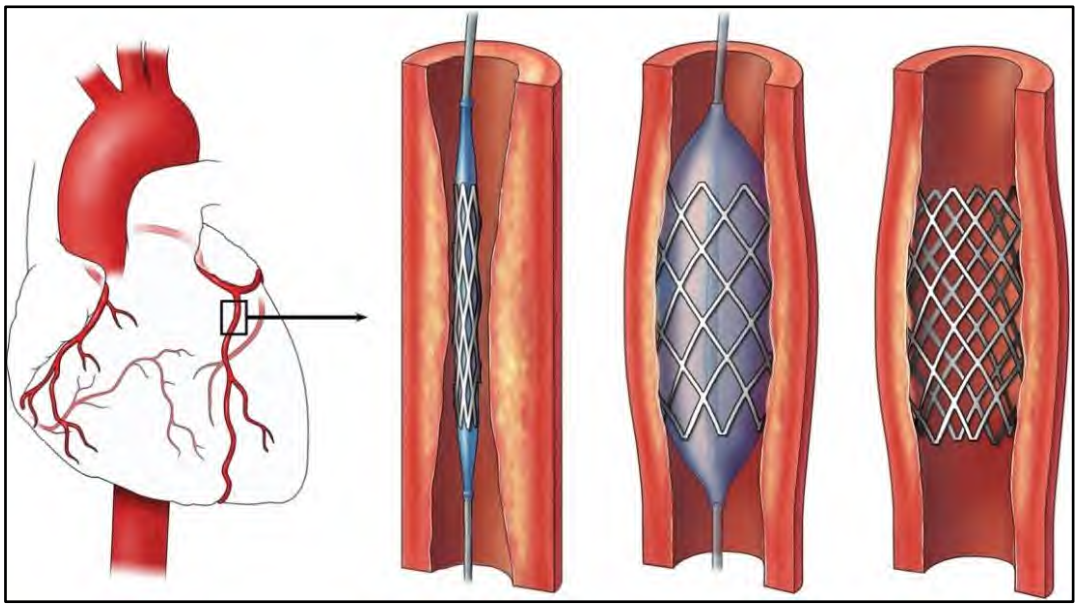


Figure 3.20 An angioplasty is a procedure to help open arteries suffering from partial blockage. A balloon is inserted into the artery and inflated which often removes small blockages. In more severe cases, a vascular stent – a small wire tube – is inserted and expanded by the balloon after which the balloon is removed leaving the stent opening the artery..

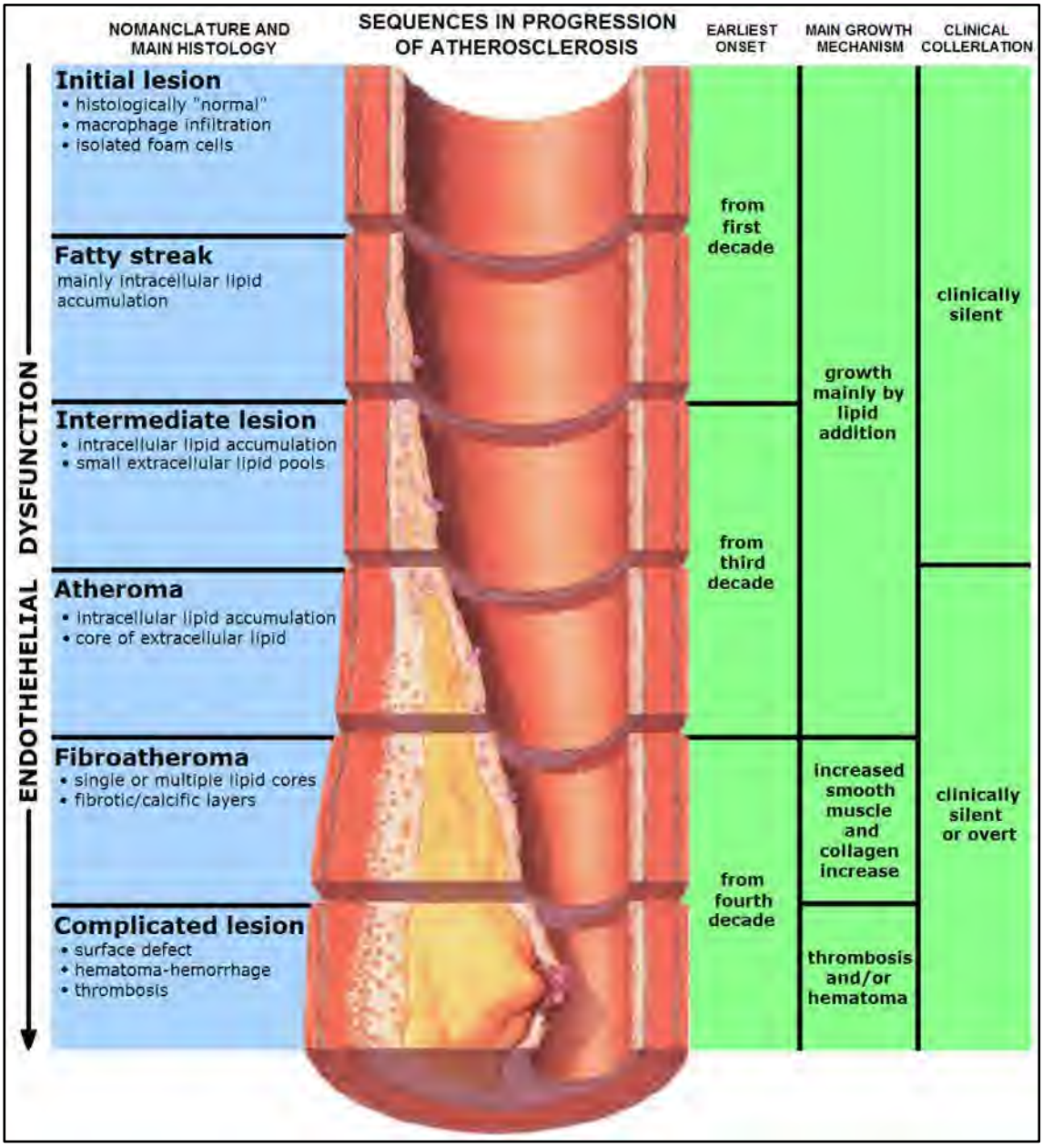


Figure 3.21 Example of Atherosclerosis and the narrowing of the arteries.[64]

3.3.3.4 There are a number of ways to control high blood pressure and the associated risks of heart disease and heart attack, including with medication. The Mayo Clinic has listed 10 ways to control high blood pressure without medication.[65]

- Lose extra kilograms and watch your waistline.
- Exercise regularly.
- Eat a healthy diet.

[64] *Stages of endothelial dysfunction in atherosclerosis* , Original uploader was Grahams Child at en.wikipedia Later versions were uploaded by Jrockley at en.wikipedia, accessed from http://en.wikipedia.org/wiki/File:Endo_dysfunction_Athero.PNG on 31 Dec 12 and used under licence CC-BY-SA-3.0

[65] Mayo Clinic Website, *High Blood Pressure (hypertension),* http://www.mayoclinic.com/health/high-blood-pressure/HI00027 accessed 13 Jul 12. In

- Reduce sodium in your diet.
- Limit the amount of alcohol you drink.
- Avoid tobacco products and second-hand smoke.
- Cut back on caffeine.
- Reduce your stress.
- Monitor your blood pressure at home and make regular doctor's appointments.
- Get support from family and friends.

Category	Systolic (mm Hg)	Diastolic (mm Hg)
Hypotension (too low)	<90	<60
DESIRED	90-119	60-79
Pre-Hypertension	120-139	or 80-89
Stage 1 Hypertension	140-159	or 90-99
Stage 2 Hypertension	160-179	or 100-109
Hypertensive Crisis	>/= 180	or >/=110

Table 3.6 The American Heart Foundation's recommended ranges for the classification of Arterial Blood Pressure for adults.[66] The Heart Foundation of Australia uses the same figures as shown above.

3.3.3.5 **Hypoglycaemia and Diabetes.** Hypoglycaemia is the condition of low blood sugar (glucose) to a level below 4 millimoles per litre which is approximately 70 milligrams per 100 millilitres of blood. It is most commonly found in Type 1 diabetics, although it is not uncommon amongst Type 2 diabetics. People with hypoglycaemia will feel hungry and tired and will need a 'rush' of sugar or other glucose rich food or drink. Hypoglycaemia can be caused by a number of events such as missing or delaying a meal or not eating enough carbohydrates or exercise or exertion that is more strenuous than expected. **Diabetes** is the condition where insulin, the hormone necessary for converting glucose into energy, is not produced in enough quantity to do the job. As a result of the glucose not being converted, it remains in the blood. Glycemia is a measure of blood sugar levels. There are two main types of diabetes:

- **Type 1 Diabetes** – the pancreas stops making insulin and because glucose cannot be used for energy, the body starts burning its own fat for energy which produces an accumulation of chemical compounds which in turn causes a condition known as ketoacidosis, which is potentially life threatening. Type 1 Diabetics will require up to 4 insulin injections per day and test their glycaemia several times a day. It is primarily genetic and cannot be prevented, even with lifestyle. Symptoms include:
    - Excessively thirsty, passing more urine.
    - Always hungry.

[66] Derived from *Blood Pressure,* Wikipedia, http://en.wikipedia.org/wiki/Blood_pressure accessed 13 Jul 12.

- Tired and lethargic.
- Cuts that heal slowly, itching, skin infections.
- Headaches and dizziness.

- **Type 2 Diabetes** – the pancreas does not make enough insulin. It is primarily a genetically (passed down) disease but lifestyle will increase the likelihood of it occurring. Type 2 Diabetics normally require medication and lifestyle changes. The symptoms of Type 2 Diabetes are the same as Type 1 Diabetes. Risk factors for Type 2 Diabetes are:
  - Have a family history of diabetes
  - Over 55 or over 45 and overweight and/or high blood pressure
  - Over 35 and from an Aboriginal or Torres Strait Islander background
  - Eat unhealthily
  - Smoke
  - Do not undertake regular physical activity.

3.3.3.6 **Blood Donations.** The process of blood donation takes a little over one hour including administration and recuperation. To fill one bag of blood takes approximately 10 minutes, donating platelets, red cells or plasma. It may take up to 2 hours using a different process. It is not uncommon to feel faint or even fall unconscious after donating blood. Physiological reasons include the actual loss of blood volume causing the dizziness, and psychological reasons include witnessing the process of your own blood being taken away. Blood has a shelf life of six weeks and a person can donate again after twelve weeks. Because of the lethargic effects of giving blood, and the reduction of haemoglobin supply, it is advisable not to operate heavy machinery or be involved in other high risk activities immediately after donation. Transport Canada recommends waiting 48 hours before piloting an aircraft. In Australia, according to CASA and their guidance on the preparation of operations manuals, 24 hours is the recommended time between blood donation and a flying assignment.[67]

[67] CASA CAAP 215-1(1): *Guide to the preparation of Operations Manuals,* p A23, dated Aug 2012.

Section

3.3.4 **The effects of acceleration on blood circulation.** Linear acceleration has little effect on circulation, however radial acceleration may cause a reduction in blood pressure to the head, and in particular to the eyes, resulting in grey out or black out. It may also cause pooling of the blood in the lower limbs. One other effect is that of the body's ability to sense blood pressure and compensate for it in a timely manner. Baroreceptors in the circulatory system measure the blood pressure and cause a response by means of adrenaline rush and increased heart rate. If BP is decreased rapidly and artificially through acceleration then the ability of the body to recover rapidly may be diminished and loss of consciousness may be the result.[68] The effects of this is most widely felt in aerobatics rather than in normal flying.

Section

3.3.5 **The Lymphatic System** can be considered to be a part of the circulatory system. Within humans there is a fluid known as the extracellular fluid, the main component of which is called tissue fluid. Plasma in the blood and tissue fluid are very similar and easily flow between each other. As blood flows to the capillaries, a pressure differential is created at that area of the capillary bed where the arteriole meets the capillaries. The fluid pressure in the capillaries is significantly higher than in the surrounding tissue. The result is fluid flow from the capillaries into the tissue which permits the transfer of oxygen and amino acids into the tissues. At the end of the capillary bed where the capillaries meet the venules, the pressure differential is reversed. The fluid pressure in the capillaries here is significantly lower whilst the fluid pressure in the tissues has remained the same. The opposite of what occurred previously. As a result, the movement of fluid is from the tissues into the capillaries which also carries waste products such as urea. Unfortunately, the transfer is not total and residual tissue fluid is left behind in the tissues. The draining of this excess tissue fluid is via the lymphatic system. The lymphatic system is a network of vessels that collects the fluid, called lymph, and returns it into the vena cava near the heart. The fluid moves through the vessels due to the constriction of muscles and the one-way valve design of the vessels. In this way the fluid is pumped in one direction only and does so without the benefit of a pump like the heart. The vessels also pass through the lymph nodes which produce a type of white blood cell that assist in helping to fight infection. If the tissue fluid is not removed, due to such things as high blood pressure or inactivity, then the fluid tends to build up around the ankles and feet. This is known as oedema.

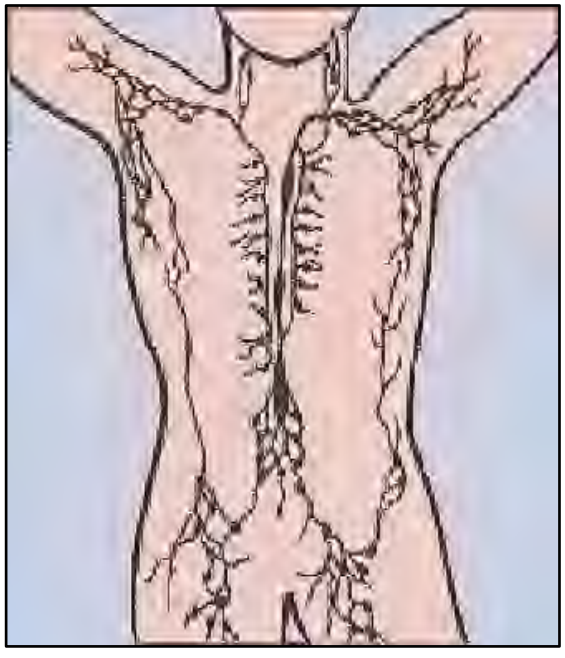


Figure 3.22 The human lymphatic system basically transports recycled blood plasma and reintroduces it into the circulatory system.

[68] The Advisory Group for Aerospace Research and Development, NATO, *The Effects of Gravity and Acceleration on the Lung,* Chapter 5 – The Effect of Acceleration on the Cardiovascular System, p 69-70, NATO, 1970.

Module 3.4

3.4 **The Nervous System.** The nervous system in the human being controls all the biological processes and movements of the body as well as receiving and interpreting stimuli from the external environment through the network of human senses. It consists of two primary areas: the Central Nervous System (CNS) which receives and processes the information, and the Peripheral Nervous System (PNS) which detects the stimuli through the senses and sends information to the CNS via electrical impulses.

Section

3.4.1 **The Central Nervous System (CNS)** The CNS is located centrally within the body and is also central to the functioning of the nervous system. Its two key functional areas are the brain and the spinal cord and the basic building block is the cell called the neuron.

3.4.1.1 The neuron is a nerve cell that specialises in transmitting information throughout the human body by means of electrical or chemical signals. There are a number of different types of neurons, such as:

- Sensory (afferent) Neurons – as the name suggests, these cells transmit information from the sensory organs to the brain.
- Motor Neurons – work in the opposite direction insofar as transmitting information. These neurons transmit motor information from the brain to the muscles.
- Interneurons – transmit information between neurons.

Neurons differ from other cells in that they do not reproduce, thus the expression: "killing brain cells," for once brain cells (neural cells) die, there is no regeneration. New connections between neurons can form, however.[69] The long length of a neuron, called the axon, can extend for up to a metre in humans.

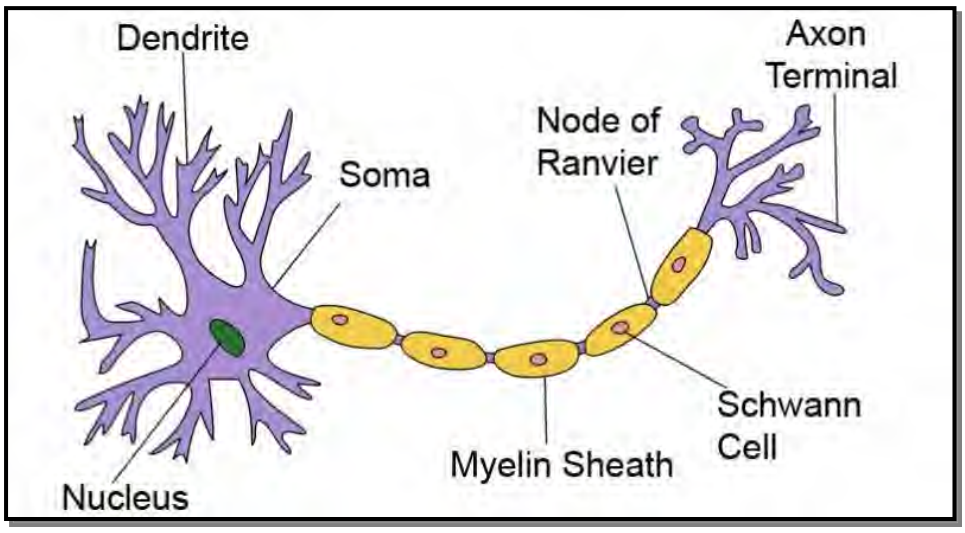


Figure 3.23 A typical neuron cell. [70]

[69] About.com – Psychology, *What is a Neuron?* http://psychology.about.com/od/biopsychology/f/neuron01.htm accessed 13 Jul 12.
[70] Derived from an image by Quasar Jarosz at en.wikipedia, CC-BY-SA, 3.0. http://en.wikipedia.org/wiki/File:Neuron_Hand-tuned.svg

3.4.2.1 The role of the brain physiologically is to generate muscle activity or to control the secretion of hormones. It consists of three core sub-divisions:

- **The Brainstem** – the core of the brain which is composed of the midbrain which connects the hindbrain and the forebrain.

- **The Forebrain** – this is the central processing unit and is responsible for receiving and processing signals from the senses, for cognitive thought and language, as well as motor skills.

- **The Hindbrain** – this is the extension from the spinal cord through which sensory information is conducted and the area in which balance and equilibrium is maintained. Also in this area is the medulla oblongata which is responsible for automatic body functions such as breathing, digestion, heart rate and the like. From the medulla oblongata extends the other key area of the CNS, the spinal cord.

3.4.2.2 The Spinal Cord is the second area of the CNS. It is long and tubular and is found within the backbone, or vertebral column, stretching from the occipital bone to the lumbar region of the backbone, specifically L1 and L2 vertebrae. The spinal cord performs three key functions:

- As a pathway for neural signals that conduct motor information which travels down the spinal cord along the neuraxis.

- As a pathway for neural signals that receive signals from the senses, and thus travel up the spinal cord along the neuraxis.

- A central processing area for certain reflex actions.

Problem	Remarks
Epilepsy	storms of abnormal electrical activity in the brain causing seizures
Meningitis	inflammation of the membrane covering the brain
Multiple sclerosis	the myelin sheaths protecting the electrical cables of the central nervous system are attacked
Parkinson's disease	death of neurones in a part of the brain called the midbrain. Symptoms include shaking and problems with movement
Sciatica	pressure on a nerve caused by a slipped disc in the spine or arthritis of the spine and, sometimes, other factors
Shingles	infection of sensory nerves caused by the varicella-zoster virus
Stroke	a lack of blood to part of the brain

Table 3.7 Problems of the Nervous System derived from the Victorian Government's Better Health Channel website[71]

Section

[71] Better Health Channel, *Nervous System,* http://www.betterhealth.vic.gov.au/bhcv2/bhcarticles.nsf/pages/Nervous_system accessed 13 Jul 12

3.4.2 **The Peripheral Nervous System.** The nerves connect the CNS to the rest of the body where a nerve is the mass of neurons outside of the CNS. This network of nerves outside the CNS is the Peripheral Nervous System, PNS. The PNS contains nerves that mirror each other; one for the left side and one for the right side. This makes the nerves 'bilateral.' There are 12 pairs of cranial nerves and 31 pairs of spinal nerves.

3.4.2.1 The **cranial nerves** of the PNS are usually mostly related to those senses and movements of organs around the head, such as eye movement, receiving information through the retina, actions of the inner ear, but they also are directly related to the senses. Many of the nerves have motor and sensory components; the motor components of the nerves transmit signals from the brain to muscles outside the brain and the sensory components allow signals to come to the brain from the body's sensory organs.

3.4.2.2 The **spinal nerves** are probably better known for the unfortunate accidents that cause spinal cord injury, the location of which may determine how much of the body is left paralysed. The 31 pairs of spinal nerves have two roots, both of which emanate from the spinal cord and combine to emerge through small openings between each vertebra known as intervertebral foramen (except for the first spinal nerve pair that emanates from just below the brain. The nerves are labelled C1 to C8 for the cervical nerves, T1 to T12 for thoracic nerves and L1 to L5 for the lumbar nerves and S1 to S5 for the sacral nerves. One last nerve is related to the coccyx and is called the CX nerve.

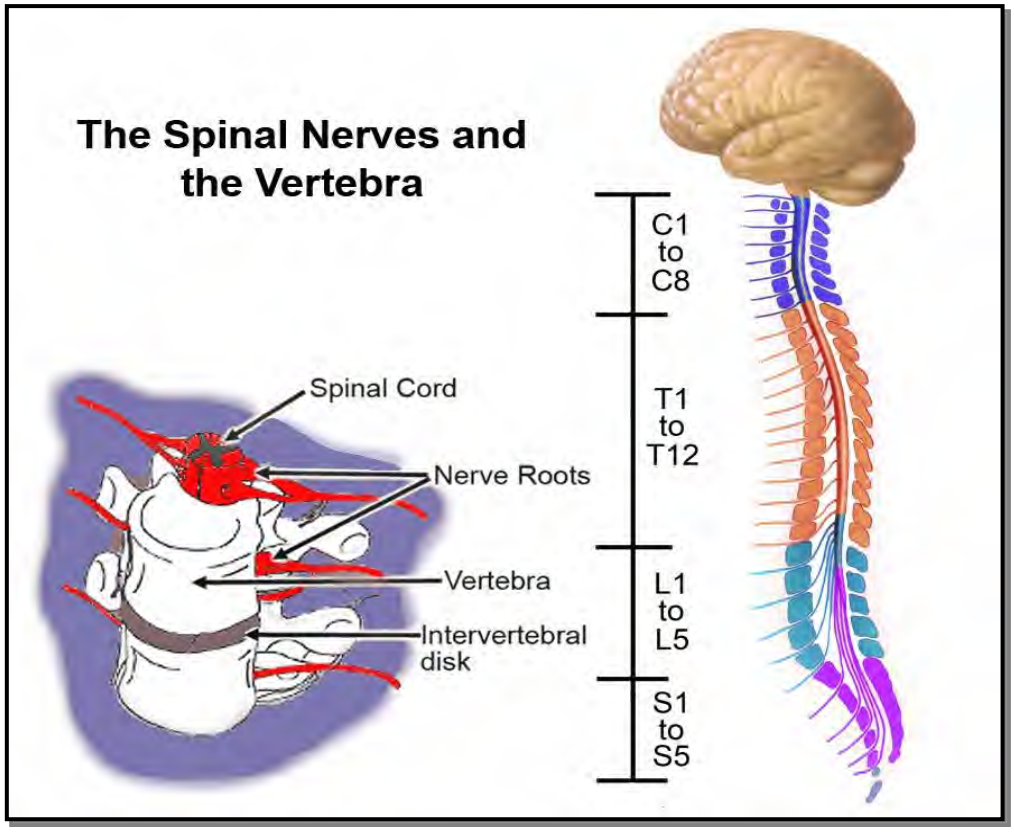


Figure 3.24. The Spinal Nerves are classed from the vertebral segment from which they emanate. See the accompanying table for effects of misalignment or irritation of these nerves on the body.

NERVE	AREA SERVICED	POSSIBLE EFFECTS/CONDITIONS
C1	Blood supply to head, pituitary gland, scalp, brain, inner/middle ear	Headaches, nervousness, head colds, hypertension, amnesia, chronic fatigue dizziness
C2	Eyes/optic nerve, auditory nerve, sinuses, tongue, forehead	Sinus trouble, allergies, deafness, earache, certain visual conditions
C3	Cheeks, outer ear, facial bones, teeth	Neuralgia, acne, eczema
C4	Nose, lips, mouth, Eustachian tubes, mucous membranes	Hay fever, hearing impairments, adenoid infections, post nasal drip
C5	Vocal cords, neck glands, pharynx	Laryngitis, throat conditions
C6	Neck muscles, shoulders, tonsils	Stiff neck, pain in upper arm, tonsillitis, whooping cough, croop
C7	Thyroid gland, bursa in shoulders, the elbows	Bursitis, colds, thyroid conditions, goiter, tendonitis
T1	Forearms, hands, fingers, oesophagus and trachea	Asthma, cough, breathing difficulties, pain in lower arms and hands, pain similar to carpal tunnel syndrome
T2	Heart and its valves and its arteries	Functional heart conditions, chest pains
T3	Lungs, bronchial tubes, pleura, chest, breast, nipples	Bronchitis, pleurisy, pneumonia, congestions, influenza
T4	Gall bladder and common bile duct	Gall bladder, jaundice, shingles
T5	Liver, solar plexus, blood	Liver conditions, fevers, hypotension, anaemia, poor circulation, arthritis
T6	Stomach	Stomach troubles, nervous stomach, indigestion, heartburn, dyspepsia
T7	Pancreas, islets of Langerhans, duodenum	Diabetes, ulcers, gastritis, hypoglycaemia
T8	Spleen, Diaphragm	Lowered resistance, acute and chronic infections, hiccups
T9	Adrenals or supra-renals	Allergies, hives, hypertension, anaemia, hypoglycaemia, obesity, hair loss
T10	Kidneys	Kidney troubles, hardening of arteries, chronic tiredness, nephritis, pyelitis
T11	Kidneys, Ureters	Skin conditions such as acne, eczema, boils
T12	Small intestines, fallopian tubes, lymph circulation	Rheumatism, gas pains, certain types of sterility
L1	Large intestines, colon, inguinal rings	Constipation, colitis, dysentery, diarrhea, some hernias
L2	Appendix, abdomen, upper leg	Appendicitis, cramps, acidosis, varicose veins
L3	Sex organs, ovaries or testicles, uterus, bladder, knee	Bladder troubles, menstrual troubles, miscarriages, bed wetting, impotency, change of life symptoms, many knee pains
L4	Prostate gland, muscles of the lower back, sciatic nerve	Sciatica, lumbago, urinary problems, backaches
L5	Lower legs, ankle, feet, toes, arches	Poor leg circulation, swollen ankles, weak arches, cold feet, weakness in legs, leg cramps
S1	Hip bones, buttocks	Sacroilliac conditions, spinal curvatures
S2		
S3		
S4		
S5		
CX	Rectum and lower regions	Hemorroids, itching at base of spine upon sitting

Table 3.8 Areas of the body affected by spinal nerves and irritation/damage or pinched nerves and some of the possible conditions.[72]

[72] Derived from a table by Dr R.L. Hartman as cited in http://www.fitnesschiropractic.com/images/spinalchart.jpg, accessed 12 Jul 12.

Section

3.4.3 **Alcohol, Drugs, Toxins and their effects on the CNS.** Alcohol is one of the most readily available drugs and because of its social acceptance, often little heed is paid to the widespread social problems it causes compared to the effect of illegal drugs. This module looks at alcohol and at legal and illegal drugs and how they affect the Central Nervous System.

3.4.3.1 **Alcohol.** Alcohol is a depressant and affects the Central Nervous System by reducing the efficacy of the transmission of signals to the brain. It does this by interfering with specific chemical messengers in the CNS, namely serotonin, gamma-aminobutyric acid (GABA) and dopamine. Serotonin and GABA will influence various areas in the brain and can stimulate or inhibit brain functions including the influence on moods, thinking patterns, motivation and emotions.[73] Dopamine is a chemical found in the ventral tegmental area which is that region of the brain associated with pleasure and reward. Dopamine concentrations are increased with alcohol resulting in a reinforcement of the pleasure sensation. All these factors cause a change in behavioural patterns, but because alcohol is also a depressant, it can also cause effects to the CNS and physiological functions. The following is from the Drinkwise organisation in Australia:[74]

- Alcohol is rapidly absorbed via the stomach, small intestine and large intestine. Vaporised alcohol can also be absorbed through the lungs into the blood stream.
- Your Blood Alcohol Content (BAC) is measured in mg of alcohol per 100mL of blood.
- Your blood alcohol will continue to rise after you have consumed your last drink. You generally won't reach your maximum BAC until 45-90 minutes after consuming it.
- Alcohol is broken down (or metabolised) in the body more slowly than it is absorbed. Consequently, the more alcohol is drunk, and the faster it is drunk, the higher the BAC will become.
- In an adult, the average rate of metabolism of alcohol is about one (1) standard drink per hour. However, there is significant variation in this rate between individuals.
- About 10% of the alcohol you absorb is not metabolised. Most of this unchanged alcohol is excreted in your urine, but a proportion is excreted via your lungs in breath and via your skin as sweat.
- Alcohol is detected in your bloodstream, including the brain, within about five minutes of taking a drink.

[73] Kim, S., *Alcohol and its effects*, http://serendip.brynmawr.edu/bb/neuro/neuro00/web1/Kim.html accessed 13 Dec 12.
[74] Drinkwise Australia, *What are the Effects of Alcohol,* http://www.drinkwise.org.au/you-alcohol/alcohol-facts/how-your-body-absorbs-alcohol/ accessed 13 Dec 12.

- Alcohol penetrates your brain and central nervous system.

- Alcohol belongs to the class of drugs called depressants. These do not necessarily make you feel depressed, but slow down the central nervous system including the transmission of messages to and from the brain.

- When pregnant women drink alcohol, it will cross the placental barrier into the foetal blood. For this reason, drinking alcohol during pregnancy and alcohol is not recommended.

- Drinking alcohol and breastfeeding carries health risks as alcohol will enter the breast milk. The alcohol concentration in breast milk is about 10% higher than the BAC in the mother.

3.4.3.2 **Toxins – Self Induced legal and illegal.** It is outside the scope of this manual to discuss all the possible drugs and their effects on the human body, but for the purposes of CRM, we shall discuss some of the more common legal and illegal drugs likely to be encountered and how they may impact the functioning of a person.

Drug	Active Constituent and Method of Delivery	Effects	Long Term Effects
Marijuana (dope, hash) 	Delta-9 tetrahydrocannibinol (THC) Usually smoked in cigarettes or through pipes (bongs) or the oil can be used in baked goods (hash brownies)	• Acts on cannabinoid receptors in the brain. • Affects memory, concentration, judgement perception, movement, decreases inhibitions, increases paranoia • Activates norepinephrine and dopamine and possibly GABA and serotonin	• Psychological dependence • Same effects of smoking (due to tar and chemicals) • Diminished sexual pleasure • Increase in testosterone in women and decrease in men
Crystal Meth, Meth-amphetamine (Ice when in crystal form) 	Methylamine and Amyl Amine. Snorted, Injected, smoked (most potent delivery method)	• Exhilaration, sharpening of focus, euphoria, increased heart rate and blood pressure and body temperature, wild mood swings, damage to immune system, decreased hunger, decreased fatigue, agitation, paranoia, bizarre behaviour, heart failure. • Activates norepinephrine and dopamine	• Extremely strong psychological dependence • Psychoses • Brain haemorrhage due to heightened blood pressure
Ecstasy (E, Adam, X, Empathy, MDMA)	3,4 Methylene-dioxy-N-methylamphetamine (MDMA) (*MDA is a similar drug but with much	• Exhilaration, sharpening of focus, euphoria, empathy, closeness, confusion, sleep disorders, teeth clenching, acne like rash, depression, paranoia,	• Psychological dependence • Damage to serotonin transmitters resulting in degradation in learning, sleep and

	greater toxicity) Tablet form ingested	chills, aggression. • Activates serotonin	emotional integration. • Cognitive impairment.
Benzodiazepines (aka minor tranquilisers such as Valium, Serepax, Mogadon)	Benzene (the hydrocarbon) and Diazepine Normally tablet form	• Impaired thinking, drowsiness, memory loss, vertigo, confusion, double vision, tremors, vomiting, fatigue, constipation, loss of appetite. • Enhances GABA resulting in sedative effects	• Long term memory loss, depression, lack of motivation, aggression, paranoia, weight gain, personality changes.
Antihistimines (such as Zyrtac, Sudafed, Claratyne,)	Diphenhydramine and doxylamine which cause drowsiness. Normally tablet or spray	• Impaired thinking, drowsiness, impaired motor skills, weariness and lack of motivation, tinnitus.	• Long term effects of overdosing are usually chronic forms of those effects shown at left.
Codeine (such as Nurofen, Panadeine, Panafen, Mersyndol)	Paracetamol, Ibuprofen , doxylamine. Usually sold in tablet/caplet form but may be in liquid form.	• Dizziness, feeling faint on standing, lethargy confusion, difficulty concentrating, euphoria, restlessness, blurred vision, stiff muscles sweating, mild allergic rash, itching or hives, decreased heart rate, palpitations stomach ache, nausea, vomiting, constipation difficulty urinating, even though the person feels the need to	• Perforated bowel, internal bleeding in the GIT, kidney failure, liver failure, dizziness.

Table 3.9 and **Figure 3.25** Some of the key drugs listed as part of CASA's drug policy are shown in the table above. Certain over-the-counter drugs can affect a person's capability to operate machinery or to remain alert such as the antihistamines shown at right.

Module 3.5

3.5 **The Senses.** We take senses for granted, but what exactly is a sense? Think of the word 'sensor'. A sensor picks up information, and that information – once interpreted – is a sense. It is defined as the faculty of sensory reception.[75] It is the ability to detect external stimuli and through a process known as transduction, converts these stimuli into nerve impulses in the form of electrical signal which are conveyed to the brain where they are interpreted as a smell or a taste and so on.

Section

3.5.1 **How Many Senses do we have?** The manner in which we, as human beings, understand our physical position in the environment is through the perception of information that is received through our senses. Aristotle first classified the key human senses; sight, hearing, touch, taste and smell, and he surmised that through these five senses, human beings can understand where they are in the known universe.

3.5.1.1 But this limited value of senses has not allowed the real acceptance of other senses. There is argument for up to 21 senses in the human body, but for our studies, we shall use nine. They are:

- **Vision** (Sight) – the ability to receive through the eyes, photons of electromagnetic energy that are reflected off objects in the visible spectrum which excite cells on the retina and which cause electrical signals that are interpreted by the brain.

- **Audition** (Hearing) – the ability to receive the vibrations of pressure waves through the auditory organs which stimulate hair follicles which then induce electrical signals that are interpreted by the brain.

- **Gustation** (Taste) – the ability of the five types of chemical receptors on the tongue which react to chemicals that stimulate nerve endings and which induce electrical signals that are sent to and interpreted by the brain.

- **Olfcation** (Smell) – the ability of hundreds of different receptors to 'bind' to a particular molecular feature and which induce electrical signals that are interpreted by the brain.

- **Tactition** (Touch) – the ability of various receptors to perceive different pressures on the skin which then induce electrical signals that are interpreted by the brain.

- **Thermoception** (Heat) – the ability of thermoreceptors on the skin to sense the presence or absence of heat (ie hot or cold). (Homeostatic thermoceptors are different and are internal and provide feedback to internal body temperature).

- **Nociception** (Pain) – the ability of cutaneous (skin), somatic (joints/bones) and visceral (body organs) pain receptors to detect sensations which induce electrical signals that are interpreted by the brain.

[75] Medicine.net, *Definition of Sense,* http://www.medterms.com/script/main/art.asp?articlekey=15769 accessed 12 Jul 12.

- **Equilibrioception** (Balance) – the ability of the nerve endings in the vestibular apparatus of the middle ear to detect movement of fluid in the semi-circular canals which induce electrical signals that are interpreted by the brain.

- **Proprioception** (Body Awareness) – the ability of various parts of the body to detect the location of body parts regardless of the ability to sense that location through other senses.

3.5.5.2 Of the above senses, we shall investigate separately the key senses that affect us in the aviation and other high-risk environments (see following modules):

- Vision.

- Hearing.

- Equilibrioception.

- Proprioception.

Section

3.5.2 **Sensory Threshold, Sensitivity, Adaptation, Habituation.** When considering a human's ability to sense its environment, one must consider the abilities of the individual senses in being able to detect and discriminate between various external stimuli. In some cases, the senses will change over time and the ability of senses will vary between individuals. The following element investigates these factors.

3.5.2.1 **Sensory Threshold** refers to a limit of ability to detect a change in a stimulus by the human sensory receptors. There are some key thresholds, such as:[76]

- Absolute Threshold – below which a stimulus cannot be detected by sensory receptors.

- Recognition Threshold – that limit where recognition of a stimulus occurs, not just detection.

- Differential Threshold – the ability to detect a change between stimuli.

- Terminal Threshold – beyond this limit, the stimulus can no longer be detected (eg the upper (UV) end of the visual range of light which would be opposite to the lower (IR) end which would constitute the Absolute Threshold).

In flight simulators, acceleration can be simulated by tilting the simulator. After the acceleration simulation has ceased, the simulator can be returned to its 'baseline' position ready for the next simulation. If this return to baseline is done slowly and smoothly, (ie below sensory threshold), the pilot in the simulator will not be able to detect the movement.

3.5.2.2 **Sensory Sensitivity** can relate to the detection ability of the sensory receptors or to the degree of sensitivity of a person to psychological and physical cues. In the former case, this may be due to a neurological condition such that the sensory receptors are not as finely tuned in some people as in others (eg one person has very good vision or a keen

[76] Wikipedia, *Sensory Threshold,* http://en.wikipedia.org/wiki/Sensory_threshold accessed 13 Jul 12

sense of smell). In the latter case, Highly Sensitive Persons (HSPs) suffer from a form of sensory overload where too many stimuli, or particular stimuli, cause a negative psychological reaction. This stimuli may be something as innocuous as the feel of a fabric against the skin, or the texture of a type of food, or an unpleasant smell that most others would not consider too bothersome. In its extreme form, it can lead to social problems, especially with interpersonal interaction and can manifest itself as extreme shyness or an inability to make eye contact or be touched by another person without feeling like being attacked. Another term used is sensory defensiveness.[77] It is a component of autism in its extreme form, but in its milder form, can manifest itself as an inability to perform well under pressure (test-itis) or a feeling of being overwhelmed when being overloaded and can lead to a 'meltdown' type situation.

3.5.2.3 **Sensory Adaptation** refers to the condition whereby the senses 'get used to' a particular environmental context.[78] Probably the most common example is night adaptation whereby after about 30 minutes of darkness, visual acuity is increased, in this case by the creation of more rhodopsin to enable the rods to perform at their peak. Other examples of sensory adaptation include the threshold shift experienced by the middle ear's ossicles where muscles attached to the ossicles will retract thus reducing the ability of the stapes to vibrate against the oval window (see section on the anatomy and physiology of the ear). The reduction in the sensitivity due to this muscle contraction reduces the hearing threshold (threshold shift) of the ear and can last for several minutes, hours or even days depending on its severity. This helps to protect the hearing organ from ongoing loud noises. (Smells are another example of how a sense will become adapted).

3.5.2.4 **Sensory Habituation** is similar to Sensory Adaptation, but where in adaptation, the sensors change their abilities to detect, in habituation the brain ignores what is being detected.[79] For example, being in a room with a noisy air conditioner may be irritating at first, but after a while, the noise is no longer noticed. The ears still hear the noise… so there is no change in the capability of the sense, but the brain does not process it the same way. It does, however, become noticeable if it suddenly stops. Sensory Habituation occurs because the senses are designed to detect changes in the environment, not things in the environment that remain constant; noises, certain tactile feelings (like wearing jewellery). Eyes are not prone to habituation because of saccadic vision, whereby the eyes are constantly moving, even when staring at an object. Because of this, the eyes are presented with new scenes several times a second – even if the difference is below our visual differential threshold so that we don't notice it – and in this way, vision always remains alert.

Section

3.5.3 **Reflexes and Biological Control Systems.** A reflex is a response to a stimulus. When discussing reflexes in the human body, we talk about reflex arcs. A reflex arc is the 'round trip' taken from stimulus to response that does not require the brain to process information. For example, if you step on a nail, you do not have to wait to receive the pain signal, think about what has happened, decide that you need to remove your foot and then actually remove your foot. The pain signal is received by neural sensory receptors (in this case a Nocioceptor – see below) and travels to the central nervous system which

[77] Wikipedia, *Sensory Defensiveness,* http://en.wikipedia.org/wiki/Sensory_defensiveness accessed 13 Jul 12.
[78] Indian University Ft Wayne, *Sensation and Perception – Sensory Adaptation,* http://users.ipfw.edu/abbott/120/adaptation.html accessed 13 Jul 12.
[79] Pearson Higher Education Teacher's Resources (auth unk), *Chap 3, Sensation and Perception,* www.pearsonhighered.com 0205832571.pdf accessed 13 Jul 12

immediately causes a reflex action (ie moving the foot away from the item delivering pain). At the same time, the signal is sent to the brain, but the reflex arc has already reacted to the stimulus before the brain has a chance to process it. This function is found in higher animals and is a biological control system designed to protect the body from harmful situations. Reflexes are processed by the CNS and medical tests of simple reflex actions test the integrity of the CNS, such as the knee jerk patella test or the bicep jerk test.

Section

3.5.4 **Sensory Receptors.** Sensory Receptors, or Senso Receptors that change one form of stimulus into another. The following table outlines the key Sensory Receptor types, their function and where they can be found in the human body.

Senso Receptors	Detects	Location
• Baroreceptors	Pressure (esp in blood)	Arterial walls where they detect stretching or contracting of the walls which corresponds to changes in pressure. This is then transduced causing secretions to the heart which cause it to beat faster or slower thus changing blood pressure to stabilise it.
• Chemoreceptor	Chemical stimuli (odours)	CO2 detecting in the medulla oblongata and aortas – detects CO2/pH levels and causes deeper breathing, Olfactory epithelium (roof of the nasal cavity behind the nostrils) detects odours, Taste buds on the tongue detect taste.
• Mechanoreceptors	Mechanical stress/strain	Inner ear to detect sound and movement. Skin to detect items related to the sense of touch. Hair, detects changes in hair position. Muscle spindles detecting muscle stretch (reflex test).
• Nocioceptors	Tissue damage/pain	Any part of the body that can detect pain. This pain can be caused by thermal influences (heat/cold), Mechanical (stress/incision/tearing) and Chemical (chemicals, esp Capsaicin from the Capsicum).
• Osmoreceptors	Water absorption of cells	Hypothalamus in the brain. It will release vasopressin which changes the osmotic quality of the blood and will hold back water (resulting in concentrated urine).
• Photoreceptors	Light	The Retina. (See anatomy and physiology of the eye).

• Proprioceptors	Body Position	Not confirmed, but deduced to be in the inner ear, muscles and ligaments.[80]
• Thermoreceptors	temperature	Skin, cornea and urinary bladder.

Table 3.10 The various sensory receptors and the function they perform.

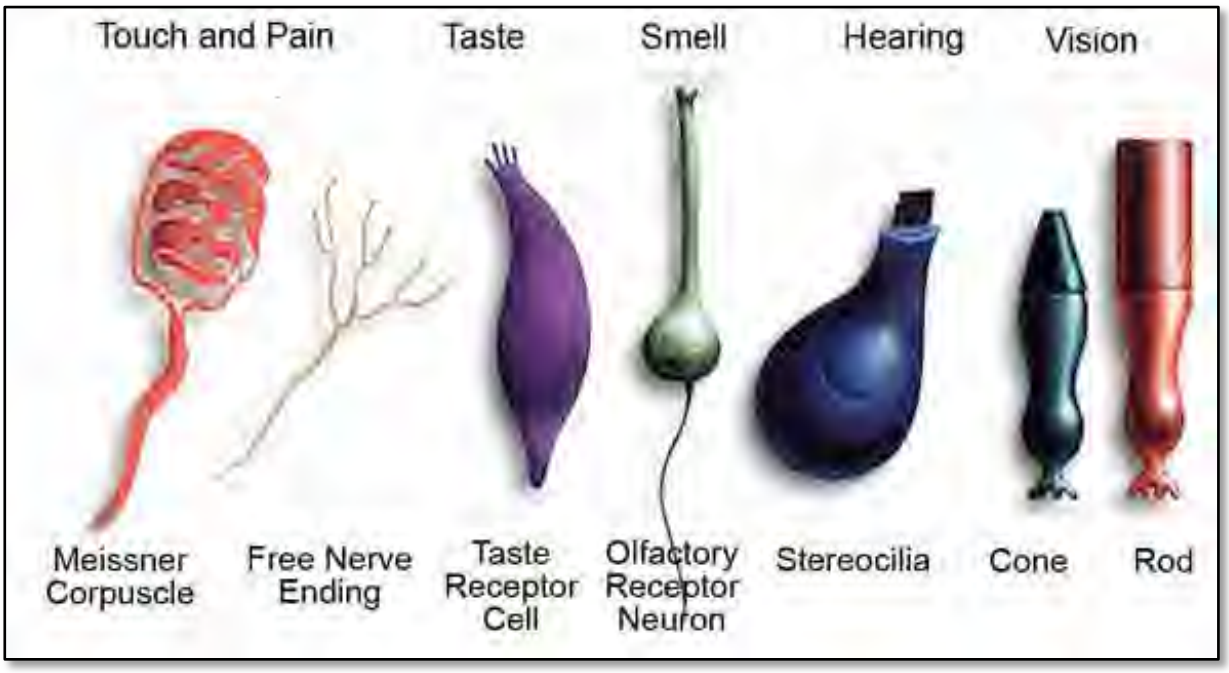


Figure 3.26 The various sensoreceptors for the various senses. Each one senses a form of data from the environment, be it an odour molecule, a photon or pressure and transmits an electrical signal to the brain through the central nervous system where those signals are decoded and interpreted by the brain.

[80] Wikipedia, *Proprioception,* http://en.wikipedia.org/wiki/Proprioception accessed 13 Jul 12.

Module 3.6

3.6 **The Eye and Vision.** Of all the sense organs, the eyes are the most important. More than 80% of the information taken in by the brain comes from our vision, and so the ability of a human to be able to see and understand what s/he sees is very important. The following sections provide information on this remarkable organ.

Section

3.6.1 **The Eye and its Anatomy.** The diagram below shows the functional components of the human eye.

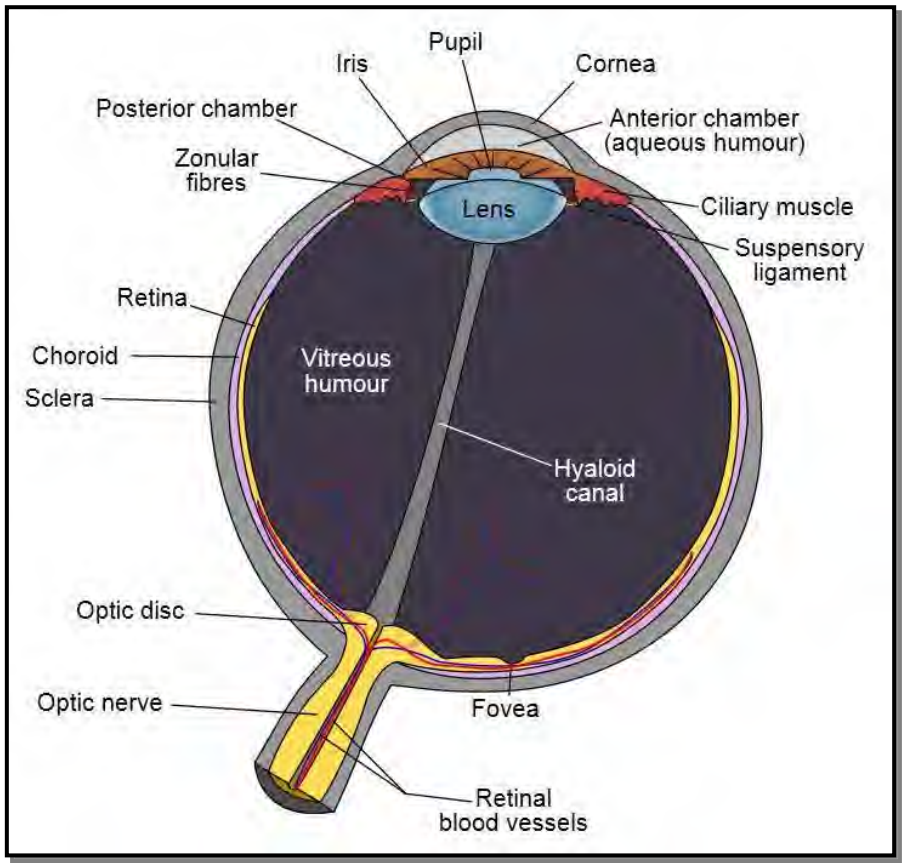


Figure 3.27.[81] The anatomy of the human eye.

Section

3.6.2 **The Physiology of the eye.** The sphere of the eye is approximately 20mm in diameter. The eyes sit in their ocular orbits, the cavities in the human skull that house the eyes, and move by means of ocular muscles that are attached to the sclera, the outer wall of the eye (also known as the 'white of the eye'.) In the front part of the eye, the sclera is replaced by the transparent cornea which forms the anterior (front) chamber. Behind the cornea is the iris which opens and closes and thus acts similar to the lens of a camera to regulate the amount of light entering the eye. Sitting behind the iris is the lens. The lens is biconvex, which means it curves outwards in the front and rear parts of the lens. The amount

[81] Public Domain image obtained from http://upload.wikimedia.org/wikipedia/commons/1/1e/Schematic_diagram_of_the_human_eye_en.svg

of curvature is determined by the ciliary muscles and it is this change of curvature by the muscles that allows for focussing of the eye on objects. This change in the optical power of the eye which allows vertebrates to focus is known as accommodation. This function becomes more difficult with age (see presbyopia below).

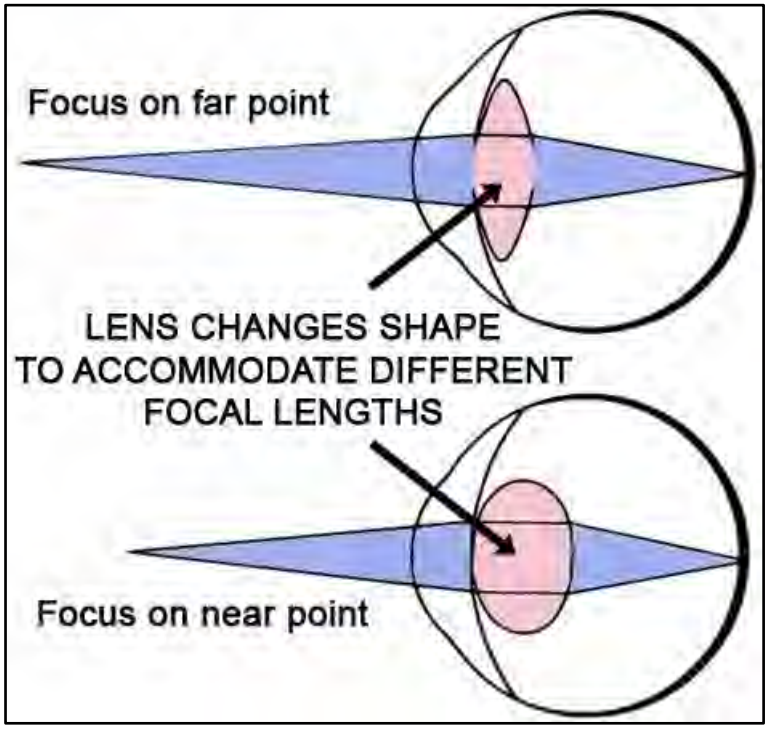


Figure 3.28 [82] Accommodation is the manner in which the muscles of the eye change the shape of the lens in order to change the optical power and focal point of vision.

3.6.2.1 Light passes through the cornea and lens and into the main section of the eye known as the posterior (rear) chamber. This chamber is filled with a transparent gelatinous liquid called the vitreous humour. Directly behind the pupil and lens is the fovea centralis which shall be discussed later. On the rear of this chamber is an extra surface layer that sits on the Choroid and Sclera, called the retina. The rear part of the retinal layer, called the retinal pigment epithelium (RPE), is made up of photosensitive cells that detect photons of light which change the chemical makeup of rhodopsin or iodopsin (depending on the type of cell, see below). This chemical change will allow or prevent sodium ions from passing into the cell which changes the electrical potential of the cell. It is this electrical change – or charge – which is transmitted to the brain via the optic nerve. The whole process is called photo transduction (photo – light, transduction – from the electrical definition of the term meaning to convert from one form of energy to another form of energy - from the Latin meaning to lead across).

3.6.2.2 **Rods and Cones.** The cells on the retina responsible for photo transduction are commonly referred to as Rods and Cones due to their shape. The 6 to 7 million cone cells provide colour sensitivity but are not as sensitive to light as rods, which means that they can adjust more rapidly to changing light conditions than rods can. Cones are responsible for high resolution vision but require good light levels to achieve this.[83] The 120 million or so rod

[82] Derived from an image by Ziguerzi and placed in public domain. http://en.wikipedia.org/wiki/File:Accommodation_(PSF).svg
[83] http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html accessed 02 Jan 13

cells are much more sensitive to light than cones are, but are not able to distinguish colour and it is reported that individual photons can trigger a rod into sensing light. The key photosensitive pigment in rods is called rhodopsin (aka visual purple). Rhodopsin can become bleached and desensitised due to bright lights and will take about 30 minutes to re-adapt its sensitivity. This is the average time required to attain optimum night vision in normal circumstances. Rods are also more sensitive to movement and since they predominate in the periphery of the retina, it is easier to notice something moving out of the corner of one's eye.

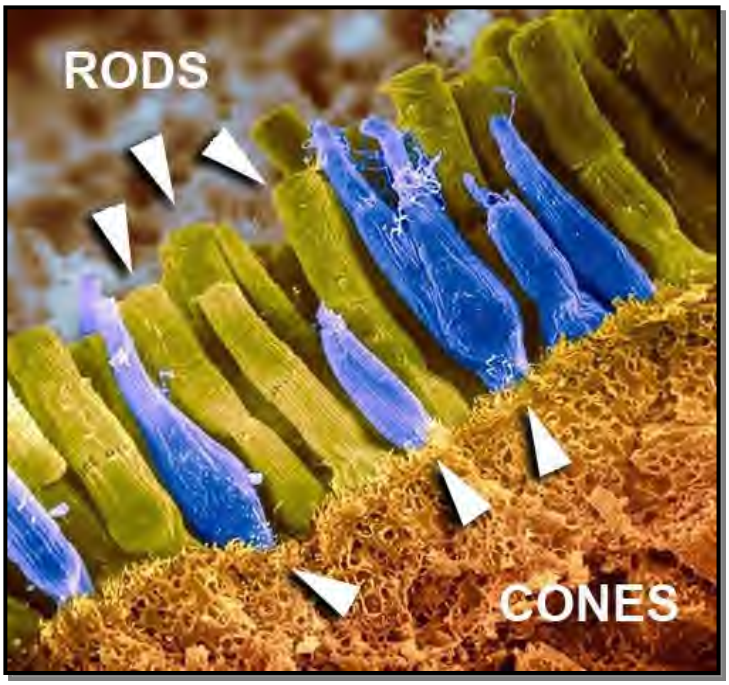
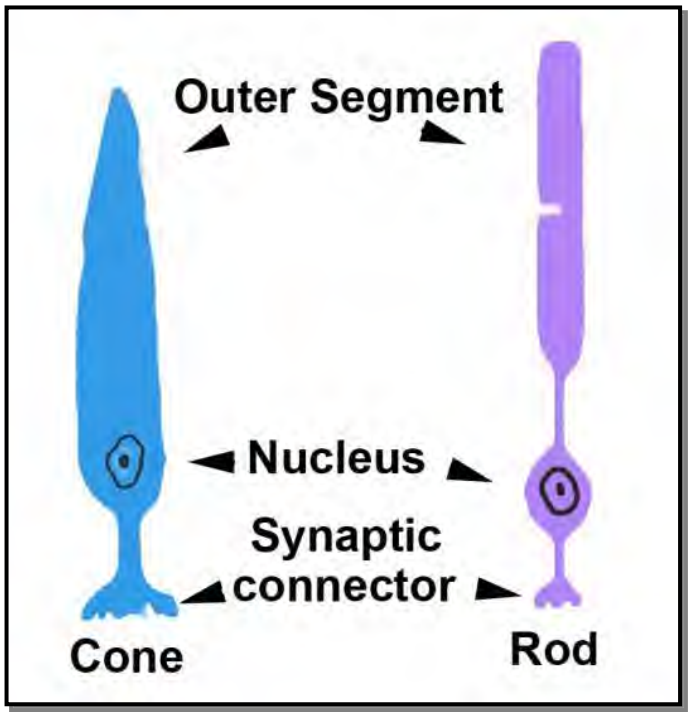


Figure 3.29 (Left) A coloured scanning electron micrograph of rods and cones showing their unique shape.

Figure 3.30 (Right) Diagram of Rods and Cones.



Another type of cell is the ganglion which is somewhat photo sensitive. In the figure above, the cones and rods are shown as different shaped cells. Both of which carry a pigment used in various light levels. The table below, derived from Kandel et al, shows key differences between rods and cones

CONES	RODS
Used for day vision (photopic vision)	Used for night vision (scotopic vision)
Sensitive to direct light only. Has less pigment than rods (called Iodopsin), but pigment is able to detect three ranges of light frequency and can thus detect all colours.	Very sensitive to light, including scattered light and low light levels due to high levels of one light sensitive pigment (Rhodopsin). This pigment cannot detect colours, though.
Loss of cones can cause day blindness which can result in being classed 'legally blind	Loss of rods leads to night blindness
Very good at resolving detail (High Visual Acuity)	Poor at resolving detail with low visual acuity
All cones located in Fovea	No rods in the Fovea, all in the periphery (20 times more rods than cones)

Table 3.11 Differences between Rods and Cones in the Retina

Section

3.6.3 **Visual Acuity and its Deficiencies.** Visual Acuity (VA) is the ability to discriminate (resolve) the fine details of an object in a person's field of view. Visual acuity will determine a person's ability to define the limit of spatial discrimination. In other words, interpreting distances to various objects. In order to resolve detail, a focused image needs to be projected onto the fovea where the most number of cone cells are concentrated.

3.6.3.1 VA is limited by a number of factors such as the structure of the retina, the manner in which light falls on the retina and on the fovea in particular, and the interpretive ability of the brain. It is measured using a fraction of distance of the subject's VA over distance of an average VA. So a figure of 20/20 (imperial) or 6/6 (metric) means that the subject can see an item at 20 feet or 6 metres that an average person should be able to see at 20 feet or 6 metres. If VA is measured as 20/40 (6/12), then it means that the subject would have to stand 20 feet / 6m from an object to be able to see it as clearly as an average VA at 40 ft/12m. In other words, 20/40 vision is the same as 1 / 2 meaning it is half as good.

3.6.3.2 Deficiencies in vision can be caused by a number of reasons; congenital, disease related, injury related or age related. The most common defects are near-sightedness known as Myopia, far-sightedness, known as Hyperopia and reduction in VA due to age known as Presbyopia. Presbyopia is usually noticeable between 40 and 50 years of age and its symptoms include difficulty in focussing between viewing distances; difficulty in focussing at close range and fine print (short arms syndrome) and eyestrain when reading for long periods.

3.6.3.3 **Myopia** can be caused by a lens that is too strong due to incorrect curvature or an overly large distance between the cornea and the fovea due to the eye being too long. In this case, the lens causes the light rays converging not on the fovea where the cones are, but rather, they converge in front of the retina within the vitreous humour. In **Hyperopia**, the opposite is the case with the lens being too weak due to incorrect curvature or the eye being too short. The focal point becomes theoretically outside the chamber of the eye. Both

conditions can usually be corrected by diverging or converging lenses placed in front of the cornea as spectacles or contact lenses.

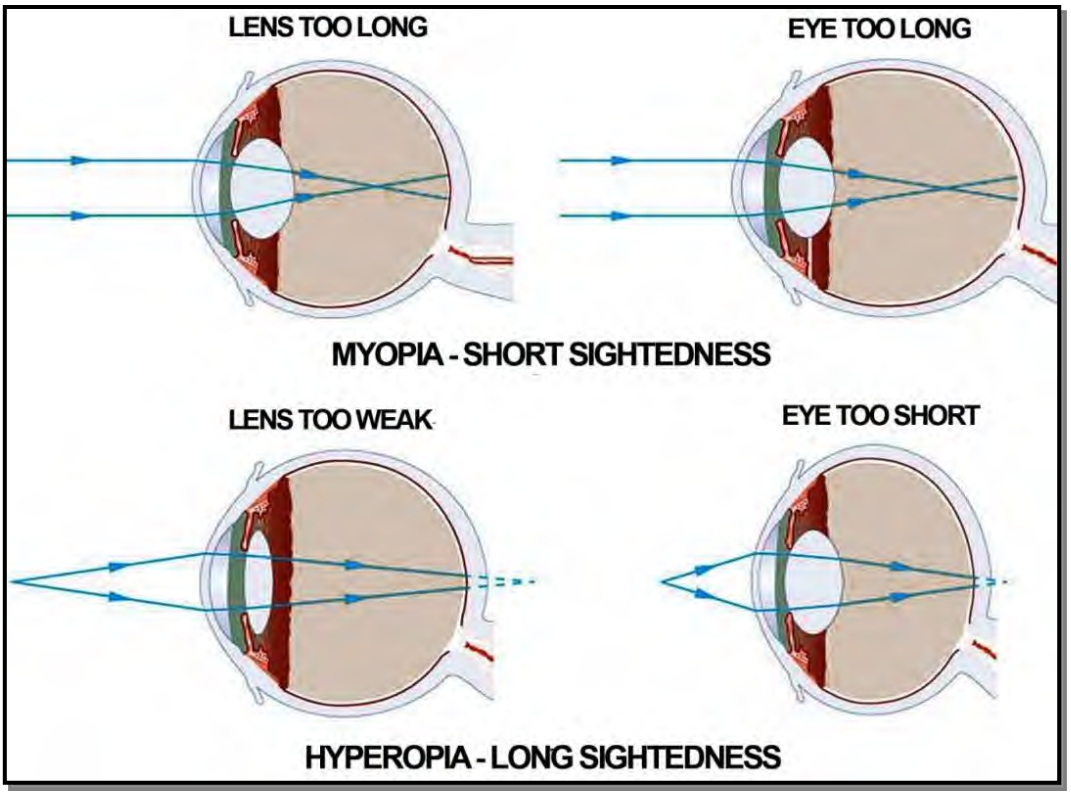


Figure 3.31 Typical sight deficiencies

Section

3.6.4 **The Visual Field and Vision.** Visual Field describes everything that can be seen by the viewer and relates to how light (photons) fall on the retina such that they can be detected and interpreted by the brain. This includes both central and peripheral vision.

3.6.4.1 **Binocular Vision and Depth Perception.** Binocular vision is literally the ability to see with two eyes (Bi – two, ocular – pertaining to the eye). Having binocular vision is advantageous, especially to humans who rely so heavily on vision, due to that fact that:

- It gives a wider field of view (200 degrees horizontally with both eyes working, but only 160 degrees with one eye working.)[84]
- It provides distance approximation with objects that are relatively close due to parallax error and the brain's ability to interpret the error (also known as Stereopsis but commonly known as **depth perception**).
- It provides binocular summation, which is the ability of two eyes to be able to detect visual cues at lower sensory thresholds than one. In other words, a faint light is easier seen with two eyes than it is with one eye to a factor of the square root of 2 (ie 1.41 times better at detecting sensory stimuli).

[84] Malik, J., *Recognising People, Objects and Actions Lecture Notes: Human Visual System,* CS294-6 (Fall 2004), University of California, Berkely, http://www.cs.berkeley.edu/~malik/cs294/lecture2-RW.pdf

Figure 3.32 [85] German Anti-Aircraft range and altitude finder. The wider the distance between the individual optics, the more accurate is the range finding ability. Here, German Grenadiers look through the rangefinder. Once enemy aircraft are spotted, the optics are focussed so that the image is clear and are not double vision. This requires movement of the lens and movement of the angle of the mirrors. It is this angular movement that gives the single vision and provides the trigonometric information to determine how far the object being viewed is. With this information, the angle from the horizontal is attained which can then give the altitude using trigonometry again. The placement of the eyes on the human face is a smaller version of this.

3.6.4.2 **Cues to Depth Perception.** Depth perception is the ability to detect the distance a viewer is from an object. As was stated above, this ability – also known as stereopsis – is a function of binocular vision primarily, however there are circumstances where binocular vision is not available (eg one eye is damaged or unable to be used) or vision is modified (eg through optical equipment such as cameras, night vision devices, etc). In these cases, depth/distance perception must be attained using other means and techniques. These techniques are called 'monocular cues' or 'depth perception cues' and provides information to the viewer to make judgements. Some cues are[86]:

- Relative Size – this technique relies on experience to be able to judge the size of known objects and relate them to each other to see which one is further away than the other. The other is size constancy – an object cannot get smaller physically, therefore if it appears to be getting smaller, then it must be due to it moving away from the viewer and the retinal image becoming smaller.

- Interposition – where one object is positioned over (overlaps) another, then the overlapped object is deemed to be further away.

[85] http://www.panzergrenadier.net/forum/viewtopic.php?f=82&t=8512&start=0&view=print accessed 01 Jan 13.
[86] Webvision – *Perception of Depth*, http://webvision.med.utah.edu/book/part-viii-gabac-receptors/perception-of-depth/ accessed 12 Jun 12.

- Linear Perspective – when objects of a known distance or dimension subtend smaller and smaller angles, that is, when parallel lines seem to converge with increasing distance.

- Aerial Perspective – where objects appear to be less sharp, with less detail and more and more grey. This is to do with reduced visual acuity with distance and the increased number of particles in the air that scatter light and its effect on colour.

- Light and Shade – highlights and shadows provide information about texture and depth.

- Monocular Movement Parallax – parallax error causing the appearance that when the viewer moves his/her head, objects closer to the viewer seem to move opposite the direction of movement of the head and objects in the distance move with the direction of movement of the head.

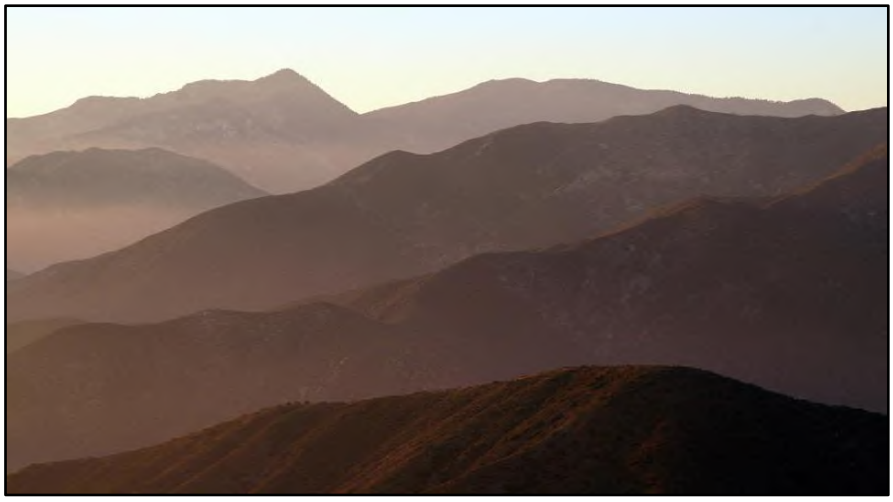


Figure 3.33 An example of aerial perspective (objects becoming less sharp and more grey with distance) and interposition (objects in front of each other). Two monocular clues to distance and part of the ability of depth perception.

3.6.5 **Day Vision, Night Vision and Blind Spots.** Photopic vision is the ability to see when the ambient light is effective. It is a requirement of cone cells to have sufficient light for them to be effective. Scotopic vision is the vision required under low light conditions and is this type of vision that primarily uses the rods cells of the retina. Between photopic and scotopic vision is mesopic vision which is used during periods of intermediate light (eg dawn or dusk). Mesopic vision uses a combination of rods and cones and is the least effective form of vision, with visual acuity being reduced along with colour discrimination. Thus operating in this environment or similar environment, such as at night using street lighting, can increase the likelihood of hazards associated with reduced visual acuity. In other words, driving or operating machinery at night under street lights or at dawn or dusk is extremely hazardous.

3.6.5.1 **Day Blind Spot.** Because the photoreceptor axions must pass information to the brain, they coalesce and leave the retinal area through an area of the eye known as the optic disk. There are no rods or cones in this area and so there is no ability to receive light information. This causes a blind spot. Because the location of the optic disk is not central on

the retina, the other eye is able to compensate for the blind spot because its optic disk is also offset. If no binocular vision is possible, then there will be a break in the visual field.

X

3.6.5.2 **Night Blind Spot.** The central part of the retina, directly behind the pupil, is used for photopic vision (see above). As such, it is primarily composed of light sensitive cones which are not effective for night vision. The Night Blind Spot is the result of this concentration of cones and causes a break in the visual field when looking directly at an object in low light conditions. To compensate for this night blind spot, it is recommended to offset one's vision by about 10 to 20 degrees in any direction. This will allow any photons being emitted/reflected from the object being viewed to fall directly on to the highest concentration of rods – the low light sensitive photoreceptors – and thus will maximise the effectiveness of night vision.

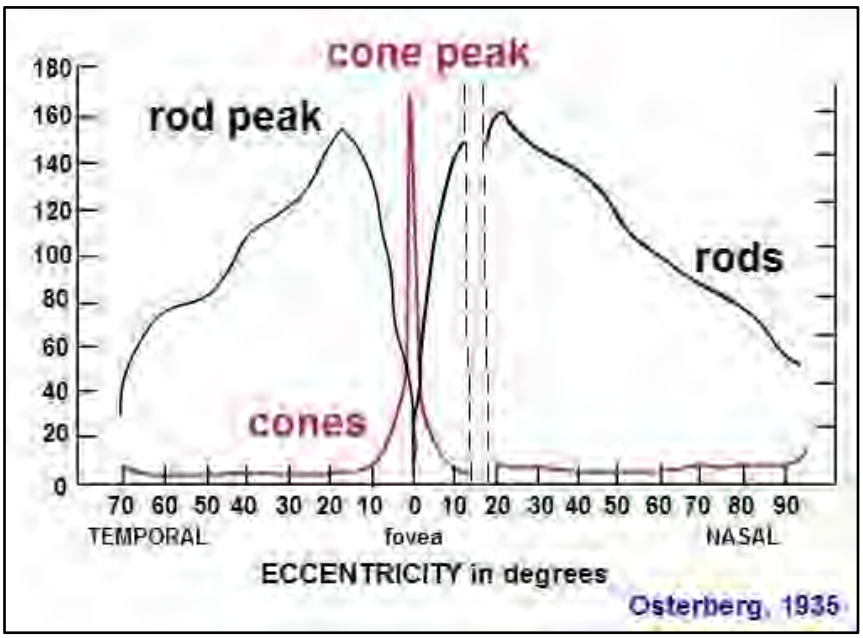


Figure 3.34 Distribution of rods and cones on the retina. Note how in the centre of the retina at the fovea centralis, the number of cones is at its maximum but the number of rods is at its minimum? This is the Night Blind Spot. By offsetting vision by about 10 to 20 degrees, the maximum amount of rods are used to discern an object being viewed. The break in the number of rods and cones at about 15 degrees towards the nose (nasal) is the location of the optic disk where no rods or cones exist. This is the day blind spot.

Section

3.6.6 **Intraocular Pressure and Glaucoma.** The aqueous humour within the eye is a type of plasma and is contained between the cornea and the lens in what are known as the posterior and anterior chambers in the anterior (front) segment of the eye. It is not to be confused with vitreous humour which is the clear liquid in the main part of the eye. The aqueous humour is secreted by the ciliary epithelium near the ciliary muscles that control the curvature of the lens. The liquid provides nutrition for the eye's tissues and helps to maintain the shape of the eye through the pressure of the liquid, known as intraocular pressure (IOP)

which is normally around 15mm Hg above atmospheric pressure.[87] It flows from the posterior chamber into the anterior chamber and drains through a small canal between the cornea and the sclera. If too much humour is produced or drainage is blocked, a higher than normal pressure, known as ocular hypertension, occurs. This high pressure places pressure on the the retina and the weak point is the first to be damaged which corresponds to the optic nerve. This damage is glaucoma and it occurs in a predictable pattern, with peripheral sight being the first to be affected. Glaucoma can occur due to other factors not related to IOP, but intraocular hypertension is one of the most common and most easily treatable if detected early.

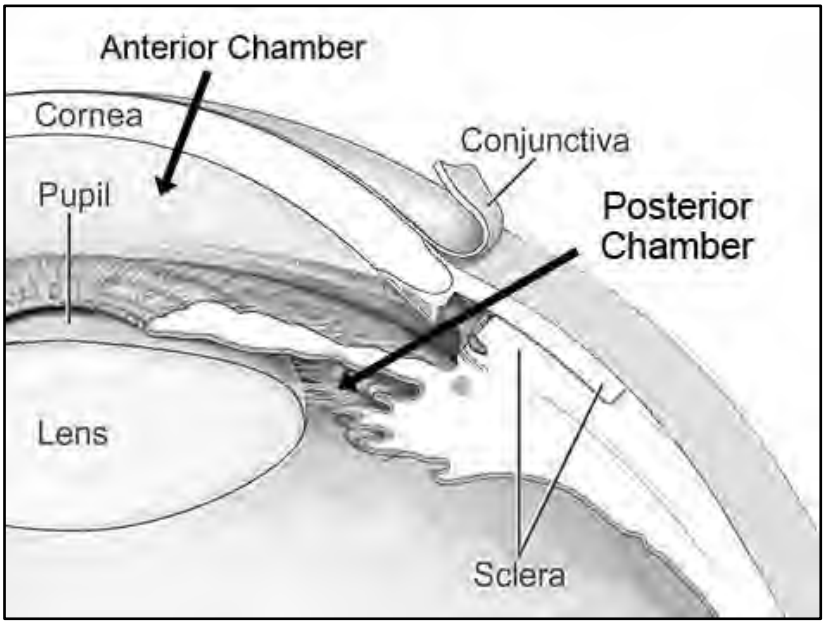


Figure 3.35 [88] The anterior (front) section of the eye showing the Anterior and Posterior chambers where aqueous humour is found. A high pressure of this liquid can damage the optic nerve and cause glaucoma. Treatment is through medication or simple surgery to cut a drain in the sclera to allow the fluid to drain into the body's circulatory system.

3.6.6.1 **Other causes of glaucoma.** Some other causes of glaucoma include:[89]

- Congenital Glaucoma – an inherited defect causing eye sensitivity and excessive tears
- Exfoliative glaucoma – where material from other parts of the eye block the drain
- Pigmentary glaucoma – when parts of the pigment break off and block the drain
- Neovascular glaucoma – related to diabetes
- Trauma-related glaucoma – related to some injury to the eye.

[87] All About Vision, *Ocular Hypertension (High Eye Pressure)* http://www.allaboutvision.com/conditions/hypertension.htm accessed 02 Jan 13.
[88] Derived from http://commons.wikimedia.org/wiki/File:Conventional_surgery_to_treat_glaucoma_EDA11.JPG, public domain.
[89] Fit and Health, *Glaucoma Overview,* http://health.howstuffworks.com/human-body/systems/eye/glaucoma2.htm, accessed 02 Jan 13.

Treatment for intraocular hypertension includes eye drops and ointments that increase fluid outflow or decrease fluid production. One method of treating glaucoma is through the use of medicinal marijuana. It is found that the THC in cannabis can reduce IOP by about 25%[90] although the side effects can be more detrimental in some patients, especially those that cannot tolerate elevated heart rates.

3.6.7 **Hypoxia and Vision and Colour Perception.** The lack of oxygen to the tissues can have a marked effect on vision. In situations of hypoxic hypoxia – most commonly when at altitude – vision can deteriorate by up to 28% at 10,000' and even 10% at 5,000'.[91] Daytime vision is not significantly affected up to 10,000' however night vision is. Up to 10,000', this is known as *the indifferent* zone, because effects on daytime vision are minor and can usually be compensated for by physiological processes. At approximately 15,000', night vision deteriorates by about 40% and accommodation decreases. Vision becomes blurred or double.

3.6.7.1 Colour vision is reliant on the cones in the fovea centralis. Loss of colour sensitivity due to hypoxic conditions at around 10,000' is exacerbated by falling light levels due to the reduced oxygenation of cone cells and the loss of visual luminence. Because the number of cones decreases the further from the fovea, the result is a requirement for a significantly higher scan rate in order to see objects clearly. There is also a corresponding increase in error rates. [92] The upshot of these experiments is that when operating at 10,000' or above, visual loss can be expected especially night vision. In low light levels where mesopic vision is used, colour sensitivity is dramatically decreased and results in the need for higher scan rates and increased likelihood of errors associated with vision.

Figure 3.36 Mesopic vision occurs at dawn, dusk and in full moon and requires both the rods and cones to work together with neither being 100% effective. During times of mild hypoxia, mesopic vision is particularly hampered with colour discrimination affected.

[90] Medical Marijuana, *Can Marijuana be an effective treatment for glaucoma?,* http://medicalmarijuana.procon.org/view.answers.php?questionID=000140 accessed 2 Jan 13.
[91] Davis, J.R., Johnson, R., Stepanek, J,, *Fundamentals of Aerospace Medicine,* Lippincott Williams & Wilkins, 2008,
[92] Connolly, D.M., Barbur, J.L., Hosking, S.L., Moorhead, I.R., *Mild Hypoxia Impairs Chromatic Sensitivity in the Mesopic Range,* Investigative Ophthalmology and Visual Science Journal, http://www.iovs.org/content/49/2/820.full accessed 02 Jan 13.

Module 3.7

3.7 **The Ear and Hearing.** The primary organ of audition, the ear is arguably the second most important organ in most industrial environments. It contains a means of hearing sound from the surrounding environment, but when combined with the middle and inner ear, provides a sense of balance as well.

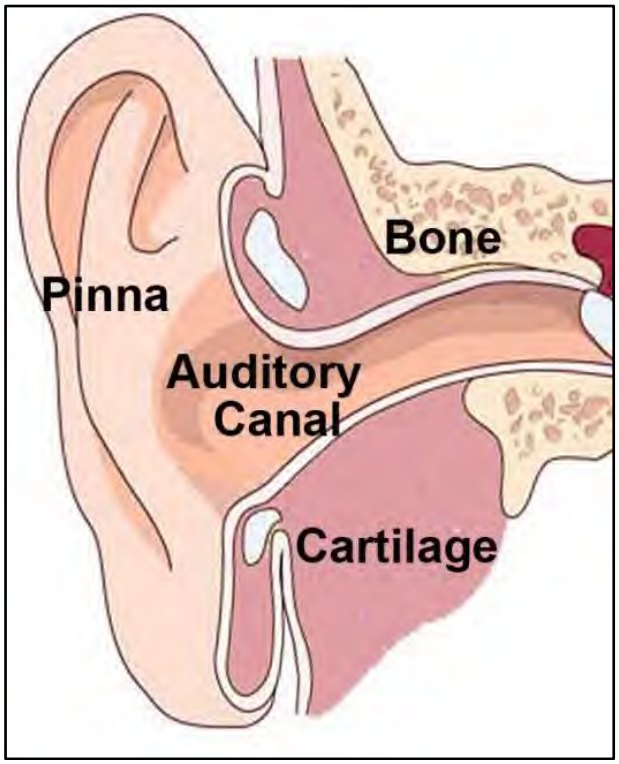


Figure 3.37 The Outer Ear

Section

3.7.1 **The Ear and its Anatomy.**[93] The ear consists of a combination of flesh, cartilage, bone and organ tissue. The outer fleshy part is called the **pinna**, or **outer ear**. It aids in localising the origin of sound and amplifies the sound by about 5 to 6 dB. The ear canal, also known as the **auditory canal**, is a small channel that measures about 25mm and has a slight 'S' shape. It channels sound to the middle ear and also warms the air and provides protection to the ear drum, known as the **tympanic membrane**. This membrane marks the boundary between the outer ear and the middle ear. It vibrates in response to sound waves. On its inner surface are three connected small bones called **ossicles**. The first is the **malleus** (hammer) which is connected to the **incus** (anvil) and finally, the third bone is the **stapes** (stirrup). These bones and the area in which they are contained constitute the **middle ear**. This middle ear is vented to the external atmosphere through a tube called the **Eustachian tube** which is mucous lined and opens in the back of the throat at the **nasopharynx**. The stapes connects to the **cochlea** where it transmits the pressure energy to that organ, however it has a built in safety feature in a muscle called the **stapedius muscle** which, when the ear is exposed to a very loud noise, contracts along with the **tensor timpani tendon** and makes the stapes less capable of transmitting the pressure energy which protects the ear. The stapes is connected at a point of the cochlea called the **oval window**.

[93] *Anatomy and Physiology of the Ear,* Author unk, US Navy Environmental Health Centre, date unk.

This is where the inner ear commences and is where pressure energy is transmitted through the cochlea and into three chambers where small cells called **stereocilia** in the **organ of Corti** vibrate in sympathy with the pressure waves. It is these cells which transduce the vibration into sensory signals which are transmitted to the brain and are decoded as sounds. Also contained within the inner ear are three small channels known as **semi-circular canals** which contain fluid known as **endolymph fluid** which it shares with the cochlea. The relative movement of this fluid against small detector cell hairs is transduced as signals and sent to the brain where the brain interprets the movement and can detect its position in space, which is the sense of balance.

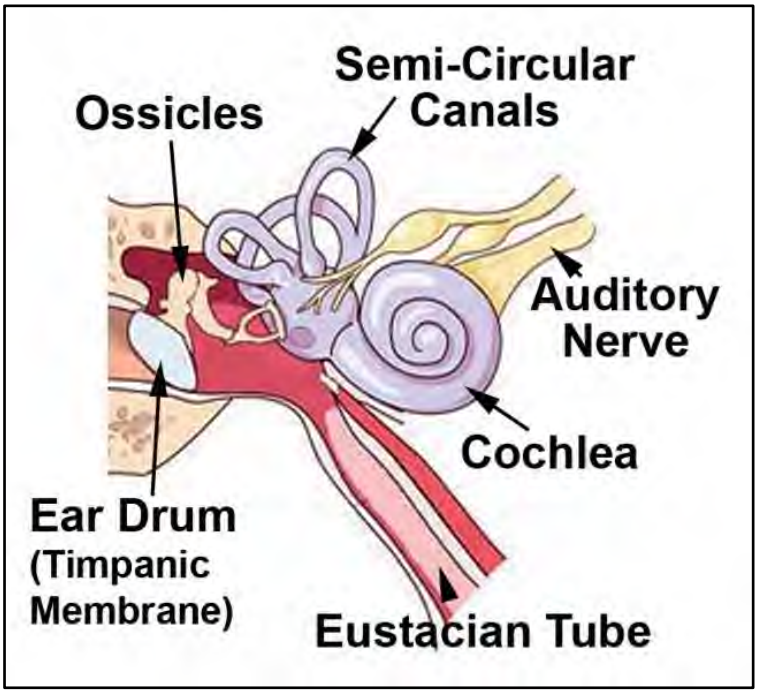


Figure 3.38 The Middle and Inner Ear

Section

3.7.2 **Audition and the Physiology of the Ear.** (see Anatomy of the Ear) Sounds, or Acoustic energy as it is known, are basically pressure waves that pass through a medium, usually the air. These pressure waves impact the pinna, which channels it through the auditory canal where it impacts the tympanic membrane causing it to vibrate. These vibrations are transmitted to the malleus where they are amplified through the angular arrangement of the next bone, the incus. Finally, these waves are transmitted through the incus which is attached to the oval window of the cochlea and which creates a movement in the fluid of the cochlea. This movement of the fluid in the cochlea thus becomes hydraulic energy and it is this energy that causes membranes in the Organ of Corti to cause stereocilia to shear against another membrane called the tectorial membrane. This movement of the hair cells causes transduction which becomes electrical signals which are transmitted to the brain through the auditory nerve which are then interpreted as noise or sounds. This is called hearing or, more precisely, audition. To put it simply: pressure waves are amplified, cause mechanorecptors to vibrate and induce an electrical signal which the brain interprets as sound.

Section

3.7.3 **Hearing Loss.** There are a number of reasons for hearing loss, but most fit into two main categories: conductive and sensorineural (aka perceptive). Sometimes, loss of hearing can be due to a combination of both, for example, Presbyacusis and an ear infection can combine to seriously degrade audition.

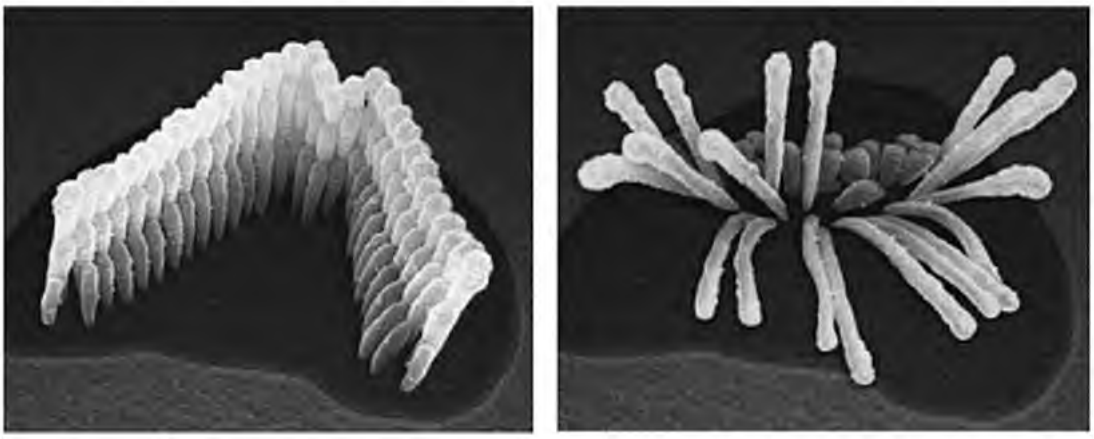


Figure 3.39[94] Stereocilia cells before a loud noise (left) and after (right)

3.7.3.1 **Conductive Hearing Loss** is normally caused by some sort of blockage or damage to the outer ear or to the middle ear that prevents acoustic energy from being conducted through the hearing organ to the receptor cells in the cochlea. This damage may be acquired through disease or injury or it could be congenital. In both cases, medical treatment or surgery may be able to counter the problem which is manifested by a reduction in the loudness of sounds.[95] Some of the reasons for conductive hearing loss include:

- Foreign objects in, or partial/full closure of the auditory canal
- Infections of the outer ear (eg from swimming) or the inner ear (especially common in children)
- Damage to the tympanic membrane
- Otosclerosis, a congenital condition where the bone grows around the stapes preventing it from transmitting pressure waves to the cochlea.

3.7.3.2 **Sensorineural (Perceptive) Hearing Loss** can be congenital or acquired and relates to damage around the inner part of the hearing organ, the cochlea, or the auditory nerve, as opposed to conductive hearing loss which centres around problems with the outer and middle ear. If the cochlea is damaged, then it is considered sensory hearing loss because the actual sensing is impaired. If the hearing loss is caused by damage to the auditory nerve, then it is considered neural damage because the impairment is in the transmission of neural signals. The result is a lack of loudness and of clarity. In some cases, the effectiveness of hearing aids is diminished.[96] Some of the causes of sensorineural hearing loss include:

- Various drugs.
- Head Injuries.

[94] Image of Stereocilia, http://www.exploresound.org/home/teachers-parents/bend-it,-break-it/ accessed 25 Oct 13
[95] Australian Hearing, *Types of Hearing Loss,* http://www.hearing.com.au/types-of-hearing-loss accessed 10 Jul 12.
[96] Ibid.

- Various diseases and viruses (see text box below).
- Excessive exposure to noise.
- The ageing process.

Some diseases that may cause hearing loss

Otosclerosis – a condition where the bone around the stirrup bone of the ossicles grows too large and restricts the stirrup's movement
German Measles (measles) in pregnant women – auditory nerve damage to unborn children
Meningitiis – as above.
Mumps – loss in one or both ears in the 90 dB range.
Presbyacusis – loss of perception of higher tones with age.
Chlamydia – hearing loss in newborns who may have the disease passed on in utero.
Fetal Alcohol Syndrome – toxic effects of alcohol in the feotus.
Premature birth – cause of sensorineural hearing loss in about 1 in 20 cases. About 33% will become deaf

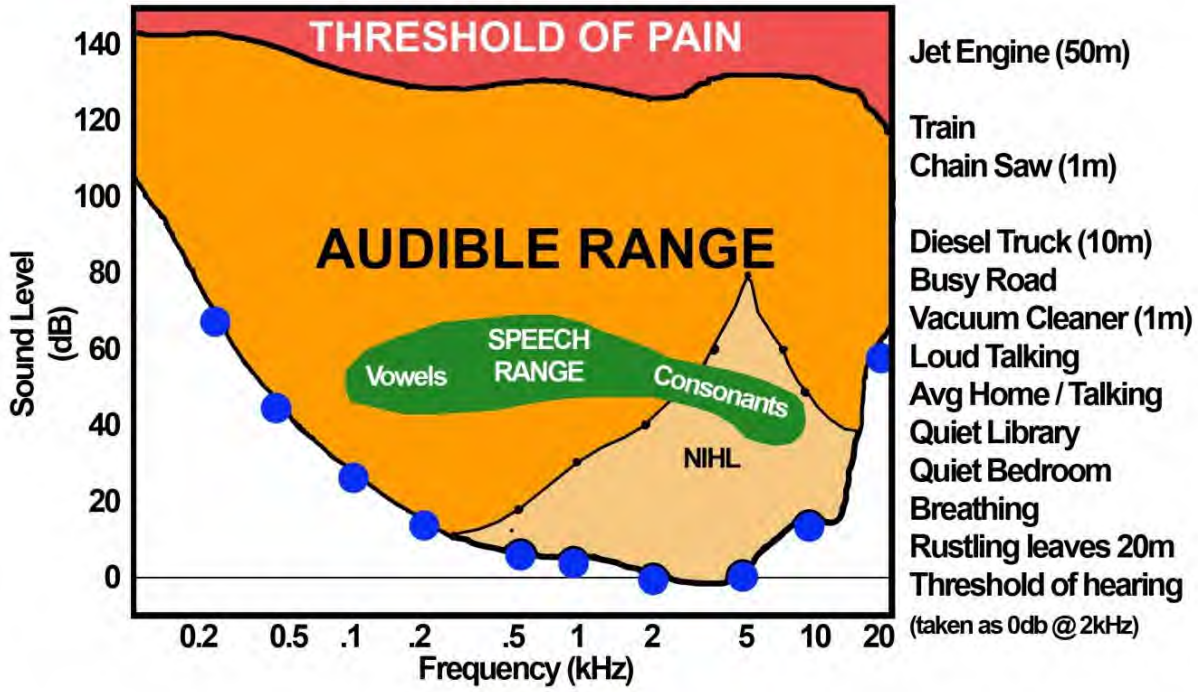


Figure 3.40[97] [98] The audible range of human hearing. The Noise Induced Hearing Loss (NIHL) range shows that area of the audible range lost to high noise levels. The speech range spans the NIHL range and the consonants in speech are the first to be lost in the higher frequency range.

[97] Derived from diagram by Dr Janet Fitakerley, University of Minnesota Medical School, 2012.
[98] Derived from http://www.sengpielaudio.com/TableOfSoundPressureLevels.htm accessed 09 Jul 12.

dBA	Descriptor	Max Cont. Exp. Time (NIOSH)
190 dBA	Heavy weapons, 10 m behind the weapon (maximum level)	
180 dBA	Toy pistol fired close to ear (maximum level)	
170 dBA	Slap on the ear, fire cracker explodes on shoulder, small arms at a distance of 50 cm (maximum level)	
160 dBA	Hammer stroke on brass tubing or steel plate at 1 m, airbag deployment very close at 30 cm (max level)	
150 dBA	Hammer stroke on anvil at 5 m distance (maximum level)	
130 dBA	Loud hand clapping at 1 m distance (maximum level)	0.9 s (none)
120 dBA	Whistle at 1 m distance, test run of a jet at 15 m distance	7.2 s (none)
118 dBA	**Threshold of pain, above this fast-acting hearing damage in short action is possible**	14.4 s (none)
115 dBA	Take-off sound of planes at 10 m distance	28.8 s (28 s)
112 dBA		56 s (57 s)
110 dBA	Siren at 10 m distance, frequent sound level in night clubs and close to loudspeakers at rock concerts	
109 dBA		1.9 mins (1.9 mins)
106 dBA		3.8 mins (3.8 mins)
105 dBA	Chain saw at 1 m distance, banging car door at 1 m, racing car at 40 m distance, possible level with music head phones	
103 dBA		7.5 mins (7.5 mins)
100 dBA	Pers music with headphones, jack hammer at 10 m	15 mins (15 mins)
97 dBA	Hammering nails into wood.	30 mins (30 mins)
95 dBA	Loud crying, hand circular saw at 1 m distance	
94 dBA	Circular Saw cutting Hardwood	1 hr (1 hr)
92 dBA		(1.6 hrs)
90 dBA	Angle grinder outside at 1 m distance	2 hrs (2.5 hrs)
88 dBA	**Over a duration of 40 hours a week hearing damage is possible**	4 hrs (4 hrs)
85 dBA	Chain-saw at 10 m distance, loud WC flush at 1 m distance	8 hrs (8 hrs)
82 dBA		12 hrs (16 hrs)
80 dBA	Very loud traffic noise of passing trucks at 7.5 m distance, high traffic on an expressway at 25 m distance	16 hrs (Cont. OK)
75 dBA	Passing car at 7.5 m d, un-silenced wood shredder at 10 m	CONTINUOUS
70 dBA	Close to a main road by day, quiet hair dryer at 1 m	
65 dBA	**Bad risk of heart circulation disease at constant impact is possible**	
60 dBA	Noisy lawn mower at 10 m distance	
55 dBA	Low volume of TV at 1 m, noisy vacuum cleaner at 10 m	
50 dBA	Refrigerator at 1 m distance, bird twitter outside at 15 m	
45 dBA	Noise of normal living; talking, or radio in the background	
40 dBA	**Distraction when learning or concentration is possible**	
35 dBA	Very quiet room fan at low speed at 1 m distance	
25 dBA	Sound of breathing at 1 m distance	
0 dB	Auditory threshold	

Table 3.12 [99] [100] [101] Sound levels and descriptors with maximum continuous exposure time Australian levels shown with US levels in brackets (see reference)

Module 3.8

[99] ibid.
[100] Safe Work Australia, *Managing Noise and Preventing Hearing Loss at Work – Code of Practice*, 2011,
[101] NIOSH, *Occupational Noise Exposure Rev Criteria 1998,* www.cdc.gov./niosh accessed 02 Jul 12.

3.8 **The Inner Ear and Balance.** The Inner Ear provides balance and hearing capability amongst mammals. For humans, both are vitally important in most industries and a lack of hearing and balance severely impairs human functionality. The following sections discuss this important organ.

Section

3.8.1 **The Inner Ear and its Anatomy.** The Inner Ear comprises two main components; the Vestibular Apparatus, which includes the semi-circular canals and associated component, and the cochlea. Both of these organs have sensory cell bundles that take detected stimuli to the central nervous system and up to the brain.

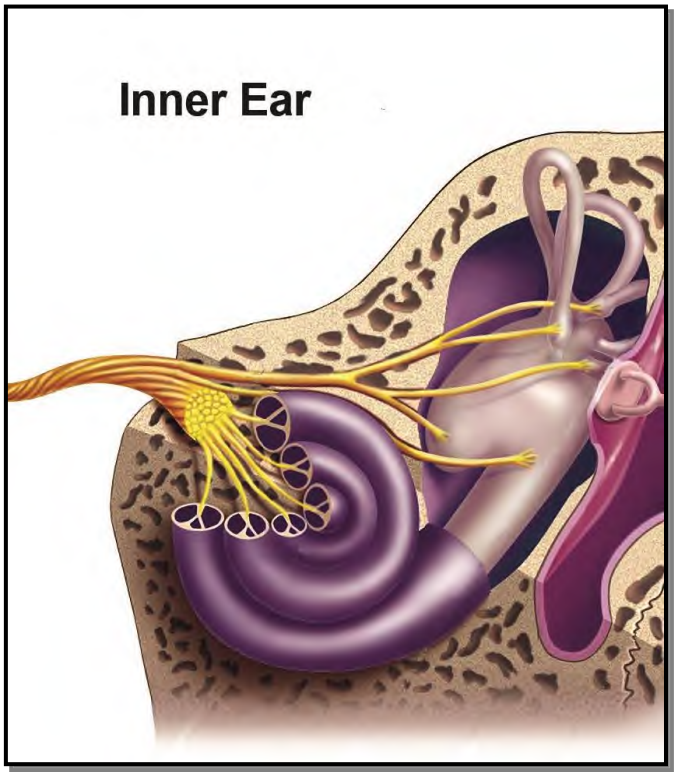


Figure 3.41 The Inner Ear and nerve endings passing to the central nervous system

3.8.1.1 **The Cochlea** is that part of the inner ear which is dedicated to hearing. The cochlea (Latin for snail) is an organ that has the outward appearance of a snail's shell in which is housed a three-chambered fluid filled tube that extends throughout the length of the 'shell'. These chambers are the scala vestibuli, the scala tympani and between them, the scala media, also known as the cochlea duct which contains endolymph fluid shared with the semi-circular canals. When a sound wave causes the ossicles to vibrate and the stapes to push on the oval window of the cochlea, the hydraulic pressure force is equal to the strength of the sound (loudness) and the speed of the movement of the ossicles is equal to the frequency of the sound (pitch). Along the length of the cochlea are tiny receptor cells that contain the small stereocilia. They are of varying length so that lower frequencies are detected by cells towards the end of the spiral and vice versa. The hydraulic force (strength and speed, or loudness and pitch) that has entered the cochlea through the oval window causes an impression in the wall separating the scala vestibule into the scala media where the pressure wave advancing along one chamber is cancelled out by the pressure wave advancing in the opposite direction in the other chamber. This corresponds to pitch and will

determine which hair cells move and the force will determine how much they move. Too much force will cause the cells to bend so far that they break, resulting in permanent loss of those hairs and thus loss of the ability of detecting sound.

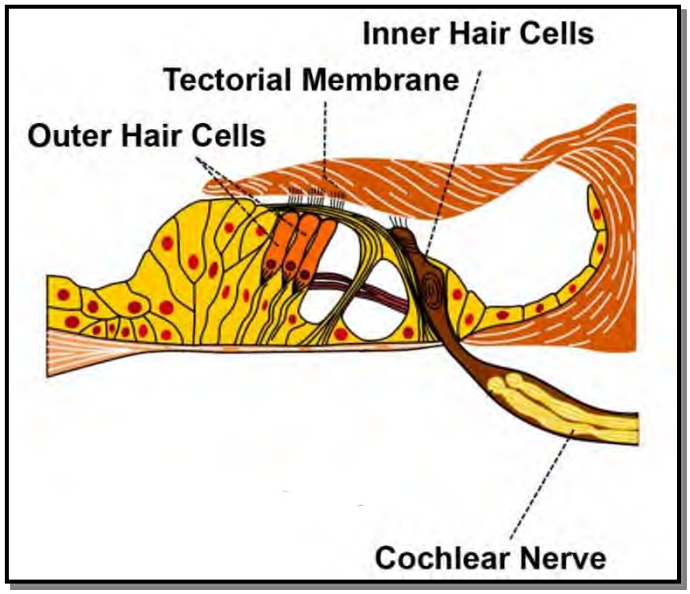
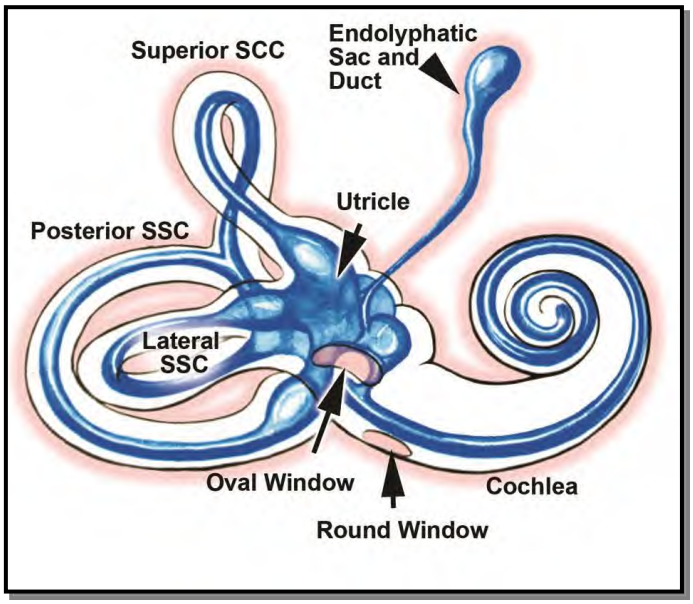
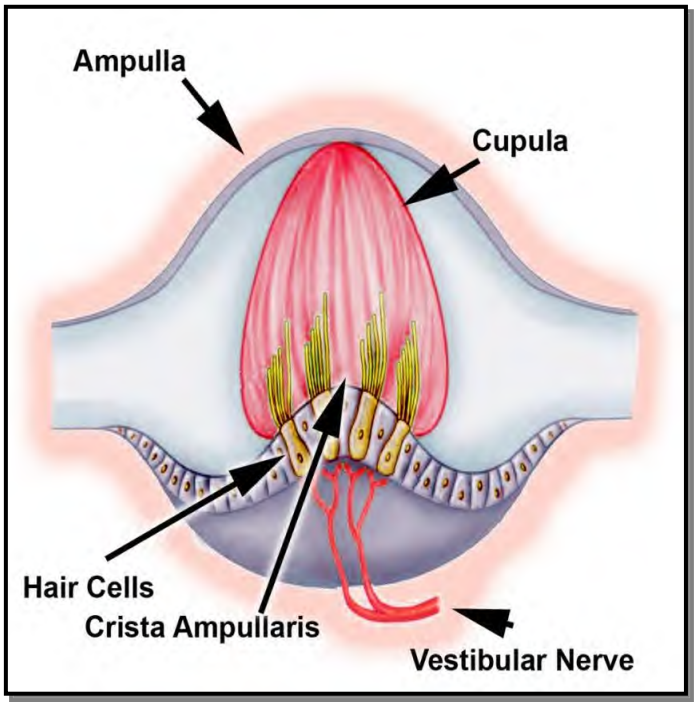


Figure 3.42 The Organ of Corti[102]



[102]© CC (?) https://commons.wikimedia.org/wiki/File:Organ_of_corti.svg accessed 12 Aug 12.



Figures 3.43 (previous page) and 44 The vestibule of the Semi Circular Canals and the sensory organs.

3.8.2.1 **Linear and Vertical Acceleration.** Like the ampulla in the SCCs, two small organs called otoliths, situated in an area of the vestibular apparatus called the vestibule, carry out a similar function, in that they use the shearing motion of hair cells to detect an accelerative movement, either longitudinally or vertically. These otoliths (oto – ear, lith – rock) contain small crystals of calcium carbonate called otoconia are contained within a gelatinous mix creating a mass which will 'lag' after an accelerative force is applied. It is this lag that causes the shearing force which will cause transduction in the hair cells resulting in an impulse that is sent to the brain and is interpreted as linear acceleration. With the radial acceleration detected by the SCCs and the linear acceleration detected by the otoliths – and confirmation by vision – the brain can detect movement of the head and, by proprioception the body. This latter effect also goes to explain the subjective postural vertical (shown below). The otoliths are called the **utricle**, which detects accelerations in the horizontal plane and the **saccule** which detects vertical.

Section

3.8.3 **The subjective vertical.** The subjective vertical is an individual's assessment of what vertical is based on his/her perception of the environment. When this perception is incorrect or based on faulty or synthetic information (such as a computer simulation of the world, faulty visual cues or naturally occurring visual cues that lead to confusion such as cloud banks), the individual can make actions that are at odds with the real (objective) vertical and, if controlling an apparatus such as an aircraft, can make dangerous control inputs based on these erroneous perceptions. There are two components to the subjective vertical; the subjective visual vertical (SVV), based on what the individual sees and the subjective postural vertical (SPV), based on what the individual feels through proprioception. (See also Somatogyral Illusion below).

Module 3.9

3.9 **Sensory Inputs and Spacial Disorientation**. In order for a person to correctly reference (orient or orientate) him/herself to the surrounding environment requires the receipt of external stimuli through the senses, in particular the senses of vision, equilibrioception and proprioception. When these senses are at variance with each other, that is to say, when they don't agree or correlate, then the subject can become disoriented, which can lead to a number of follow on effects, both physiological and psychological. According to the ATSB,[103] the career incidence of spatial disorientation will occur to between 90 and 100% of pilots, so if a pilot flies long enough, (s)he will encounter spatial disorientation. To counter these effects, an individual requires knowledge and skills; knowledge of the effects and their causes and the skills to combat them. This module discusses various forms of disorientation.

Section

3.9.1 **Categories and Types of Disorientation.** There are three main categories[104] of disorientative illusions and three main types of spatial disorientation:[105] The three main categories are:

- Vestibular/somatoagyral Illusion category causing spatial disorientation.
- Vestibular/somatogravic Illusion category causing spatial disorientation.
- Visual Illusion or visual effects category causing spatial disorientation.

Disorientation can be very dangerous when operating machinery like aircraft, it is therefore helpful to distinguish between types of spatial disorientation, such as:

- Type 1 SD (where the person does not recognise that (s)he is suffering from SD).
- Type 2 SD (where the person recognises that (s)he is suffering from SD).
- Type 3 SD (incapacitating SD).

These shall be discussed first.

3.9.1.1 **Type 1 SD.** This is the most dangerous of categories for SD which, if unrecognised, may lead to the individual operating the machine inappropriately and leading to an unsafe attitude and subsequent incident or accident. In many cases, the machine (usually an aircraft) remains under control, but the operator does not realise that (s)he is flying it into an unsafe scenario, such as rising terrain.

3.9.1.2 **Type 2 SD.** In this instance, which is more common than Type 1 SD, the operator realises that (s)he is suffering the effects of something and may or may not realise that it is SD. Usually it is because sensory inputs do not correlate between what the instruments say and what his/her body says. This conflict alerts him/her to the problem and so long as

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[103] Newman, Dr D.G., *An overview of spatial disorientation as a factor in aviation accidents and incidents,* Aviation Research and Analysis Report – B2007/0063, ATSB, Commonwealth of Australia, 2007, p2.
[104] Rash, C.E., *Awareness of Causes and Symptoms of Flicker Vertigo Can Limit Ill Effects,* Flight Safety Foundation Human Factors and Aviation Medicine, Vol. 51, No. 2, March-April 2004.
[105] Newman, Dr D.G 2007., op. cit..

appropriate corrective action is carried out (immediately commence flight with reference to instruments or hand over control to another person), then an accident will likely not occur.

3.9,1.3 **Type 3 SD.** This is the most extreme form of SD in that the individual is physically and psychologically so overwhelmed that (s)he is unable to recover from the situation. The result is an inability for the operator to successfully recover the apparatus with appropriate control inputs, with the result often that the machine remains out of control until impact.

Section

3.9.2 **Vertigo – Medical, Flicker, Pressure and Coriolis Effect.** Vertigo is a term often used to describe SD, but vertigo is more associated with a vestibular abnormality[106] rather than an illusion that 'tricks' the body in a more or less healthy vestibular apparatus. In either case, the effect is similar in that a spinning or turning sensation is felt when that condition does not exist.

3.9.2.1 **Flicker Vertigo** occurs due to a low frequency modulation (also called a flash or flicker) of light, usually between 1 cycle per second to 20 cycles per second, but often expressed in terms of cycles per second, or Hertz (Hz). It is a rare occurrence overall, but when it does occur, is most often found in helicopter operations where the pilot or passenger has a flickering light falling upon his vision. In helicopters, front seat occupants (ie pilot/co-pilot or passenger in pilot seat) are exposed to this effect due to the design of the windscreen and eyebrow windows. In the rear of the aircraft, patients or those lying down with a view to the sky and sun through a window may also be affected. This is a concern especially for Emergency Medical Services operations where aircrew can often be screened (either by medical professionals or by experiencing the effect and naturally leaving the industry) and thus are rarely effected, however patients being transported in this position are not screened and may have a pre-existing propensity for this abnormality. Notwithstanding the helicopter experience, flicker vertigo can also occur in other circumstances like a strobe light or its reflected light (such as in cloud in dark light conditions) or through a relatively slow moving propeller, such as on approach to land, whilst flying towards a sun that is low on the horizon or taxiing towards lights whilst on the ground.

3.9.2.2 The effects can be incapacitating, but in most cases are mild and cause an uncomfortable feeling with slight dizziness, which often clears as soon as the flickering stops. It is interesting to note that in one US Navy survey, a quarter of respondents said that they found flickering effects to be annoying and distracting (with one respondent claiming it was the cause of a near accident) and that about one fifth felt drowsy after the effects of flickering light.

3.9.2.3 The likely effect of rotor systems with the onset of flicker vertigo can be determined by multiplying rotor RPM with the number of blades and dividing by 60 to get the flicker Hertz rate. An MD 500C with a four bladed system and a RRPM of 485 has a flicker rate of 32.4 Hz whereas the Bell 206 with its RRPM of 442 and two bladed rotor system has a flicker rate of 14.8 Hz, therefore the incidence of flicker vertigo in a two bladed rotor system is higher as the flicker rate falls in the 1 to 20 Hz category of vertigo inducing flicker rates.[107]

3.9.2.4 To combat flicker vertigo, aircrew firstly need to: realise what causes it; if they are susceptible to it; avoid conditions that are conducive to it (as described in the previous paragraphs): and also protect those who may be susceptible to it, especially patients.

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[106] US Department of the Army, *FM 3-04.301 Aeromedical Training for Flight Personnel*, Washington DC, 2000.

[107] Rash, C.E., *op.cit*.

3.9.2.5 **Pressure Vertigo** also known as Alternobaric Vertigo, occurs due to an imbalance of pressure in the middle ears of the left and right systems. The most common cause is when a person tries to equalise (Valsalva) pressure in the middle ears but can only successfully equalise one ear and not the other. The resulting pressure differential has an effect that causes a vertigo sensation with a disorienting and tumbling sensation being the result.[108] The effect usually only last for 10 or 15 seconds, but in some cases may last longer.

3.9.2.6 **Medical Vertigo** can be caused by a number of reasons and is known as benign paroxysmal positional vertigo (BPPV). It can be caused by such things as rolling over in bed or looking up and may be intermittent, temporary or – if due to some injury or disease – continuous. It usually only affects one ear but can cause such symptoms as nausea, nystagmus and loss of balance.[109] One other cause can be that the calcium carbonate crystals from the otoliths (otoconia) have escaped from the saccule or utricle and may be interfering with the SCCs. MRIs can detect otoconia in the SCCs. Treatments are usually for nausea symptoms, as vertigo will often resolve itself after a period of time. Certain physiotherapeutic movements may dislodge any otoconia and are claimed to be extremely successful. [110]

Section

3.9.3 **Vestibular Equilibrioception Illusions.**There are a number of illusions related to equilibrioception, such as listed below. In order to fully understand these concepts, knowledge of the following terms is useful:[111]

- Visual dominance – a learned phenomena that is acquired through training, whereby a person excludes all other sensory skills and uses only visual cues. This is used by pilots when flying on instruments, but requires concentration and practice and can be disrupted if concentration is lost.

- Vestibular suppression – the active process of visually overriding undesirable vestibular sensations.

- Vestibular opportunism. The propensity of the vestibular system to fill an orientation void swiftly.

3.9.3.1 **Somatogravic Illusion**, also known as the dark night take off or pitch up illusion. Like most illusions, it occurs when there are poor visual cues, such as at night or in foggy conditions. It was prevalent especially during WWII and the Korean War with naval pilots taking off at night from aircraft carriers into very dark conditions. Many ditchings were attributed to this effect. The illusion occurs because the acceleration of the aircraft is perceived by the vestibular apparatus correctly, but it cannot determine if it is linear acceleration or an angular acceleration (ie a pitch up). As a result, the pilot often has a tendency of pushing forward on the controls causing the aircraft to pitch down. At low altitude (or taking off from an aircraft carrier), this can have disastrous results.

[108] Newman, Dr D., responding to Rushworth, S., "The night the world went mad," *Flight Safety Australia,* January-February 2004, CASA, Canberra.
[109] Better Health Channel, *Benign paroxysmal positional vertigo (BPPV),* http://www.betterhealth.vic.gov.au/bhcv2/bhcarticles.nsf/pages/Vertigo_benign_paroxysmal_positional_vertigo accessed 12 Jul 12
[110] Better Health Channel, *op.cit.*
[111] US Army Aviation Centre Student Handout, *Spatial Disorientation Review*, Jun 1997, Ft Rucker, Alabama.

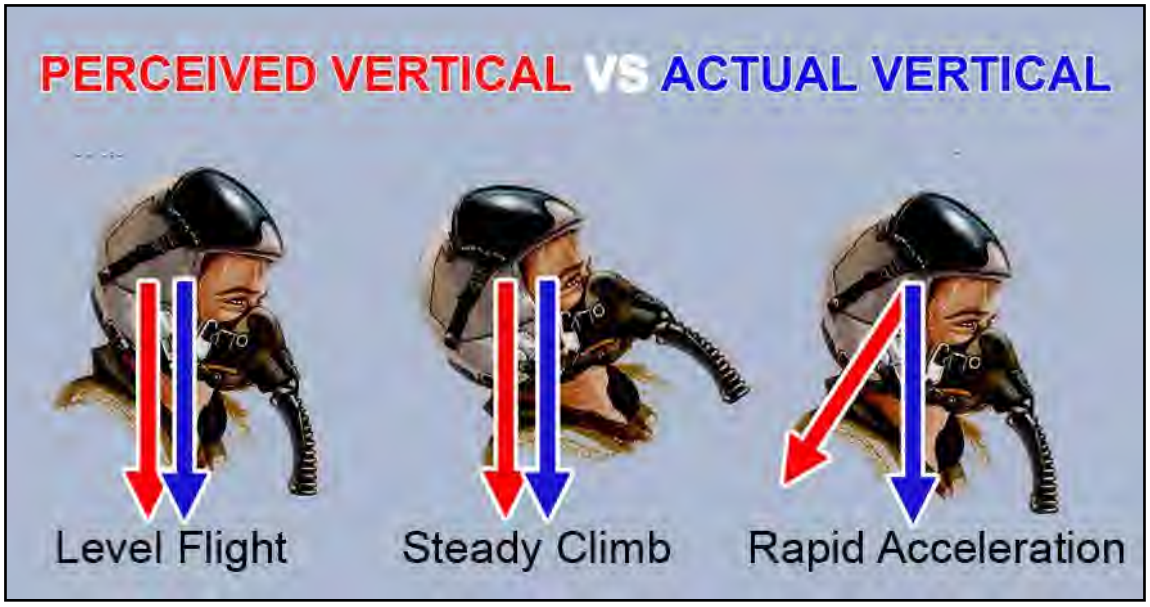


Figure 3.45 An example of the somatogravic illusion. In this example, the perceived vertical (red arrow) and the actual vertical (blue arrow) are in the same orientation during steady level flight or steady climb, however during periods of rapid acceleration, the inner ear's linear acceleration detectors give the same sensory input to the brain as when the body is in a steady climb. In times of low visual cues, the brain may be fooled into thinking that it is in a climb. During WW2, aircraft carrier pilots taking off into a dark night with no visual cues to use as reference, often thought that they were in a climb and would push down on the controls resulting in a rapid descent and most often, a ditching into the water.

3.9.3.2 **Somatogyral Illusion**, also known as the 'graveyard spiral,' is another illusion directly related to lack of visual cues. In this situation, the considerations of acceleration need to be taken into account. As you may or may not recall from physics, acceleration is the rate of change of velocity or direction. When that change of direction or velocity becomes constant, the SSC will only register the angular change and not any other change. Because the eyes are necessary to confirm what the body feels, if there are poor visual cues, as in the previous example, then when the turn or spin is stopped, the SSCs will now register this new change and the pilot will experience the sensation of a turn in the opposite direction of the original turn.

In many instances, the visual system will react to the vestibular system and may result in involuntary eye movements, as if often seen in people after spinning around rapidly. These eye movements are known as nystagmus and can affect the visual ability of the individual in either making it difficult to read instruments or, worse still, falsely confirming the faulty information of the SSCs resulting in a re-entering of the spin.

3.9.3.3. **The Black Hole Approach**, once again, is another visual illusion, although this one only takes place in darkness. Dark night approaches, especially when there are no lights below the aircraft, will often give an illusion of height which may lead to the pilot correcting for this by flying lower than required. Initially, if the pilot tries to maintain the same sight picture on the runway lights, without any peripheral cues, this may result in a steep approach which then starts to flatten out as the runway gets nearer. The most common causes are featureless terrain below the aircraft (especially water) and few peripheral cues such as lights, or the above factors and bright lights (such as an urban area) past the runway environment.

There are a number of reasons given for this phenomenon which has claimed many lives over the years. Colonel R. Gibb of the USAF cites a number of them, such as:[112]

- Size/Shape/Depth Constancy – where long thin runways give the illusion that the aircraft is higher and further than it actually is.

- Lack of Familiar/Relative Size – a common problem with night vision devices. Known sizes help to judge distances so the inability to see them, or their absence, can make distance and size judgement difficult.

- Bias to Over-estimate Visual Angles – judging visual angles of a runway without confirmatory cues, especially when proceeding down a glide path, can result in the pilot trying to keep the angles constant. By doing so, the pilot tends to steepen the initial part of the descent and then only realises doing so towards the end when altitude is lost and the aircraft is already close to the ground.

- Lack of terrain orientation cues – this illusion makes the runway appear to 'float' in space making distance/height judgement difficult to correlate.

Section

3.9.4 **Motion Sickness.** A number of different contexts can all be covered by the term Motion Sickness; car sickness; sea sickness; simulator sickness; and air sickness are all forms of motion sickness. It occurs when visual-vestibular conflicts occur, that is to say when what the eyes see does not necessarily match what the body is telling them and is related to problems with how the body determines the vertical plane.[113] This is why it is important to understand the subjective vertical. It can happen if the vestibular system detects motion but that motion is not confirmed by the visual system or vice versa or a combination of both. In any case, there is a mis-match between what is seen and what is 'felt'. It is also important to note that visual cues can be simulated, such as in some amusement park rides or simulators or computer games. Simulator sickness can also be matched to variance of the vestibular system and visual systems and can be especially significant in more experienced aircrew, especially those in high performance aircraft. This is thought to be due to their expectation of a particular sensation and then not experiencing it due to the limitations of the simulator in high speed environments. In low speed environments (eg transport aircraft, etc) a simulator has a higher degree of motion fidelity, and so the perception variance is not as great.[114]

[112] Gibb, COL R., *Visual Spatial Disorientation: Re-Visiting the Black Hole Illusion,* Arizona State Uni and USAF, http://www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA462899 accessed 12 Jul 12

[113] Bles, W et al. *Motion Sickness: Only one provocative conflict?*TNO Human Factors Research Institute, Soesterberg, the Netherlands, 1998, sourced from http://www.ncbi.nlm.nih.gov/pubmed/10052578 accessed 12 Jul 12.

[114] Ibid.

A Final Word on Spatial Disorientation…

According to a Boeing study of worldwide commercial airline accidents, the approach and landing phase of flying, although only accounting for 4% of the total flight time, accounts for 52% of all accidents/fatalities; of those, 55% are due to flight crew error. [It has been cited] that out of 287 worldwide aviation accidents between 1980-1996, more than 75% of approach and landing accidents (ALA) happened when a precision approach aid (glide path, GP) was not available or not used. They also found that the rate for an ALA at night was approximately three times the rate during daylight.

Colonel R. Gibb, USAF

Figure 3.46 [115] A Barany Chair is used to demonstrate spatial disorientation to US Air Force cadets.

[115] US Air Force, Public Domain.

Module 3.10

3.10 **Information Processing and Memory.** With the advent of computers in the 50s and 60s, psychologists now had an analogy for how the human mind processed information. Previous theories about how humans responded to a situation centred around what was known as the behaviourist theory; where a stimuli resulted in the behaviour which could be conditioned by training or the environment alone. Now information-processing was looking at cognitive functions such as attention, memory, perception, problem-solving, and communication. The analogy drawn was likened to the computer model, where the input processes are centred around the analysis of stimuli, then the storage processors look at how that stimuli is manipulated based on a number of factors including previous experience, and finally the output processes look at the response to that stimuli. The key to this model is the middle process of manipulating the information. The following sections look at these three key process areas.

Section

3.10.1 **The Central and Peripheral Nervous Systems** are discussed elsewhere in this workbook and shall not be elaborated upon further. But in summary they can be described as a means of sensing the environment and transmitting that information through the nervous systems to the brain as electrical impulses. The brain is then able to process that information and make a response by commanding parts of the body to react. For example, riding a bicycle on a rough road, the eyes search the road ahead for obstacles. When obstacles are seen, the brain orders the body to make appropriate movements to avoid the obstacles. The primary senses used in this example are vision and equilibrioception and proprioception. The primary motor movements used as a reaction are the movement of the handlebars by the arms and shoulders, the cycling of the pedals by the legs, and the maintenance of balance by the core muscles. All of these actions, both incoming and outgoing, are transmitted and processed via the nervous system and its two component parts, the central nervous system and the peripheral nervous system.

Section

3.10.2 **Mental Set.** Mental set can be considered to be the manner in which a person approaches a situation or problem. A lot like the definition of personality in the previous element, a mental set may have some measure of consistency over time when considered in the context of attitude and behaviour, for example a positive state of mind may be the result of an optimistic mental set. In other words, the way a person approaches life will influence the behaviour of a person based on a person's mental set. In this context however, we are looking at the way in which a person approaches a problem that requires a solution. A mental set can be influenced by the environment of the person processing the information. In the lead up to coining an old phrase, a mental set could be thought to be like a box in which a solution may be found to a problem. A person may be channelled into thinking that the only solution would be in that box - or mental set - but if told to "think outside the box," then that person may dispense with the restrictions of that mental set and look for alternative solutions to the problem. In essence, a mental set will influence the way a person strives to solve a problem. Mental set may be based on previous experience and can be subject to things like expectation bias.

3.9.2.1 **Expectation Bias**. Whilst experience can help us through problem-solving, it often causes a breakdown in effective cognitive information-processing. In this case by making the individual confident that something will occur because it has occurred in the past in a similar circumstance. Then, when that event does not occur, it comes as a surprise. In

situations that are dynamic and high risk, this assumption can be very dangerous. An example might be a person expects the morning commute to work to take X minutes on a particular day of the week because it has always taken X minutes. As a result, that person may factor his appointments based on that assumption, and is surprised when one day he is late for an important meeting because the commute took an extra 20 minutes because of unexpected roadworks.

Section

3.10.3 **Channel Capacity and Filtering.** As part of the cognitive information-processing theory, one aspect is the idea that the human brain is a single channel – or serial - processor. This means that it can detect multiple stimuli but it can only process it one item at a time, or only in series, not in parallel. In order to overcome any temporal stress or in order to maintain some sort of discriminatory process, an individual may filter some of the information in order to acquire the information that is regarded as being important.

3.10.3.1 **Attention.** Attention is the ability of an organism to centre and focus its cognitive processes towards acquiring information. In humans, it is the focussing of the senses on an object or event, and therefore excluding other competing stimuli, in order to facilitate perception and comprehension of that object or event. It is a vital component of memory and is used when moving information from sensory memory to short-term memory (see below).

Section

3.10.4 **Task Saturation, Task Interference and Multitasking**. Task Saturation is where there are too many items of information to process. For example, where it is necessary to monitor a number of radios, all of which are receiving transmissions, and drive a vehicle, it becomes increasingly difficult to do both well. This situation would constitute task saturation: too many things to process at the same time.

3.10.4.1 **Task Interference** is where one task takes over the time allotted for another task or the tasks overlap. This results in a reduction of efficiency and could be argued to be the pre-cursor to task saturation. In other words, task interference may occur before task saturation. In a study at the University of California in Irvine, two researchers conducted a study of office workers and discovered that 28% of the work day was lost due to task interference. Their study showed that a worker would be interrupted from his/her primary task every 11 minutes and it would take, on average, 25 minutes from that interruption before s/he was able to return to the primary task. Most of the interruptions were by colleagues stopping by to chat, the arrival of emails, a new task being assigned or telephone calls.[116]

3.10.4.2 **Multi-tasking** is a term used to describe the ability to do more than one thing at a time. It is often said that women are better than men at multi-tasking. Do an internet search on the subject and you will be surprised at the number of 'studies', both technical/scientific and anecdotal, that favour women over men in multi-tasking exercises and then the same number that favour men over women. One study by the University of Michigan came up with an interesting theory that has some anecdotal merit. The study claims that women are perceived to be better multi-taskers because of the expectations brought upon them by themselves and by society, leading them to attempt to accomplish (and usually succeed) at completing more tasks during a given period than men. One of the unfortunate by-products

[116] Stolovitch, H., D,. PhD, Talent Management, *Task Interference: the Silent Performance Killer,* http://talentmgt.com/articles/view/task_interference_the_silent_performance_killer accessed 02 Jan 13

of this is that women tend to suffer more stress about those tasks than men do.[117] But just because women accomplish more in a given time period does not mean that their brains are able to process things simultaneously. Rather, there is a rapid movement from one task to the next; what is known as concurrent activity is actually rapid serialisation of activities. The simple fact is that multi-tasking decreases performance, because any task that requires cognitive processing, requires undivided attention because, as we saw earlier, the human brain is a single channel processor and can only process information one item at a time. On a larger time scale, tasks that are left incomplete in order to commence another task, will most often suffer the effects of divided attention and are more likely to be left incomplete or not accomplished to their optimum.

Section

3.10.5 **Mechanics of Perception, Constancy and Selective Perception.** The concepts of sensory perception (the ability of the senses to receive external stimuli and for the brain to interpret that stimuli and make sense of it) are discussed elsewhere in this element, but the ideas of constancy and selective perception would be served well to be discussed here.

3.10.5.1 **Constancy** is the ability of the human brain to perceive things differently whilst at the same time not needing to re-evaluate or re-interpret its properties.[118] This was discussed briefly in the paragraph on monocular cues, where a car that is driving away seems to get smaller, but the brain understands that the car has not changed its dimensions, it is only our perception of the car that makes it appear to become smaller and that the car's shape is remaining constant. A plate looked at from above will look like a circle, but looked at from a 45 degree angle will look like an ellipse. The shape has remained constant, but our perception – and therefore our understanding of our distance relationship from it – has changed. It is this constancy that allows us to make judgements about our position in space. Another example for helicopter aircrew is the boresight technique when conducting an approach to a pinnacle or mountain top. The technique involves choosing a visual cue in the distance that can be used as a reference to assist with a constant angle approach. The diagram below explains the concept which relies on the human brain perceiving a change in the apparent angles and dimension but knowing that their dimensions are remaining constant whilst his/her viewpoint is changing. This is known as shape constancy. Size constancy is similar to shape constancy for physical objects, but can also be applied to any measurable dimension including sound. A sound getting fainter is an indicator that it is being mechanically muted or that the sound source and the receiver (listener) are moving further apart. The 'size' of the sound is not remaining constant, but that may not indicate any change to the sound itself, merely the distance from it. Brightness constancy is a skill that many artists try and capture. It refers to our ability to recognise that colours will seem to change depending on the light levels surrounding it, however we understand that the colours will remain constant and that our perception will change.

3.10.5.2 **Selective Perception.** Many men have been accused of having selective hearing; where he only hears what he wants to hear to the exclusion of other things. This is a good example of the concept of selective perception, however there is a further aspect to it: that of restructuring what has been perceived or having it influenced based on a subjective frame of reference. Because memory relies on association or rehearsal (see the section on memory), the human mind may adjust what was perceived and relate it to something that it

[117] Hohlbaum, C., L., Psychology Today, *The Power of Slow – Women Suffer from Multitasking More than Men,* http://www.psychologytoday.com/blog/the-power-slow/201112/women-suffer-multitasking-more-men 02 Jan 13.
[118] AllPsych ONLINE, *Psychology 101: Chapt 5 – Sensation and Perception,* http://allpsych.com/psychology101/perception.html accessed 19 Dec 12.

already has in store, (ie in memory), which makes it easier to store the new information. A prime example is of a person who is expecting a particular message to be transmitted and when s/he receives a message, s/he 'hears' what was expected rather than what was actually transmitted. This is a type of cognitive bias in which expectations can warp perceptions.

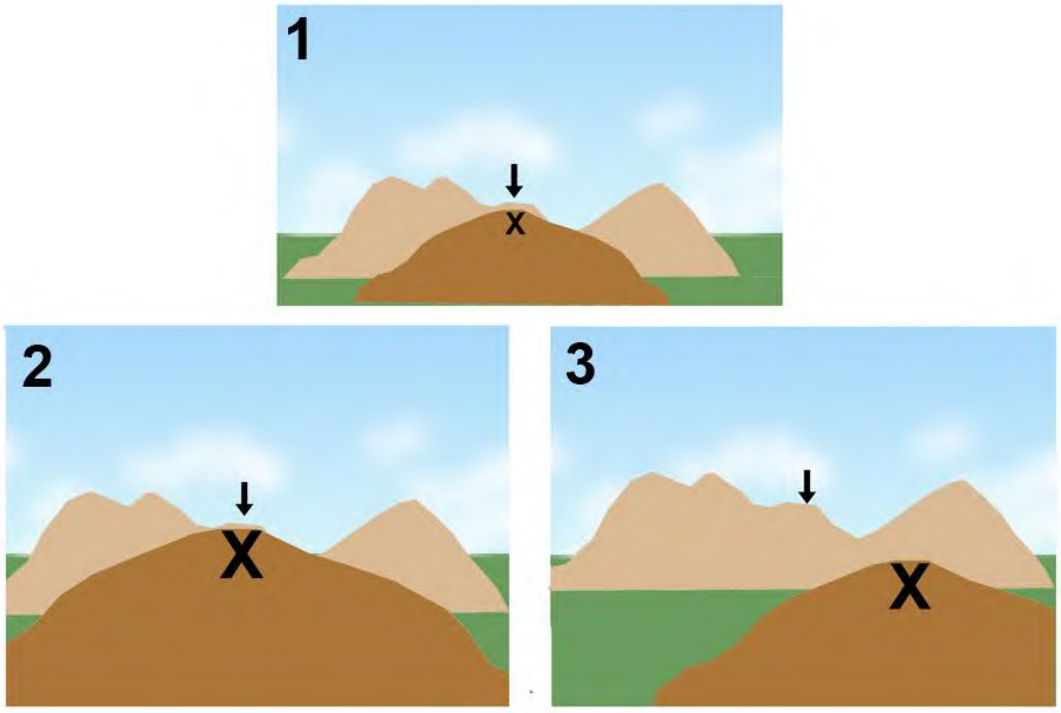


Figure 3.47 The boresight approach uses the concept of constancy to assist with an approach to a hilltop by a helicopter. In scene 1, the pilot wishes to make an approach to land on the pinnacle landing site marked with an 'X' and this is the view s/he sees through the windscreen. S/he chooses a reference point in the distance, in this case a small knoll between a small saddle and a large saddle marked with an arrow, which appears to 'touch' the pinnacle landing site. As s/he approaches the pinnacle landing site s/he manoeuvres the helicopter so that the reference point and the pinnacle landing site maintain a constant distance even though the pinnacle landing site appears to be getting larger, as seen in scene 2. By doing so, the pilot can be sure that s/he is on a constant track (direction) and a constant approach angle. In scene 3, the pinnacle landing site seems to be lower and to the right of the reference point which is a tell tale sign that the pilot has misjudged the approach and that s/he is overshooting (too high) and is veering to the left of track. The same technique is used to aim a gun with the bore of the barrel and the sight using the same relationship, ergo the name of this helicopter technique.

Section

3.10.6 **Memory.** The ability to recall information is vital to processing new information. This ability is called memory and is made up of various component functional areas using different parts of the brain. An interesting aspect of memory is that of primacy or serial position effect. Quite often the first thing learnt is often the thing that is most easily remembered, especially skills that need to be used in high stress situations. The following sections deal with memory, the different types, and factors that will affect it.

3.10.6.1 **Functional Description.** The ability to encode, store, retain and subsequently recall information and past experiences in the human brain [1] Technically, it is a set of encoded neural connections in the brain and it is the re-creation of past experiences by the synchronous firing of neurons that were involved in the original experience.

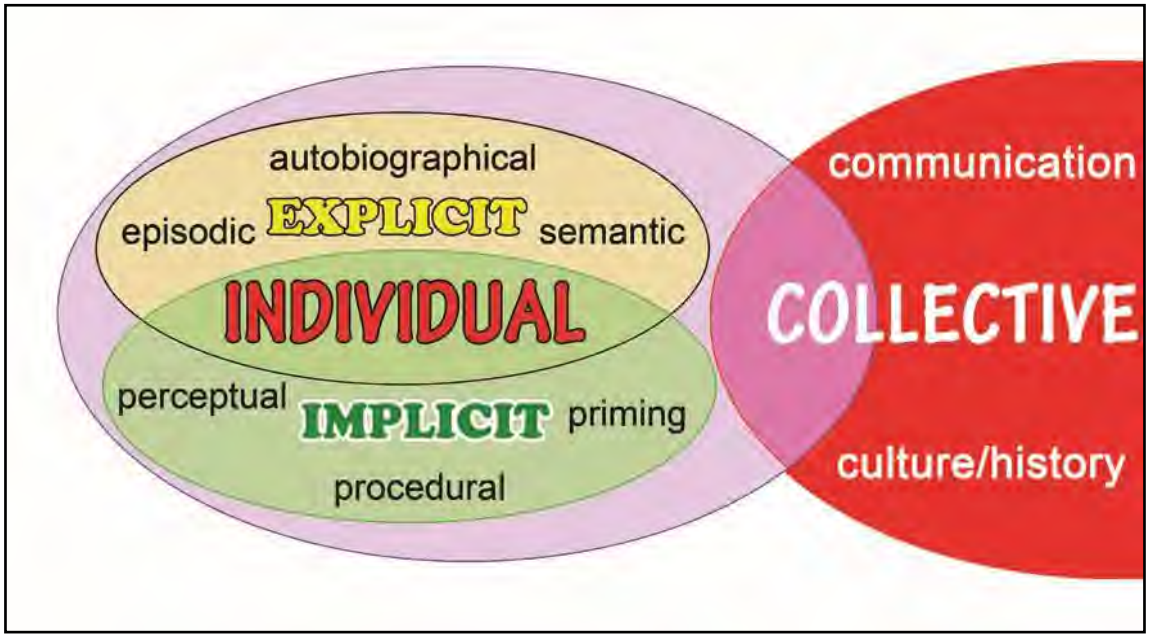


Figure 3.48 The various aspects of memory. Within a culture or group, there will be a collective memory of the important components of the cultural background. For an individual, s/he will have specific memories (overlapping with some cultural memories), and those specific memories will be implicit or explicit.

3.10.6.2 **Learning** is the process where we acquire knowledge of the world. In this case, the neurons that fire together so that they re-create an experience are altered so that they have the tendency to fire again thus creating a memory. Learning creates memories, but also relies on memory because it is the already stored knowledge that allows for one of the key components of memory to be used, that of association. There are many different forms of memory. The following list provides some insight into how our memory is structured.

- **Individual Memory** – Those memories held by one person as opposed to a group of people (such as Collective Memory).

- **Collective Memory** –Those memories held by a group or society and passed down as part of the culture. An example is that of the legend of ANZAC in Australia. There are no longer any survivors from that campaign, but the memory of the battles fought on the Gallipoli Peninsula have been passed down through cultural norms, writings, paintings and audio/visual media. Before the advent of writing, a culture's memory was strictly oral/aural and even thereafter, the tradition of storytelling within a culture as a part of passing on of history, was still strong.

[1] http://www.human-memory.net/intro_what.html

3.10.6.3 **Memory Model.** When discussing the components of memory, a number of models have been posited to assist with analysis. One of the more commonly used is the Atkinson-Shiffrin multi-store model for memory.

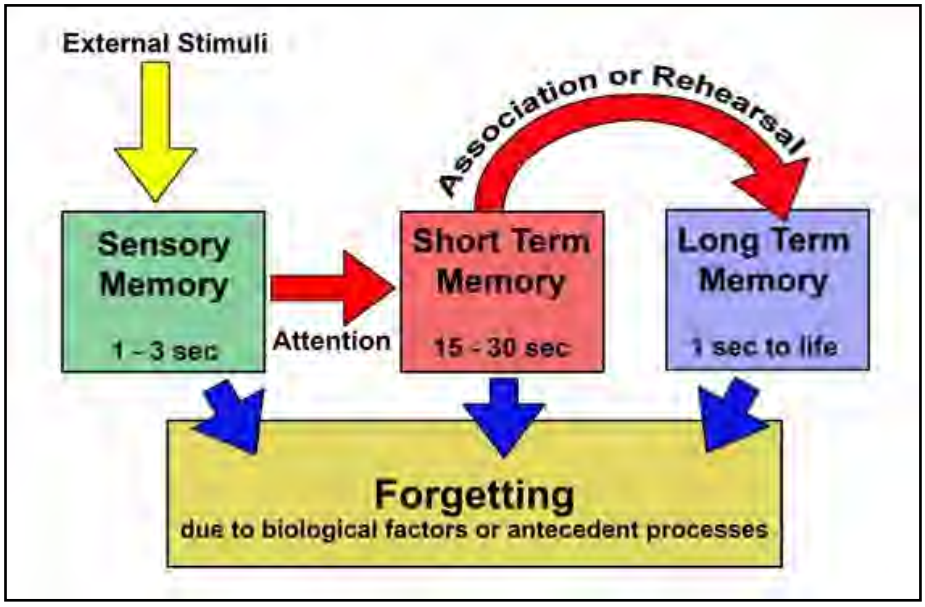


Figure 3.49 A derivation of Atkinson and Shiffrin's multi-store diagram used to describe the functional components of memory. External stimuli is sensed by the senses and will last for a few seconds unless the individual pays attention to certain aspects of the stimuli whereupon it will go into short-term memory. In both cases, the information will be forgotten unless it is placed in to long term storage due to association or rehearsal.

- Sensory Memory – The ability to retain impressions of sensory information for a short period of time and hold in a buffer. Information received through our senses can be perceived or ignored. If it is ignored, then it will not be held in sensory memory; if it is perceived, then it will be. It is outside of conscious control. It can be considered to be part of the process of perception. An example of sensory memory being used is in scanning the rear view mirror of a car to check on traffic. The brain will perceive the information and only use it if necessary. For example, if a car is seen to be too close that it may be a hazard that will bring it to the attention of the individual (see Attention below). The components of Sensory Memory include:
    - **Iconic Memory** – the memory associated with seeing something.
    - **Echoic Memory** – the memory associated with hearing something.
    - **Haptic Memory** – the memory associated with touching something.
    - **Olfactory Memory** – the memory associated with smell. It is interesting to note that the area of the brain associated with memory, that of the hippocampus and amygdala, are situated very close to the olfactory bulb and olfactory cortex, that part of the brain that processes the sense of smell. Their proximity, only a few synapses apart, would suggest that any smell sensation would be quickly and easily transferred into a memory which would persist for a longer period, even without consolidation.

Information is passed from the sensory memory to the short-term memory through attention which is the cognitive process of concentrating on one aspect of the environment whilst ignoring other things.

- **Short Term (Working) Memory** – the ability to remember and process information at the same time. Because of this time sharing, it is only able to hold and process a small number of items for a short time, nominally 7 items for about 15 to 30 seconds has been the most accepted figure. Examples include the act of reading where a sentence will not make sense if the start of the sentence is not held in memory until reading the whole sentence is complete. In order for Short Term Memories to be put into Long Term Memory, repetition or meaning/association need to be applied with motivation (ie processing information that is of interest to a person) is a reinforcer of the acquisition and consolidation of information. There are three main sub-categories of Short Term Memory which are considered to be implicit, in that they are not brought out into the open deliberately for use, but are used somewhat sub-consciously or without deliberate thought:

    - **Priming** – as the name suggests, priming starts an action in a particular direction, just as priming a fuel line will cause the fuel to run along the line, priming can cause a person to do or think in a particular way. It is an implicit memory effect where one stimulus influences another stimulus. It occurs when other memory types are repeated.

    - **Procedural Memory** – used to perform certain actions, it is usually recalled without conscious cognitive processing, in other words, a person doesn't need to think about it. For example, knowing how to drive a car requires procedural memory for someone who is experienced at doing so.

    - **Perceptual Memory** – the ability to perceive what feels correct, to identify objects and to assess large groups of data. It relies on past experiences.

- **Long Term Memory** – the storage and recall of information through a semantic or meaningful system and, to a lesser extent, on sound. Long term memory relies on long-term potentiation of neural pathways. In other words, when the neurons are created, altered and strengthened, they form the pathways that become memories. Special gaps or junctions in these pathways are called synapses. By creating special proteins that can bridge these gaps, the communicative strength of these pathways become stronger and their efficiency increases in transmitting stimuli to the brain. Forgetting can occur when those pathways are not used anymore or become weakened. If another pathway is superimposed over it, it can cause interference such that one memory seems to be influenced by another. There are three main sub-categories of Long Term Memory:

    - **Explicit Memory** – (also sometimes known as Declarative Memory) is a category of Long Term Memory that uses information consciously and seeks to do so by cognitive processes. In other words, it is different from memories that are subconscious. These can then be further divided into:

    - **Episodic Memory** – the recollection of experiences and specific events that allows us to reconstruct a series of events. It can also be thought of as part of Autobiographical Memory in that it also a part of our lives and personal experience. Autobiographical Memory also holds context so that

the person recalling the events can state not only the events, but the emotions and stresses of the time. Flashbulb Memory is a part of Autobiographical Memory and is associated with specific, often shocking events. September 11 is one such event and almost everyone can recall exactly what s/he was doing when news of that event reached them. One theory is that the emotional charge associated with the creation of that memory gives them longevity, but in many cases, not the accuracy associated with the vividness of the recollection.

- **Semantic Memory** – the storage of facts, meanings and concepts about the external world and does not have to have personal experience, although it is generally derived from Episodic Memory.

3.10.6.4 **Information Storage and Recall.** As stated previously, a memory is not a memory if it cannot be recalled. There are a number of techniques used to assist with memory enhancement, and some studies cite that merely practicing puzzles, word games, games of concentration and other intellectual games will improve memory and stave off debilitating conditions such as Alzheimer's Disease. The two main methods of memorising information are:

- **Association** – where an item of information is related to an already existing memory or item of information.

- **Rehearsal** – where information is repeated so often that it is imprinted into the brain.

In both situations, a strong motivation to memorise information will assist in the task, such as when a person is interested in the subject at hand and it gives him/her pleasure, as opposed to being motivated in order to pass a test.

3.10.6.5 **Serial Position Effect.** This phenomenon is important for anyone passing on information and expecting the recipient to be able to recall aspects of it. It is related to the concept of 'Primacy of Learning' which was discussed in the element on the Human Mind in that the ability of a person to recall information is linked to the placement of that information in the episodic memory. In other words, information that is given first has a higher probability of being remembered than information that is given after it. Information that is given last, has an even higher probability of being remembered. The diagram and its caption below, provides a good example of how an experiment captured this phenomenon. What is important to note is that information that is not written down, will have a varied probability of recall, even after a short time.

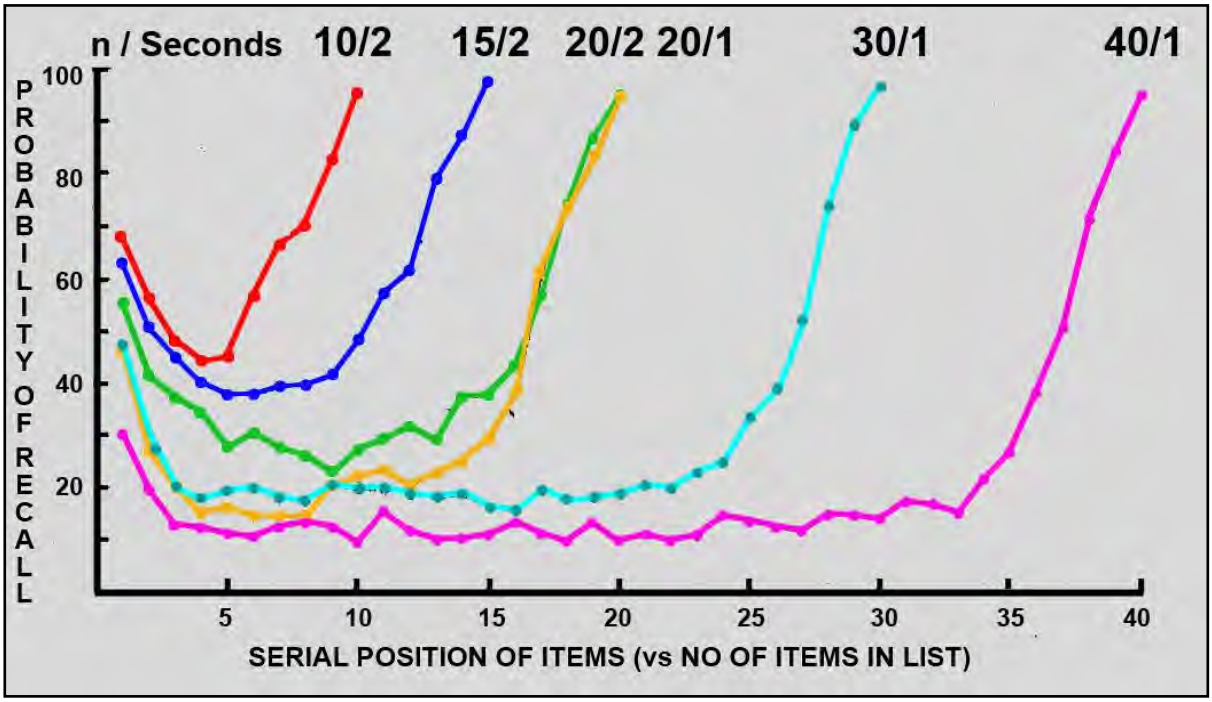


Figure 3.50 Serial Position Effect is the probability of remembering an item of information based on its position in the order in which it is delivered. The graph above shows the probability of remembering items (in this case random words) depending on its position in the list. The numbers on the top relate to the number of items in the list (n) and the time of exposure of each word (ie 40/1 means 40 words exposed for 1 second each). As can be seen, items at the beginning of the list and at the end of the list, are more likely to be remembered. See also 'Primacy of Learning' in the element on The Human Mind.

Module 3.11

3.11 **Stress.** The word stress conjures up many different meanings. In mechanics, it means force applied to a body and it is termed in the dimension of 'pressure' and measured as pascals or pounds per square inch. For a human, stress can be thought of as being pressure, but it can be associated with a physical state, a physiological state or a psychological state, where the optimal state is being disrupted. In other words, if the body is in its optimal state of equilibrium – often called homeostasis – and some form of stimuli takes it out of this state, then the body is encountering stress. For example, if a person is sweltering in 40 degree temperatures, then his/her body is outside its optimum environmental temperature range of approximately 22 to 28 deg C, and therefore the person is in a state of (physical) stress. If the mind is being disturbed by external stimuli (eg financial worries) that take it out of its relaxed optimal state, then the person is experiencing a form of (psychological) stress. Other definitions look at the physiological outcomes and try and place it in context. Stress is the human body's response to a stressor where the hypothalamus in the brain signals the adrenal glands to produce more adrenaline and cortisol which is released into the bloodstream. These two chemical hormones initiate some reactions such as increasing the heart rate, respiration, blood pressure and metabolism. Blood vessels begin to dilate to allow more blood flow to the larger organs and muscle groups, preparing them to react. Pupils also dilate to allow extra light in and increase vision. Glucose is released by the liver as an immediate energy source and sweat is released to cool the body. All the above physiological responses are primal responses that may be inappropriate in today's 21st Century lifestyle, but when put into context 40,000 years ago, it prepared pre-historic homosapiens to fight or flee. This is the 'fight or flight' reaction and is still a reaction of the modern human body to stress.

Section

3.11.1 **Types and Definitions of Psychological Stress.** Stress is the body's reaction to an expected or unexpected event which causes an increased arousal. It has been defined as: 'a process by which certain work demands evoke an appraisal process in which perceived demands exceed resources and result in undesirable physiological, emotional, cognitive and social changes"[119]. It can be defined as Physiological stress or Psychological stress. Psychological stress may not be a physical danger to the body but can lead to physiological responses which may then lead to illness due to a change in the hormonal system and a lowering of the human immune system. The body then becomes more susceptible to illness. A medical definition of stress is:

> *a state of physiological or psychological strain caused by adverse stimuli, physical, mental, or emotional, internal or external, that tend to disturb the functioning of an organism and which the organism naturally desires to avoid.* [120]

Note how the medical definition includes both physiological and psychological strain?

[119] Salas, E., Driskell, E. and Hughs, S. (1996) "The study of stress and human performance', in J.E. Driskell and E. Salas (Eds.) Stress and Human Performance, Lawrence Erlbaum Associates, New Jersey, pp.1-45 as cited in http://www.cdc.gov/niosh/mining/pubs/pdfs/jadmu.pdf accessed 02 Aug 12.

[120] Dorland's Medical Dictionary for Health Consumers. © 2007 by Saunders as cited at http://medical-dictionary.thefreedictionary.com/stress accessed 02 Aug 12.

3.11.2 **Life Stress Scoring.** A well-known means of gauging stress was a test created by two psychiatrists: Thomas Holmes and Richard Rahe looked into the link between stress and illness and used medical patients in their first experiments, and then US Navy sailors in subsequent experiments. Their resultant Social Readjustment Rating Scale (SRRS) was a tool that they believed could tell if a subject was experiencing significant psychological stress and thus was more susceptible to illness. The scale has been used for decades but must be used with caution for it is subjective depending on the cultural context. For example, the church constitutes a significant part of the make up of US society, but this is not necessarily the case in Australian society, therefore changes in church activities would have a greater stress impact in a US survey than in an Australian survey. The differences are even greater between Western societies and non-Western societies. As a means of highlighting the relationship, the Holmes and Rahe Stress Scale (as it has become known as) is reproduced below with appropriate caveats thereafter.

Life event	Life change units
Death of a spouse	100
Divorce	73
Marital separation	65
Imprisonment	63
Death of a close family member	63
Personal injury or illness	53
Marriage	50
Dismissal from work	47
Marital reconciliation	45
Retirement	45
Change in health of family member	44
Pregnancy	40
Sexual difficulties	39
Gain a new family member	39
Business readjustment	39
Change in financial state	38
Death of a close friend	37
Change to different line of work	36
Change in frequency of arguments	35
Major mortgage	32
Foreclosure of mortgage or loan	30
Change in responsibilities at work	29
Child leaving home	29
Trouble with in-laws	29
Outstanding personal achievement	28
Spouse starts or stops work	26
Begin or end school	26
Change in living conditions	25
Revision of personal habits	24
Trouble with boss	23
Change in working hours or conditions	20
Change in residence	20
Change in schools	20
Change in recreation	19
Change in church activities	19
Change in social activities	18
Minor mortgage or loan	17
Change in sleeping habits	16
Change in number of family	15

reunions	
Change in eating habits	15
Vacation	13
Christmas	12
Minor violation of law	11

Table 3.14 The Holmes and Rahe Social Readjustment Rating Scale (or just the Holmes and Rahe Stress Scale). According to the creators, if a person reviews his/her life for the last 12 months and then applies this scale and scores the stressors experienced over that 12 month period, then it can reflect the level of stress and the likelihood of associated illness that may accompany it. A score of more than 300 means there is a high chance of illness; a score of 150 to 299 means a 30% reduction from the high chance of illness; and 150 or below means low chance of illness. The scale is very subjective and reflective of 1960s American culture. It is a good indicator, however, of the place of significant stressors in modern western society where such things as death of a spouse or dismissal from work or marriage or retirement are considered significant stressors. This may not be the case in say a farmer's village in Vietnam where stressors there may be more related to an agricultural society.

Section

3.11.3 **Anxiety.** Anxiety is a psychological – and often a physiological – reaction to an event or situation over which the subject feels (s)he has little control or which may have a negative outcome. One definition that has been used is that 'Stress is caused by a stressor, whereas anxiety is stress that continues after the stressor is gone.' [121] In essence, it is a form of psychological stress, and responses can include:[122]

- **A physical response** - due to the arousal of the nervous system which may result in such symptoms as sweating, hot flushes, increased heart rate.
- **A cognitive response** - which may include negative thoughts about the situation and the ability of the subject to deal with it.
- **A behavioural response** - such as avoidance or even uncharacteristic responses such as aggression, irrational behaviour or even self-harm.

3.11.3.1 Causes of anxiety come from many different sources such as:[123]

- **Hereditary** – some family histories have higher than normal numbers of members who suffer from anxiety disorders.
- **Biochemical Factors** – often, an imbalance in chemicals in the body that assist with the regulation of emotions can cause unusual anxious reactions and anxiety attacks. Some of these symptoms can be relieved by medication.
- **Life Experiences** – A form of conditioning, some people can react to situations presented to them (even if they don't physically experience them) which can cause anxious reactions. Examples include near drowning experiences and then the ability to perform in or near water which may cause anxiety.

[121] The Neuron: Advanced Placement Psychology, *Stress*, http://theneuron.wetpaint.com/page/Psych+M.D.-+Stress accessed 02 Aug 12.
[122] Australian Psychological Society, *Understanding and managing anxiety,* http://www.psychology.org.au/publications/tip_sheets/anxiety/ accessed 15 Jul 12.
[123] Ibid.

- **Personality and Thinking Style** – Some personality types, especially those with low self esteem, are more likely to experience higher levels of anxiety in certain situations. Part of this construct is the manner in which a person thinks. A person who is a perfectionist, will often feel greater anxiety and be more at risk of worrying than someone who is not a perfectionist.

- **Behavioural Styles** – People who tend to avoid situations often do not learn how to meet the challenges head on, and so may become anxious when forced to do so. Compare this to someone who does often meet the challenges and understands how to handle them or how to handle not succeeding in that challenge. In the latter case, knowledge often dispels fear.

Section

3.11.4 **Temporal Stress.** There are many forms of stress, but probably the most common is time pressure – or temporal stress.[124] Temporal stress is a psychological stress brought about when the subject perceives that the time available is insufficient for him/her to be able to complete a task. As a result, certain skills can be seen to degrade, including motor skills and cognitive skills. For example, a person who believes that (s)he has only 20 seconds to complete a task requiring a certain amount of dexterity and which often takes more than 20 seconds, will make more manual errors and may seem to be ' all thumbs.' The same applies for tasks requiring mental effort. In the same situation, the subject will often experience 'mind block' and even simple tasks like arithmetic may be difficult to do.

3.11.4.1 Another aspect of temporal stress is the phenomenon known as 'cognitive lockup.' This is when the subject perceives that there is a time limit on a number of tasks, but will remain fixated on one task that is almost complete or is easy to complete even though another task is more important to achieve. In other words, the subject will 'lockup' and not process correctly, the importance of the other task as part of his/her priority system.[125] This study found that the 'lockup' occurred only when a task was almost completed, in the order of 90% or more. In the event that the task was not, then often the subject would give up on it and switch to the more important task.

3.11.4.2 A rather paradoxical finding with regard to time pressure is that too much time can cause complacency such that work output can diminish. The old saying that 'if you want to get something done, give it to a person who is busy,' has some credence to it. People with time pressures seem to be more focussed on the outcomes, however people with too much time pressure can often be stifled due to psychological barriers and lock up. The key is to find the right means of spreading out the time pressure with key milestones along the way. Another factor is to remove any distractions to the task which helps to relieve some of the associated anxiety that comes with time pressure.

[124] Case Western Reserve University (2009, February 16). *Perception Of Time Pressure Impairs Performance*. ScienceDaily. Retrieved September 19, 2012, from http://www.sciencedaily.com- /releases/2009/02/090210162035.htm
[125] Schreuder, E.J.A., and Mioch, T., *The effect of time pressure and task completion on the occurrence of cognitive lockup,* CEUR Proceedings, 4th Workshop HCP Human Centred Processes, 11 Feb 11.

Section

3.11.5 **Physiological Responses to Psychological Stress.** According to the US Centre for Disease Control, more than 50% of all visits to health care professionals in the US are due to stress related or stress induced illnesses. Below is a sample of some of the physiological responses to stress:

- Tension, or migraine, headaches.
- Upset stomach, problems retaining food.
- Tightness in chest, back, shoulders, aching jaw, tight forehead.
- Shortness of breath, dizziness.
- Tingling sensation in fingers toes.
- Nervous tension all over; heart palpitations, feelings of anxiety.
- Diarrhoea or constipation.
- Constant low grade fever, cold, or sore throat.
- Rashes, hives, skin irritation.
- Increased blood pressure.
- Fatigue and sleep disturbances.
- Menstrual problems, missed menstrual periods.
- Anger.
- Concentration problems.
- Depression.
- Lack of interest in food or an increase in the desire for food.

Section

3.11.6 **Physiological Stresses – Dehydration and Fatigue** There are a number of self-induced physiological stressors that a person has direct control over. The mnemonic 'DEATH' is used to describe them, it stands for:

- Drugs.
- Exhaustion.
- Alcohol.
- Tobacco.

- Health/Hypoglycaemia.

Of the above, we have already discussed drugs and alcohol and hypoglycaemia. However there are two components of the above list that are worth mentioning; they are Exhaustion which is fatigue, and Health, the component of which we shall discuss is hydration.

3.11.6.1 **Dehydration.** Dehydration (aka hypohydration) is the loss or reduction of body water which has an effect on the body's metabolism. It can manifest itself as a loss of water, loss of electrolytes or both, the latter, being called isotonic dehydration, is the term often used to sell sports drinks. There are a number of technically correct definitions for various types of dehydration. For our purposes, we are concerned with the state in which water volume and sodium have been lost by the body such that homeostasis (balance) is not maintained and the ability of the individual to operate at his/her optimum is adversely affected.

3.11.6.2 **Causes.** The most common cause is the lack of deliberate hydration during strenuous exercise or extreme heat, that is, not drinking enough fluids. When the body loses about 2% of water volume, the first signs of dehydration will start to manifest themselves. [126] Other causes include:

- Extreme diarrhoea.
- Vomiting.
- Fever.
- Excessive sweating and hyperthermia.
- Burns.
- Use of amphetamines.
- Excessive consumption of diuretics such as caffeine and alcohol.
- Certain infectious diseases such as cholera and gastroenteritis.
- Malnutrition, extreme dieting or salt reduced diets.
- Medication.
- Human intervention or lack of intervention.

3.11.6.3 **Symptoms.** The onset of dehydration will commence with a general feeling of thirst and dryness of the mouth, loss of appetite, lack of sweating and decreased urinary output which may be darker than normal and may be irritating to pass. A person may also feel fatigued and/or irritable. Symptoms can be mild or extreme, but include such things as:

- Headaches, dizziness and/or fainting or seizures.

[126] http://en.wikipedia.org/wiki/Dehydration accessed 02 Jan 13

- Loss of cooling due to sweating leading to hyperthermia.
- Fatigue and lethargy.
- Decreased blood pressure.
- Confusion and delirium.
- Unconsciousness.
- Swelling of the tongue.
- Renal failure.
- Coma leading to death.

The story below taken from a UK newspaper[127] tells of how a fit young man of 22 years of age died of dehydration in a hospital due to medical illness, medication and lack of care by staff. Note the various symptoms and compare them to those cited above.

The Telegraph

02 July 2012.

Kane Gorny's mum Rita Cronin told an inquest into her son's death that when the police turned up at St George's Hospital, they were turned away by doctors and she was repeatedly ignored by staff when she begged for help for her son.

Giving evidence at the first day of a four-day inquest, she revealed how she received a distressed phone call from her son the day after his operation, in which he revealed he had called the police because he was so desperate for a drink.

The inquest heard Ms Cronin immediately went to the hospital, where Kane was "confused and angry," shouting at staff and behaving in an uncharacteristic abusive manner.

Despite expressing her concerns that he was not behaving normally, one doctor asked if he was "coming off booze" and another asked if he was "always like this."

Kane, who had been a keen footballer and runner until he suffered a brain tumour the previous year, was undergoing a routine hip replacement after life-saving steroids he had been given had weakened his bones.

Due to his condition, he needed hormone medication to control fluid levels in his body, but despite repeated reminders by Kane and his family, staff failed to give him the tablets.

He became severely dehydrated but his requests for water were refused and he died on May 28 2009.

After his death, while Kane's family held his lifeless body, they were asked by a nurse whether they had "finished" and could she "bag him up now," the hearing at Westminster Coroner's Court was told.

[127] http://www.telegraph.co.uk/health/healthnews/9370376/Man-22-who-died-from-dehydration-in-hospital-rang-police-for-a-drink-of-water.html accessed 02 Jan 13.

A coroner had such grave concerns about the case she referred it to the police.

Mrs Cronin told the hearing: "He sounded really, really distressed. He said 'they won't give me anything to drink.'

"He also said 'I've called the police.' He said: 'I've called the police you better get here quickly, they're all standing around the bed getting their stories straight.'"

Ms Cronin added: "They weren't doing anything. They seemed out of their depth. It felt to me like the two locum doctors were nervous about calling anyone more senior than them, I would have expected them to do that."

The inquest heard Kane was restrained by security guards and sedated with strong medication to calm him down.

Later, he was put into a side room, where no one visited him for the rest of the evening.

Realising he couldn't have been given his night-time medication, Ms Cronin asked a nurse when he would be receiving his dose. The nurse promised to flag it up with the night nurse.

But the next day when Ms Cronin arrived at the hospital at 7.45am, she found her son looking "delirious" with swollen lips and tongue.

She told the inquest: "He was lying on the bed on his back. His lips were very swollen and his tongue was swollen. He just looked delirious.

"At that moment three nurses were standing outside the room. I said 'there's something wrong with my son'.

"The night nurse said 'he's had a good night and there's nothing wrong with him.'

"I said: 'He's not well' and the other nurse tutted and said 'She's already told you he had a good night,' and with that they walked off."

It was then Ms Cronin noticed Kane's tablets sitting on the table by his bed.

Ms Cronin said she then approached the locum doctor, who reassured her everything was fine and it "wouldn't do him any harm" to miss a dose of his medication.

Unsure what to do to get someone to look at her son, she approached another more senior doctor as he was carrying out ward rounds, the inquest heard.

Ms Cronin said: "He took one look at him and started to call everyone to come in here quickly.

"It suddenly dawned on me he hasn't had his medication, hasn't had his bloods done, nobody's given him a drink, nobody's bothered to put his drip back on him. Nobody's done anything since he became aggressive."

Kane's family were left outside the room while doctors tried desperately to save his life.

Following his death from dehydration, they were asked to help move his body so a nurse could put a clean sheet under his lifeless body.

Later a nurse asked them "Have you finished seeing your son yet? Can I bag him up now?" the inquest was told.

The death certificate said Mr Gorny had died because of a 'water deficit' and 'hypernatraemia' - a medical term for dehydration.

3.11.6.4 **Effects and Rate of Onset.** Mild dehydration is common in everyday life and may cause discomfort as a feeling of being thirsty, but what about more severe cases? Below are some effects and rates of dehydration.

- 1% of body weight as fluid – thirst and reduced performance. Core temperature increases by up to .4 deg C.
- 2% of body weight as fluid – some thirst and reduced urinary output, cognitive function begins to deteriorate. Core temperature increases by up to .8 deg C.
- 4% of body weight as fluid – reduced urinary output, tachycardia, reduced blood pressure.
- 5% of body weight as fluid – body's capacity to work reduced by 30%. Core temperature can increase by up to 2.0 deg C.
- 6% of body weight as fluid – life threatening event.

3.11.6.5 **Rehydration methods and fluids.** For minor dehydration, removing the fluid loss causes (ie out of the heat or cease strenuous activity) and the intake of fluids – preferably just water, is the most effective method of staving off more severe symptoms. Plain water is most efficient at relieving the thirst craving. More severe dehydration is usually accompanied by more severe fluid loss and loss of electrolytes, therefore rehydration by drinking or by intravenous input for more severe cases is most effective as well as the introduction of electrolytes using isotonic fluids. Seawater, alcohol and urine are diuretics and will worsen conditions of dehydration. Hydration must be carried out as a deliberate action and part of deliberate planning during activities that are likely to be strenuous or in conditions of severe heat. Monitoring urine output and the colouration thereof is an initial indicator of hydration levels. A reduction in the urge to urinate is an indication that dehydration has already commenced.

3.11.6.6 **Fatigue.** When hearing the word 'Fatigue,' most people immediately think of the physiological phenomenon where the muscles are unable to maintain the performance normally expected of them. A feeling of tiredness usually brought about by physical exertion. However, fatigue is also a psychological phenomenon as well; where the brain is not able to perform at the level expected of it; also a feeling of tiredness usually brought about by prolonged mental activity.

Fatigue in itself is not a malady; it is a symptom of another cause or causes such as:

- Overwork/overstimulation (physical and/or mental)
- Lack of sleep.
- Illness/Disease (see also Chronic Fatigue Syndrome below).
- Medication.
- Lifestyle.
- Transmeridional travel (aka jet lag, see circadian rhythm below).

- Depression.
- Boredom/understimulation.

Key symptoms of fatigue are:

- A feeling of tiredness, lethargy and a lack of motivation.
- Inability to form cogent sentences.
- Irritability.
- Reduced reflex response.
- Soreness in areas of the body that have been overworked.
- Headaches and sometimes migraines.
- Reduced immunity and increased susceptibility to viruses and infections.
- Reduced mental capacity and impaired judgement.
- Reduced hand-eye coordination.

3.11.6.7 **Acute vs Prolonged vs Chronic Fatigue and mitigations.** There are three key temporal classifications for fatigue, they are:

- **Acute Fatigue** is short term and localised. It can be caused by not enough sleep over a short period of time; high physical exertion or high/low mental activity. It can be rectified by ceasing those overstimulating activities or under stimulating activities and finding an appropriate balance as well as rest and sleep.
- **Prolonged Fatigue** is considered to be fatigue that lasts for at least four weeks and is a symptom of prolonged exertion or a temporary lifestyle change away from the ordinary, for example, leaving home for a business trip that extends for several weeks that entails high mental activity and travel. The same mitigations listed above for acute fatigue can be used to alleviate the effects of prolonged fatigue and a change in lifestyle. A rest period of a few to several days may be required to overcome prolonged fatigue.
- **Chronic fatigue** is ongoing and involves experiencing the feeling of fatigue for at least six months. There are two key types of chronic fatigue; that brought about by lifestyle and that which is illness based causing ongoing feelings of fatigue regardless of lifestyle (see below). Non-medical based chronic fatigue is primarily a psychological symptom of a malaise brought about by a lifestyle which could be personal or work related. Long term employees within one organisation doing the same job for extended periods can experience chronic fatigue. The solution for most non-medical chronic fatigue is a lifestyle change and removal from the environment in which it has manifested.

- **Myalgic Encephalomyelitis (ME) aka Chronic Fatigue Syndrome** is a medically based condition whose symptoms include fatigue over an extended period but which is also usually associated with other symptoms like memory impairment, sore throat and lymph nodes, muscle pain, unrefreshing sleep, headaches and joint pain.[128]

Section

3.11.7 **Circadian Rhythms, Dysrhythmia and Sleep.** The study of the rhythmic cycles within biological organisms is called chronobiology (chronos – Gr. time). Many organisms are affected by their environment as well as by internal mechanisms. For example, certain tidal creatures in rock pools on the shoreline will align their activities with the tides and become more active during high tide when there is more water activity compared to low tide when the rockpools are isolated. In humans, there is a natural cycle of human biology which is influenced by internal mechanisms (biological clock) and external environment (daylight). These cause a natural pattern known as the circadian rhythm. Circadian (circa – L. circle or around; di-es – L. day) rhythm is a person's natural cycle of wakefulness and desire for sleep and is usually aligned with day and night.

When this alignment is out of synchronisation, it is known as circadian dysrhythmia. Examples of circadian dysrhythmia are jet lag (crossing three or more time zones) or shift work especially at night. These situations can be called 'Phase Shift' because they shift the natural phase of sleep/wake.

3.11.7.1 The **Biological Clock** may refer to the endogenous (inbuilt within our biology) rhythm found within humans and other animals. Studies during the 1960s found that when humans were isolated from external cues, such as sunlight, clocks, daily cycles of human behaviour, that the internal natural biological clock adopted a cycle of approximately 24.5 to 25 hours. This suggests that external cues help to reset the internal biological clock to the 24 hour cycle. In humans the suprachiasmatic nuclei (SCN) is thought to take greatest control over resetting the biological clock.[129] The SCN is situated in the hypothalamus and receives light information from the retina via the retinohypothalmic tract and optic nerve. The SCN takes this light information and controls the secretion of hormones which enables the entrainment – the forcing of cycles to match another cycle – of the body's functions to the daily rhythm. In other words, the SCN makes sure that the body's natural 24.5 hour (approx.) cycle resets to 24 hours based on the light information. One of the key secretions is melatonin.

3.11.7.2 **Melatonin** is a secretion of the pineal gland and is controlled by the SCN. It helps with sleep-wake cycle. It causes the body to feel drowsy and causes a lowering of the body's core temperature thus urging the body to sleep. It is inhibited by light signals, especially light in the blue range of the visible spectrum (460 to 480 nm) such as would be seen as a blue sky on a sunny day. This explains why darkness – and to some extent dark, cloudy days – causes drowsiness and can influence moods. By reducing light, especially blue light, the melatonin secretions can be increased thus forcing drowsiness' effects to come earlier. This can also be done by artificially increasing melatonin (through drugs) which can help to reset the biorhythmic phase. Melatonin has been sold commercially since the '90s as a cure for jet lag and to assist with insomnia or shift work, but there is still conjecture as to other side effects, especially with mood swings, blood pressure variations and fertility. In humans it

[128] University of Maryland Medical Center, *Chronic Fatigue Syndrome – Diagnosis,* http://www.umm.edu/patiented/articles/how_chronic_fatigue_syndrome_diagnosed_000007_4.htm accessed 03 Jan 13.
[129] Robert Smyth Academy, A2 Biology – Biorhythms, http://psychology4a.com/biological_rhythms.htm, accessed 12 Jul 12.

occurs naturally with the amount varying depending on the time of day, and over a longer term, varying with age. In the short term daily cycle, melatonin production and secretion increases rapidly around 8pm local time peaking at 2am local time. This is based on the body experiencing light patterns that match this time frame. After 2am, when the body is receiving the most amount of melatonin and is becoming the most drowsy, the production starts to decrease and reduces to its lowest at around 7am local time. In the longer term over a lifetime, these times can change. In new-borns, melatonin is not secreted until a few months of age and so babies do not reach the sleep-wake cycle that adults experience until the secretions start. In teenagers it has been found that melatonin production starts later than normal thus bringing on drowsiness later in the evening and peaking later in the cycle continuing to cause drowsiness past the night hours and into the morning. In the elderly, melatonin production is reduced causing alertness much earlier in the morning. This explains the late rising of teenagers and the early rising of the elderly and the disrupted sleep patterns of babies.

3.11.7.3 **Sleeping and Napping, Patterns and Disturbances.** It has been discovered that there are two key natural drives for sleep: one is based on circadian rhythm (see melatonin above), the other is based on sleep homeostasis. Homeostasis is the body's desire for equilibrium. Sleep homeostasis is the natural tendency for the body to find an equilibrium for sleep versus wakefulness. Not enough sleep can result in a 'sleep debt' to which the body tries to compensate with an increased desire for sleep and which can extend for a number of days. The opposite is also true with too much sleep resulting in longer levels of wakefulness. This may sound obvious when one gives it some thought. The result is called Sleep Propensity, or sleep urge – that feeling that a person gets when (s)he feel like (s)he wants to fall asleep. Low SP means higher wakefulness whereas high SP means higher drowsiness.

Figure 3.51
Napping is a means to reconstitute sleep debt and provide for greater levels of alertness. (It is imperative, however, to choose an appropriate place to nap). (Photo orig unk)

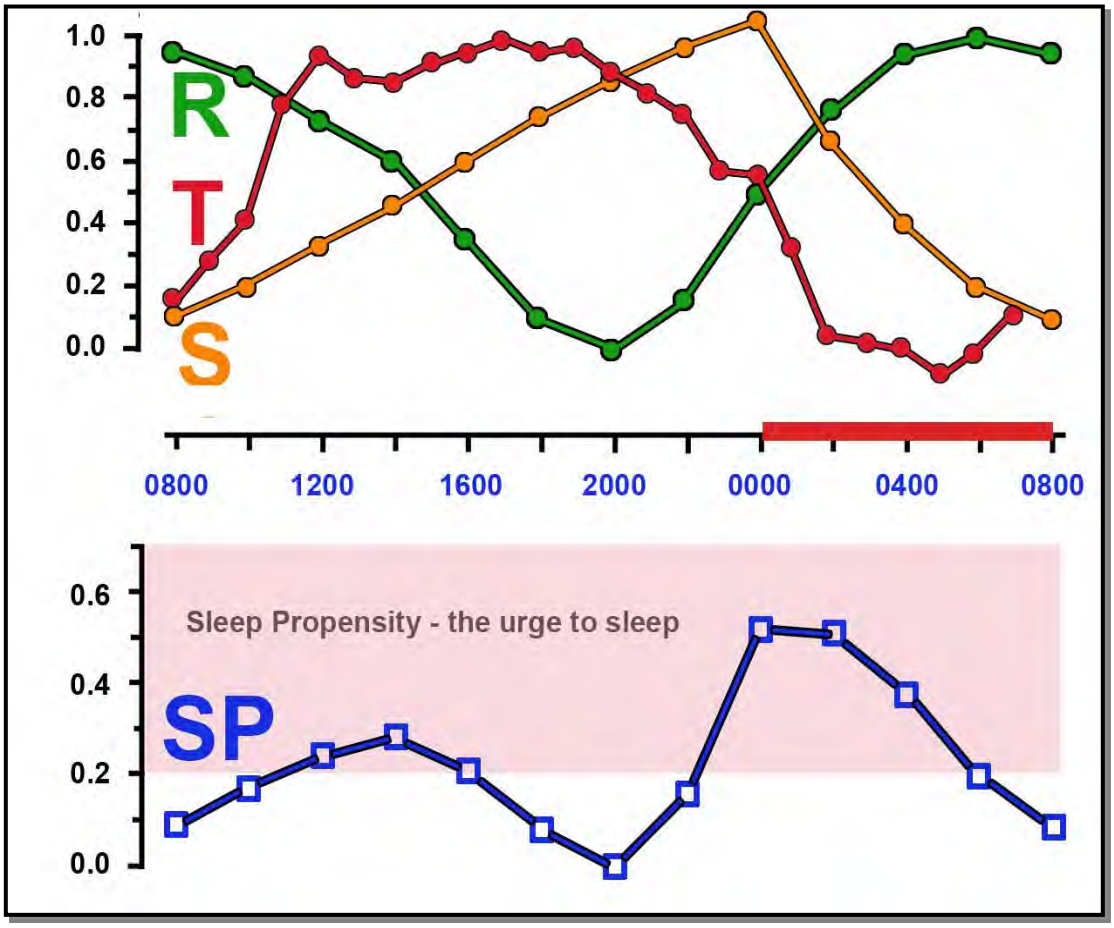


Figure 3.52 The Sleep Propensity graph. Sleep Propensity (SP) is the desire of the body to sleep. The SP graph has been obtained by multiplying the likelihood of entering REM sleep (R) being a good indicator of circadian rhythm which is linked to melatonin production, and the body seeking sleep homeostasis (S). These are two key drives for sleep and when multiplied, give an accurate indication of the body's desire for sleep. Note also the body temperature shown as a red graph (T), and the dip in body temperature in the early afternoon. Not shown is melatonin production which is low during the day and then increases from 8pm (2000 hrs) until it peaks at 2am and then it declines until 7am. The red bar indicates when the test subjects were allowed to sleep for an 8 hour period.[130] [131]

3.11.7.4 **Sleep Phase** is a term used to describe the peaks and troughs of the daily circadian cycle related to sleep and can be quite regular for most people. When reviewing the graph above it is easy to see the normal daily sleep urge pattern. In particular, the 2pm dip which equates to the increase in drowsiness and decrease in body temperature. In most adults, the main circadian dips are between 2am and 4am and 1pm and 3pm. This can change from person to person but is relatively constant. One euphemism often used is the 'Larks and Owls' descriptor to classify early risers (larks) or people who stay up late (owls).

[130] Derived from Bes F; Jobert M; Schulz H. *Modelling napping, post-lunch dip, and other variations in human sleep propensity*. *SLEEP* 2009;32(3):392- 398.
[131] Temperature scale derived from the Body Temperature graph, 12th Edn of Encyclopedia Brittanica and the Project Gutenberg archives.

3.11.7.5 **Teenagers'** sleep patterns shift somewhat. During adolescence, a sleep phase delay occurs.[132] This results in teens feeling more alert late at night and more drowsy in the morning. Their strongest dips occur between 2pm and 5pm and between 3am and 7am or even later. Because most teens need to be roused to go to school and conform to adult timetables, this can result in teens not achieving enough sleep and explains their lacklustre performance early in the day. Some schools in Britain experimented with later class times for teenagers with 10am starts commonplace.

3.11.7.6 **The Phases of Sleep** follow a reasonably regular pattern repeating itself about every 90 minutes, often called a sleep cycle. There are two classifications of sleep: REM sleep and Non-REM sleep. REM stands for Rapid Eye Movement and is a light phase of sleep also called paradoxical sleep because brain activity is high and similar to that found during waking hours. The phases of sleep are described below as cited in the National Sleep Foundation (US) website which explains it well:[133]

- **NREM** (75% of night): As we begin to fall asleep, we enter NREM sleep, which is composed of stages 1-4
    - **Stage 1 (N1)**
        - Between being awake and falling asleep
        - Light sleep
    - **Stage 2 (N2)**
        - Onset of sleep
        - Becoming disengaged from surroundings
        - Breathing and heart rate are regular
        - Body temperature drops (so sleeping in a cool room is helpful)
    - **Stages 3 and 4 (N3 and N4)**
        - Deepest and most restorative sleep
        - Blood pressure drops
        - Breathing becomes slower
        - Muscles are relaxed
        - Blood supply to muscles increases
        - Tissue growth and repair occurs
        - Energy is restored
        - Hormones are released, such as: Growth hormone, essential for growth and development, including muscle development

- **REM** (25% of night): First occurs about 90 minutes after falling asleep and recurs about every 90 minutes, getting longer later in the night
        - Provides energy to brain and body
        - Supports daytime performance
        - Brain is active and dreams occur
        - Eyes dart back and forth
        - Body becomes immobile and relaxed, as muscles are turned off

[132] National Sleep Foundation, *Sleep Drive and Your Body Clock,* http://www.sleepfoundation.org/article/sleep-topics/sleep-drive-and-your-body-clock accessed 15 Jul 12.
[133] National Sleep Foundation, *What happens when you sleep?* http://www.sleepfoundation.org/article/how-sleep-works/what-happens-when-you-sleep accessed 15 Jul 12.

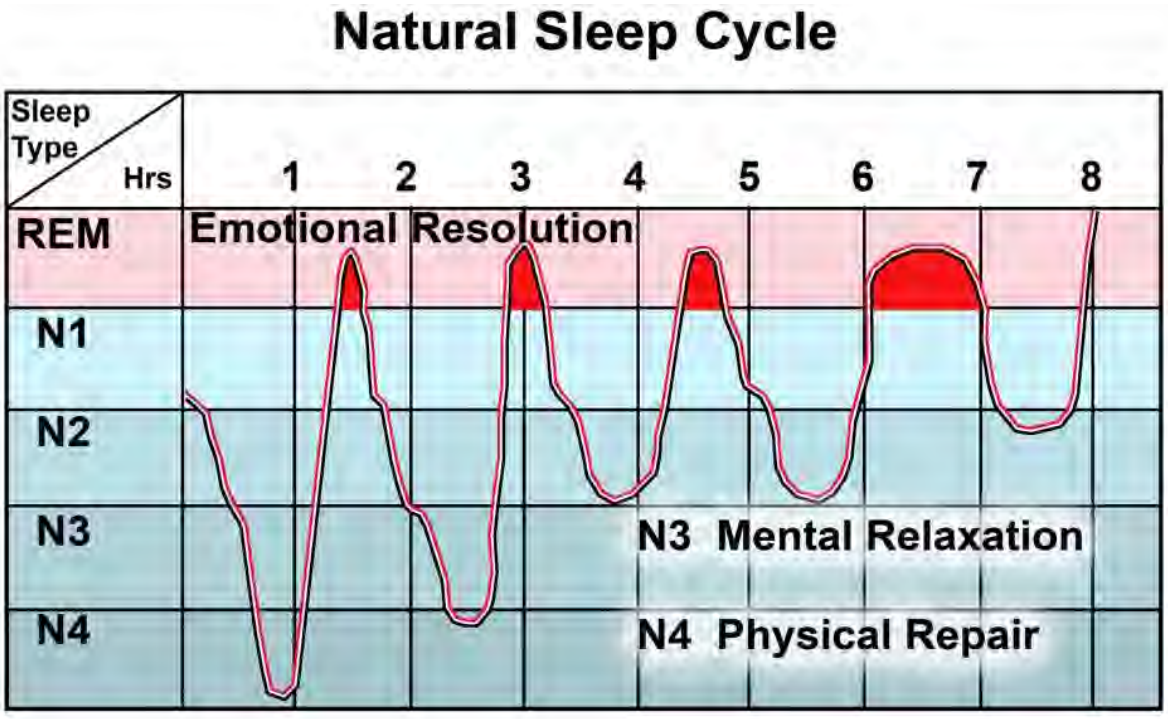


Figure 3.53 Natural Sleep Cycle. [134] A generalised graph showing times and lengths of REM sleep and NREM sleep.

3.11.7.7 **Naps** are short periods of sleep taken during the day. It has both beneficial and negative effects. Integrating a nap into a normal workday is not widely accepted in many cultures that have their origins in northern Europe and Britain, but is widely accepted in countries that are situated in hotter climates where midday breaks are sanctioned as part of the normal daily cycle. Naps do not provide the same benefit as a prolonged sleep and so should not be used as a substitute for restorative sleep, however naps are useful in providing short term rejuvenation and allow for increased alertness and productivity provided that they do not last longer than about 20 minutes (known as a 'Power Nap'). After this time, the body is more likely to enter N3 sleep (see paragraph on sleep) whereupon the depth of sleep is so great that emerging from it takes a significant amount of time with an associated feeling of grogginess. This is known as sleep inertia and occurs when a person is roused from N3 or N4 sleep. One other type of nap is the Caffeine Nap. Because caffeine takes up to 30 minutes to take effect, a cup of coffee immediately prior to taking a nap has no effect on the actual nap itself, but rather will increase the alertness of the body upon rousing.[135]

[134] Derived from studies conducted by DRs Cartwright, R.D., Luten, A., Patel, A., and Yound, M., as presented at 11th Annual Conference of APSS. As cited in *'Getting More REM Sleep Contributes to Waking Up in a Good Mood", Hammon, A.C.,* http://www.quantadynamics.com/research/performancerem.htm, accessed 30 Oct 13.

[135] Wikipedia, *Nap,* http://en.wikipedia.org/wiki/Nap accessed 15 Jul 12.

Notes:

GROUP 2 – THE HUMAN CONTEXT

The Element/s in this Group relate to the Human Being and how his/her body works.

ELEMENT 4 – Human Error and Threat Management

Contents:

Module 4.1

4.1 **Principles and Components of TEM.** CASA has gone to great lengths in recent years to articulate its policy on threats and human error, which it calls TEM – Threat and Error Management. It categorises the concept into three key areas:

- Threats
- Errors
- Undesired Aircraft States (UAS).

For our purposes, because CRM applies not only to aircrew, but to anyone conducting what could be considered a high risk activity, we shall call the last key area:

- Undesired Apparatus Situation (UAS)

We shall also use some other terms as listed in the Australian Standard on Risk Management because Risk and Error Management go hand in hand and complement each other. These definitions have been adapted from the reference[136] which is the outcome of a combined effort by the Standards Councils of Australia and New Zealand which also had representation by such organisations as Emergency Management Australia, International Association of Emergency Managers, Law Society of NSW, Risk Management Institution of Australia, UNSW, Engineers Australia, Australian Computer Society, et al. The definitions of interest are:

- Risk – the effect of uncertainty on objectives.
    - An effect is a deviation from the expected which can be positive or negative
    - Is often characterised by reference to events and consequences or a combination of both and the associated likelihood
    - Uncertainty is a partial or complete lack of information related to an event, its consequences or its likelihood.
- Consequence – the outcome of an event that has an effect on objectives.
- Likelihood – the chance of something happening.
- Risk Assessment – the process of identifying risks, analysing them and then evaluating them.
- Risk Management Plan – a scheme that specifies the approach, management, components and resources to be applied to the management of risk.

Section

[136] Australian Standards, AS/NZS ISO 310000:2009, *Risk Management – Principles and Guidelines,* Joint Technical Committee OB-007, Risk Management, Sydney and Wellington, Oct 2009,

4.1.1 **Definition of Threats.** One definition of threat is that it is: *"…an event, or an error, made by others, that occurs beyond the influence of the flight crew, increases operational complexity, and which must be managed to maintain the margins of safety."*[137] This is obviously an aircrew-centric definition which does not suit all activities where CRM is used. The advice issued by the Australian aviation regulator on the subject of TEM provides another definition of threat. Their definition is a derivation of the University of Texas definition which is relevant to multi-crew aircraft operations but which CASA has modified in order to encompass single pilot operations. Because CRM applies to other high risk environments, not just aviation, we shall make a further modification to CASA's definition. For our purposes, threat is defined as:

A situation or event that has the potential to impact negatively on the safety of an operation / activity or any influence that promotes opportunity for human error(s)[138]

4.1.2 **External, Internal and Latent Threats.** An **External Threat** is any situation or event that has the potential to have a negative impact on the operation and which is outside the control of the team/crew/individual and which may have to be dealt with as part of the operation. Probably the most common external threat to most high risk activities is weather. In aviation and in emergency services, weather has the potential to change the tactical situation during an operation quickly and cause unexpected results. An **Internal Threat**, on the other hand, is any threat that comes from within the team or the crew or the individual. An example of internal threats can be human performance limitations and psychological limitations. The final type of threat category is **Latent Threat**. These are 'hidden' threats that may not be readily obvious to the outside observer but are often revealed to persons within the organisation, especially to those that have a working knowledge of what is going on 'behind the scenes'[139] or through safety analysis[140]. These can often be uncovered during the course of an accident investigation.

Some examples of External Threats, Internal Threats and Latent Threats are shown in the table below.

EXTERNAL THREATS	INTERNAL THREATS	LATENT THREATS
Environmental conditions	Fatigue	**Commercial Pressure**
Terrain	Complacency	**PR Pressures**
Other operators	Inexperience	**Management Changes**
External influences	Human Perf Limitations	**Ineffective**

[137] Robson, D., *Vol 15 of Civil Aviation Reference Manual - Human Being Pilot: Human Factors for Aviation Professionals,* Aviation Theory Centre, 2008.
[138] *Teaching and Assessing Single Pilot Human Factors and Threat and Error Management,* CAAP 5.59-1(0), October 2008, CASA, Canberra.
[139] CASA, *Safety Behaviours,* 2009, Canberra
[140] CAAP 5-59 op.cit.

		Documentation
Physical Stress inducing conditions (eg Noise)	Teamwork barriers (eg Crew Unfamiliarity)	**Faulty or sub-optimal equipment**
Hostile environments (eg enemy action)	Cultural constraints	**Schedule/Rosters/Duty**
Obstructions	Incorrect mental model	**Poor ergonomics**
	Personal Stress	**Reversionary Behaviour (stress induced return to pre-learned responses)**
	Poorly ingrained or executed training	**Poor morale within the organisation due to various factors**
		Reduction in manning within the organisation resulting in loss of corporate knowledge and residual stress

Table 4.1 Various examples of threat types

Figure 4.1 A Threat Awareness Reporting Program for internal security threats to the US. Threats come in many different types. In this case, it is a threat to national security through the release of sensitive information that could endanger lives. (Public Domain)

4.1.3 **Categories of Threats.**

- **Anticipated Threat** – Many threats come as no surprise to the operator. These threats appear to the operator as part of the planning process and allows for the operator to plan for their occurrence. For example, a weather report will provide a significant amount of information related to threats to the operation which a person can plan for, such as an approaching cold front with a wind speed and direction change and associated rain and cloud. By planning for this threat, stress can be significantly reduced and mission success optimised. Anticipated threats can be external, internal and even latent and an experienced operator can plan for them and put in place mitigations to minimise their effects.

Figure 4.2 [141] A storm approaches. Environmental threats are external threats which might be anticipated or unanticipated.

- **Unanticipated Threats** – These threats are those that are not known to the operator and which present a very significant hazard to him/her. It is these threats that increase the likelihood of errors occurring which can result in negative mission impacts. An example of an unanticipated threat could be exactly the same as the anticipated threat listed above; that is the approaching cold front with associated weather changes. It is unanticipated if the operator was unaware of its approach. In this case, is the operator at fault? The answer would be 'Yes' if s/he had the pre-requisite knowledge that a check of the weather was necessary for the operation and that this was a rule that was expected to be followed. If the operator was unaware of this necessity, then the approaching cold front would be an unanticipated threat.

In the above definitions, it can be seen that a threat will have a type and a category: An External, Internal or Latent type of threat AND an Anticipated or Unanticipated category of threat.

Section

4.1.4 **Definition of Error.** As with the definition of threat, error has also been defined by CASA. For our purposes, we shall modify the definition so that it is relevant to any high risk operation, as follows:

Errors are Individual or Team actions that:

[141] CC-BY-SA-3.0 http://upload.wikimedia.org/wikipedia/commons/9/98/Cumulonimbus-tav.jpg Cumulonimbus cloud in central Oklahoma. This photo is (c) 1999 Tim Vasquez and is released under the terms of GNU FDL. Source: dutch wikipedia, original upload 15 aug 2004 by [[:nl:Geb

- *Lead to a deviation from individual/team or organisational intentions or expectations;*
- *Reduce safety margins; and*
- *Increase the probability of adverse operational events.*

Section

4.1.5 **Categories of Errors.** James Reason's Error Categorisation system is extremely useful in not only studying errors, but also how we react to them. He classified two broad areas in which to study errors: Intended Actions and Unintended Actions[142]. By classifying errors in this way, he was able to separate them further into four key types of errors based on the work of Donald Norman who said:

> *"If the intention is not appropriate, this is a mistake. If the action is not what was intended, this is a slip.[143]"*

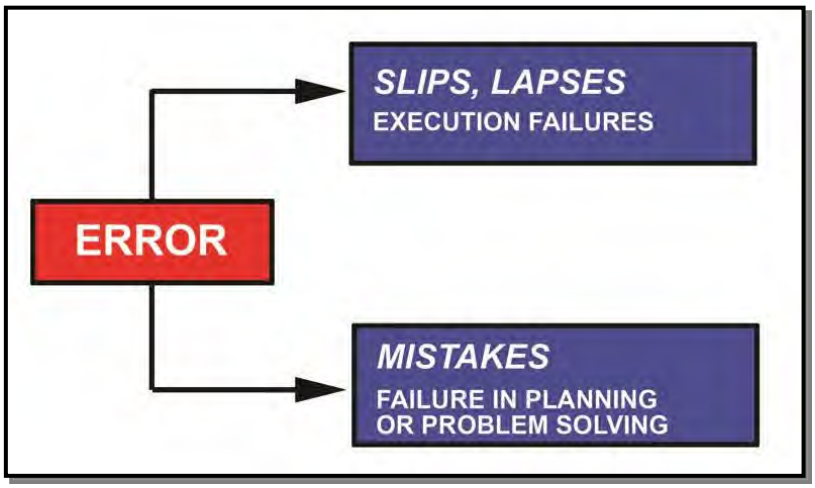


Figure 4.3 Two categories of Errors: Unintended Actions (Slips and Lapses) and Intended Actions (Mistakes).

4.1.5.1 **Slip.** An unintentional situation where the intention was correct but the action was incorrectly carried out. An example might be something like reaching for a can of soft drink on the edge of your desk whilst sitting in the auditorium, and accidentally bumping it causing it to spill. The intention was correct, and the action that was intended to be performed was appropriate, but the intended action did not occur.

4.1.5.2 **Lapses.** When an unintentional situation occurs because an act is committed, or not committed, due to a lapse in concentration or knowledge. Here is an example: Let's say you are driving in the US in a left hand drive car. You are told that the indicator and the windscreen wiper controls are reversed, (ie indicator is on the left and windscreen wiper control is on the right). You approach a turn and you unintentionally activate the windscreen wiper when you intended to activate the indicator. This is a lapse because you have been

[142] Reason J. *Human Error*. New York: Cambridge University Press; 1990
[143] Norman, D. A. (1983): *Design Rules Based on Analyses of Human Error*. In Communications of the ACM,

instructed in the differences, but you had a lapse in concentration when it came time to apply your knowledge. Using the can of soft drink example from the paragraph above, it is when the individual places the can under his/her seat with the intention of taking it when s/he leaves, but forgets and leaves it behind. This is a lapse.

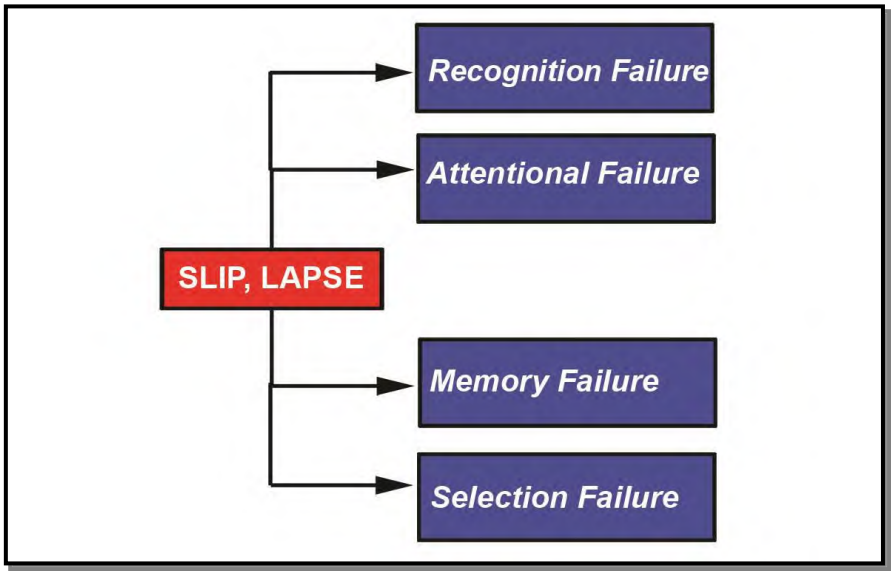


Figure 4.4 Some examples of slips and lapses, both of which are unintended errors.

4.1.5.3 **Mistakes.** When an unintentional situation occurs due to a deliberate act that was a result of lack of knowledge. In the above examples, the driver drives down a one way street but did not realise it was a one-way street. The intention was appropriate (ie drive to the other end of the street), but due to inadequate knowledge, the action was inappropriate. In other words, a mistake was made, but there was no malicious intent in the making of the mistake. In the soft drink example, if a person takes a can of soft drink into the auditorium, but did not realise that there was a 'No Food or Drink in the Auditorium' policy, then this was a mistake borne out of ignorance of the rule.

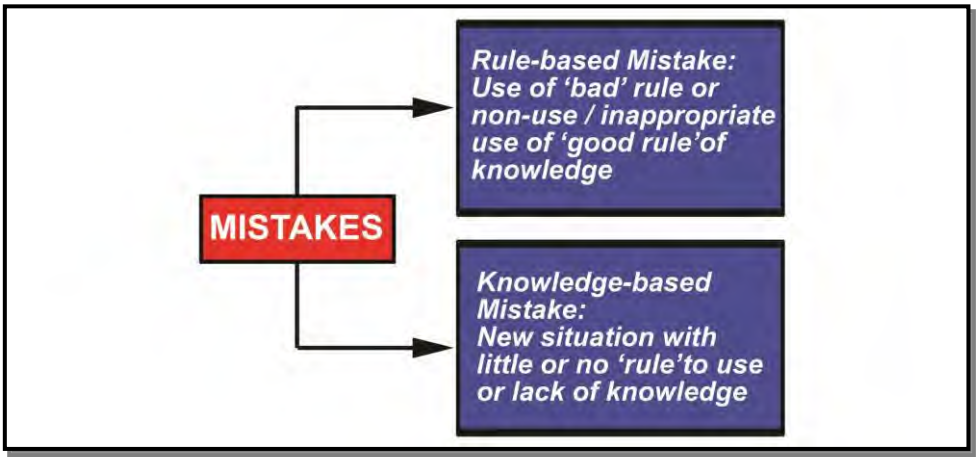


Figure 4.5 Mistakes can be due to poor application of good rules or when a new situation arises and the operator has no background knowledge upon which to rely.

4.1.5.4 **Violation.** Where an intentional inappropriate action is carried out with intent. Again, using the above examples: where the driver knows that the street is a one-way street,

but drives down it against the flow of traffic anyway, or if the soft drink drinker knew of the 'No Food or Drink' rule, and took the can of drink into the auditorium anyway.

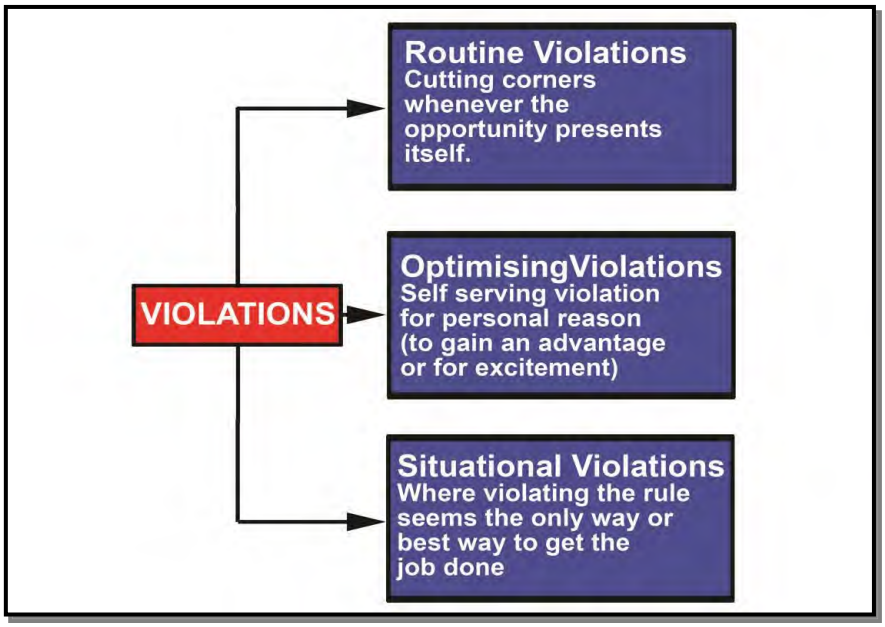


Figure 4.6 Various types of violations where rules were deliberately ignored.

4.1.5.5 **Dealing with Errors, Mistakes and Violations.** The key to the above situations is that the first three are situations where inappropriate acts were committed but without the intention of committing an inappropriate act. The last act is different because the action was committed with the intention to do so even though the individual knew it was the wrong thing to do. This is important to differentiate between the two types of actions. Errors and mistakes are free of malicious intent whereas violations have malicious intent. When a supervisor is confronted with an error, mistake or violation, this differentiation should be taken into account when dealing with it. Note also that this differentiation is used in the HFACS classification discussed next.

Section

4.1.6 **Human Factors Analysis and Classification System.** Following on from Reason's and Norman's classifications, two US Navy doctors devised a taxonomy to assist with investigating aviation accidents and incidents. This classification system became the accepted method of categorising various Human Factors causes of incidents and accidents which, in turn, looked closely at the errors and unsafe situations that precipitated them. In effect, it was an expansion on Reason's models of accident causality.

4.1.6.1 **The construct of the Taxonomy.** A taxonomy is a method of classification, usually into a tier or level system. Normally used to classify biological organisms (eg vertebrates or insects or all animal life on the planet), here it is used to classify unsafe conditions that may be useful in accident investigation and which can also be used to look more closely at human error. The concept behind the taxonomy is to provide a system for an investigator or other person looking into incidents and accidents a means by which to classify possible HF causal factors. It has been seen that almost all accidents will have recurring 'themes' and it is these 'themes' that are being identified. The following is a brief description of the taxonomy as it pertains to errors and violations at the first level.

4.1.6.2 **The HFACS 1st Level** divides the unsafe acts into the two categories: errors and violations, and then expands upon them. In their model, they look at the act of making an error as being:

- **Skill Based** – where the method in which an operator executed a routine task resulting in an unsafe situation due to things like prioritisation failures, or incorrect execution of a standard checklist item, etc.

- **Decision Errors** – where the intended action was carried out but was based on faulty cognitive skills in judgement and decision making. (Mistakes fit into this category).

- **Perceptual Errors** – where decisions are made based on limitations to the perceptions of the operator due to things like poor visibility or incorrect information being supplied.

4.1.6.3 The system also classified violations into two general areas:

- **Routine Violations** – where a rule was violated on a regular basis and which may have been tolerated by some higher authority.

- **Exceptional Violations** – where the violations were isolated and not normally carried out by the operator and which would not be condoned by the authority.

The Human Factors Analysis and Classification System		
ORGANISATIONAL INFLUENCES	Resource/Acquisition Management	
	Organisational Climate	
	Organisational Process	
SUPERVISION	Inadequate Supervision	
	Planned Inappropriate Operations	
	Failure to Correct Known Problem	
	Supervisory	

	Violation		
PRECONDITIONS	Environmental Factors	Physical Environment	
		Technological Environment	
	Conditions of Individuals	Cognitive Factors	
		Psycho-Behavioural Factors	
		Adverse Physiological States	
		Physical/Mental Limitations	
		Perceptual Factors	
	Personal Factors	Coordination/Communication/Planning Factors (CRM)	
		Self-Imposed Stress	
ACTS	Violations	Routine	
		Exceptional	
	Errors	Skill Based Errors	
		Judgement and Decision Making Errors	
		Misperception Errors	

Table 4.2 Human Factors Analysis and Classification System (HFACS)

Section

4.1.7 **Errors and Threats.** As stated previously, a threat is any event or situation that has the potential to impact negatively on the safety of the operation/activity or any influence that promotes opportunity for human errors. Whilst threats may increase the chance of human error occurring, there are occasions where errors occur without threat. Some of the examples have already been cited in the paragraphs above. Here are some further examples or explanations.

4.1.7.1 **Error Types Independent of Threats.** Because we are human, we make errors… and these errors can be made at any time, not just when threats induce them. An example of an error that is not induced by a threat – ie it is independent of threats – can be something like activating the wrong switch (slip) when you are not under any sort of pressure or forgetting to save a file before closing down your computer (lapse) or driving 60 km/hr in a 50 km/hr zone because you were unaware of the speed limit (mistake).

4.1.7.2 **Error Types Induced by Threats.** Errors that are induced by threats are manifold. This whole manual is full of various threats to safety and the errors that can be induced by those threats. For example, making a mathematical error during planning whilst under time pressure to start a mission or task (slip) or allowing yourself to be interrupted whilst you are conducting certain checks and forgetting to complete certain actions (lapse) or driving down a dead end street because the kids were screaming in the back seat (mistake).

4.1.7.3 **Procedural Methods to prevent Errors.** There are many ways to try and prevent errors, some of which use set procedures. As has been said, Standard Operating Procedures are those actions which have been prescribed and standardised in order to address particular situations which have been encountered before and are likely to be encountered again. That is one Procedural Method designed to prevent errors. Here are some others, many of which are also addressed in other elements of this manual.

- **Use SOPs** – Standardised procedures such as Standard Operating Procedures (SOPs) are designed to remove much of the need for cognitive processing which is the first step in committing an error. By using standardised procedures that have been proven to work helps to reduce the likelihood of errors.
- **Use Checklists** – Checklists and Manuals, especially those created by the manufacture of mechanical equipment (vehicles, aircraft, machines), provide the best possible means of avoiding errors in handling. By adhering to the manufacturer's recommended operating limits and emergency actions, the likelihood of damaging the equipment through erroneous operation is minimised. (Be aware, however, that in many cases, these can also be a threat, especially if the quality of the writing or the interpretation of the terminology is questionable. An example would be the translation of manuals from one language into another language where nuances in the languages can be lost in translation and can cause misunderstandings and confusion).

- **Use CRM Principles: Teamwork** – By using every member of your team – including those persons who are not in your immediate team but who's input can assist in you achieving your goals – you reduce the chance of error by engaging more cognitive processing and viewpoints and experience.

- **Use CRM Principles: Communication** – By communicating and articulating conditions, it allows others to assess your actions and thought processes. This may be something as simple as repeating some important information out loud so the other person next to you can hear it and understand what your understanding is, or it could be something more prescribed like reporting to the chain-of-command any unusual situation and your actions so that they have situational awareness of what you are doing so that they can log your position and decisions for future reference.

- **Use CRM Principles: Planning, Briefing and De-Briefing** – By conducting proper prior planning, the individual and/or team is able to consider the mission or task and create a mental model of what to expect. As part of that modelling, contingency planning is an important component; the 'If…Then…' logic loop. By contingency planning, the operator tries to consider the most likely and worst possible scenarios and by so doing, is thinking about what threats there are to consider that may jeopardise the safe outcome of the mission/task.

- **Use CRM Principles: Decision Making** – In the element on Decision Making, there are a number of DM models that are discussed. One common element in all of them – and which has been discussed above also – is that of monitoring

and reviewing. By monitoring plans and reviewing them against the mission/task aims, the operator can make adjustments to increase safety and efficiency and minimise the likelihood of errors. This also applies to the DM principles especially when plans go awry and DM needs to be conducted during high stress situations. Monitoring and Reviewing new plans becomes even more important.

- **Use Appropriate Persons to provide crosschecking** – The ability to successfully apply good Threat and Error Management relies a great deal on experience. In many cases, the team leader is not necessarily the most experienced person for the situation. In these situations, it is important to get experienced persons involved in the decision making processes. This also applies to planning a mission or task where the input of an experienced person is vital especially if that person has an unbiased view on the mission/task being planned and can provide frank and honest advice.

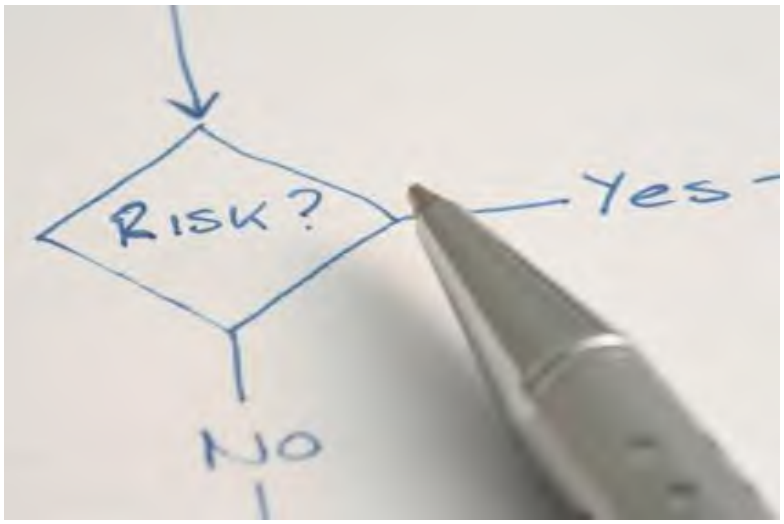
Module 4.2

4.2 **<u>Managing Human Error by Risk Management.</u>** In all human activities, error can occur, either by failures of the individual or by failures in the systems in which the individual is required to work. It is understanding this risk and then putting in place mitigations that we can hope to minimize the likelihood and/or consequences of error. Risk management consists of establishing the components of risk; the underlying hazards and the relevant context, the exposure of the individual to the hazard, the likelihood of the occurrence happening and the consequences. From these components comes a risk assessment. Below is a very brief synopsis of a risk assessment. Compare it to the diagram below derived from the Australian Standard.

4.2.1 **Putting the hazard in Context**. This is the start of risk management; placing the risk into context. This means understanding the nature of the operation that is to be assessed for risk and then identifying the risks. For example, a mustering operation using helicopters may not see Helicopter Underwater Escape Training as a vital need. The operation is mainly conducted over inland areas where water is scarce and so the risk of ditching a helicopter into the water is remote. A more appropriate risk might be power lines. The offshore oil regular public transport operation that goes from a runway environment, over a large expanse of water to an oil platform would not have the same risk for power lines but would have a significant risk for ditching a helicopter in the water.

4.2.2 **Analysing and Assessing the Risk**. After putting the risk into context, the next stage is to assess what the possible outcomes of that hazard may be and the exposure to that risk. In the above example, if the RPT operation decided to conduct some low-flying training over an inland training area, then the risk of ditching is probably non-existent. The consequence of ditching remains the same, but the exposure is different for each operation; high level of exposure for a flight to an oil rig but extremely low/non-existent for the low flying training. These two factors will determine the risk level for that particular hazard.

4.2.3 **Accepting the Risk and Applying Treatments**. Once the risk level has been established, the organisation must apply its own system of determining how to control these risks. One control may be once a risk has been defined, the operator may decide operational mitigations should be put in place. Another may be that a senior member of the organisation must authorize the operation to be conducted and to take responsibility for it.



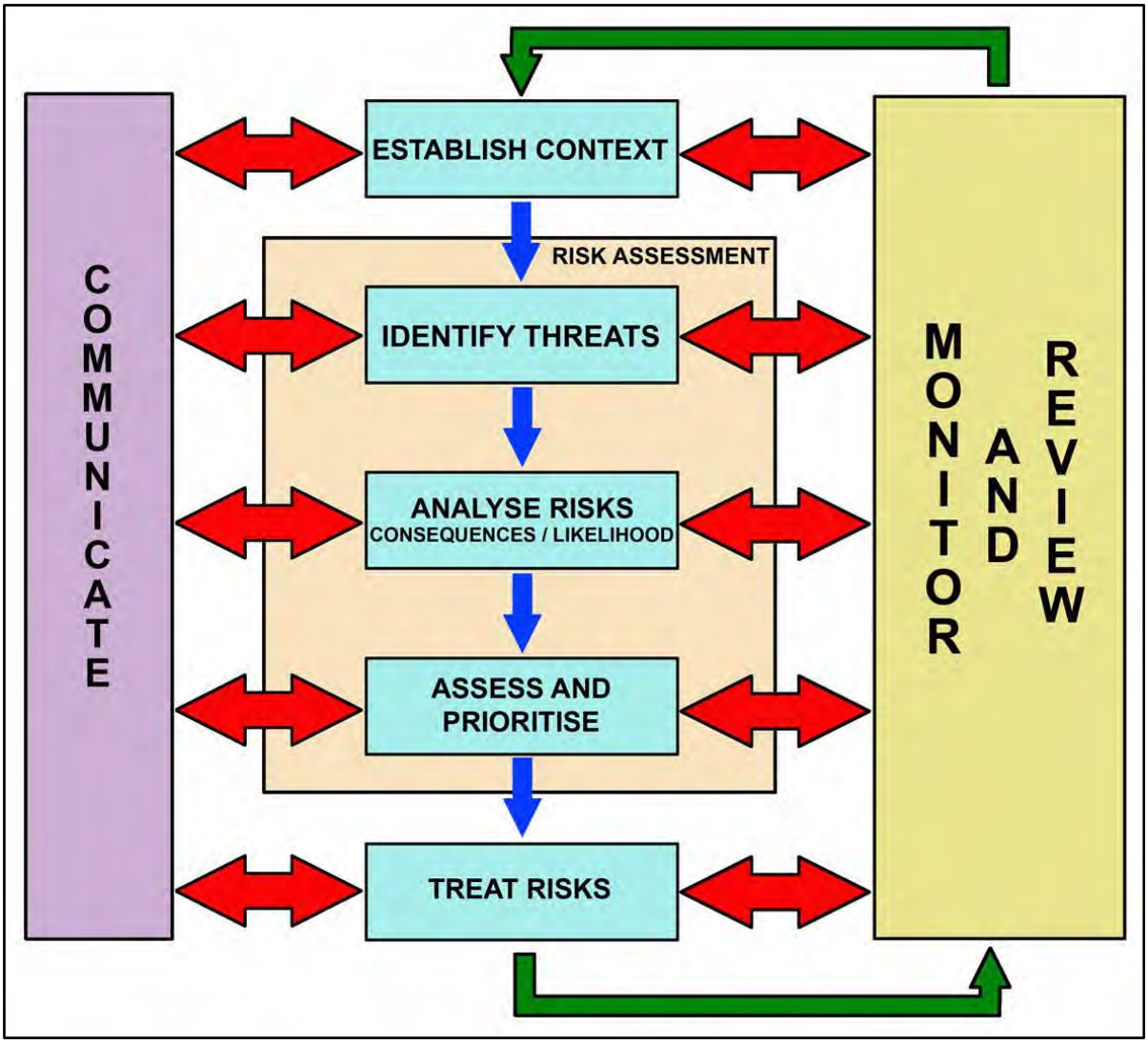


Figure 4.7 The risk management process – with a minor modification – as per the Australian Standard. Note how it is a multi stepped and concurrent process. As each step is accomplished, it is the subject of communication amongst stakeholders and is monitored and reviewed. Once risks have been treated, they are also monitored and reviewed. The whole process is a Risk Management Process, with the Risk Assessment a component of it and the subsequent plan to treat the risks the Risk Management Plan.

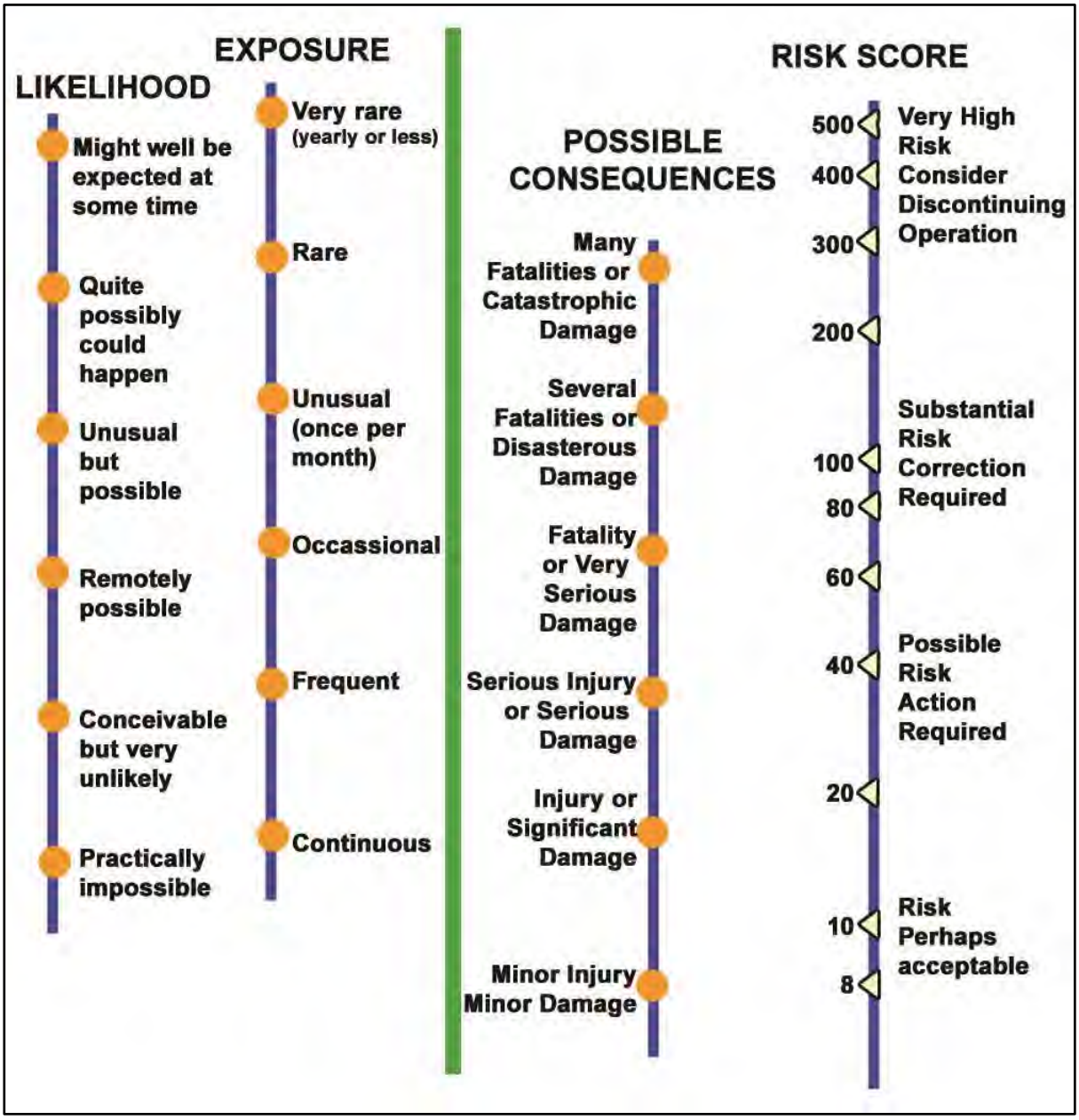
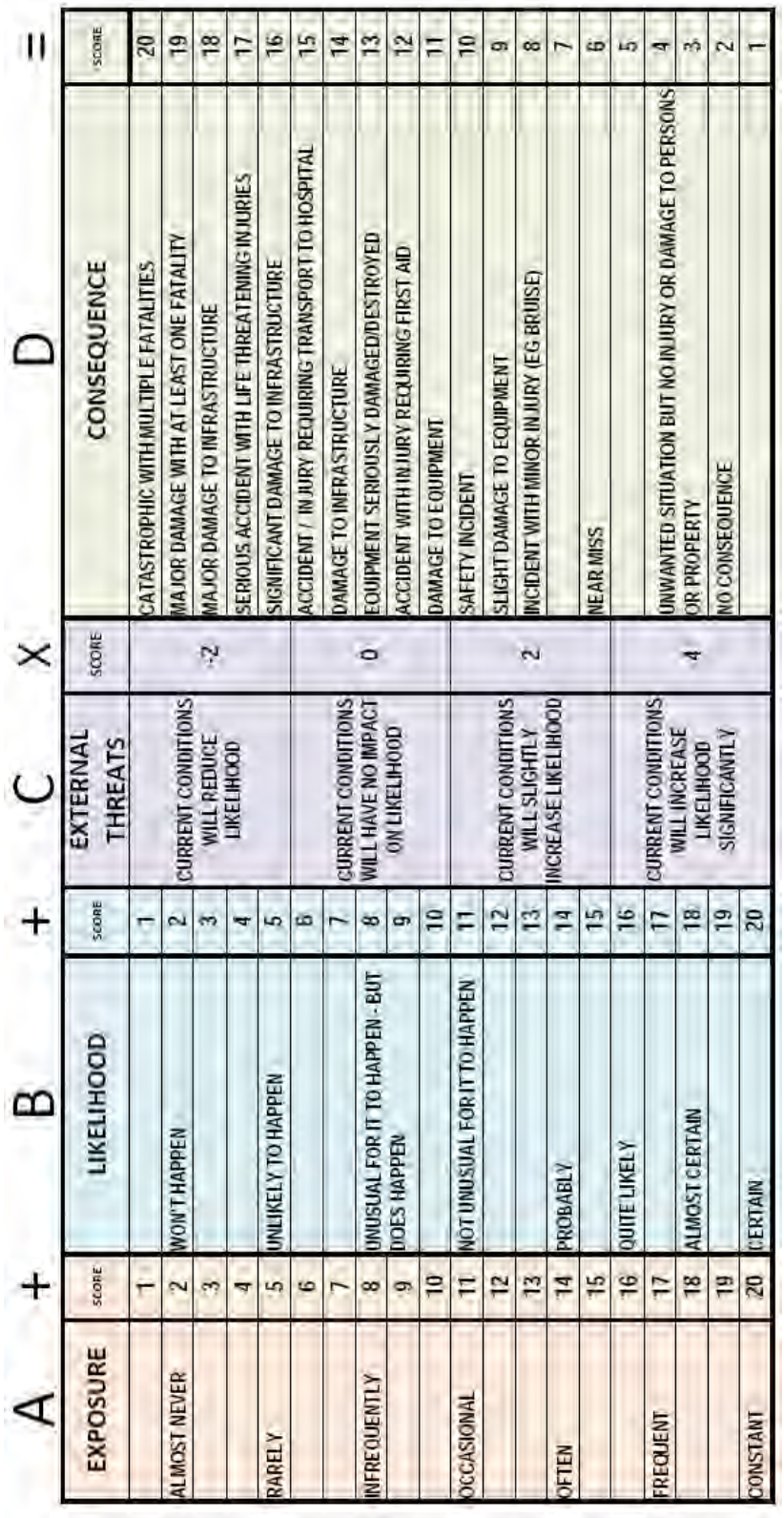


Figure 4.8 A risk nomogram. This simple tool is another means of conducting a risk assessment in order to ascertain a risk score. In this method, the assessor of the risk identifies points on each vertical line representing Likelihood, Exposure and Possible Consequences. S/he joins the first two, extends the line so that it reaches the central Tie Line, and then joins that intersection with the Tie Line through the Possible Consequences reaching the Risk Score. This score can be used in Safety Management Systems but, like most similar tools, is subject to bias.



A	+	B	+	C	X	D	=
EXPOSURE	SCORE	LIKELIHOOD	SCORE	EXTERNAL THREATS	SCORE	CONSEQUENCE	SCORE
	1		1			CATASTROPHIC WITH MULTIPLE FATALITIES	20
ALMOST NEVER	2	WON'T HAPPEN	2	CURRENT CONDITIONS WILL REDUCE LIKELIHOOD	-2	MAJOR DAMAGE WITH AT LEAST ONE FATALITY	19
	3		3			MAJOR DAMAGE TO INFRASTRUCTURE	18
	4		4			SERIOUS ACCIDENT WITH LIFE THREATENING INJURIES	17
RARELY	5	UNLIKELY TO HAPPEN	5			SIGNIFICANT DAMAGE TO INFRASTRUCTURE	16
	6		6			ACCIDENT / INJURY REQUIRING TRANSPORT TO HOSPITAL	15
	7		7	CURRENT CONDITIONS WILL HAVE NO IMPACT ON LIKELIHOOD	0	DAMAGE TO INFRASTRUCTURE	14
INFREQUENTLY	8	UNUSUAL FOR IT TO HAPPEN - BUT DOES HAPPEN	8			EQUIPMENT SERIOUSLY DAMAGED/DESTROYED	13
	9		9			ACCIDENT WITH INJURY REQUIRING FIRST AID	12
	10		10			DAMAGE TO EQUIPMENT	11
OCCASIONAL	11	NOT UNUSUAL FOR IT TO HAPPEN	11			SAFETY INCIDENT	10
	12		12	CURRENT CONDITIONS WILL SLIGHTLY INCREASE LIKELIHOOD	2	SLIGHT DAMAGE TO EQUIPMENT	9
	13		13			INCIDENT WITH MINOR INJURY (EG BRUISE)	8
OFTEN	14	PROBABLY	14				7
	15		15			NEAR MISS	6
	16	QUITE LIKELY	16				5
FREQUENT	17		17	CURRENT CONDITIONS WILL INCREASE LIKELIHOOD SIGNIFICANTLY	4	UNWANTED SITUATION BUT NO INJURY OR DAMAGE TO PERSONS OR PROPERTY	4
	18	ALMOST CERTAIN	18				3
	19		19			NO CONSEQUENCE	2
CONSTANT	20	CERTAIN	20				1

Figure 4.9 A risk calculating spreadsheet. Another form of assessing risk. The residual score is a subjective valuation that is put in place by the safety management managers of the organisation.

Module 4.3

4.3 **Undesired Apparatus States.** (aka for aviation purposes: Undesired Aircraft States). A variation on the CASA definition of this undesired state, which can be applied to aircraft and to other types of machinery:

> *"An operator induced position or speed deviation, misapplication of controls or incorrect configuration of the system or equipment associated with a reduced margin of safety."*[144]

When we discuss UAS, it is easy to think of the default setting of the aviation environment, but with some lateral thinking, the UAS scenario can quite easily be applied to any apparatus that is used to complete a mission or task, especially – but not limited to – transport machinery. Any machine can be put in an undesired state, but transport machinery have the added dimension of speed and inertia and so in most cases, undesired states for those apparatus may have significantly greater consequences. Not all UAS will lead to an accident or incident, but if not corrected and the apparatus is not returned to normal conditions, may indeed do so.

Section

4.3.1 **Categories of UAS.** The causes behind UAS can be varied, but fall into these broad categories:

- **Handling of the Apparatus** – due to mishandling on the part of the operator with some examples being:
  - Incorrect speed
  - Poor or incorrect or inappropriate operation of the apparatus
  - Incorrect location (ie being lost or not being in the correct place or violating a restricted or hazardous area)
- **Ground Navigation** – usually applied only to aircraft but includes the above conditions but when operated on the ground.
- **Incorrect Apparatus Configurations** – due to non-compliance with rules or procedures or errors, with some examples being:
  - Incorrect flap settings (aircraft);
  - Operating with some form of hindrance still in place (eg hand brake still applied to a vehicle; warning flag or cover still in place when it should have been removed)
  - Incorrect equipment set up;
  - Incorrect loading.

4.3.2 **Error Management vs UAS Management.** The first part of this element was devoted to Error Management; where a slip, a lapse, a mistake or a violation's potential

[144] Derived from CAAP 5.59-1(0), op cit.

outcome is mitigated as much as possible. When discussing transport machinery, an error in operation can quite easily become an undesired apparatus state which needs to be managed. The question is then when does an operator go from error management to UAS management? The Eastern Airlines 401 accident is often seen as a good CRM example for distraction leading to disaster. It has many of the elements of poor CRM in it and this example is no exception. The case study below discusses some of the elements of this terrible disaster.

4.3.3.1 In the EA401 disaster is a prime example of very poor error management that became a UAS which was not managed in time. If one of the aircrew had noticed the UAS perhaps 30 seconds earlier, then all may have survived. In that case, the error management would have immediately turned to UAS management in an effort to return the aircraft to a safe flight path. Good error management in the first instance would have prevented the UAS because if the captain had demonstrated good CRM principles, he would have done the following in order to ensure errors did not occur:

- Placed the aircraft in a safe flight regime (perhaps even requesting clearance to climb to a higher altitude to afford greater safety);
- Ensured one person was responsible for flying or monitoring the autopilot to maintain a safe flight regime;
- Systematically executed a solution to the problem;
- Requested assistance from ATC during the conduct of their troubleshooting and, if the flight crew could not positively identified the front gear was down and locked, requested a low level flypast past the tower for a visual check and if it was still questionable, set up for a potential emergency landing.

Eastern Airlines Flight 401. One of the more tragic accidents in aviation history occurred four days after Christmas in 1972 when a Lockheed L-1011 operated by Eastern Airlines crashed into the Florida Everglades because of crew inattention to the flightpath. The aircraft was not experiencing any critical emergency, except for a faulty indicator light.

Eastern Airlines Flight 401 commenced its approach to Miami International Airport when the light indicating that the front landing gear was down and locked failed to illuminate. The crew requested to 'go-around' and aborted their landing approach so that they could sort out the problem. The aircraft was cleared to track away from the airport and the city and head to the west over the swamps of the Everglades where there were no lights – just inky blackness. All four members of the flightdeck crew began troubleshooting the problem.

During this period, the aircraft was being flown by the autopilot, however it has been determined that a member of the crew may have inadvertently deactivated it during this period. The aircraft flew relatively well except for a very gentle descent which was unnoticed by the aircrew, all of whom were pre-occupied with determining if the problem was an actual nose gear problem or whether it was merely a problem with the indicator light. When one of the aircrew finally noticed that they had lost altitude, he tried to make a correction but during the manoeuvre the left wingtip struck the surface of the swamp and the aircraft crashed. 99 people died in the swamp that night and a further two in hospital soon after – all because of an error on the part of the aircrew which ended up being an undesired apparatus state.

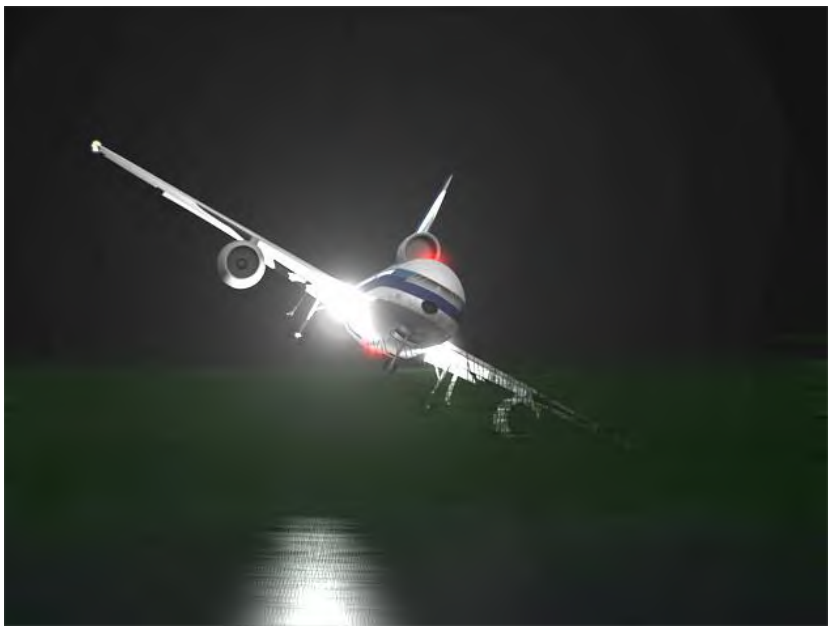


Figure 4.10 Eastern Airlines Flight 401 – its left wingtip about to impact the Everglades Swamp – was completely serviceable and airworthy except for a $12.00 light which was the factor that started the chain reaction that caused the accident.

(Image by Anynobody CC-BY-SA-2.5, http://en.wikipedia.org/wiki/Eastern_Air_Lines_Flight_401)

Module 4.4

4.4 **Countermeasures.** A countermeasure is action taken to prevent or mitigate an event or occurrence or the potential for an event or occurrence. In this context, it is the range of actions that can be used to ensure that threats and errors are prevented or their effects mitigated. Countermeasures can be human activities, procedural activities or system features.

Section

4.4.1 **Examples of Countermeasures.** The Australian aviation regulator, CASA, has created its idea of the countermeasures needed as part of TEM training. Those[145], along with some others, are shown below:

- **Use of SOPs** – SOPs are developed by organisations as the best current method of dealing with set piece situations. They are designed to maximise efficiency and safety and minimise the need for expending cognitive processes in trying to find a solution to a problem. The effective and consistent use of SOPs is the cornerstone to executing a safe mission or task. SOPs should be reviewed constantly and updated with any detection of shortcomings or with advances and changes to equipment used in the operation or the determination of better, safer and more efficient methods of achieving goals.

- **Use of Cognitive Skills** – these include the effective use and management of the following:

    - **Situational Awareness** – see the element on SA for a full account of SA and methods of identifying, and mitigations to, its loss.

    - **Information Flow** – As part of the element on SA and the element on Communication, information flow is discussed with key elements being the assessment of the information provided and comparing that to what is expected. This can be aural and oral communication; visual communication and data from automation. By analysing the information against expected conditions and mental models, likely errors can be identified and mitigated.

    - **Planning and Mental Modelling** – The elements on Situational Awareness and on Planning, Briefing and De-briefing discuss elements on this topic.

- **Team and Interpersonal Skills** – this topic is also covered in an element on the Group Dynamic with key aspects being effective communication within the team environment, using assertiveness when the situation calls for it – even in an hierarchical environment – and managing workloads.

- **System Measures** – devices created to enhance safety are considered to be TEM safety measures. Things like Ground Proximity Warning Systems (GPWS) or Traffic Collision Avoidance Systems (TCAS) and other such warning systems are perfect examples of automated features that will assist with countering the threat of anticipated and unanticipated threats and errors.

[145] Banks, I., *Threat and Error Management (TEM) SafeSkies Presentation,* Powerpoint Presentation, 27 Aug 2011, http://www.casa.gov.au/wcmswr/_assets/main/lib100030/banks-tem.pdf accessed 29 Sep 12.

NOTES:

GROUP 3 – THE INTERACTIVE CONTEXT

The Element/s in this Group relate to how the Human Being interacts with other team members and the environment.

ELEMENT 5 – Communication

Contents:

Module 5.1

5.1 **Principles and Components of Communication.** When considering the principles of communication, there are a number of factors to take into account. Just asking a person what the principles are will elicit any number of responses, and most of them will probably be correct. But like any form of communication, it all depends on context. In this module we shall discuss four principles of interpersonal communication because communicating with other people is the foundation of CRM, and we shall have a look at the individual components of communication through the communication models.

Figure 5.1 President John F. Kennedy addressing US Congress. JFK's speeches are credited as being some of the most inspiring of modern day leaders.

Section

5.1.1 **Principles of Interpersonal Communication.** One of the more revealing and appropriate discussions on the principles of interpersonal communication can be found in a paper from a college in the US where they define the principles as follows:[146]

- Interpersonal Communication is inescapable – everything a person does in any interaction with another person contains an element of communication; facial gestures, body language, tone of voice, Even the act of deliberately not communicating communicates a message, intended or not.

- Interpersonal Communication is irreversible – regardless of the best of efforts of the sender or anyone else in authority. Once a message has been sent and received, it will have an effect.

- Interpersonal Communication is complicated – regardless of how simple we try and make it. As was noted in the reference, one theory states that between two people communicating, there are often six individual filters (what they refer to as 'six people' communicating), to wit:

    - Who you think you are.

    - Who you think the other person is.

    - Who you think the other person thinks you are.

[146] *Four Principles of Interpersonal Communication,* http://www.pstcc.edu/facstaff/dking/interpr.htm accessed 20 Aug 12

- Who the other person thins (s)he is.
- Who the other person thinks you are.
- Who the other person thinks you think s(he) is. (Phew!)

Furthermore, the process of communicating means the exchange of concepts. A word is nothing more than a concept either spoken or written. In and of itself it is either a series of sound waves or a series of shapes – type of cipher – and means nothing unless the receiver can decipher them.

- Interpersonal Communication is contextual – and relies on frames of reference that can include psychological references, relational references, situational references, environment references and cultural references all of which serve to change the meaning of a communication.

In order to understand communication, we can refer to the Communication Models that have been derived over the years.

5.1.2 **The Communication Model** Communication can be described in a number of ways, many of which are explained through models. A model is a "…systematic representation of an… event in idealised and abstract form…[where] the act of abstracting eliminates certain details to focus on essential factors."[147] A number of models have been proffered over the years with various degrees of suitability, such as:

- The Linear Model.
- The Interactive Model.
- The Transactional Model.

5.1.2.1 **Linear Model –** Shannon and Weaver's model being one of the first that has stood the test of time. The reason for its success has been its use in various disciplines and fields such as journalism, linguistics, speech and hearing pathology.[148] One of the reasons for its success was its simplicity in breaking down the communication process into a structure where each constituent element explained the process but also its weaknesses. It was commissioned by Bell Labs (part of the Bell telephone group of companies) and so the concept of 'noise' was inherent in the electronic nature of communication within that industry. In the communication model, noise meant any signals that obscure or confuses the signal carried. Because of today's reliability of signal carriage, the term noise has been used as a metaphor to describe any barriers to effective listening.

[147] Mortensen, C.D., *Communication: The Study of Human Communication,* (NY McGraw Hill, 1972) as cited in http://www.shkaminski.com/Classes/Handouts/Communication%20Models.htm accessed 20 Aug 12.
[148] Foulger, D,, Models of the Communication Process, Evolutionary Media, Brooklyn College 2004 as cited on http://davis.foulger.info/research/unifiedModelOfCommunication.htm accessed 20 Aug 12

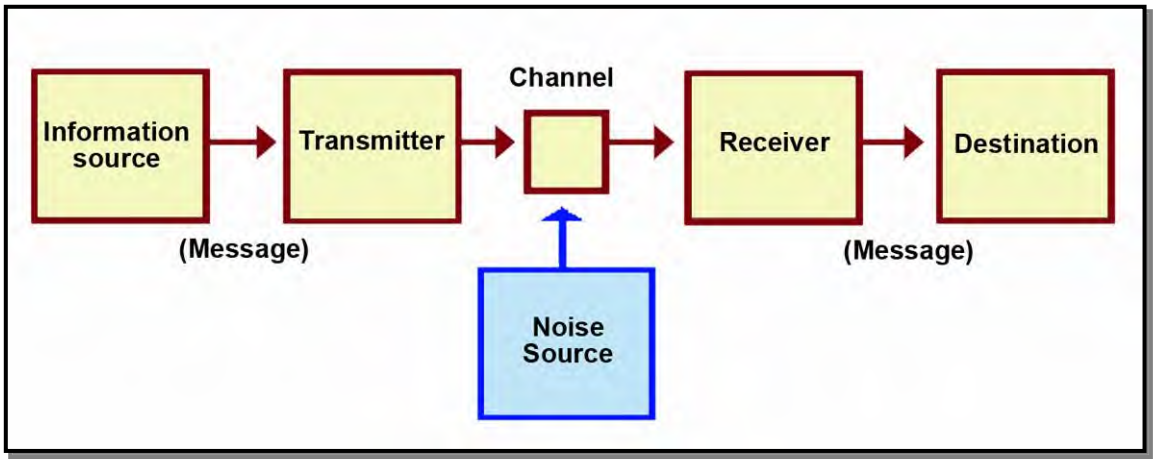


Figure 5.1 Shannon's Linear Model of Communication.

5.1.2.2 Because of the electronic nature of Shannon's model, it did not effectively provide an explanation of one of the key concepts of communication; that of feedback. In Shannon's model, because the information source and destination were usually geographically removed, the feedback often took the form of a serial communication where one message was conveyed and then ceased, then the response (feedback) commenced and ceased, et cetera. In reality, feedback can take a number of forms, with non-verbal cues being one of the most common, albeit often understated, forms of communication feedback. This gave rise to the Interactive Model of Communication.

5.1.2.3 **Interactive Model of Communication.** The interactive model of communication is a variation on the Linear Model. In its most simple form, Shannon's model is merely adjusted to reflect Feedback. This was in response to a number of criticisms of his model in that it did not accurately reflect a real communication interchange. It is important to remember that Shannon's model had its basis in electronic communication via radio and telephone, where the receiver was most likely not within visual range of the transmitter.

5.1.2.4 In the modified version of the Interactive Model depicted below, the feedback changes the receiver to a sender (ie the Destination becomes the Information Source) and the same issues that the original message encountered are also encountered by the feedback. This message also converts the destination into the information source.

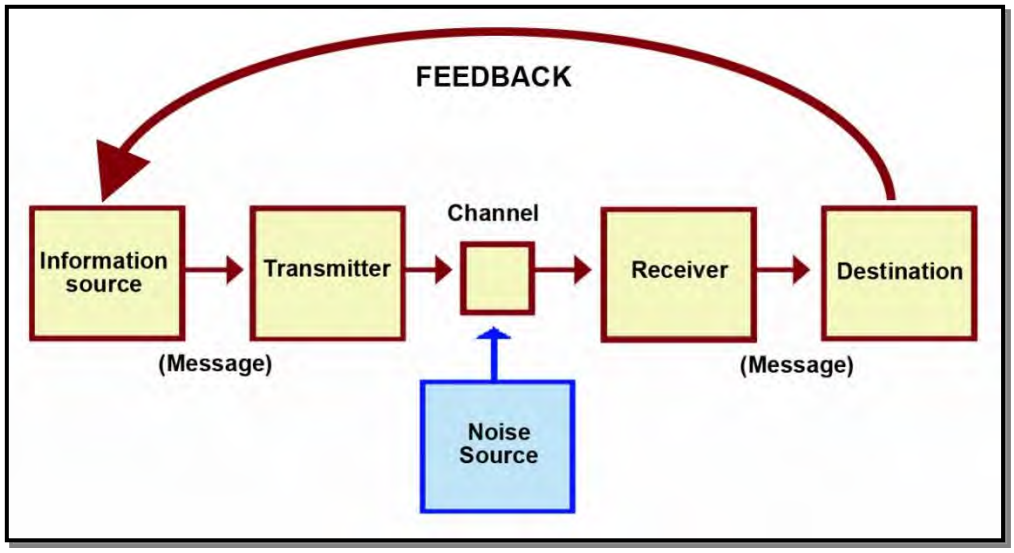


Figure 5.2 Shannon's Linear Model of Communication with Feedback included making it an Interactive Model of Communication. This model has significant drawbacks and can be reworked to more accurately reflect an Interactive Model, such as the modified version below.

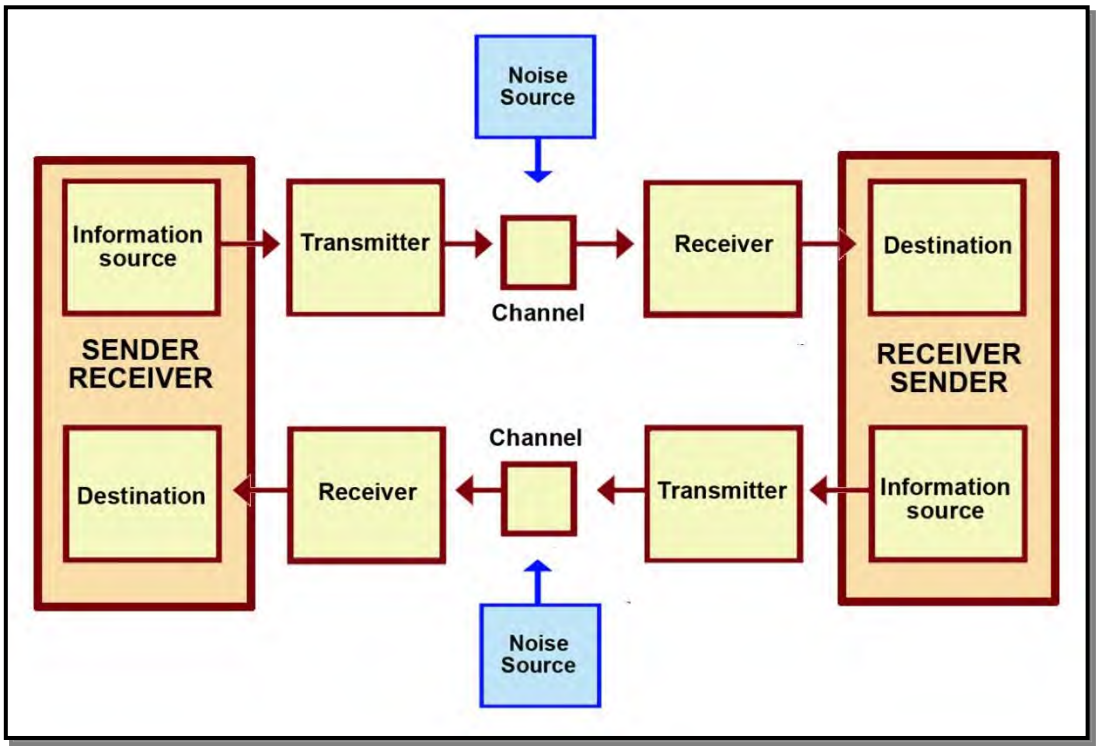


Figure 5.3 The Transactional Model of Communication consists of offering one piece of information for another, as though it was some sort of exchange system. In this model, the communication is continuous and does not end at the receiver or sender.

5.1.2.5 **Transactional Model of Communication.** Arguably the most accurate model of the three offered here for use with interpersonal communication. The Transactional Model of Communication contends that communication is a system of exchanges – or transactions – that are continuous. In the Transactional Model, instead of 'terminal' terms used to describe the individuals engaged in the communication (ie the source is a defined origin and

the destination is a defined terminus of the message, as if they were terminals on a battery), the participants in the communication are merely labelled 'Communicator A' and ' Communicator B.' This is because in this model, the communication is a continuous flow and does not 'terminate' at a destination.

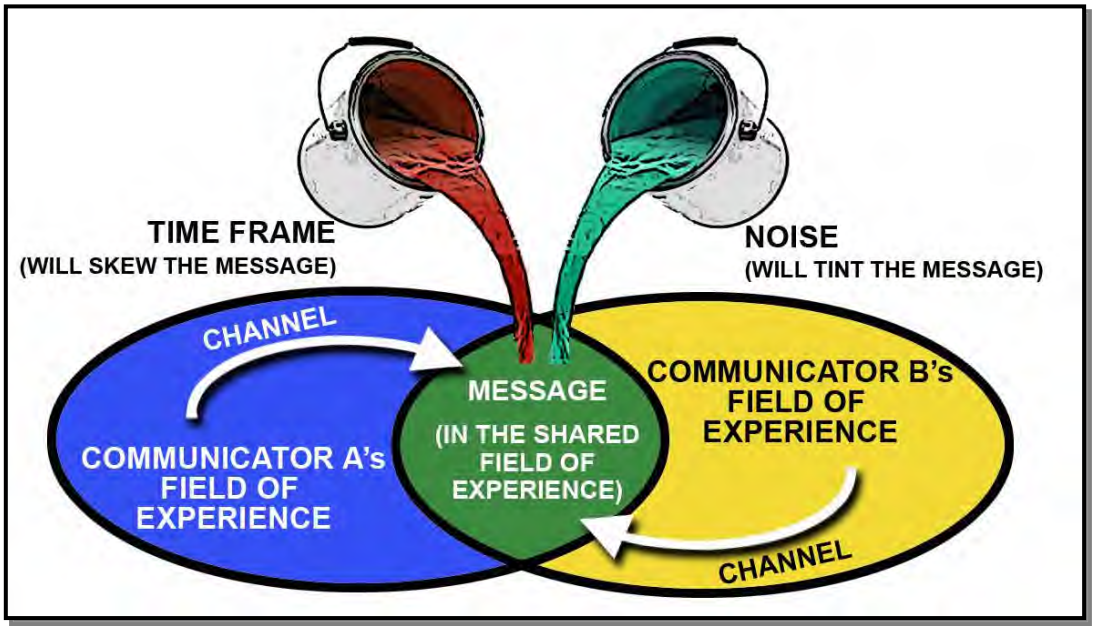


Figure 5.4 The Transactional Model (artist's version) where Communicator A and Communicator B each have individual fields of experience but where they overlap, communication can occur, however time and noise are influences on the quality and meaning (colour) of the communication.

5.1.2.6 **Inequality in the Communicators** is a significant contextual influence in this model in that it is a good abstract of communication if all communications are symmetrical, that is to say that the messages emitted come from more-or-less equals. Two peers talking is a good example of symmetrical communication,[149] but in a situation where there is an authority gradient (eg boss to employee), then there is not the same degree of symmetry, and it can be quite asymmetrical. In this context, the model has to be adjusted to show that it is not symmetrical. This inequality in communication is a barrier to its effectiveness and must be taken into account during or prior to any critical activity.

Section

5.1.3 **Verbal, Paraverbal and Non Verbal Communication.** When studying communication between individuals, there are a number of components that need to be understood to fully appreciate and contextualise the message. According to Windle and Warren, [150] these are:

- **Verbal Communication** – that communication that relates to the words chosen to convey the message.

[149] Foulger, 2004, *op.cit.*
[150] Windle, R, Warren, S., *Communication Skills*, CADRE – the National Center on Dispute Resolution in Special Education, http://www.directionservice.org/cadre/section4.cfm accessed 20 Aug 12.

- **Paraverbal Communication** – the way we say the words chosen to communicate the message (eg the emphasis on certain words, the intonation, etc), examples include:

    - Quality of the voice – monotone indicates a poor communicator or someone who is not enthusiastic.

    - Rate of speech and Rhythm – if not a natural tempo (eg some cultures speak very fast or some people are naturally fast speakers), then it can be an indication of nervousness or a desire to reach the end quickly without delving too deeply into detail.

    - Volume – can be a cultural dynamic or a sign of nervousness if not a natural aspect of the individual.

    - Inflection and Intonation – showing emphasis or lack of emphasis on some parts of the message.

- **Non-Verbal Communication** – the way our bodies communicate, consciously or sub-consciously (eg hand signals are conscious communications; body language may be sub-conscious communications). Examples include:

    - **Body Language** – facial expressions are usually difficult to fake, and are a good indication – to the initiated – of the true feelings of a person. (It is interesting to note that Joe Navarro, formerly of the FBI, claims that there are no expressions that denote deception, but facial expressions will tell what a person is really thinking as opposed to a person trying to get you to believe you are thinking something else.)[151] Folded arms are the most immediately obvious, non-facial indicator of attitude in most cases. The manner in which a person sits or stands, their posture and other cues.

[151] Navarro, J. Psychology Today, *Body Language vs Micro-Expressions,* 24 Dec 11 as cited in http://www.psychologytoday.com/blog/spycatcher/201112/body-language-vs-micro-expressions accessed 20 Aug 12.

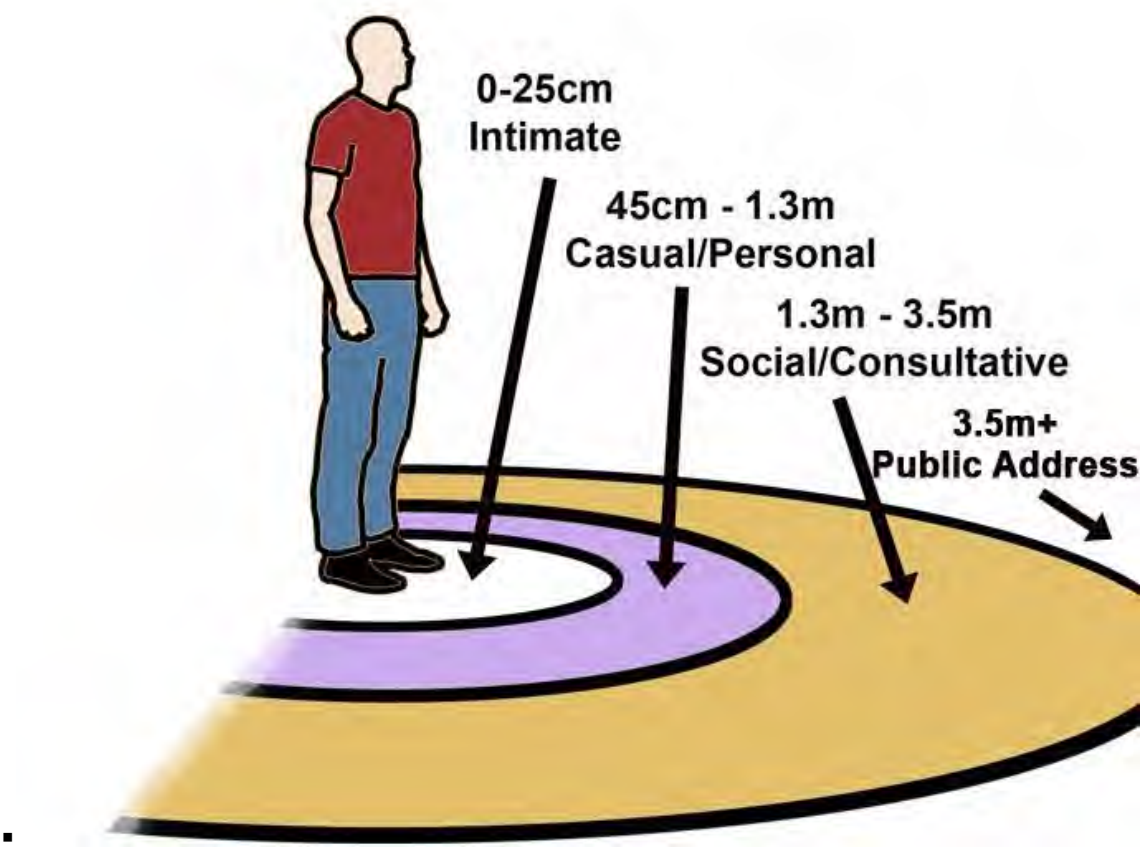
Figure 5.5 Even non human body language provides tell-tale signals to other. The chart at left is designed to educate people on how dogs communicate non-verbally through their posture and mannerisms.

- **Eye Contact** - In western cultures, eye contact is a positive affirmation of interaction, but in Japan Africa, Latin America and the Caribbean, avoiding eye contact is a mark of respect. In Arabic cultures, prolonged eye contact is a sign of trustworthiness between males but not between the sexes.[152] [153]
- **Posture.**
- **Mannerisms.**
- **Proxemics** – how close a person stands to another which is culturally and contextually dependant. In western cultures, especially in countries with a lot of space (eg US, Canada, Australia), individuals, especially males, are likely to give each other a lot more 'personal space' than males from, say, Japan. Personal space is also subjective and culturally contextual, the

[152] Burleson, D., *Consulting Tips for Foreign Cultures and religions*, BC Burleson Consulting, http://www.dba-oracle.com/consultant_religon_culture_guidelines.htm accessed 19 Aug 12.
[153] Diversity Council, *Cross Cultural Communication – Translating Non-Verbal Cues*, Diversity Council, *www.diversitycouncil.org/toolkit,* accessed 19 Aug 12

following 'personal space' rings were developed by an American and are subjective based on his culture and geographic location:[154]

- Intimate space – touching to 25cm – for close friends and family.
- Casual-Personal space – 45cm to1.3m – for informal conversations with friends.
- Social-Consultative – 1.3m to 3.5m – Formal Transactions.
- Public – 3.5m and on – for addressing groups of people.



- **Protective Barriers** – lecterns and other 'props' that serve as a form of protective barrier are often an indicator of a person's ability to communicate especially in front of an audience.

Section

[154] Changing Minds, *Proxemic Communication,* http://changingminds.org/explanations/behaviors/body_language/proxemics.htm accessed 01 Jul 12.

5.1.4 **Barriers to Communication.** There can be a multitude of barriers to effective communication. Anything that stops, hampers, alters, confuses or otherwise changes the intent of a message or its ability to be understood in the way that the sender meant it is a barrier to communication. They can be physical, physiological or psychological barriers. Some examples are listed in the table below. [155]

Figure 5.5 [156] Environmental Conditions such as noise can be a significant barrier to communication in high risk environments.

TYPE OF BARRIER	EXAMPLES
Physical	• Time – time zones, time of transmission, time available • Environment – noise, visual hindrances, line of sight hindrances, Ionosphere, propagation of radio waves • Machinery – technical difficulties with equipment used in the communication process • Ergonomics – comfort, layout of environment • Channel – medium through which communication is sent • Distractions – competition for attention • Gestures – non-verbal communication may not be standardised • Physical Stress – the environment may hamper the ability to communicate (eg rescue swimmer tries to communicate to helicopter crew but has to help keep a near-drowning victim afloat • Channel Selection – frequencies or methods of transmission do not synchronise (eg wrong frequencies)
Physiological	• Age – ability to perceive communication (presbyopia or presbyacusis) • Illness or other disability – ability to receive or transmit visual/verbal/aural communication hampered by acute, chronic or congenital condition, illness or disease • Stress (Self imposed) – drugs, exhaustion, alcohol limits the ability to perceive sensory inputs effectively
Psychological	• Experience and Knowledge base – lack of a common frame of reference hampers transfer of information\ • Bias and Expectation – receiver's expectation skews the message • Cultural or Religious – method of perception of a message or a difference in the use of terminology or non-verbal signals Language – different use of the elements of language and language itself (includes accents and dialiects)

[155] Peace Officers Standards and Training, *357 Communication Strategies Course,* (date unkn), as cited on the Nevade Post Website accessed through search engine.
[156] David Hawgood © http://www.geograph.org.uk/photo/2968663 licensed for use by CC – BY – SA – 2.0

	• Procedural – differences in procedures between organisations (eg one organisation may use one set of abbreviations or codes that differ from another organisation)
	• Context – incorrect attribution or lack of knowledge of context
	• Purpose – the reason behind the communication such as
	  ○ Duelling – competition between communicators
	  ○ Ritualised communication – eg greetings are a ritual where one person is not really concerned about the welfare of the other, but asks “How are you?”
	  ○ Small Talk – breaking down barriers without serious intent to find out about the other or reveal personal information about one’s self.
	• Gender – difference in communication styles between men and women
	• Hierarchical – differences in rank
	• Selective Listeninig – deliberately ‘zoning out’
	• Motivational Inertia – a lack of effective reason to listen
	• Ulterior Motive – sender has a secondary reason for communicating a

Table 5.1 Barriers to Communication

Module 5.2

5.2 **Improving Communication Skills.** There are a number of things a person can do to improve communication skills. In this module we shall look at three key communicative components:

- **Transmission of a message** – using verbal, paraverbal and non-verbal communication.
- **Inquiry** – were an outgoing communication is used to request or clarify an incoming communication.
- **Reception** – where the incoming message is presented and how we receive it.

It is important to note that many communication strategies are contextually based; what is seen as appropriate in one situation is not always appropriate in another. An example would be the confusion associated with using certain hand gestures in some countries compared to one's home country, or the manner in which one person speaks to another who may hold a more senior rank. The skills listed below must be used with cultural consideration.

Section

5.2.1 **Improving Transmission Skills.** When one discusses communication, one usually considers how best to get his/her message across rather than how best to listen and receive. This is because of our egocentric psychological make-up. Both are equally important. For the first part, we shall look at outgoing communication where we are trying to transmit a message, either verbally, paraverbally or non-verbally. Here are some ideas to use:[157]

- Make eye contact if appropriate for the culture concerned.
- Understand your body language and use it appropriately.
- Understand the body language of your audience and adjust your communication accordingly.
- Keep to the topic.

- Be genuine and don't try and assume another guise.
- Be sensitive to cultural or gender relevant issues.

[157] Peer Center, *1. Introduction to Communication Skills – Communication Skills – Peer Training.* http://peer.hdwg.org/training_toolkit/communication_skills accessed 18 Aug 12

- In many Asian and Arabic cultures, displaying agreement with a person does not necessarily indicate actual agreement. Nodding of the head and "affirmatory" aural cues may be a sign of trying to avoid an awkward moment. This may be problematic in an instructor/student environment where the student is of Asian/Arabic cultural background and is being asked if (s)he understood a procedure.

- Focus on the other person, assess what (s)he knows and fill in any blanks in knowledge.

- Make an effort to display appropriate gestures that you are receiving the message and when you don't understand it, ask for clarification.

- Allow the other person appropriate opportunity to speak and don't dominate the communication.

- Arrange for an area that is free of distractions and, if necessary, has privacy.

- Show interest and be enthusiastic.

- To ensure continuation of conversation, use open-ended questioning.

- To get the facts only, use closed questioning (see paragraph below on Questioning Skills).

5.2.1.1 **Transmission Techniques** – The following is from the British Civil Aviation Authority's publication CAP 413 on radio telephony.[158] While it is directed towards aviation operators, the principles hold true for any radio operator.

- Before transmitting check that the receiver volume is set at the optimum level and listen out on the frequency to be used to ensure that there will be no interference with a transmission from another station.

- Be familiar with microphone operating techniques and do not turn your head away from it whilst talking or vary the distance between it and your mouth.

- Severe distortion of speech may arise from:

    - talking too close to the microphone;
    - touching the microphone with the lips; or

[158] Civil Aviation Authority, *CAP 413 Radiotelephony Manual Edn 19*, 15 Dec 09.

- holding the microphone or boom (of a combined headset/microphone system).

- Use a normal conversation tone, speak clearly and distinctly.

- Maintain an even rate of speech not exceeding 100 words per minute. When it is known that elements of the message will be written down by the recipients, speak at a slightly slower rate.

- Maintain the speaking volume at a constant level.

- A slight pause before and after numbers will assist in making them easier to understand.

- Avoid using hesitation sounds such as ‘er’.

- Avoid excessive use of courtesies and entering into non-operational conversations.

- Depress the transmit switch fully before speaking and do not release it until the message is complete. This will ensure that the entire message is transmitted. However, do not depress transmit switch until ready to speak.

- Be aware that the mother tongue of the person receiving the message may not be English. Therefore, speak clearly and use standard radiotelephony (RTF) words and phrases wherever possible.

- Messages should not contain more than three specific phrases, comprising a clearance, instruction or pertinent information. In cases of doubt, e.g. a foreign pilot having difficulty with the English language or an inexperienced pilot unsure of the procedures, the controller should reduce the number of items and if necessary these should be passed, and acknowledged, singly.

- One of the most irritating and potentially dangerous situations in radiotelephony is a ‘stuck’ microphone button. Operators should always ensure that the button is released after a transmission and the microphone placed in an appropriate place that will ensure that it will not inadvertently be switched on.

- After a call has been made, a period of at least 10 seconds should elapse before a second call is made. This should eliminate unnecessary transmissions while the receiving station is getting ready to reply to the initial call.

Section

5.2.2 **Improving Inquiry Skills.** Inquiry is the seeking of information in order to enhance knowledge, clarify a situation or solving a problem. There are a number of techniques that can facilitate the acquisition of information and overcome some of the barriers to communication. The points listed above hold true for inquiry and questioning, but here are some further points to use.

5.2.2.1 **Use Open rather than Closed Questions.** An open question is one where the respondent has the opportunity to answer the question in more ways than a simple 'Yes' or 'No'. Often, the manner in which the question is phrased begs for a detailed answer. They often begin with the 'W' interrogatives: 'Who?' 'What?' 'When?' (sometimes) 'Where?' (sometimes), 'Why?' and 'How?' A **Closed Question** invites merely a 'Yes' or 'No' response or a specific and quantifiable answer (eg a number) and usually start with Do, Does, Did, Is, Are, Was, Has, Have, How Many, Could, Would and Will.[159] Here is an example of both types of questions seeking the same answer when the questioner knows the answer but wants to illicit a certain response from the respondent. In this case, the questioner knows what happened but wants the respondent to provide a certain answer:

Closed Question: **"Did you knock on the door to the apartment when you went into the building?"**

Answer: **"Yes."**

Open Question: **"What did you do when you went into the building?"**

Possible Answer 1: **"I spoke to the lady from apartment 12."**

Possible Answer 2: **"I went up the stairs then I was invited into the apartment."**
Possible Answer 3: **"Before or after I went into the apartment?"**

5.2.2.2 **Use Funnel Questions.** Funnel questions are useful in assisting with a person remembering specific details by funnelling them towards the items in question. It is a technique used by law enforcement and is characterised by starting with a general (big) question and then following up with more specific (smaller) questions that relates to the question immediately prior. The first questions usually are closed questions and the follow up questions are usually open questions that invite the respondent to elaborate on their answer.

5.2.2.3 **Use Probing Questions.** This type of questioning looks at seeking specific information and invites the respondent to be definite and take responsibility for their actions or statements. This is useful when definition is required, that is to say, when certain

[159] Peer Center. *Op.cit.*

parameters need to be defined and also when people may be unwilling to provide you with the answers you seek. A probing question explores the situation and demands more clarity and definition and can often ensure that further problems don't arise. Here is an example:

Person 1. "Management needs this project completed asap… so stop what you're doing " and get started on it."

Person 2. "OK. When does it need to be finished by?" (1st probing question).

Person 1. "As quickly as possible."

Person 2. "Tomorrow? Next Week? When?" (2nd probing question).

Person 1. "Next week."

Person 2. "Who in management has requested it?" (3rd probing question).

Person 1. "Does it matter? Just get it done."

Person 2. "I need to know in case I come across a problem."

Person 1. "I think it's Ted Johnson in Human Resources."

Person 2. "Will he authorise me ceasing work on my current project so I can start on this?" (4th probing question).

Person 1. "I don't know. Just get it done."

Person 2. "Can you get him to confirm that he will authorise me to cease work on this project so I can start on his project."

Person 1. "Fine. I'll find out."

5.2.2.4 **Don't Use Leading Questions.** We have probably all seen TV courtroom dramas where one lawyer asks the witness a question only to have the other lawyer cry out:

"Objection! Your honour. Counsel is leading the witness."

A leading question is one where the questioner phrases the question in such a way so as to place the preferred answer in the question and then complete the question so that it is a closed question inviting a yes or no answer. It counts on the natural human tendency to avoid conflict by agreeing with others. Leading questions usually serve an ulterior motive and usually in favour of the questioner. It requires a respondent to be willing to enter into a conflict with the questioner when the answer is opposite to the one sought by the questioner. Here is an example of a leading question with two possible responses and their results:

Person 1. "That was a great dinner that Jenny cooked, wasn't it?"

Person 2. "Yes." (No conflict with questioner. Does not require any further comment.)

Person 2. "No." (Conflict with questioner. May require further comment.)

In the above example, the two underlined components of the question are 1) the preferred response, and 2) the closed question ending. The respondent had two basic choices: to agree with the preferred response in which case conflict is avoided and no further interaction is necessary; or to disagree with the preferred response with the result being:

- Conflict with questioner (in the form of disagreement with his/her statement).
- Follow up comments usually necessary.
- Emotional response likely.

5.2.2.5 **Rhetorical Questions.** Rhetoric can be described as akin to oration; the art of speaking and speech so that the orator can inform, entertain, persuade or motivate his/her audience. A rhetorical question is a type of speech that is a form of statement designed to make a point but is phrased as a question to which there need not be a reply. It can be said by a person as if "thinking out loud" and who does not expect an answer. For example:

Person 1. (Looking at a picturesque vista) "Isn't that beautiful."

Person 2. “”.

Note how the question can easily be written without the question mark? This can then be read as either a statement or a question. The reason for rhetorical questions is merely to interact with the listener.

5.2.2.6 **Reasons for the various questioning techniques.** The differences in the questioning techniques allows for various outcomes to be facilitated, not just the seeking of information. Some of the reasons to use the different techniques are:

- **Seeking knowledge** – the basic aim of most questions.
- **Mentoring, Managing and Coaching** – by questioning a less experienced person in a particular field, the more senior person can ascertain any deficiencies in knowledge that need to be addressed.
- **Persuading** – Rhetorical questions and, to a lesser extent leading questions, permit the questioner to state his/her opinions in the hope that it may persuade another person along a particular course of action.
- **Building Relationships** – All human relationships are built on understanding the human condition. This can only be done by inquiry and observation. Anyone who has been on a date knows that asking the other person questions about themselves is a positive way to keep the date running smoothly and building the foundation of any further relationship. The same applies in most work situations also as well as less intimate human relationships like salesman and customer, etc.
- **Avoiding Conflict** – A technique often used by management in retail or similar environments, and can quite easily be used in a work environment especially when dealing with angry people. It is centred around a calming questioner asking the appropriate questions and allowing the other person to ‘vent’ their frustrations. The questioner then seeks to find the root cause of the problem through funnel questioning and then seeks to find how the aggrieved can be satisfied through closed questions or, if particularly skilful, through leading questions.
- **Avoiding Potential Misunderstandings or Potential Future Problems** – By using probing questions, clarifying confusion or defining conditions can be achieved. The latter case – defining conditions – can ensure that responsibility is taken for decisions early such as in the example conversation above under probing questions.

Section

5.2.3 **Improving Listening Skills.** It is said that we will only remember between 25 and 50% of what we hear.[160] By increasing our ability to take in information that we hear, we are able to increase productivity and be in a better position to influence and persuade. Furthermore, because a significant percentage of conflict is due to misunderstanding communication, one can stand to reduce interpersonal conflict.

[160] Mind Tools, *Active Listening – Hear what people are really saying*, http://www.mindtools.com/CommSkll/ActiveListening.htm accessed 12 Jul 12.

5.2.3.1 **Active Listening.** the most important thing a person can do in order to improve his/her listening skills is to become an active listener. This means that the act of listening is a conscious process rather than just allowing the noise of the other person's voice to be heard. Active listening is not just hearing what the other person saying, but comprehending the message in the context. This may mean actively isolating yourself from any potential or actual distractions (a barrier to communication) and staying focused on the person and the message. By understanding barriers to communication as well as your own weaknesses in communicating and listening, then this is the first step to being an active listener. Here are some examples of barriers to communication and ways to become an active listener:

- **Actively attend to the communicator** – to attend to someone means to wait on that person (eg attendant), so to actively attend to someone means to give them your full attention. Remove any distractions so that the interaction between you and the communicator can be free of noise (ie anything that may interfere with the communication).

- **Be deliberate in trying to understand what the other person is saying** – free your mind of any other thoughts and concentrate on the words and meanings that the communicator is trying to impart. If you don't understand something, ask them to stop and rephrase or explain the item or concept. Not only does this help you as the listener, it also tells the communicator that you are actively trying to understand them, thus making them more ready to assist you in comprehending the message.

- **Acknowledge the other person** - as with the point above, by acknowledging the communicator and what (s)he is saying, you are showing to the person you're interest and understanding or lack of understanding. This acknowledgement may be verbal or non-verbal. For example, looking into the communicator's eyes; nodding the head; taking notes; maintaining a responsive posture; giving verbal responses are all examples of acknowledging the other person.

- **Understand the context** - most communication is contextual. This means that the meaning has to be relevant to the context in which it is set. Many miscommunications have been due to being placed out of context. It is important for the listener to try and empathise with the communicator or with what the communicator is describing.

- **Give feedback** - feedback allows the communicator to know that what (s)he is saying or communicating is being understood in the manner is intended. The listener should provide some form of feedback to assist with this. This could be done by paraphrasing what the communicator is saying, or asking for clarification, or other such devices.

- **Understand emotions** - communication can be clouded by emotion, either on the part of the communicator or on the listener. A good communicator removes

emotion from the message if the message is designed to only convey information. This is different to those situations where emotion is part of the communication, such as in a song, a poem, or a passage from a work of fiction. This is not often the case in work related communication, and so emotion usually only serves to cloud the meaning. (Image orig unk)

- **Pass judgement after the communication** - a very powerful tool in interpersonal communication is listening to the entire message, digesting it, and then making a deliberate judgement. The mere act of doing this sends a message in itself, that you have received the message, used cognitive processes to consider its meaning, weighed up alternatives and made a choice. The other person may not necessarily agree with your decision, but they will know that your response has been considered and deliberate, not taken lightly and has not been based on emotion alone.

- **Make your responses appropriate for the situation** - whilst it may be tempting to show superiority by demeaning the other person, refraining from doing so and giving an appropriate response again sends a definitive message. Ensure your response is honest and candid but given with respect. Be empathetic, and attempt to preserve dignity and the feelings of other people, but not at the cost of honesty.

5.1.5.2 Being an active listener is very difficult, especially if you are not used to it. It is important to understand your own weaknesses and other barriers and endeavour to overcome them if communication is to be successful.

Module 5.3

5.3. **Using Standardised Communication.** In most high risk environments where communication is paramount, there usually exists a certain convention towards standard signals, phrases and key (procedure) words. Standardised Communication assists in communicating ideas and commands and helps to overcome some of the barriers to communication such as those outlined in the paragraphs above. It also reduces the time spent communicating because the standardised method of communication carries with it a value that has already been pre-determined and usually does not require interpretation by persons who are familiar with the standards being used. There are numerous standardised phrases and key words or procedural words for various industries, and so it would be inappropriate to delve into all of them here. Here are some examples from various industries:

- **Roger:** I understand and/or I will comply. In general use in aviation, maritime, military and other industries (other terms include Romeo or Copy [to indicate good receipt of message]);
- **WILCO:** (I) will comply (with your request). (Primarily aviation and military)
- **Securité. Securité. Securité:** Safety Message. Pronounced 'say-queue-ree-tay,' it literally means "SAFETY. SAFETY. SAFETY" in French. Like many radio pro-words, French words have been used in English radio usage. This term is used primarily in the maritime environment, and to a lesser extent in the aviation environment, as the start of an important broadcast related to an item of safety.
- **Mayday. Mayday. Mayday.** I am in distress. As with Securité above, this also has French origins. The French exclamation 'Help me!' is 'M'aidez!' which is pronounced 'Mayday'. This is the origin of the word and its use as the start of a distress message in an aviation and maritime environment.
- **10-4.** Another form of 'Roger' (see above). The 'Ten' Codes are a series of codes used in place of clear speech and were developed in Illinois in 1937 for the police. They later became used in Citizen's Band radio.

Section

5.3.1 **Key Words** – Many words have specific meanings and, in some cases, legal meanings. Aircraft flight manuals are documents that contain key words that must be adhered to in order to ensure safe flight. Below is an example of some key words used in most flight manuals.

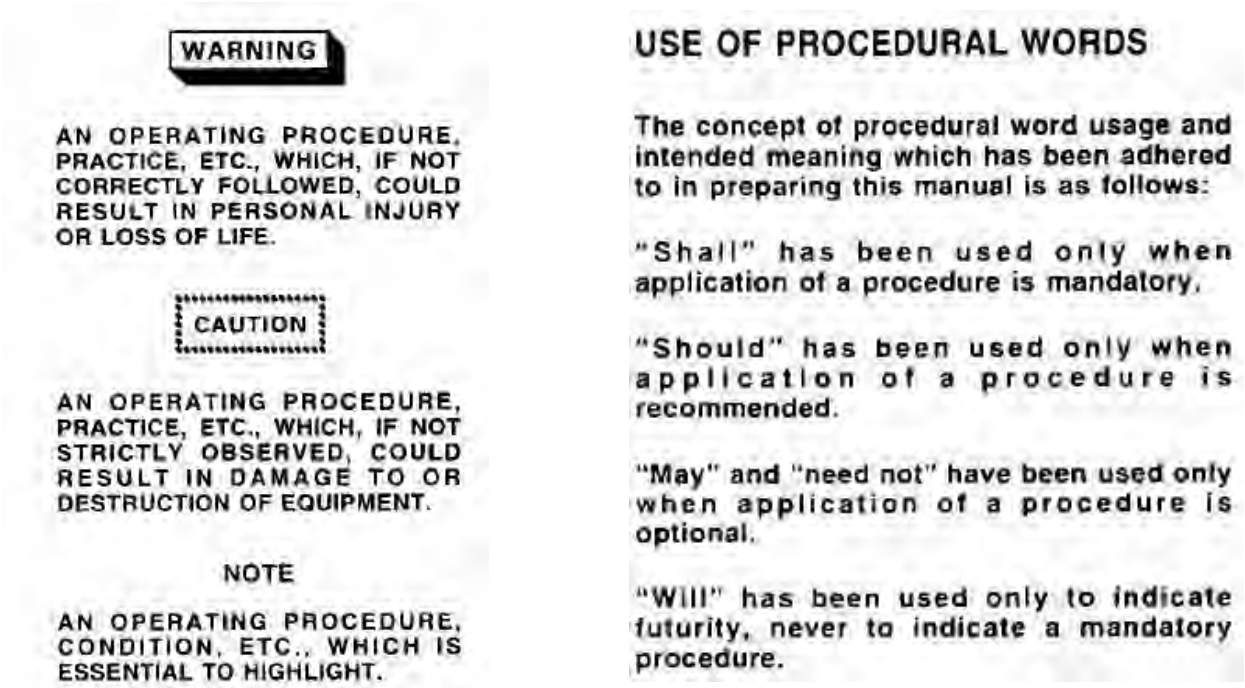


Figure 5.5 Key words used in many flight manuals specifying the meanings of specific words and how they should be used.

Section

5.3.2 **Non Verbal Communications.** This type of communication has been discussed in the paragraphs above, but within high risk activities, there are usually a number of specific action signals that are used to represent specific messages. The image below shows a Landing Signals Officer on board a WW2 aircraft carrier signalling to the pilot of an approaching aircraft such information as whether he is above or below the correct glide path or whether he needs to roll his wings left or right to achieve a correct centreline approach.

Figure 5. [161]A Landing Signals Officer aboard a US Navy aircraft carrier duri

Within aviation, these are prescribed within aeronautical publications. Below is an example of standard hand signals take from Civil Aviation Orders.[162]

[161] Landing Signals Officer, http://en.wikipedia.org/wiki/File:Paddles_ww2_bw.jpg, Public Domain
[162] Civil Aviation Orders, CAO 20.22 Air Service Operations, Marshalling and Parking of Aircraft, CASA, Canberra

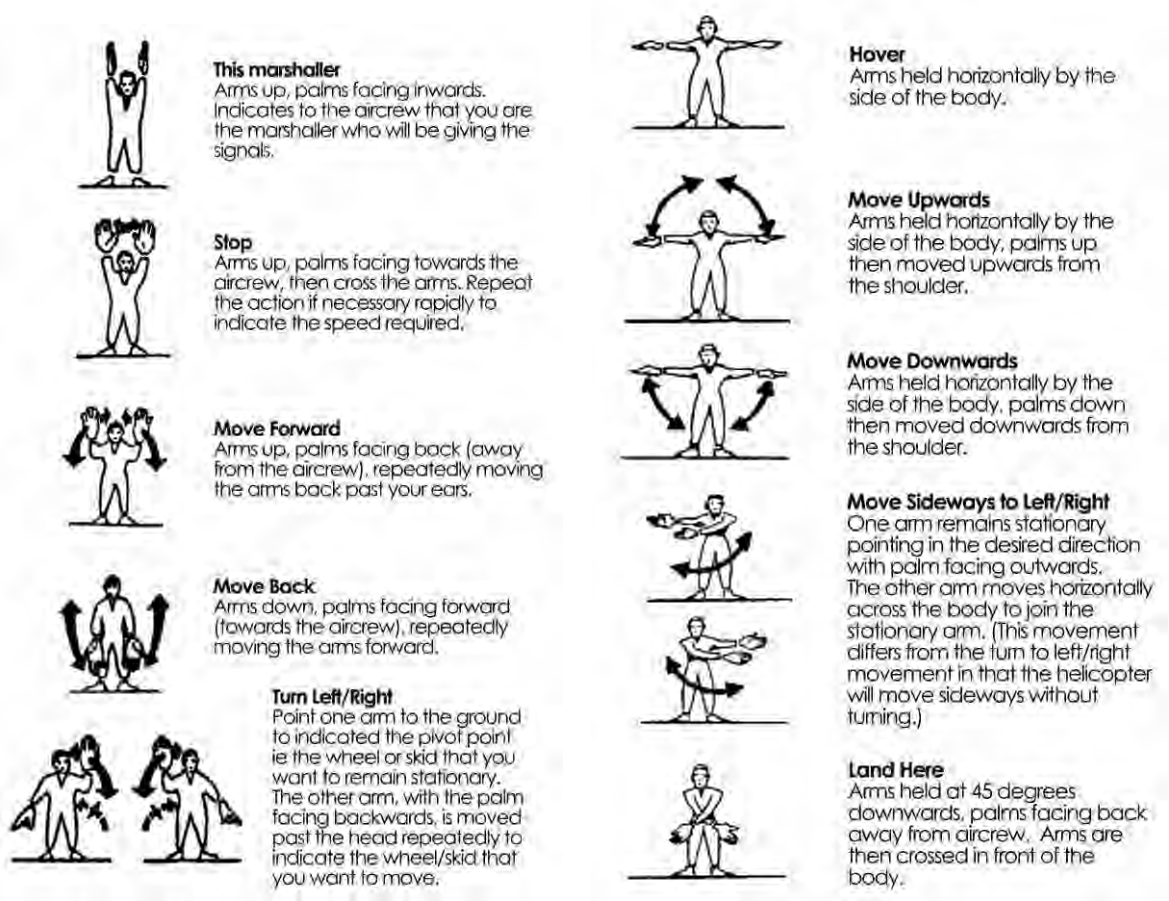


Figure 5.6. Marshalling signals used in Australia as listed in Civil Aviation Orders.

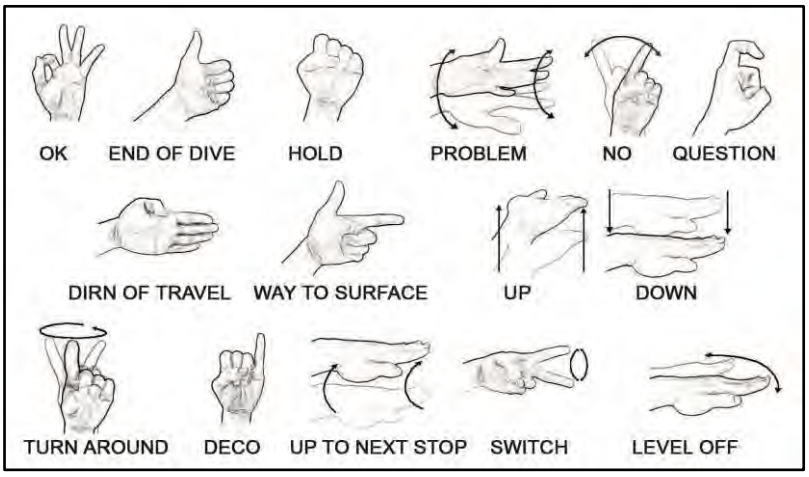


Figure 5.7 Cave Diving signals. SCUBA divers will see some differences between standard dive hand signals and cave diving hand signals.

NOTES:

GROUP 3 – THE INTERACTIVE CONTEXT

The Element/s in this Group relate to how the Human Being interacts with other team members and the environment.

ELEMENT 6 – The Group Dynamic

Contents:

Module 6.1

6.1 **Defining Teams vs Groups.** Probably the best definition of a team versus a group, when discussing teamwork, came out of the ADF CRM course. It is paraphrased thus:

> A Group is a collection of individuals who are associated by some common theme and who may work together.
>
> A Team is a group where the individual members are chosen for their specific skills and who will cooperate and collaborate and employ their skills for a specified aim.

The key differences between teams and groups, according to the definitions above, are that:

- Team Members are chosen.
- Team Members possess particular skills.
- Team Members will use those skills co-operatively.
- Teams have specific aims.

Some examples can include a group of football players who may be chosen to form a team or a group of volunteers who may be given specific training and skill sets and then chosen to form a civil defence team (eg SES) or a team of volunteer firefighters.

Section

6.1.1 **Types of Teams and their make-up.** There are two distinct classes of teams and sub-categories. The classes of teams are as follows:

- Independent – where team members contribute to the success of the team by individual (independent) performance where that performance has no direct bearing on the performance of another team member. An example would be an archery team where each archer performs individually and that person's score contributes to the team's performance. At no time does one team member actively influence or depend upon the performance of another. The team's success relies solely upon the best individual and independent performance of each team member.

- Interdependent – where team members contribute to the success of the team by co-operative and collaborative performance of tasks and where the individual's role within the team depends on that cooperation and collaboration.

In some cases, a team may require its members to perform somewhat independently and then interdependently, such as a cricket or baseball team when at bat or when fielding.

6.1.1.1 **Sub-categories of teams.** There are a number of dimensions to types of teams with some of the definitions applicable between sub-categories. The FAA has devised the following three sub-categories[163] in which have been placed various team descriptors:

- Functionality:
    - Functional Team – where team members are from the same work unit;
        - Work Team – for example, the sales team in a real estate office where individuals work independently but in an effort to ensure the sales department succeeds.
    - Cross Functional Team – where team members are from different work units but are brought together for a specific task;
        - Multi-Disciplinary Team – for example, a surgical team from different medical disciplines who have been brought together to treat a complex medical issue requiring different specialities, such as the separation of conjoined twins who require orthopaedic, paediatric and surgical specialist teams.
- Purpose:
    - Task Force – a team that has been brought together to investigate a specific issue or problem but who may not have to implement solutions (see Problem Solving Team);
    - Problem Solving Team – where team members are brought together for a specific issue and to develop and implement solutions.
    - Developmental Teams – where team members concentrate on developing new products, systems or procedures.
- Temporal (Time related):
    - Temporary – a team whose longevity is only dictated by the specific task for which it was raised.
    - Permanent Team – a team that is required on a permanent basis.

[163] FAA Human Factors, *Team Performance Module>Team Types, https://www.hf.faa.gov/webtraining/TeamPerform/Team 012.htm accessed 14 Sep 12*

Figure 6.1 Portrait of Squadron Leader Sharon Bown – RAAF Combat Surgical Team Commander, Tarin Kowt Afghanistan (by Captain Conway Bown, copyrighted image) The commander of this multidisciplinary military medical team was unusual in that she was not the most senior ranking person within the group nor was she the senior medical practitioner. Her selection was due to her ability to command and her knowledge of the RAAF system and team management and oversight as well as her background as a nurse and a sub-unit commander. [164]

Section

6.1.2 **Roles within a Team.** Much has been written about the individual roles of members within a team. For our purposes, we are mainly concerned with two key classifications: leaders and followers. But in order for a team member's position to be completely understood, we must review the concept of team roles. A team role can be specific, ie the task the individual is expected to perform such as 'fast bowler' in a cricket team or 'goal keeper' in a soccer team, or it can be more abstract such as 'implementer' or 'shaper', where the personality and work ethic is the key determinant of what the role is.

6.1.2.1 **Belbin's Team Roles Theory.** Dr Raymond Meredith Belbin was a British researcher who devised an 8-role model based on the types of personalities and traits within teams, especially successful teams. A team role was defined as the manner in which one team member interacted with other team members in order to facilitate the team's progress

[164] *Portrait of SQNLDR Sharon Bown, RAAF Combat Surgical Team* by Captain Conway Bown. In the collection of the RAAF Museum, Point Cook. © 2009. All rights reserved.

towards achieving the team's aim. It was similar to a personality trait test. It was later revised and the labels changed and then another team role added to make the 9-role team model.[165]

TEAM ROLE	DESCRIPTORS	STRENGTHS	WEAKNESSES
Completer / Finisher (CF)	Anxious, conscientious, introvert, self-controlled, self-disciplined, submissive and worrisome.	Painstaking, conscientious, searches out errors and omissions, delivers on time.	Inclined to worry unduly. Reluctant to delegate.
Implementer (IMP)	Conservative, controlled, disciplined, efficient, inflexible, methodical, sincere, stable and systematic.	Disciplined, reliable, conservative and efficient, turns ideas into practical actions.	Somewhat inflexible. Slow to respond to new possibilities.
Team Worker (TW)	Extrovert, likeable, loyal, stable, submissive, supportive, unassertive, and uncompetitive	Co-operative, mild, perceptive and diplomatic, listens, builds, averts friction, calms the waters.	Indecisive in crunch situations.
Specialist (SP)	Expert, defendant, not interested in others, serious, self-disciplined, efficient.	Single-minded, self-starting, dedicated, provides knowledge and skills in rare supply.	Contributes on a narrow front only. Dwells on technicalities
Monitor / Evaluator (ME)	Dependable, fair-minded, introvert, low drive, open to change, serious, stable and unambitious	Sober, strategic and discerning, sees all options, judges accurately	Lacks drive and ability to inspire others.
Co-ordinator (CO)	Dominant, trusting, extrovert, mature, positive, self-controlled, self-disciplined and stable.	Mature, confident, a good chairperson, clarifies goals, promotes decision making, delegates well.	Can be seen to be manipulative. Offloads personal work.
Plant (PL)	Dominant, imaginative, introvert, original, radical-minded, trustful and uninhibited.	Creative, unorthodox, solves difficult problems	Too preoccupied to communicate effectively.

[165] Aritzeta A., Swailes S., and Senior, B., *Team Roles: psychometric evidence, construct validity and team building,* Centre for Management and Organisational Learning, University of Hull, UK, 2005.

Shaper **(SH)**	Abrasive, anxious, arrogant, competitive, dominant, edgy, emotional, extrovert, impatient, impulsive, outgoing and self-confident	Challenging, dynamic, thrives on pressure, has drive and courage to overcome obstacles	Prone to provocation. Offends people's feelings.
Resource Investigator **(RI)**	Diplomatic, dominant, enthusiastic, extrovert, flexible, inquisitive, optimistic, persuasive, positive, relaxed, social and stable.	Extrovert, communicative, explores opportunities, develops contacts.	Over-optimistic, loses interest after initial enthusiasm.

Table 6.1 Belbin's Team Role types and their characteristics. [166]

Figure 6.2 Teams rely on members having particular skills and attributes and the ability to cooperate with each other to achieve team aims.

[166] Ibid.

Module 6.2

6.2 **Leadership and Followership** Leadership and Followership are two terms that can incite debate. First of all, the word 'Followership' is only a relatively recent word in the English language and is not even recognised in some dictionaries, whereas 'Leadership' has its origins from the early 19th Century. There is some variance in the connotations of the meanings of both terms; leadership is seen as something positive whereas followership is seen as being submissive and negative. Any person who has been involved in team environments will know that this is not the case and that a team can only exist if it has a leader and followers and that both are interdependent. You cannot have one without the other.

Section

6.2.1 **Definition of and Types of leadership.** Trying to define leadership will bring many different definitions to the table, but perhaps the most common themes amongst all potential definitions are the themes of influencing others towards a team goal. To that end, the definition we shall use is:

> *Leadership is a process by which a person influences others to accomplish an objective and directs the [team] in a way that makes it more cohesive and coherent.*[167]

There are different leadership styles related to personalities. This influences the manner in which a leader leads a group or a team. The manner in which a leader is placed in command will also have an influence on the leadership style both on the part of the leader and on the part of the follower. The two key leadership types are:

- Designated leadership; and
- Situational leadership.

6.2.1.1 Designated leadership is the condition when the group or Team Leader is designated as the leader by a higher authority, for example, by virtue of rank rather than skill or training.

6.2.1.2 Situational leadership is the condition where the group or Team Leader assumes the role by virtue of his/her skills or training. There may be circumstances where the designated leader may defer to a more appropriate person within the team due to their expertise. That person may assume the role of leader due to the situation. If not handled correctly, this situation may be detrimental to the group's cohesion and its ability to achieve the mission.

Section

[167] Clark, D. R. (2004).*The Art and Science of Leadership*. Retrieved 29 Sep 12 from http://nwlink.com/~donclark/leader/leader.html

6.2.2 **Styles of Leadership.** Just like in Belbin's Team Role model (Section 6.1.2), there are also descriptors for various types of leaders. Below are some of the more common ones.[168]

- **Transactional** – A leader who relies on a worker/servant relationship based on the fact that the worker has agreed, by accepting a job, to agree to certain conditions such as obeying a recognised leader. In other words, the transaction is payment of salary in return for productivity and adherence to the rules. This type of leader is reliant on an accepted norm (ie be productive and you will be paid) rather than inspiration (ie a person is inspired towards productivity).

- **Autocratic** – A recognised leader has significant control over subordinates and subordinates are expected not to question the authority and may be subject to harsh penalties if they do. This type of leadership is good for unskilled workers or for workers in extremely high risk environments where unquestioning obedience to higher commands are necessary (eg the military). In a business environment it can be an efficient system but is often plagued by high staff turnover and absenteeism.

- **Bureaucratic** – A leadership style where rules and procedures need to be followed diligently, such as in industries where occupational health and safety may be at significant risk (eg working with heavy machinery) or where non-adherence to the rules can result in significant losses (eg banking). Persons who follow the rules are often suited to this type of leadership and may rise in the ranks because of that, however this does not lend itself to inspiring others nor does it lend itself to flexibility and so may cause problems in other types of environments.

- **Charismatic** – A leadership style whereby the leader can inspire followers based on their personality type. Religious sects are particularly good examples of charismatic leadership where the result is an organisation with lack of purpose and which can easily falter if the leader is removed.

- **Democratic/Participative** – A leadership style where the members of the organisation are active participants in the decision-making process. The benefit of this type of leadership is high moral and a feeling of inclusion amongst the workers. The pitfall is that decision-making can often be slow and productivity can consequently be slow as a result.

- **Laissez-Faire** – From the French meaning ''leave it to be done," this type of leadership is where the leader allows his/her workers to work in their own manner with little input from the leader. This may be deliberate or not deliberate in that in the former, the leader allows his workers freedom whereas in the latter, the leader either doesn't want to, or doesn't know how to manage his/her workers effectively and so leaves them to their own devices.

- **Task Oriented** – A leader who knows the task required and works diligently towards achieving that task and also drives his/her workers towards achieving that task can be thought of as task oriented. This type of leadership may also be reminiscent of Autocratic Leadership (see above) in some aspects. However this

[168] MindTools, *Leadership Styles,* http://www.mindtools.com/pages/article/newLDR_84.htm accessed 19 Sep 12.

classification centres more around getting particular work completed whereas Autocratic centres around the manner in which a leader manages and may not be related to getting a task completed.

- **People/Relationship Oriented** – This style of leadership often puts people first and task second. This is good for morale and can be effective in certain environments in building good teams and encouraging risk taking, however it can often be the cause of ill-discipline and lost productivity.

- **Servant** – A type of leader that 'leads from behind' and does not aim to be singled out as a leader. This sort of leader manages the team quietly and meets the team's needs and then allows the team to take the credit for achieving goals, all the while diligently working in the background. The pitfall of this type of leader is that other leadership styles often get noticed more readily and thus can seem to be more effective even if not.

- **Transformational** – Arguably the optimum type of leader. The transformational leader looks to transform the team by inspiring it towards achieving shared goals. The transformational leader is often charismatic and people oriented but may often lack the detail of a task oriented leader or the discipline of a transactional or autocratic leader which may hamper productivity.

Section

6.2.3 **Roles of a Leader.** To be a good team leader, the person needs to possess a wide and varied skill set in order to undertake the varied roles of a leader. Such roles include:

- Building the team by employing each member to the best of his/her abilities and developing the skills of team members.

- Managing the workload even if it means assigning team members to tasks to which they are not the best qualified in order to strengthen the skill sets and to prevent otherwise more competent team members from being overworked.

- Managing time.

- Making decisions for the good of the team and its aims even if they are unpopular.

- Co-ordinating and monitoring activity.

- Prevent and solve conflicts.

- Enforcing discipline.

- Listening and employing team members' inputs.

Section

6.2.4 **Qualities of an Effective Leader.** A person may be an effective manager, but that does not all that is required in an effective leader. The roles listed above are some of the tasks expected of a leader, but there are some 'non-technical' skills – to use a term that is relevant to what we are discussing – that are necessary in an effective team leader, such as:

- Professional and technical skills.
- Social skills.
- Decision-making skills.
- Authority and credibility.
- Ability to praise, to critique, to delegate, to motivate and to cope with team members.
- To seek assistance and manage that assistance.
- Empathy.
- A willingness to do the best for the team's welfare including enforcing discipline.

'Leadership is the glue that binds groups of individuals together to form efficient and effective teams. The basic function of a leader is to inspire people to produce their best efforts.

It is important to distinguish the difference between leadership and management:

> *Management is about effectively and efficiently planning, organising, directing, coordinating and controlling human, financial and material resources.*

Leadership is about influencing the behaviour of people for a purpose. It is about empowering others in a manner that enables each individual to willingly work as a member of a team in order to achieve that, which as individuals, would be unachievable.

Leaders must remember that ultimately the most difficult task that they will be asked to perform is to lead their team during an emergency situation or critical incident.

Leaders must establish mutual confidence between themselves and the members of their team. This can be achieved through formal and informal communication and, unobtrusive interest in their lives outside the service.

The leader must be interesting and interested. The leader must possess moral and physical courage as well as high standards of integrity, loyalty and service.

Leaders set the example and it is imperative that their own personal behaviour provides an example for the team to follow.'

from: SA CFS Operations Management Guidelines 2007)
used with permission

Photo: Sunday Mail

Section

6.2.5 **Followership.** Unfortunately, being termed a follower has negative connotations. As stated above, it is sometimes seen as being akin to being a sheep whereas being a leader is seen to be a more positive role for which to strive. This is definitely not the case. The term "Followership" was likely first coined around 1928 by Mary Parker Follett[169] who was a management consultant, reformist, social worker and author during that period. Her work into leadership and followership and organisational behaviour and reciprocal relationships were seen as ground breaking and were resisted during her time, but today are accepted as being the norm. It is also suggested that the idea of transformational leadership (see above) was a concept that was her idea

Regardless of the origins of the word, in our understanding of the concept of leadership, then followership has a logical counter-meaning. Anyone who studies group dynamics and team behaviour or who has worked in any sort of team environment, will know the importance of followership in order for a team to achieve its goals. The following paragraphs address the concept.

6.2.5.1 **Qualities of an Effective Follower.** Belbin's Team Roles (Section 6.1.2) has already described various traits of team members, but it does not suggest which is best. It can be argued that all have their strengths and weaknesses and the University of Hull's study has shown that the most effective teams are those that have a good cross-section of team roles and personality types.[170] But there are certain qualities of followers that are particularly useful within team environments and good followers can simultaneously be good leaders, even if they don't mean to be. Look at the definition of the Servant style of leadership (Section 6.2.2) and you can see a situation where a follower may indeed be a leader. Below are some insights from *Forbes Magazine* that give some good insights into what it means to be a follower and display followership qualities.[171] Further to the *Forbes* qualities are some followership qualities as suggested by Colonel Phillip Meilinger of the US Air Force who was

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[6] Klenke, Dr K., *Qualitative Research in The Study of Leadership,* Emerald Publishing Group, Bingley, UK. 2008
[170] Aritzeta A.,et al, op.cit.
[171] Turak, A., *The 11 Leadership Secrets You've Never Heard About,* Forbes Magazine online, 17 Jul 2012, http://www.forbes.com/sites/augustturak/2012/07/17/the-11-leadership-secrets-you-never-heard-about/ accessed 29 Sep 12.

the Dean of the School of Advanced Airpower Studies.[172] (It is interesting to note that the key elements of Colonel Meilinger's paper have been adopted by the FAA and then subsequently referenced in the CASA publication *"Safety Behaviours – Resource Guide for Pilots."*[173])

- **Great Followers Seize the Initiative** – A good follower is one who can see opportunities for the team and bring those opportunities to the leader with ideas on how best to exploit them.

- **Great Followers Create their Own Jobs** – A good follower, when confronted with a new job or role, quickly identifies those items that are easily achievable and then presents the leader with a timeline for completing them before the leader allocates the tasks. In that way, the follower can remove certain stressors from the leader, create achievable goals for him/herself and then be ready to tackle more difficult tasks which may have been made easier by removing the more mundane. This also provides more autonomy and creates an environment where progress is easily seen which enhances morale and inspires others.

- **Great Followers Anticipate** – A good follower has the ability to foresee what problems may arise for the team and/or the leader and will do his/her best to remove that problem well in advance of it arising. This has the benefit of removing stress from other team members.

- **Great Followers Communicate** – A good follower provides updates before being asked to do so and does so in writing. By doing so, the team leader has a record that he/she will treat credibly (because it is in writing and therefore there is a record of the communication) rather than a verbal communication that may not be treated with the same credence. Furthermore, a constant record of work achieved is also a good means of providing consolidated feedback for personnel appraisals rather than trying to recall a person's achievements throughout a reporting period.

- **Great Followers are Goal Driven** – A good follower understands that team leaders are often busy and often do not have time to supervise. So a good follower will conduct 'reverse reasoning' and will determine what needs to be achieved (the end state) and how it needs to be achieved (the method) thus relieving the stress of other members of the team.

- **Great Followers Offer Solutions** – Anyone can identify a problem and then make it someone else's. A good follower offers a solution which, in many cases because of the follower's intimate knowledge of the problem, will probably be the most logical solution to it. This action, arguably more than any other, is one of the greatest attributes of a good follower, but one must remember that the person who implements the solution must have the appropriate skills to do so and that the proposed solution is practical.

- **Great Followers are Empathetic** – Team Leaders (for example, bosses) are humans too, and demonstrate the same foibles as anyone else. They will have

[172] Meilinger, COL P.S., *The Ten Rules of Good Followership*¸ as prepared for the AU-24 Concepts for Air Force Leadership (date unk).
[173] *"Safety Behaviours. Resource Guide for Pilots."* Civil Aviation Safety Authority, Canberra, 2009.

their own doubts and insecurities and other fallibilities that they will often not show. A good follower understands this and does his/her best to show that without stepping outside the bounds of propriety. A simple statement that the boss is doing a good job or encouragement that a suggestion sounds like a good idea often does wonders. The follower must ensure, however, that such an action is not delivered in a way that can seem obsequious.

- **Great Followers are Loyal** – In most team situations, there are going to be times when the followers don't necessarily agree completely with the team leader. But a follower who openly disagrees with the team leader and shows disagreement, disrespect or – worse still – disloyalty is the epitome of a poor team player. A good follower follows direction even if s/he disagrees with it and so long as it is safe, legal, morally correct and in accordance with expected practices. A good follower also does not privately undermine the team leader or his/her decisions amongst other members of the team.

- **Great Followers Tell the Team Leader How It Is** – A good follower is not a 'yes' man and is willing to stand up for what s/he believes in provided it is for what s/he believes is for the good of the team and not for any individual. This may lead to a disagreement, even an argument, but provided that this is done in private then that may be acceptable depending on the nature of the organisation. Any such conversations must be done in private and once over, is never discussed outside that private situation.

- **Great Followers Fix Problems without Seeking Credit** – There is a saying that is often misused: "Discretion is the better part of valour." This actually means that whilst a valiant act is good, being discrete about it and not seeking the glory is a more noteworthy part of that act. The same applies for teamwork. A person who solves a problem for the team and does so quietly and doesn't seek the glory, is truly an exemplary team member. These sorts of actions DO get noticed.

Section

6.2.6 **Assertiveness for Subordinates.** In some instances, it is imperative for a subordinate to demand attention be given to him/her when a dangerous situation arises and s/he has the solution. An example might be in a cockpit when the co-pilot has identified a significant deviation from the flight path which the captain has not recognised. In most western cultures, where individualism is prized (eg Australian, American, British, etc), the subordinate is expected to speak up when the situation demands it. In collectivist cultures, (eg Middle Eastern, Asian, etc), this is not necessarily the case and a subordinate may be reluctant to speak up for fear of embarrassing a more senior member of the team and causing him/her to 'lose face'.

CASA's *"Safety Behaviours"* manual[174] provides some guidance and suggestions for how a subordinate can assert him/herself in times of crisis in a team environment. Whilst this is aimed towards flight crew, its applications can be used in other high risk environments. It is called 'PACE' and has been derived from works by Besco and by QANTAS. It stands for:

[174] Ibid.

- **Probing** for better understanding – where the subordinate asks questions in order to gain information to better understand the situation. Merely by asking probing questions, the person being questioned has to justify his/her response.

- **Alerting** the Team Leader of the anomalies – if the probing questions don't cause a change in behaviour of the team leader, then the subordinate may have to increase the level of assertiveness and explain/highlight to the Team Leader that his/her course of action is against procedure/doctrine/SOPs/ regulations.

- **Challenging** the suitability of the present course of action – the subordinate then increases the alert another step by informing the team leader that the present course of action is unsuitable and places the team (passengers/other personnel/situation) in greater risk and explains why. The subordinate offers a solution.

- **Emergency Warning** of critical and imminent danger – the subordinate then must take steps to tell the team leader that if s/he does not change the course of action, then the subordinate will have to take steps to do so, which may be taking over control of the aircraft/vessel/vehicle/situation, etc.

Module 6.3

6.3 **Managing the Team.** A team leader is, by default, a team manager. Leading and managing are interdependent skills in team environments and if a team leader cannot manage, then team goals are likely to go unrealised. What is the difference between leading a team and managing a team? Well, leadership was defined earlier as the ability to convince team members to take a course of action in order to achieve team goals. Part of that definition was "…*directs the [team] in a way that makes it more cohesive and coherent."* By directing, that could mean that the team leader directs not only what actions the team takes in order to achieve its goals, but also directing individuals and their activities and interpersonal relationships in order to ensure cohesion. Management deals with such things as planning, organising, budgeting and co-ordinating. In other words, doing the things that allow the team and its members to move forward to achieve goals.

Section

6.3.1 **Dealing with Team Members.** One of the more demanding tasks of a Team Leader is dealing with team members and their varied characteristics and traits. We have already discussed some convenient team role traits in the paragraphs above and it is handy to have those strengths and weaknesses again so we can discuss how to deal with them. We can assume that the strengths are things we want in a team member and so no action need be taken about them except perhaps to encourage them… but it is the weaknesses that need to be dealt with. So taking the table and adjusting it slightly, we now have the nine key team roles and their weaknesses and some suggestions as to how to deal with those weaknesses.

TEAM ROLE	STRENGTHS	WEAKNESSES	TEAM LEADER SOLUTIONS
Completer / Finisher (CF)	Painstaking, conscientious, searches out errors and omissions, delivers on time.	Inclined to worry unduly. Reluctant to delegate.	• Encourage the individual to relax. • Provide positive reinforcement. • Ensure tasks are delegated effectively so that s/he does not get overloaded.
Implementer (IMP)	Disciplined, reliable, conservative and efficient, turns ideas into practical actions.	Somewhat inflexible. Slow to respond to new possibilities.	• Encourage individual to critically review other team members' suggestions and opinions for applicability. • Encourage individual to 'think outside the box' using the most outlandish plans s/he can think of.
Team Worker (TW)	Co-operative, mild, perceptive and diplomatic, listens, builds, averts friction, calms the waters.	Indecisive in crunch situations.	• Provide positive reinforcement of the individual's value to the organisation and his/her reliability in decision making. • Encourage the individual to make decisions at critical times and act upon them even if they are not the optimal.

			• Demonstrate the faith the team has in that person's abilities. • Show that a poor decision made early is better than no decision at all.
Specialist (SP)	Single-minded, self-starting, dedicated, provides knowledge and skills in rare supply.	Contributes on a narrow front only. Dwells on technicalities	• Get individual to expand his/her viewpoints and area of work to develop new skills. • Provide mentoring in other areas. • Actively cross-pollinate skill sets.
Monitor / Evaluator (ME)	Sober, strategic and discerning, sees all options, judges accurately	Lacks drive and ability to inspire others.	• Use this person as a workhorse and a sounding board. • Encourage individual to take a more active role in supervision to develop leadership skills with appropriate team members.
Co-ordinator (CO)	Mature, confident, a good chairperson, clarifies goals, promotes decision making, delegates well.	Can be seen to be manipulative. Offloads personal work.	• Determine if person is appropriate for supervisory work. • Ensure that personal work is done by the individual and that he reports to Team Leader.
Plant (PL)	Creative, unorthodox, solves difficult problems	Too preoccupied to communicate effectively.	• Encourage the individual to interact with other team members in small groups settings. • Provide opportunities for this person to develop his/her communication skills in set piece environments.
Shaper (SH)	Challenging, dynamic, thrives on pressure, has drive and courage to overcome obstacles	Prone to provocation. Offends people's feelings.	• Provide counselling where necessary to ensure group harmony. • Give this individual tasks that need to be done quickly and can often be done with individual effort only.
Resource Investigator (RI)	Extrovert, communicative, explores opportunities,	Over-optimistic, loses interest after initial	• Give this individual ownership in the task. • Supervise stages of the task to ensure fulfilment.

	develops contacts.	enthusiasm.	• If new tasks arrive, decide if it is appropriate to give these to him and have someone else assume control of the former task if appropriate.

Table 6.2 Belbin's Team Role model and the strengths and weaknesses of each and how a Team Leader might deal with those.

Section

6.3.2 **Workload Management and Crew Co-ordination.** An important aspect of being a Team Leader is the management of the team's efforts to achieve team goals. In order to do that it is imperative that the Team Leader provides the team with all the resources required to accomplish the tasks. Two of the most important are clear goals and time to accomplish them. Below are some points of management that many team leaders fail to coordinate and achieve. These points are generic and would be applicable for, say, a team that is trying to solve a problem within an organisation where there is time to do a lot of administration. In other situations (eg aviation or emergency services), there may not be time to undertake all the steps listed below. Many of them will be irrelevant because teams may already be in place or time may not be available. In any case, review the points and discard those that would not be applicable.

- Review the situation
    - What needs to be achieved?
    - What are the key hazards and their risks?
    - What assets do we have?
        - Manpower (incl. expertise).
        - Budget.
        - Equipment (incl. logistics).
        - Facilities.
        - Time.
    - What planning needs to be accomplished?
    - What will be the chain of command up and down from the Team Leader?
- Establish the team's goals
    - Are they achievable with the assets available?
    - Are they in keeping with the expectation of the chain of command and the organisation?
    - Ensure they are SMART: Specific, Measurable, Achievable, Realistic, Timely.
- Gather and Get to know your Team
    - What are the individual skills available?

- What strengths and weaknesses do they have?
- Is there time to help with cohesion?
- What will be the team breakdown and their roles? (supervisors, sub-teams, specialists)

Figure 6.3 The coach of the US Navy football team will know the strengths and capabilities of his team players and will assign roles accordingly. (Photo in the public domain. US DoD)

- Plan and Allocate Tasks
  - What needs to be achieved?
  - Who is responsible?
  - Ensure time and resources are available.
  - Provide a reporting/communication chain.
- Communicate, allocate and be visible and available
  - Check with each team member's progress.
  - Offer assistance where needed but don't get overly involved in one task alone (keep the big picture.)
  - Hold progress meetings where appropriate.
  - Allocate or re-allocate resources where necessary (including time).
  - Keep the chain of command updated up and down the chain.
- Provide encouragement, enforce discipline.
  - Give credit where appropriate.
  - Provide encouragement.
  - Enforce discipline (in private and in accordance with the principles outlined in Section 6.3.3.)
- When complete…
  - Conduct an analysis of the activity. (See section on debrief)
  - Capture the lessons learnt and provide them for use where appropriate.
  - Give appropriate credit where it is due.

Section

6.3.3 **Enforcing Discipline and Providing Counselling.** In adult environments, enforcing discipline can be exceptionally hard. Furthermore, certain work environments can assist or can hamper what one would consider appropriate discipline. Take, for example, the military environment. Set guidelines and procedures and an expectation of quick and decisive action can greatly assist discipline and its enforcement whereas a work environment that has entrenched procedures and workplace methods (eg public service) may not lend itself to enforcing appropriate discipline without an inordinate amount of administration. This may discourage management from pursuing a discipline action because of the associated time and effort in conducting the administration. Another difficult workplace is one where volunteers are key to the organisation. Disciplining a volunteer is difficult, as a volunteer has no real commitment to an organisation other than his/her willingness to be there. Below are some tips to discipline in workplace organisations.

6.3.3.1 **Checklist before enforcing discipline.** The following points should be considered before enforcing discipline. It is very common for infringements to cause an immediate emotional response which can sometimes cloud clear judgement. The person enforcing discipline should consider the following critically and without bias and then consider what action to take.

- Was the infringement a Slip, Lapse, Mistake or Violation? (see Element of Human Error)
    - Slips and Lapses are usually made without intent. A Mistake is usually made with intent but without malice and can be corrected by better procedures or better training. A violation, on the other hand, is made with malice and is deliberate and must be actioned appropriately. Answering this question can usually set the tone for how to deal with the infringement.
- Did the person clearly understand the rule or procedure that was violated?
    - In this situation, a clarification of a mistake and a violation is being sought. If the person did not know s/he was committing a violation, then it was a mistake and should be treated accordingly.
- Has the rule or procedure been consistently and fairly enforced or has a double standard existed and did the person know that violating the rule could lead to disciplinary action?
    - Double standards send mixed signals to people and can cloud a person's judgement as to what is acceptable and what is not. For example, here is a routine violation: It is SOP that technical manuals be open and available at the page of the procedure whilst a maintenance procedure is being performed so that the tradesman can refer to it during the procedure… however the tradesman knows the procedure well and the workspace is small and cramped such that it is difficult to have an open manual nearby. As a result, it

has been common practice not to have it open during that particular procedure and this has been unofficially accepted by the supervisors. Now a new Engineering Officer is in charge and sees that the tradesman is violating SOPs by not having the manual open during the repair and decides to enforce discipline. Strictly speaking, the tradesman was committing a violation, but historically, what he was doing was common practice that management turned a blind eye to. What should the Engineering Officer do?

- What is the seriousness of the offence compared to other violations?
    - The punishment should be appropriate for the offence.
- Was the offence unusual for the person? In other words, was this out of character and, if so, was there an extraneous reason for the offence?
    - For example, a person who is usually punctual is late for work. S/he regularly stays back after hours to ensure his/her work is complete. Is it appropriate to punish this person?
- Has the person admitted to the mistake or violation and taken responsibility for it?
    - In some cases, this may be all that's required… especially if the mistake or violation was of a minor nature. If responsibility has been taken, then that should be taken into account in the discipline meted out.
- Are there prescribed offenses and punishments already in place and can they be used?
    - Some organisations have prescribed crimes and punishments. For example, in some police force units, a person who makes a mistake during a drill may be forced to buy all the team members coffee and doughnuts, but a violation of a more serious nature may already have prescribed fines or administrative or even legal action in place.
- If set punishments are not prescribed, what is an appropriate punishment?
    - This is the eternal question. In many cases, counselling may be all that's required and the associated embarrassment of being in that situation is enough punishment for the offender. In other cases, the disciplinarian may have to ascertain what 'currency' to use as punishment. Currency is something that is valuable to a person and removing it is usually an effective punishment. The same tactic is used when dealing with children when 'value' is a concept that becomes known to them. An example of using currency can be something like in a volunteer organisation, a person's currency is the

sense of belonging and involvement in the organisation especially when it is doing something of value (eg fighting a fire in a volunteer fire fighting organisation or conducting search and rescue operations for a civil defence organisation). In these cases, discipline may be enforced by excluding the offender for a certain number of jobs or call outs and then re-admitting that person back into the fold when 'his lesson is learnt'.

Figure 6.4 The manner in which discipline is enforced will be dictated by a number of factors such as if a set of guidelines or rules are already in place, the accepted culture of the organisation, expectations of the team and the severity of the infringement. Subjective factors such as the style of leadership are also influences. (Photo orig unk)

Module 6.4

6.4 **Reasons Why Teams Fail.** There are a myriad of reasons why a team may fail to achieve its goals. All of the positive attributes of leaders and followers cited above will have opposing traits and weaknesses which will contribute to team failure. All one has to do is to look at a positive and consider what the opposite or negative might be and then apply that to a team environment.

Dysfunction	Description
Absence of trust	Team members must have trust in themselves and in other team members such that they can be open and honest about strengths and weaknesses, attributes and mistakes.
Fear of conflict	As has been discussed in Element on Group Behaviour and in Planning and Briefing and Debriefing, conflict may be avoided by not being honest with each other. A team that is honest with each other and that can stand to have honest debate in order to achieve group goals is far stronger than one that seems to always be in agreement.
Lack of commitment	Continuing on from the fear of conflict above, the inability of a group to openly and honestly discuss issues will mean that there is not an environment to actively commit to a task or concept. Open discussion leads to more convincing arguments and if a person can be convinced of an idea, s/he is more likely to commit to it.
Avoidance of accountability	A lack of commitment logically leads to a lack of acceptance of responsibility and accountability. Only by being convinced of the value of team goals will people commit to it and only by committing will people accept responsibility for their actions and the actions of the team.
Inattention to results	If a person fails to accept his/her responsibility and that of the team, then individual needs are often put ahead of the team's aims. Things such as ego and career advancement aims of the individual only serve to hamper the team's efforts. The lack of commitment, accountability and drive for the team will lead to poor workmanship in the team environment and the subsequent inattention to detail will most likely lead to sub-optimal performance… even failure.

Table 6.3 The key dysfunctions of a team. [175]

[175] Derived from *"Guide to Managing and Optimising Team Performance,"* http://www.adm.monash.edu.au/human-resources/leadership-development/team-performance.html#2 accessed 29 Sep 12.

Problem	Characteristic behaviours	Team Leader's Strategy
Unhealthy or uncontrolled conflict within the team environment	• Attacks against individuals by other members of the team. • Use of sarcasm in discussions. • Team members close up and do not enter into discussions or contribute due to conflict. • The dialogue's tone, content and style is aggressive and argumentative. • Body language is aggressive. • Lack of support between team members for individual viewpoints.	• Team Leader must interrupt any attacks or the use of sarcasm and highlight that it is not helpful to the team's goals. • Members should be discouraged from conducting personal attacks and focus on processes and actions. • All members should be actively encouraged to express their views and made to feel that any viewpoint can have merit, regardless of what the individual may think. • Create rules about the manner in which sensitive or contentious topics are discussed and control the discussion.
Trouble reaching consensus	• Steadfastness in holding onto a position or viewpoint without considering the merits of another person's view or stand. • Arguments go around in circles even without the input of new information (ie same issues arise that lead to arguments). • Discussions are not given formal closure and are left 'hanging' and seemingly unresolved.	• Highlight the importance of being open to new ideas and to 'clear one's mind' of just one idea and allow freedom for new ideas to exist. • Ask individual team members to comment positively and negatively on another team member's ideas in order to get more critical analysis. This also helps other team members to 'buy into' another idea without losing face. • If consensus cannot be reached easily (ie due to dogmatic behaviour by team members), then highlight the ramifications of not reaching consensus. • If consensus is hard to reach, ask individuals what they think they need in order for consensus to be reached (ie what is the compromise). This may not be acceptable to the team's aims and the Team Leader will have to make appropriate decisions.

Lack of effective communication within the team	• Members are not given the opportunity to complete their input without others interrupting. • Some members do not seem to want to participate due to some barrier. • Problems may be touched upon however no-one seems to want to take the step in airing them. • Attributing meanings to ideas or concepts without clarification of them. • Non-verbal communication does not agree with verbal communication (eg body language)	• Make rules for discussion and ensure they are adhered to so that everyone has an opportunity to contribute. • Seek out the quiet members and ask for their opinions. • Ask for specificity. Don't allow assumptions to go unchecked. Ask for examples that are relevant. • If body language seems to defy the message, ask appropriate questions to get the real message. • If the Team Leader is the problem, ask for assistance from outside the team to assist with facilitating discussion.
Apparent lack of progress (especially noted at meetings and briefs)	• Poor participation/attendance at meetings. • Meetings don't seem to contribute to team goals. • Action items are not completed on time. • Closed issues continue to be revisited.	• Ensure the requirements for meetings and briefs are understood by all members of the team and conduct roll calls for the benefit of minutes. • Revisit the team's goals and critically assess the progress that has been made and what is left to be done. • Ask for reasons for the late completion of assigned tasks (in a manner so as not to cause embarrassment). • Consider ways to assist with the timely completion of tasks (eg more manpower or reassess tasks). • Team Leader should shepherd the conversation away from issues that have already been closed.
Ill-defined goals	• Individuals seem to pursue goals that are not synchronised or even in conflict with the team's goals. • The team appears to spend too much time on non-core goals and aims. • Discussion on team's goals does not align with actual team goals. •	• Remind members of team goals during each meeting and ensure that everyone understands what is trying to be achieved and the manner in which it is to be achieved. • Ensure discussion is directed towards achieving the team's goals.
Poor	• Team Leader does not involve all the team	• Team Members must be confident to discuss poor leadership with Team

leadership	members. • The Team Leader does too much of the work him/herself. • The Team fails to meet goals or deadlines. • Internal conflicts continue to hamper progress. • Leadership perspective is short sighted and fails to capture the full picture.	Leader. • Assist the Team Leader by removing extra stressors by such things as conducting extra tasks. • Go up the chain of command if leadership problems still exist, especially if the Team Leader refuses to take action to solve the issues raised.

Lack of management support	• The work of the team is not accepted by chain of command.
	• Resources are withheld hampering the team's efforts.
		• One of several preventable problems has occurred:
		  ○ Team does not have support from the Chain of Command;
		  ○ Chain of Command has not 'signed off' on goals and resources;
		  ○ Chain of Command and other stakeholders have not been kept informed of team progress.
		• Keep Chain of Command and stakeholders informed along the way and encourage their input into the progress (ie allow them to take some ownership in the team's work)
		• Ensure resources are used correctly and economically.

Lack of resources	• Manpower is not allocated appropriately. • Budget is not allocated appropriately. • No budget for necessary materials or outside participation.	• Ensure manning is appropriate by verifying priorities of effort and then getting agreement on manning and how it will be provided. • If Chain of Command and stakeholders will not or cannot assist with allocation of funds or resources required, then team success is unlikely; Inform the Chain of Command and consider disbanding the team and abandoning the efforts.
Absence of trust	• Team members unwilling to be vulnerable within the group. • Team members are not genuinely open with one another about their mistakes and weaknesses.	• Allow team members to spend time together to get to know each other. • If team bonding sessions are possible and appropriate, consider undertaking them. • Identify and discuss individual strengths and weaknesses and encourage individuals to be open about themselves.

		• Spend considerable time in face-to-face meetings and working sessions.
Fear of conflict	• Teams do not engage in unfiltered and passionate debate of ideas. • Veiled comments and passive aggressive actions hamper free discussion.	• Manage conflict if it results in positive outcomes but ensure that conflict does not get out of hand and become personal. • Ensure the communication ground rules (eg everyone has a chance to speak uninterrupted) allows for controlled conflict. • Observe and understand individual team member's natural conflict styles so as to be able to control them. •
Lack of commitment	• Teams do not engage in debate and discussion and therefore do not air their opinions regarding a course of action. • Courses of action are agreed to for simplicity's sake.	• Ask for people's opinions – good and bad – about prospective courses of action. • Review commitments at the end of each meeting to ensure all team members are aligned. • Adopt a 'disagree and commit' mentality - make sure all team members are committed regardless of initial disagreements. •
Avoidance of accountability	• Team members do not commit to a clear plan of action and therefore do not feel responsible for the outcome	• Explicitly communicate goals and standards of behaviour • Regularly discuss performance versus goals and standards
Inattention to results	• Team members put their individual needs (such as ego, career development, or recognition) before the collective goals of the team	• Keep the team focused on tangible group goals • Reward individuals based on team goals and collective success

Table 6.4 Characteristic Behaviours of dysfunctional teams and how they can be resolved.[176]

[176] As derived from Leucke, R,, *Creating Teams With an Edge: The Complete Skill Set to Build Powerful and Influential Teams,* Harvard Business Essentials Series, Harvard Business School Press, 2004.

GROUP 3 – THE INTERACTIVE CONTEXT

The Element/s in this Group relate to how the Human Being interacts with other team members and the environment.

ELEMENT 7 – Situational Awareness

Contents:

Module 7.1

7.1 **Defining Situational Awareness** There are a number of definitions of what Situational Awareness, or SA, is, but perhaps the most productive definition is one which is oft used in aviation and can be attributed to Dr Mica Endsley and his paper presented to the Human Factors Society in 1988.[177] He defined SA as:

> *"…the perception of elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the future."*

In 1995[178] he then expanded upon his definition by stating that SA is:

> *"…the primary basis for subsequent decision making and performance in the operation of complex, dynamic systems..." At its lowest level the operator needs to perceive relevant information (in the environment, system, self, etc.), next integrate the data in conjunction with task goals, and, at its highest level, predict future events and system states based on this understanding."*

Even though these definitions are centred around aircrew in an aviation environment, the concept has been widely accepted in any dynamic and high risk environment where decisions need to be made quickly and decisively. It is important to note that good decision making is dependent on good SA.

The key elements of these statements represent the three key elements of SA.

Section

7.1.1 **The Levels of SA.** To understand how SA works, it is important to understand their levels. Looking at the statements above there are three key elements:

- Perception (level 1).
- Comprehension (level 2).
- Projection (level 3).

7.1.1.1 **Level 1 SA: Perception.** The ability of a person to perceive or sense information that may be deliberately or not deliberately presented to him/her. Some factors may conspire to prevent this sensing of information such as barriers to communication, poor data display, equipment failure, poor training or skills, illness, stress, etc.

7.1.1.2 **Level 2 SA: Comprehension.** The ability of a person to logically analyse the information perceived and determine its meaning and importance and apply a value to that information.

[177] Endsley, M. R. (1988). Design and evaluation for situation awareness enhancement. Paper presented at the Human Factors Society 32nd Annual Meeting, Santa Monica, CA.
[178] Endsley, M. R. (1995). Situation awareness global assessment technique (SAGAT). Paper presented at the National Aerospace and Electronic Conference (NAECON), Dayton, OH as cited in *Summary of the various definitions of Situational Awareness,* Royal Aeronautical Society Human Factors Group website, http://www.raes-hfg.com/crm/reports/sa-defns.pdf accessed 20 Sep 12.

7.1.1.3 **Level 3 SA: Projection.** The ability of a person to project (predict) the ramifications of the information perceived & comprehended on the conduct of his/her mission in the future.

Section

7.1.2 **Errors related to SA.** Endsley also conducted research into the causal factors of SA Errors leading to safety incidents using NASA's Aviation Safety Reporting System (ASRS) in 1996 and collated the following information as shown diagrammatically in Figure 7.1.[179]

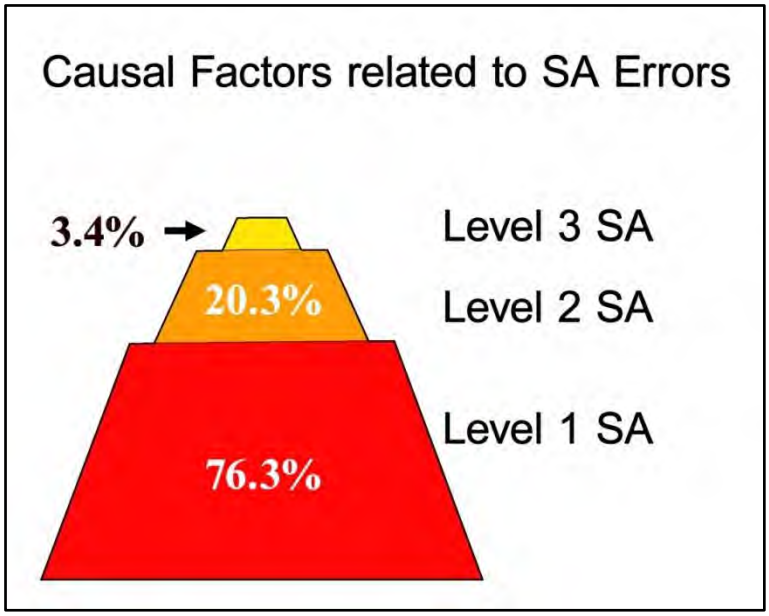


Figure 7.1 Endsley's research from safety reports related to SA errors.

It is interesting to note that the majority of SA related errors were in the first level, which relates directly to the human component of SA in perceiving information. Perception ultimately comes through the human senses and there can be many barriers to perceiving that information. When the 76.3% of level 1 related errors are broken down into further categories, the following statistics are worth noting:

- 11.6% were related to not having the information available, for example:
    - System and design failures, failures of communication and failure of the crew to perform the needed tasks (related to information).
- 11.6% were related to having the information available but it being difficult to detect, for example:

[179] Endsley, Dr M, and Robertson, M.,*Training for Situational Awareness*, SA Technologies as cited in http://www.satechnologies.com/Papers/pdf/SATrainingchapter.pdf accessed 21 Sep 12.

- Runway markings were poor, noise in the cockpit, poor lighting or other factors that impeded sensory perception of the information.

- 37.2% were related to the information not being observed, for example:

  - Crew scan was incomplete, attention narrowing (tunnel vision); distractions related to the task as well as other distractions or high workload.

- 8.7% were related to a misperception of the information, for example:

  - An expectation that the information was going to be something other than what it was.

- 11.1% were related to errors of memory, for example:

  - Disruptions to routine, high workload or distractions, etc.

When looking at the Level 2 reasons for loss of SA related safety incidents, it can be seen that only about 1 in 5 incidents could be attributed to an inability to comprehend the information. This would be logical in that aircrew are normally highly trained and so information that is perceived by such persons is information that will usually be comprehended. It would be unusual circumstances where information was provided that did not make sense to a trained member of aircrew. Where this fails is when the information presented does not fit with the expectations of what that information relates to. In other words, when the piece of information does not fit the puzzle as expected. For Level 2 SA errors:

- 20.3% were related to a failure to correctly comprehend the situation for reasons such as:

  - Automation factors; not having a complete or correct mental model or an over-reliance on default values in mental models where new information did not match what was expected.

Finally, the last level of SA – projection – is the category with the smallest representation. The 3.4% of incidents were predominantly related to mental modelling being incorrect or an over projection of current trends into the future.

Section

7.1.3 **Understanding Feedback Loops and SA using the Perceptual Control Model.** To better understand how SA is gained and lost and ways to enhance it, it is first useful to re-visit some of the concepts covered in the element on human behaviour in Element 2 The Human Mind. In order to do so, it is also helpful to discuss a concept known as the Perceptual Control Model (PCM).

7.1.3.1. **Negative Feedback Loops.** The PCM is nothing more than a negative feedback loop. A negative feedback loop is where a variable set of conditions is compared to a preferred set of conditions (the reference) and then action is taken to change the variable set to match the preferred set by removing (negating) the differences. Negative feedback loops are common in electronics and mechanics and can be seen in any control device such as thermostats, autopilots and the like. It is also common in biology where biological functions have evolved in order to keep homeostasis – a comfortable level of existence.

7.1.3.2 **The PCM as a Negative Feedback Loop.** In psychological theory, the concept of behaviour as being part of a negative feedback loop was mooted by William T. Powers who coined the notion that biological organisms behave in such a way so as to control their perception of the world around them. (For further explanation of the term 'Negative Feedback Loop', see the text box below). The key is how the biological organisms perceive what is happening. This then suggests that control is from within the organism rather than from the outside the organism. This makes it different from mechanical control devices that have control input from outside the device (eg a human setting a thermostat temperature).

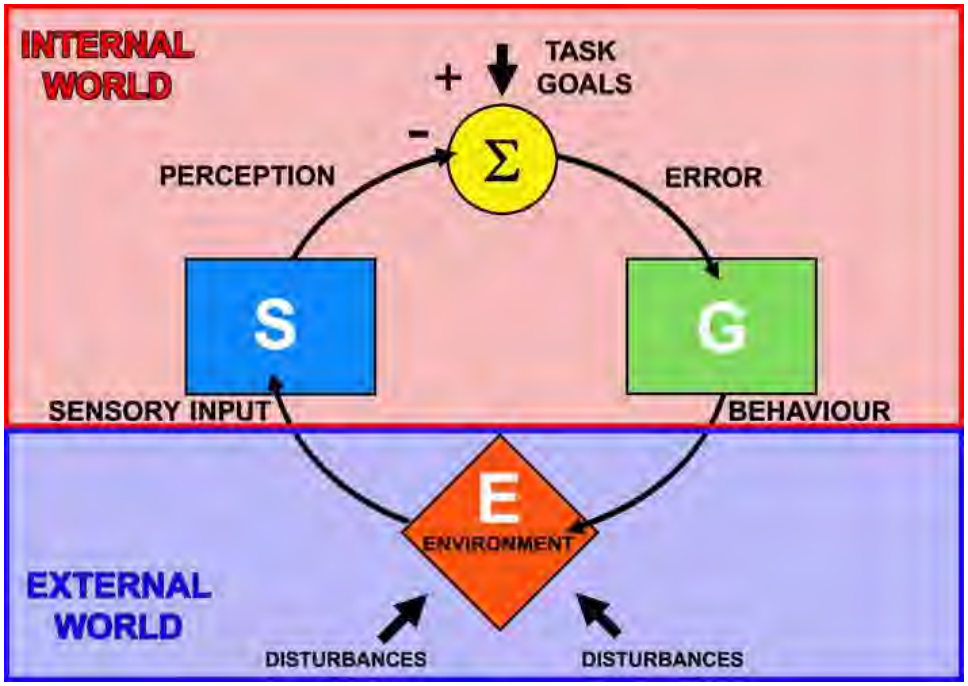


Figure 7.2 William T. Power's Perceptual Control Model[180]

[180] Derived from Hendy, K.C., *Situational Awareness and Workload: Birds of a Feather?* From the paper delivered to the Symposium on 'Situational Awareness: Limitations and Enhancements in the Aviation Environment, Brussells, 24-28 April 1995.

The Perceptual Control Model is used to describe why an organism (or device) may react or be programmed to react in a certain way when confronted with a particular set of conditions such as perceiving the environment around it. It is best explained thus:

- The Environment (E) is the world around the organism (or device) and its interaction with it. This interaction is detected by the sensors of the senses. We shall use an example of a person driving a car. The environment is the road conditions, the traffic, the characteristics of the car such as the speed, engine noise, feedback through the steering wheel, and any other aspect of the world around the person driving the car which the person can sense.

- The sensory input (visual cues, audio cues etc) is provided into the transfer function 'S' which is the processing of the information in the brain transferring it from electrical stimuli of the senses to cognitive processes and then understanding their meaning. This is the perception function. (For a further explanation of this concept, go to Element 3 , The Human Body).

- This perception is then used and compared to the understanding of the goals of the mission or task which, in this example, is the safe driving of the car. This comparison is summed and compared to those goals (Sigma or Σ). The result is the difference between what is wanted and what is desired. For example, if the vehicle is travelling at 75 km/hr and the desired speed is 60 km/hr, then this is seen as an error of 15 km/hr. The difference between what exists and what is desired is seen as an error.

- The error signal is then sent to the next transfer function and processed and amplified (Gain, or function 'G') and the required information processing determines what action needs to be taken in order to make the error nil. That is to say, to 'null' the error or cancel it. In the above example, the person driving the car will think about the error, decide that either the accelerator needs to be eased off or the brakes applied depending on the road conditions and will then initiate and execute a behaviour through the muscles in the right leg.

- This action then changes the environment (E) with the vehicle slowing down and the whole process occurring again.

This model of perceptual control is useful for a number of different reasons both in mechanical / electrical applications and psychological applications. It is also useful when considering barriers and enhancements to SA. Each of the components of the above diagram can be used as areas of SA to be investigated for hindrances and enhancements to SA.

Why is it called a Negative Feedback Loop?

This term is probably not the best to describe this type of device or situation. A negative feedback loop looks at one state and compares it to a reference and decides what the differences are and then tries to remove – or negate – the differences, after which the new state is fed back into the system and it starts all over again in a loop where it is compared again, corrected and fed back into the loop. The opposite is a Positive Feedback Loop where instead of minimising the difference between one state and another, the device or situation increases the difference and feeds that back into the loop.

In the negative feedback loop, the ultimate aim is to remove the differences and make the condition stable or balanced. In the positive feedback loop, the ultimate aim is to make the differences greater, or reinforce them, which leads to unstable conditions. An example of positive feedback is a microphone that is too close to its speaker. The microphone's job is to pick up sound and then increase the sound (aka gain) through the amplifier and broadcast the amplified sound through the speaker. If the microphone picks up the louder sound from the speaker, then it will continue to get louder and louder each time it passes through the loop until the speaker fails because it cannot handle the continuously increasing sound. Instead of amplifying it, the speaker is only able to emit a loud squealing sound.

Better names have been suggested for these two types of loops such as: self-reinforcing and self-correcting or reinforcing and balancing feedback loops.

Section

7.1.4 **Using the PCM to identify barriers and enhancements to SA.** The PCM, as it applies in the psychological sense, is a useful tool when discussing barriers and enhancements to SA. In order to do this, we shall look at different phases in the cycle of the PCM and discuss how each pertains to SA with regards to hindering it, and then ways to mitigate those hindrances. Look at the following paragraphs and compare it to Figure 7.2.

7.1.4.1 **Sensory Input.** Sensory input refers to what external stimuli is detected by the several human senses, which will then be converted into information to be processed by the brain and compared to the preferred model. As we have discussed in Element 3 The Human Body, there are nine easily identifiable and discrete human senses that are readily agreed upon. To that end, we shall not cover what needs to occur in order to enhance these senses in great depth here, as this has already been covered. Instead, we shall touch upon how the senses assist with SA as part of the PCM.

7.1.4.2 **How Sensory Input Enhances SA.**

- **Vision** – the most important of the senses. Good vision allows for easier assimilation of information in the natural environment and in the man-made environment. Good vision is key to gaining information, which is key to SA.

- **Audition** – hearing, like vision, is a key sense in dynamic environments. Being able to hear aural cues is imperative to good SA. Some examples include communication information such as radio communications, warning signals,

other members of the team) or disturbances in the natural and man-made environment, such as changes to wind noise whilst flying or driving or changes to the sound of engines and machinery such as transmissions.

- **Tactition and Proprioception and Equilibrioception** – Tactition (touch) is also a sense that helps confirm the two key senses of vision and audition. In an aircraft it can be the shape of certain switches or something like a stick shaker which causes the control column and control wheel of an aircraft to shake if the aircraft's speed slows down too much close to the stall speed. We shall put proprioception (knowing where parts of the body are and what aspect they are in relation to the force of gravity) together with tactition also, purely for convenience. Being able to reach out and locate a control mechanism (eg a throttle lever or gear stick) and being able to discern its position without having to look assists greatly with SA. This ability to feel where the body is and comparing to where it should be, along with Equilibrioception (the sense of balance), goes a long way to assisting with sub-conscious assessment of the individual's place in the environment. There is a caveat however; the individual must know how to confirm this information, which can seem to be erroneous (see Section 7.2.1 on sensory illusions).

- The other key senses such as smell, taste, thermoception (the ability to detect heat) and nociception (the ability to detect pain) help to complement the other senses in SA but to a lesser degree. All of them work together to provide the sensory input through the transfer function to the brain through the central nervous system.

- Information is also received through other sensors not related to the human body but which are then processed by the human senses and the brain. For example, the speed sensor on a machine could be a speedometer, an airspeed indicator, a GPS or other such sensor. The information may then be received through vision, audition or tactition.

Section

7.1.5 **Perception.** The way in which an individual interprets information to make sense of the environment is derived from the manner in which the information is sensed and then compared to known or assumed values. These are the two fundamentals of perception. For example, if two identical cars are seen by a person but one appears larger than the other, the person will believe that the smaller one is further away based on previous experience. It won't be necessary for the person to physically measure the distances to the two cars because experience has shown that his perception of that sensory input is most likely representative of the actual environment. If that experience is not available however, then a judgement will be made based on deductive reasoning. The key to perception is a frame of reference.

7.1.5.1 **Enhancing Perception.**

- Perception is related to the understanding of the environment through experience and training. In order to enhance perception, the individual must have the ability to discriminate between various types of information and be able to recognise (perceive) them and understand (comprehend) their meaning. If experience and training are inadequate to recognise the information, then an ability to deduce what the meaning is most likely to be is the next step; deductive reasoning.

Section

7.1.6 **Reference State and the Sum of Error.** The Reference State is the desired state or the parameter against which the variable state is measured. In a control device like a thermostat, it will be the temperature set by the operator. In a variable situation like a flying mission, it might be something like the altitude required en route or perhaps the speed on an approach to landing. In a fire fighting context, it may be something like the size of a controlled burn. The next component in the cycle is the comparator. The comparator is the device or person that/who looks at the actual state and compares it to the desired state and determines if the two are the same. If they are not, then their conditions are considered to be in error. For example, in a thermostat, if the desired temperature is 25 degrees and the actual temperature is 28 degrees, then there is a three degree error. If the desired altitude of an aircraft is 5000 feet and the pilot sees that s/he's flying at 5,400 feet, then the error is obviously 400 feet. If, in the fire fighting context, the controlled burn seems to be getting larger than is desirable for the environmental conditions (eg control lines, wind strength, terrain and vegetation), then the state of the fire is considered to be in error with the desired state which is subjective and based on the experience of the firefighters and the knowledge of the conditions. There can be a number of errors, all of which are combined – or summed – to make the total sum of error. This is the second level of SA – comprehension, that is, understanding what the information means and how it relates to the task.

Figure 7.3 Various Comparators: A thermostat; a pilot; and a firefighter. All these individual operators/items are vital in a negative feedback loop as a means of assessing conditions and maintaining SA.

7.1.6.1 **Mental Models as the Reference State.** In an SA context, a reference for a future condition can be created in advance. For example, if a pilot is planning a flight, then s/he will consider what s/he wants to achieve (the goal) and may make a best guess as to what to expect during the flight based on the weather forecast, the aircraft's capabilities, the location of suitable diversions/alternate airfields, and other variables, and will then be able to create a mental model of what is desired and what to expect. This mental model will be based on a number of factors, such as:

- The information available to the operator prior to the task, such as weather briefings or information about the area to be operated in or other factors as well as information passed between team members or other stakeholders;

- The amount of knowledge and training the operator/s have so that intelligent deductions can be made about what to expect; and

- The task/mission requirements of the operator and/or the organisation (ie the goal).

Using the above example, if the pilot then flies the route, then along the way s/he will process what is going on around the aircraft in the actual environment and then compare it to the mental model. The differences between the mental model of what is desired (the goal) and expected, and what is being experienced are compared and the difference is the error.

7.1.6.2 **The Error and Nulling it.** Once the error has been established, the operator (the mechanical or electronic correction device, the pilot and the fire fighting team in the above examples) needs to take action in order to null the error. That is to say, to negate the total sum of error so that the actual state matches the desired goal state and then that is fed back into the loop. This requires an ability to conduct the actions necessary to make those corrections and, in the case of human input into more complex situations, the ability to make the appropriate judgements as to what actions to take and how to take them. This is the behaviour component of the model.

7.1.6.3 **Gain and Behaviour.** In typical feedback loops, there is usually a form of gain or amplification of signals in order for corresponding behaviour to occur. When the negative feedback loop is modelled for human activities, it is often unnecessary to include amplification of signals. What is more important is the behaviour necessary to null the errors which is discussed below.

7.1.6.4 **Effective Behaviour.** Effective behaviour is that set of actions that assists with achieving aims. In the examples above, some of the behaviours are relatively simple. In the case of the thermostat, either the cooling or heating device turns on or off in order to bring the temperature to the desired goal state. In the example regarding flying at the wrong altitude, the pilot will adjust power and attitude of the aircraft in order to return to the desired goal altitude of 5,000 feet. In the example of a controlled burn getting too large, the commander of the fire fighting team will issue commands to effect the control of the fire by such things as using a water tanker or clearing another control line or conducting a smaller control burn to remove fuel from the larger burn. In all cases, the operator must take steps to null the error and these steps are termed the ‘behaviour’. Behaviour has already been defined in Element 2 The Human Mind as the way an organism (or device) reacts to a situation.

- Behaviour needs to be effective in order for an error to be nulled and a condition to be changed. This relies on skills in judgement and skills in application of actions. Good judgement and good skill application are primarily the results of experience and training and good team behaviours.

7.1.6.5 **The Environment and Disturbances.** The final phase of the loop is the change in the environment brought about by the behaviour of the organism/ device as well as further disturbances, which are brought about by conditions other than the behaviour of the organism/ device. Because the organism/ device has executed the behaviour, the environment changes. So, in the examples above, the temperature changes or the altitude

changes or the size of the fire changes. In all cases, this change of the environment (as well as any external disturbances) is then sensed, perceived, compared, behaviour modified to null the errors and then the environment is changed again… and so on, and so on

Module 7.2

7.2 **Practical SA Considerations.** The above paragraphs discussed the theory behind SA and the application of the Perceptual Control Model (negative feedback loop) as used to explain the psychology in SA. The following paragraphs will outline some hindrances to be aware of and some suggested mitigations to enhance SA in a team environment.

Section

7.2.1 **Losing and regaining SA.** Many factors contribute to a loss of SA; physical, physiological and psychological. But perhaps the most prevalent cause of SA loss is the overloading of a person who is not equipped to rapidly process relatively large amounts of information. For any activity a human undertakes, a certain amount of mental resources is required in order to use cognitive processes to think through the problem. This amount of cognitive resources is limited. With higher training or a lesser workload, the demands on the cognitive resources are reduced. In the higher training sense, a lot more information can be processed rapidly. The individual is able to quickly discriminate what information can be ignored and what information should be processed and can then process that information quickly and accurately. Below is a list of signs of a loss of SA, possible causes and possible mitigations:

7.2.1.1 Loss of awareness of position

- Symptom:
  - Individual or team is unsure of his/her/its position geographically.
  - Individual has lost awareness of his/her body position relative to the earth (eg the leans).
- Possible Causes:
  - Poor planning and/or lack of references (eg maps, mental model, visual cues.)
  - Changes to expected route or changes to mission/task or inability to positively confirm position due to external circumstances (eg weather or hazards requiring a diversion or preventing good visibility or communications).
  - Physiological factors such as vertigo, illness, sensory illusions, toxins in the system.
  - Lack of attentional resources by the individual or team.
  - Task overload due to excessive tasking or due to equipment factors (includes task saturation) that causes cognitive overload resulting in a loss of positional awareness.
- Mitigations:
  - Conduct appropriate planning prior to mission/task.

- Create *aides-memoire* to assist during the mission/task (see Section 7.2.2 on cheat sheets and mud maps).
- Consult with other team members to get as much information as possible prior to the mission.
- Consult with other team members to provide them with as much information as possible prior to the mission and share the mental model.
- Conduct rehearsals (eg dirt dive, dry run, fly through) and go through the mission/task step-by-step with each person practicing his/her role at the appropriate time and place.
- Establish contingency plans in case the mission/task changes or environmental conditions change and establish conditions for when they need to be activated.
- Have all references and equipment ready and easily accessible and work areas organised (eg cockpit or vehicle or operations centre, etc).
- Know the default operating conditions for the vehicle/machine/apparatus (eg power settings vs attitudes vs speed; expected speeds for the performance of the vehicle and ancillary equipment).
- Continuously monitor the status of the mission/task and compare that status against expectations (See Section 7.1.3 on Feedback Loops). If the error becomes too great, then return to known conditions or activate contingency plans.
- Ensure all team members are physically and psychologically fit for the mission/task.
- Remove any stressors from the team environment (eg extraneous tasks, mission creep as discussed in Element 9 Task and Mission Planning, Briefing and Debriefing).
- Be specific about the aims of the mission/task and don't allow mission creep to occur.
- Know how to use automation to assist but also understand not to rely totally on automation (eg GPS or navigation aids; autopilots; etc).

7.2.1.2 **Ambiguity or confusion**

- Symptom:
  - The situation encountered by the individual or the team cannot be processed so as to make sense with regard to the task or mission. This may also be accompanied by anxiety and psychological discomfort.

- Possible Cause/s:

    - The incoming information does not fit in with the expected mental model.

    - There is a lack of an appropriate mental model due to inadequate planning and/or briefing.

Figure 7.4 Members of a formation flying team conduct a 'walk through'. Similar to a 'dirt dive' for skydivers, a 'walk through' allows all members to get a good understanding of what is required in a dynamic environment. In this image, the formation leader is leading the other team members around a formation procedure and demonstrating the hand signals he will be using which can be seen from each cockpit.

    - The individual cannot process information due to psychological stressors that inhibit cognitive processes (eg overloaded, distracted, emotionally stressed, outside comfort zone, self-doubt).

    - The individual cannot process information due to physiological reasons that inhibit cognitive processes (eg illness, fatigue, toxins).

    - The equipment is performing outside of the range of knowledge of the individual or team (eg automation is not working as expected or machinery is performing strangely).

- Mitigations:

    - Create an appropriate mental model of what to expect.

- Draw, and have handy, a diagram of your route which can be used easily and can also be used for briefing others. Sometimes known as a 'mud map'. Annotate on it pertinent information like headings/directions and distances, frequencies and radio changes and call signs, estimated fuel at significant points, places to divert to, safe zones (eg for firefighting). (See the example below).

- Create a handy 'ready reference' or 'cheat sheet' for use with information you require so that you don't have to search for reference material. Leave space for notes. (See example below).

- If conducting a specialised coordinated activity, do a 'dirt dive' like skydivers do. Have individual teams and/or team members assume positions and walk through the activity so that people have a time and space appreciation of where people/assets are. This is handy for things like formation flights or battle preparation or SAR activities.

- Ensure appropriate people have the training and experience required for their positions within the team or that advisors are available to assist, especially in OJT (On the Job Training) situations.

- Ensure all persons are psychologically and physiologically fit for the activity and that any distractions or stressors are not likely to affect the mission or task.

- Remove any distractions to the mission or task.

- Conduct effective briefings for all persons involved and ensure everyone is familiar with what is expected of the mission and of the each person involved and their respective roles.

- Create time driven or event driven matrices to be used as checklists. This is handy for protracted activities and project work.

7.2.1.3 **Fixation or channelisation;**

- Symptom:

  - A person or persons will fixate on one item to the detriment of others. (An example is Eastern Airlines Flight 401 that crashed in Florida. Whilst the entire crew was trying to solve a problem with the indicator light for the nose wheel, the aircraft's autopilot had been accidentally disconnected and the aircraft was making a gradual, almost unnoticeable, descent from 2000' until it crashed into the Everglades. No-one on the flight deck noticed the 100,000 pound aircraft descending… they were all fixated on a $12.00 light.)

- Possible Causes:

  - Inappropriate priorities. The perception that one item or task is more important than all others and therefore there is a deliberate narrowing of focus.

- Target fixation where there is a non-deliberate narrowing of focus on one item or task.
- The human condition which funnels a person or team to attempt to achieve easily attainable goals first.
- Lack of a proper delegation of duties.
- Task overload due to excessive tasking or due to equipment factors (includes task saturation).
- Cognitive overload where the skills to solve a problem are lacking resulting in more attention being placed on the problem to the detriment of other attentional duties.

- Mitigations:
  - Prior to the task or mission, ensure all team members are aware of their duties during normal and abnormal (eg emergency) situations.
  - In team situations: During abnormal situations, ensure the most critical task is accomplished first (eg remove the team from danger by flying the aircraft, driving the vehicle, monitoring the situation) and that that task is then monitored whilst the abnormal situation is dealt with by other team members.
  - In solo situations: During abnormal situations, ensure the most critical task is accomplished first (eg remove yourself from danger: fly the aircraft, drive the vehicle, monitor the situation) and that that task is given priority after which time, time-sharing between that task and dealing with the abnormal situation shall occur.
  - Identify times of high stress and ensure team roles are allocated and/or maintained.
  - Place one person as overseer/manager of the whole situation and do not allow that person to become too involved with solving the abnormal situation.
  - Communicate your situation with others and request assistance (eg ATC monitoring, operational assistance through operations, etc)
  - Do not allow difficult situations to overload the team. If the situation is too difficult to solve, default to the next safest option (eg abort the mission, divert to a safe area, etc)
  - Use checklists but do not forget to monitor all other variables at the same time (ie don't allow the checklist to become the only focus of your attention. Ensure time-sharing occurs).

7.2.1.4 **Poor communication;**

- Symptoms:

- Incorrect information passed to members of the team;
- Failure to communicate necessary information between team members (including single person operations with external agencies) (eg no communication between crew members; no communication between teams and ATC/HQ/Ops etc).
- Failure to acknowledge communications.
- Communication garbled or unusable including incoherent or wrong personal communication or unusable electronic communication.
- Inability to understand communications due to lack of common frame of reference (eg incorrect mental model, language barriers).

- Possible Causes:
  - Inadequate planning and establishment of a shared mental model.
  - Lack of knowledge of communication methods such as use of communications equipment, frequencies, etc. due to poor planning or inadequate training.
  - Lack of knowledge of communication procedures (including language and SOPs).
  - Lack of a proper delegation of duties.
  - Task overload causing breakdown in communication.
  - Physical barriers such as noise, vibration, ergonomics, equipment malfunctions, range and line of sight issues.
  - Psychological barriers such as authority gradients, cultural differences, self-doubt.
  - Physiological barriers such as hearing impairment, speech impairment, illness, toxins.
- Mitigations:
  - Prior to the task or mission, ensure all team members are aware of the requirements of the mission/task and the communications plan.
  - Ensure communications equipment is suitable for the task and that all personnel who are required to use it are familiar with it. Conduct tests prior to the mission/task to ensure its function.

- Ensure SOPs are known by all team members (including proper phraseology and signals) and use them.
- Identify if language barriers are likely to be a problem and attend to them by creating back up plans and an environment where people feel comfortable in asking for clarification.
- Clarify any ambiguities or misunderstandings as soon as they arise.
- Communicate your situation with others and request assistance (eg ATC monitoring, operational assistance through operations, etc) where necessary.
- Identify likely communications barriers such as lack of appropriate compensation equipment (eg headphones and intercom in an aircraft) or ergonomics (eg physical position of team members who may be out of sight) or environmental conditions (eg terrain obscuring line of sight communications, RAIM for GPS, time of day for HF communications) and put contingencies in place for them.
- Establish no-comm (no-communication) procedures (ie what procedures will be used during periods of no communication such as being out of radio range).
- If communications are sparse, disrupted, suffering interference or intermittent, ensure all questions are closed questions (eg talking on a radio where one person can hear the other clearly but the other can only hear a carrier wave resulting in using Press To Talk 'clicks' to communicate).
- Establish an environment where every team member feels comfortable in communicating their concerns without fear of reprisal.
- Establish rules for communication (eg sterile cockpits or priority of communications).

7.2.1.5 **Incorrect application of skills or procedures:**

- Symptoms:
  - Required targets are not met or limits are exceeded (eg altitude limitations are exceeded, speed limits or vehicle operating limits are exceeded, restricted or hazardous areas are entered unknowingly).
  - Expected procedures are not adhered to.
- Possible Causes:
  - Inadequate training or experience.
  - Task saturation causing a narrowing of focus and inability to scan the big picture.

- Physiological limitations such as degraded performance due to environmental conditions, stress, fatigue, toxins, etc.
- Psychological stress due to time limitations, unanticipated conditions, self-doubt, performance anxiety.
- Distraction.
- Complacency.
- Human Error conditions such as slips, lapses, mistakes and violations.

- Mitigations:
  - Ensure team members are qualified and trained for the mission/task and that each has satisfactory recent experience.
  - Identify times of high stress when task saturation is likely to occur and ensure that the big picture scan is maintained and a narrowing of focus is avoided.
  - Be aware of any physiological limitations that may be present such as hypoxia, excessive heat or cold, excessive physical stress, fatigue, drugs and alcohol, etc
  - Be aware of any psychological limitations such as personal stressors that may be distracting the concentration of the individual, or temporal (time-related) stress, or new and novel conditions. Other cases may be performance anxiety (“test-itis") or the individual may have self-doubt about his/her capabilities causing undue stress and concern.
  - Know your own limitations and that of team members and endeavour to not allow the situation to demand more from yourself or your team than capabilities allow.
  - Use reminders to notify if limits are being approached (eg automation visual or aural warnings; notes scribbled on windscreens in grease pencil within or near your field of view; other team members).

7.2.1.6 **Expected milestones or events are not achieved:**

- Symptoms:
  - Expected or planned targets/milestones/events are not met at the expected time or place (eg a waypoint is not found at the predicted time; a rendez-vous with another person or callsign does not occur at the appointed time/place; a radio call is expected but is not received).
  - Actual performance of machine/s does not match the expected performance (eg performance is sluggish or unusual; fuel on board is different to what is expected.)

- Possible Causes:
  - Planning was incorrect; errors made; incorrect data used.
  - Mental model was not correct or not made at all.
  - Expectation Bias (see Element 3 The Human Body, paragraph 3.9.2.1) creates an incorrect expectation, which is based on inappropriate or incorrect mental modelling (eg a similar situation leads a person to expect a certain outcome but is surprised when the outcome is different).
  - Environmental conditions are different to that expected and the associated effects were not taken into account.
  - Machinery configuration is not as expected (eg undercarriage has not been retracted/extended; flaps not in correct position; powerplant is not in correct power setting; ancillary equipment is not being operated properly; unexpected malfunction of equipment is occurring.)
  - Automation has not been used correctly (eg wrong data input or wrong modes selected and information not interpreted correctly).
  - Communication has been faulty and/or assumptions made which were incorrect.

- Mitigations:
  - Ensure team members are qualified and trained for the mission/task and that each has recent experience which is satisfactory and which will permit sound planning and decision-making.
  - Ensure planning is accurate using most up-to-date data.
  - Create mental models and ensure all team members have input and are briefed.
  - Create time or event driven timeline matrices.
  - Create a mud map (see Section 7.2.2).
  - Plan for contingencies and know when to implement them.
  - Use checklists to ensure correct machinery configuration.
  - Conduct a final check prior to operation (eg final walkaround visual check before commencing; check of warning indicators; check of configuration; obtain an external check from ATC/another aircraft/ another vehicle/ another team or team member).
  - Double-check or externally check data to be input and data output from automation.

7.2.1.7 **Unable to process information and project it:**

- Symptoms:
  - Information received is not interpreted correctly, not understood or not used at all.
  - Information is not received by the operator or is incorrect or is missing elements of it.
- Possible Causes:
  - Planning was incorrect; errors made; incorrect data used.
  - Mental model was not correct or not made at all.
  - Expectation Bias (see Element 3 The Human Body, paragraph 3.9.2.1)creates an incorrect expectation, which is based on inappropriate or incorrect mental modelling.
  - Operators lack sufficient knowledge and experience to correctly comprehend information or make deductions about information that is novel.
  - Operators fail to implement information in a timely manner due to complacency or distraction.
  - Communications systems are faulty or conditions prevent full receipt of communications.
  - Information received and used is incorrect and the team is unaware that this is the case.
- Mitigations:
  - Ensure team members are qualified and trained for the mission/task and that each has recent experience which is satisfactory and which will permit sound planning and decision-making.
  - Ensure planning is accurate using most up-to-date data.
  - Create mental models and ensure all team members have input and are briefed.
  - Create time or event driven timeline matrices and integrate new information into the timelines.
  - Create a mud map (see Section 7.2.2).
  - Confirm information is correct and advise the operational command chain of intentions based on any new information received, especially if the new information results in a change to original plans.

- Know and identify when complacency/fatigue/boredom/over confidence are factors affecting the individual/team and make deliberate efforts to overcome these factors.

- When new information is received, use it as soon as possible and implement it into the plan.

- Understand that automation can lead to complacency and take steps to prevent it.

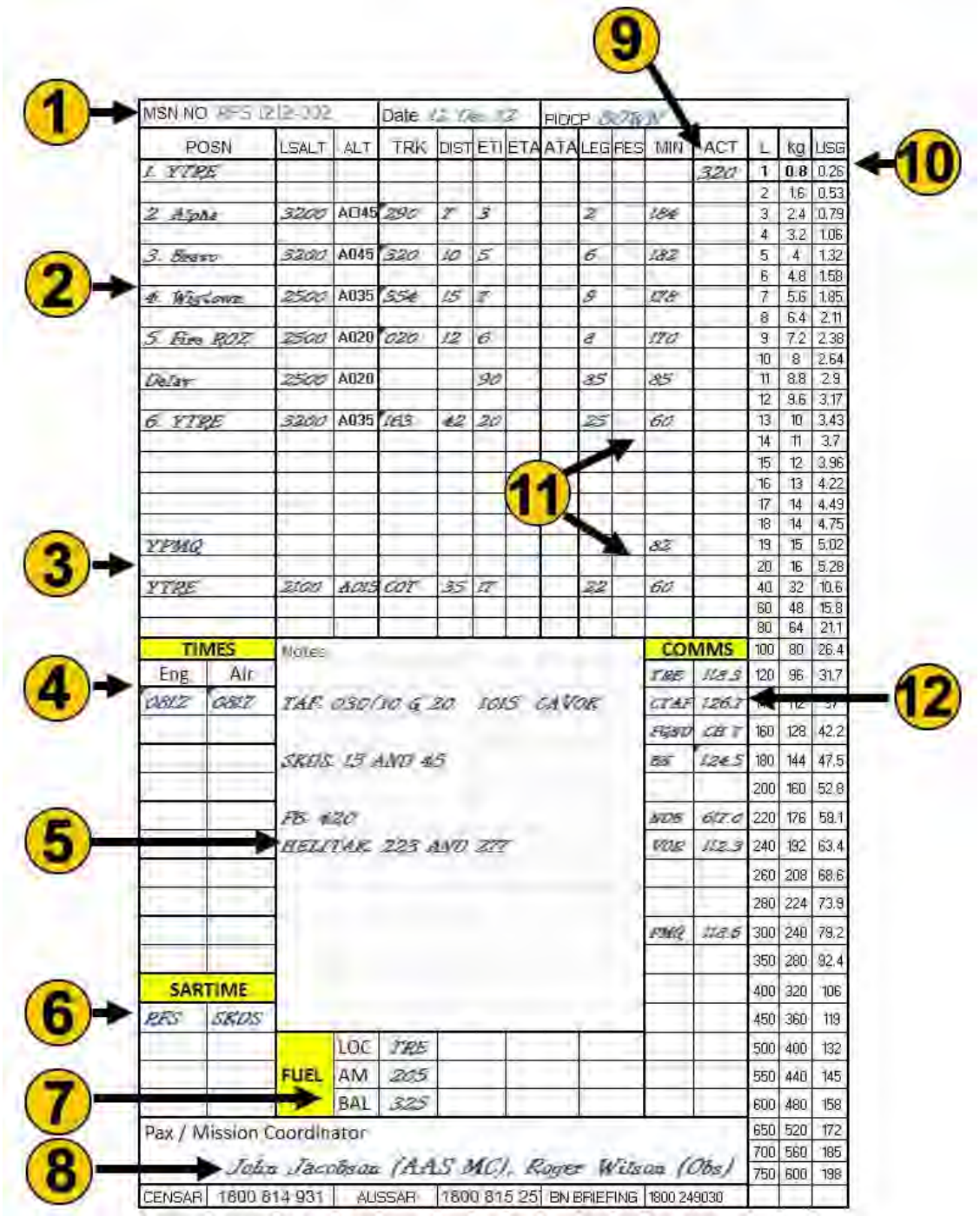


Figure 7.3 The author's knee board cheat sheet created using a standard spreadsheet program and printed to A5 size.

Section

7.2.2 Using a Cheat Sheet to Aid in SA. The most useful tool in gaining and maintaining SA is prior preparation and planning and then organisation. The Cheat Sheet used by me (the author) is my way of planning the mission and then providing a means of capturing the information in a useful and organised way that is readily available in a cramped cockpit in often bumpy conditions. Below are the key aspects of my Cheat Sheet. Anyone can design their own for any situation requiring enhanced SA.

CHEAT SHEET FOR A MISSION IN SUPPORT OF FIREFIGHTING OPERATIONS

(to accompany Figure 7.3)

1. The **Mission Number** or **Task Number** as provided by the client, in this case one of the Rural Fire Services. Any type of Mission/Task no can be used provided it makes sense to whomever may need this information at a later stage (eg operations or accounts).

2. The **Flight Plan Waypoints** in order. If necessary, the Lat/Longs or Grid References could be added during the planning stage so that it is available for loading into a GPS in the cockpit. (That's why there's a space between each waypoint for that exact purpose). In this example, the flight route passes through three waypoints before reaching the Restricted Operating Zone around the fire where it is anticipated that there will be a 90 minute delay in the flight route as the support to firefighting commences. Once that is complete, the flight route recommences.

3. **Diversion Destinations**. In this case, because fuel may be an issue, I have included the next logical place for me to get fuel. This is part of my contingency planning. I have left the leg details blank because I don't know where I may start my diversion from. If and when I decide I need to divert, I can make quick calculations then and annotate them on the Cheat Sheet. The leg from my fuel point to my home point I have already planned and I can then ascertain what is my minimum fuel required after leaving YPMQ, my fuel stop.

4. **Start and Stop Times**. These are necessary for billing the client and for keeping track of maintenance time. The first is engine start when billing the client begins. The second is take off time, when maintenance hours are logged. Landing time is input directly below the take off time and the engine stop time is input directly below the engine start time. In this example, I can have five engine start/stops and associated take offs and landings.

5. **Notes**. These are notes required during the flight. In this case it is the TAF for YTRE, when my skeds calls (SAR calls) are to be made and the callsigns of aircraft in the area.

6. **SAR Details**. Normally this would contain which agency is holding my SAR and what the SARTIME is. Here, it is RFS and shows skeds reporting.

7. **Fuel Purchase Details**. Information on where fuel was purchased and how much was purchased and the associated balance. These sorts of details are important

for various commercial operators but may not necessarily be necessary for other operators. In this example, at TRE, 205 litres was purchased with a balance of 325 litres on board after refuel.

8. **Passenger/Mission Crew details**. The names of the passengers and crew for future reference.

9. **Actual Departure Fuel**. In this section goes the amount of fuel on board the aircraft upon take off. From this point, fuel calculations commence and the fuel on board at each waypoint is input into the blank cells to compare against the minimum required fuel at each waypoint. If fuel on board is more than the minimum required, then 'you're good to go!'

10. **Fuel Conversion Table**. This is a handy item when fuel information is needed in three types of units: Litres for buying fuel; KGs for calculating weight and balance and USG to check on the fuel gauges which are, unfortunately, in USG on this aircraft. All these conversions are available on most electronic flight book applications for smart phones and tablets and the conversions are readily available in the En Route Supplement… but a quick comparison table means I will always have the figures I want quickly without key strokes or scrambling for a phone or tablet. (Note: In this table, the conversion is for AVTUR not for AVGAS. This Cheat Sheet was used for a turbine-powered aircraft in reality, but the example here is for a piston powered aircraft. Ed.)

11. **Min Fuel at each Destination**. This is an important figure and shows that the minimum fuel I should have in my tanks upon arrival at my destinations will be 60 litres as calculated for my aircraft as per the aeronautical publications. From this figure it is easy to calculate how much is the minimum fuel at each waypoint simply by adding the estimate of how much you expect to burn on each leg. This way fuel on board can be compared to minimum fuel required.

12. **Communications information**. The most important frequencies for the mission are written down here including all aviation frequencies and ground frequencies and the frequencies of any navigational aids that I may require.

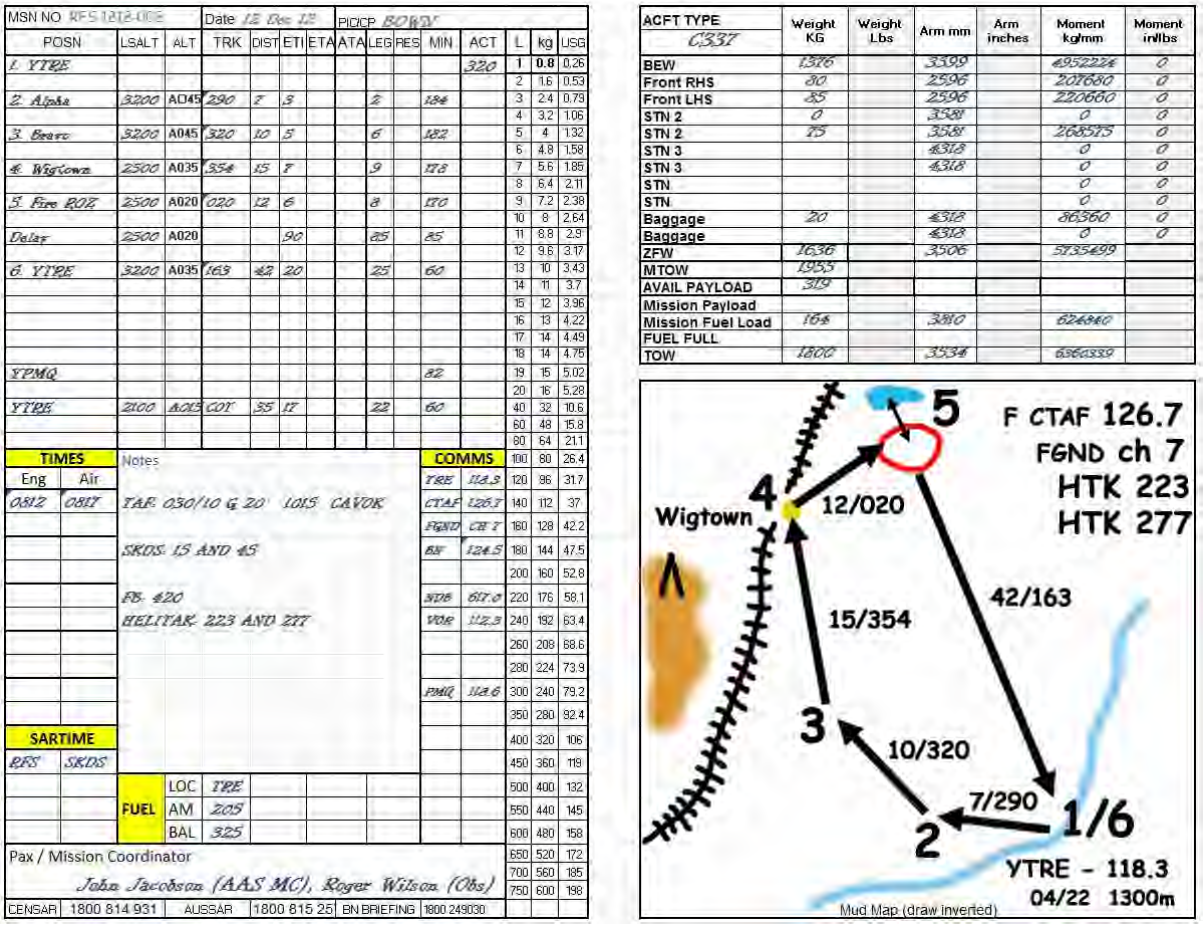


Figure 7.4 The Cheat Sheet with a Mud Map drawn on it. Have a look at the mud map and see what information you can discern from it.

7.2.2.1 **Using a Mud Map for Self Briefing and Briefing Others.** By creating a mud map, an individual can brief him/herself and get a good mental model of what to expect during the task. Keeping it simple and with the barest information required ensures its utility. Also, writing the information in larger letters makes it easier to read in bumpy conditions and when you can't afford to have your scan inside the cockpit for too long.

From looking at Figure 7.4, a person with some aviation knowledge can tell the following:

1. Departing out of YTRE, which is waypoint 1 and 6, the river should be on your left. The first track is westwards for 7 miles and in a light aircraft, that should take about four minutes or so.

2. At waypoint 2, there will be a turn to the right through 30 degrees for 10 miles… about 5 minutes. In the distance, you should see a radio mast on a mountain.

3. At waypoint 3, there will be another turn to the right through 34 degrees for 15 miles, about 7 or 8 minutes. A railway line should converge from the left guiding us into waypoint 4. If visibility is bad, or we get lost, this will be a good lead in feature.

4. Waypoint 4 is the village of Wigtown. The railway passes through it. There, you can expect a turn through 26 degrees and 12 miles, six minutes, we arrive at the Restricted Operating Zone, the Fire CTAF.

5. Waypoint 5 is the fireground. Fire CTAF frequency is 126.7. Fireground frequency is Channel 7. Aircraft conducting operations there are Helitack 223 and 227 and their water supply is to the north of the fireground. If visibility is bad, this area should be avoided to ensure maximum separation.

6. Returning to YTRE is 42 miles, about 20 minutes on a heading of 163. It shouldn't be too hard to find YTRE, but if the visibility is bad, then we can expect to see the river converging from the left. If we pass the river, we've gone too far. YTRE's frequency is 118.3 and the runway is 04/22 and is 1300m long.

NOTES:

GROUP 4 – THE OPERATIONAL CONTEXT

The Element/s in this Group relate to the Human Being and how (s)he works in the operational environment.

ELEMENT 8 – Judgement and Decision Making

Contents:

Module 8.1

8.1 **Defining Judgement.** Decision Making (DM) is a complex process consisting of two key functional activities. It can be defined as a process where a person evaluates alternatives (makes judgements) and will then select a course of action (ie makes a choice).This first component of DM requires further discussion.

Section

8.1.1 **Types of Judgement – Perceptual (Intuitive) vs Cognitive (Analytical). Perceptual Judgement** is when a decision is based on the perception of the environment and a rapid assessment is made based on that quick perception and a judgement made without the need for analytical thought. Instead of analytical thought, the judgement is based on what some would call intuition. This type of judgement is most useful for those simple and common tasks. **Cognitive Judgement** on the other hand, is when a decision is made using more complex and analytical processes especially where significant uncertainties exist. Some examples of perceptual (intuitive) judgement would be such things as when a driver is approaching a set of traffic lights which turn from green to amber. Intuitive judgement is used in this type of situation by the driver who will decide on whether to continue through the intersection or come to a stop. A number of factors will play a part in the decision making process as s/he makes the judgement: such things as distance from the intersection; road and weather conditions; traffic; condition of the vehicle; etc. The driver will have perceived these conditions already and will already have a baseline on which to base his/her decision which will be intuitive for the conditions being experienced.

Section

8.1.2 **Hazardous Attitudes and Judgement.** The most common set of hazardous attitudes as they pertain to high risk environments are listed as follows[181]:

- **Anti-authoritarian** – an attitude that influences a subject's decision making behaviour such that (s)he wilfully disregards those in authority or authorised procedures and regulations.

- **Impulsivity** – an attitude that influences a subject's decision making behaviour such that (s)he feels the need to take a course of action so quickly, that any consideration as to its effectiveness is secondary to the need for something to be done quickly.

- **Invulnerability** – an attitude wherein the subject feels that his/her actions will have little or no negative consequence. This is not to say that s/he does not believe that accidents do happen, but that (s)he will not be the victim of one.

[181] *Flight Safety Australia, NOV-DEC 2007,* Issue 59, Civil Aviation Safety Authority, Canberra, 2007

Such persons are more likely to take unnecessary risk.[182] To further the analogy from paragraph 8.1.1, young males driving in the situation described (ie approaching a set of traffic lights turning from green to amber) will often have their driving behaviour influenced by this sense of invulnerability and for the most part may likely be more inclined to take risks other, more experienced drivers would not.

- **Exhibitionist** (aka Macho) – that attitude whereby the subject feels compelled to demonstrate his/her superior skills to others. Continuing with the traffic lights analogy, young males with their peers in the vehicle will often have their judgement skewed in this environment and will more often than not be more included to take greater risks in order to satisfy this exhibitionist attitude. (See also Maslow's Hierarchy of needs in Element 2 on The Human Mind).

- **Resignation** – an attitude in which the subject often feels that the effect is not necessarily related to any cause in themselves. In other words, the subject resigns him/herself to thinking that little of what (s)he does is really of any importance and they (s)he has little impact on the end result, be it good or bad. Another aspect of this type of attitude is one of compliance for the sake of harmony, even if the request may be unreasonable. The subject just wants to be seen as being 'the nice guy' and will agree to requests that others may reject.

Section

8.1.3 **Barriers to Effective Judgement – Knowledge, Skills and Training.** Judgement is the evaluation of options. For effective judgement to occur, the person doing the judging must have appropriate level of skills to make the evaluations. There are other barriers noted below which pertain to the whole decision making process, but for the judgement component of decision making, the most critical barrier is experience which is Experience-based and can be thought to be made up of Knowledge, Skills and Training.

8.1.3.1 **Knowledge, Skills and Training.** Experience is the ability of a person to be able to accomplish a task effectively or to make an evaluation of a situation effectively based on the involvement or exposure of the individual to that task, situation or event. This is known as **'empirical knowledge'** which can be defined as knowledge based on direct observation or experimentation/experience as opposed to **'theoretical knowledge'** which is derived from information given by others (eg studied from books or dictated in a classroom setting). In order to breakdown the idea of Experience, let's look at the individual components which are interwoven with each other and are complementary:

- **Knowledge** – that component of experience based on:

    - Theory – as learnt in a classroom or teacher/student context or as written down in procedural or technical documents (eg SOPs or the Flight Manual)

    - Empirical Observation – the direct observation and experience of the individual.

[182] PHAK

- On the Job Experience (OJE)– especially with mechanical tasks such as creating or working with complex systems such as machinery, electronics, administrative and/or technical procedures (eg business dealings, the law, etc)

- **Skills -** that component of experience based on:

  - Innate skills – those skills that a person has inherited that pre-disposes him/her towards a particular ability in a task and which can often be improved upon (eg good spatial awareness, good hand-eye coordination, good artistic skills, an ear for music, etc)

  - Taught skills – those skills that have been taught and practiced in a formal and informal setting where knowledge has been passed from one person to another person

  - Acquired skills – those skills that have been achieved through experience and trial and error and which may not have been deliberately taught.

- **Training** – that component of experience based on:

  - Formalised Theory Training – such as ground school

  - Formalised Practical Training – such as flying lessons or field training

  - On the Job Training (OJT) – such as unqualified persons experiencing how a particular skill is used in a supervised environment

  - Continuation Training – qualified personnel being given the opportunity to practice and hone skills in order to increase the individual's capability in that skill set

  - Mentored Training – a formal or informal relationship between an experienced person and an inexperienced person that allows the latter to develop particular skills under direction of the former.

8.1.3.1 **Other Factors Contributing to Errors in DM.** A NASA sponsored study of DM errors in the aviation environment drew upon 37 accidents in the US and saw that about two thirds of them were due to crew tactical errors, mostly not due to slips or lapses (see Element 4 on Human Error and Threat Management).[183] In it it cited four possible contributors to these decision errors, namely:

- **Ambiguity** – The situation did not present itself as one that was easily recognisable as an error inducing situation because the cues were ambiguous. An example of this might be the Air France accident over the Atlantic where the pilots did not recognise that the aircraft was in a flat stall (ie the aircraft was level,

[183] Orasanu, J., Martin, L., *Errors in Aviation Decision Making: A Factor in Accidents and Incidents,* NASA-Ames Research Centre, 1998.

but the wings were not producing lift resulting in a flat and level descent, rather than a nose down descent).

- **Risk was Underestimated** – The associated risk (threat) attached to a situation was underestimated

- **Conflict of Goals** – Where the desired outcome was at odds with safety, for example where a pilot decides to persist with a dangerous landing because the airline has indicated that a 'go-round' is not desirable due to extra fuel costs.

- **Consequences were not Anticipated or Evaluated** – This is part of Level III Situational Awareness where the projection of current conditions into the future of the mission is necessary. In this case, Level III SA was faulty.

Module 8.2

8.2 **Defining Decision Making.** Decision Making (or DM), as stated above, is the evaluation of options and the selection of the best one; judgement and choice. Below are some pertinent points related to DM.

Section

8.2.1 **Decision Making Concepts.** There are a number of theories about decision making and how we, as humans, accomplish this task. Many of them may assist whereas many may not. Below are some concepts regarding the motivations behind DM.[184]

- **Cognitive Dissonance** – Where an individual tries to justify what s/he knows to be a poor decision (eg justifying smoking by saying 'We all have to die sometime.')
- **Consistency Theory** – Where an individual justifies his/her decision based on his/her values and morals and by other information that helps to support that system to the exclusion of other evidence.
- **Commitment** – Where the individual feels obliged to continue with a task because s/he made a public commitment to it (see also Sunk Cost Effect below).
- **Certainty Effect** – The desire to remove risk completely rather than merely reducing it.
- **Choice Supported Bias** – Where the individual tries to justify a choice based on some criteria that may be skewed, such as a distorted memory of a similar situation. In essence, contributing factors are not given equal weight due to internal biases.
- **Confirmation Bias** – Where the individual looks for positive reasons to support a decision and avoids or ignores negative reasons to counter the decision in an effort to confirm that his/her decision was correct.
- **Scarcity Principle** – Where an individual is motivated to make a choice or decision based on the likelihood that the opportunity to acquire/achieve the end result may be taken away from him/her (ie made scarce). An example is a real estate auction where bidders may be motivated to increase their bids based on the idea that someone else may acquire the property instead of him/her, even though rationally that person would not pay as much as s/he is bidding. In essence, it is the desire to have something that you may not be able to have. Very common in relationships.
- **Sunk-Cost Effect** – The desire of an individual not to forfeit an investment in a situation. In other words, the cost already sunk into the venture does not want to be lost. The individual makes an irrational decision based purely on the hope that the situation may change in their favour when all indicators suggest the opposite. Many decisions regarding investments such as shares are influenced by this.

[184] *"Theories about Decision Making,"* http://changingminds.org/explanations/theories/a_decision.htm, accessed 14 Sep 12.

Section

8.2.2 **Hypotheses and Determining Causes.** The American Psychological Association defines hypothesis as being *'a tentative and testable explanation of the relationship between two (or more) events or variables, often stated as a prediction that a certain outcome will result from specific conditions.'* [185] The important thing to note here is that the hypothesis has to be testable. This differentiates it from being merely a theory. Determining Cause is a means of testing a hypothesis so that effective decision making may occur. A false hypothesis can be likened to an incorrect assumption.

8.2.2.1 **False Hypothesis.** High expectancy can lure a person into a situation where s/he is expecting a certain set of circumstances and acts in that expectation even though those circumstances may actually not exist, and any information to counter this hypothesis is either scant, or faulty, or does not convince the operator that his/her assumption is wrong. Some of the conditions which precede such an unsafe condition include the following:[186]

- **A High Expectancy of a Particular set of Circumstances** – For example, a pilot conducts the same flight into controlled airspace twice a day and expects a certain route to be approved by Air Traffic Control. But on one particular day, the expected clearance is slightly different. The pilot does not pick up the difference and flies the route in the manner in which he/she was expecting only to be corrected by ATC when they notice that he/she is off course. The pilot is then surprised to learn that he/she was in error and that his/her hypothesis as to what was correct and what was not was false.

- **When attention is diverted elsewhere** – In the above example, the pilot may have been distracted or not concentrating such that he/she did not fully process the information.

- **When the Expected set of Circumstances Serve as a Defence.** In the above example, the pilot may have desired a particular flight route or type of approach; one that s/he felt comfortable with and to which s/he did not have to put much effort into. This is a type of 'wishful thinking' where the pilot desires a particular set of circumstances as opposed to expecting a particular set of circumstances.

- **After a period of high concentration** – In many cases, the change from high workload to low workload is accompanied by a relaxation of a person's defences including high-level information processing. It is in these conditions that false hypotheses easily manifest themselves. In the above example, the pilot may have had a very eventful en-route segment and was now 'almost home' and allowed him/herself to be lulled into that false sense of security and relaxed his/her guard. This often happens to drivers returning from a long road trip who let their guard down and have an accident within minutes of arriving home.

[185] American Psychological Association Glossary of Terms, http://www.apa.org/research/action/glossary.aspx accessed 22 May 2012.
[186] Hawkings, F.H., *Human Factors in Flight*, Ashgate Publishing, 1987, Aldershot

- **Motor Memory (Reflex action) that is Incorrect** – This is a condition, where a physical response is made but is made incorrectly and which is not readily picked up by the operator who believes that s/jhe did the right thing. (This may not readily apply to our example).

8.2.2.2 **Determining Cause.** This can be summarised as being when one is presented with an effect, and the subject wants to deductively determine the cause of that effect. Here, the subject can use two generalised techniques: looking for that which may be different and looking for that which is the same, or more precisely – the common denominator.[187] By doing so, the individual can test his/her hypothesis for validity and make a decision based on the outcome. This only works if the individual remains as objective as possible to the outcome of the cognitive process.

Section

8.2.3 **Limitations to Effective Decision Making –** There can be a number of reasons affecting the quality of DM, many of which are related to the judgement and choice selection components of the process. Some of them are listed below:

- Situational Factors:
    - Time Constraints.
    - Environmental barriers.
    - Spatial barriers.
    - Operational factors.
    - Mechanical.
    - Knowledge and training.
    - Information.
    - Group/Team.
    - Societal/Cultural norms. (eg organisational context).

[187] *Reasoning Skills and Determining Causes Help,* http://www.education.com/study-help/article/inductive-reasoning-part-ii accessed 30 Jun 2012.

- Physiological factors:
    - Sensory limitations (impairments to vision, hearing etc).
    - Illness.
    - Affects on the body (vibration, G Force).
- Psychological factors:
    - Beliefs.
    - Hazardous Attitudes (see above).
    - Expectation Bias.
    - Confirmation Bias.
    - Societal/Cultural norms. (eg religious factors, Groupthink).

Section

8.2.4 **Procedural Tools to assist with Decision Making.** In many cases, procedural tools are already in place to assist with making a decision. Perfect examples of this are Standard Operating Procedures, Regulations and Checklists. For many instances, decisions have been made for the operator by equipment manufacturers (eg Flight Manuals and Checklists), by the organisation (SOPs) and by authorities (Regulations and Orders). These tools provide procedures by which actions should or must be taken depending on the variables. For example, during a non-precision instrument approach (a procedure designed to be flown in cloud or low visibility that will get a pilot and his/her aircraft into a position to make an approach to land at an airfield), a pilot who is unable to sight the runway or its environs at the end of the approach, is required to conduct a missed approach. This is a requirement of the regulator so the decision – based on the variables experienced by the pilot at the time of the approach - has been made for him/her.

8.2.4.1 Operational Decision Making Tools are vitally important in conducting aviation operations. Often, they will have Decision Making Triggers associated with them.

- **Crew Determined DM Triggers –** The following DM triggers are determined by the crew or organisation as opposed to the regulator or manufacturer:

- **Equidistant Point** – A point of equal distance to travel between two other points. It is not affected by airspeed or groundspeed of the travelling object.

- **Equitime Point** – A point of equal time to travel between two other points. It IS affected by airspeed or groundspeed. It describes a point on a journey where the time required to return to the point of departure is the same as the time required to reach the destination. This is a time-critical decision tool where the decision to be made is dependent on the time available rather than fuel available. For example, a passenger on board a flight on a long overwater leg becomes ill and the only choices to land are the point of departure or the destination. Assuming that both options are suitable for the emergency (ie they both have appropriate medical care), and that there are no other pertinent external factors then the decision is made easier for the pilot in command.

- **Point of No Return** – A point where returning to your origin will take more fuel or effort than is available thus forcing the person/s to continue to the destination or disaster. For aircraft, it IS affected by airspeed or groundspeed and fuel burnoff as well as SOPs and regulations relating to reserve fuel. (For motorised watercraft it is affected by speed and wind induced drag, swell and currents.) (This term was first coined during WWII and is also known as Radius of Action).

- **Manufacturer Determined Checklist DM Triggers**

  - **Land Immediately, Land As Soon As Possible and Land As Soon As Practical emergencies** – Emergencies determined by the aircraft manufacturer that require action by the aircrew.

  - **Should, Shall, Must** – Semantic terms used by the manufacturer with specific meanings that often require action by the aircrew.

- **Regulator Determined DM Triggers:**

  - **Rules and Regulations and Recommendations** – Semantic concepts requiring action by the crew to ensure safety and efficiency as described above.

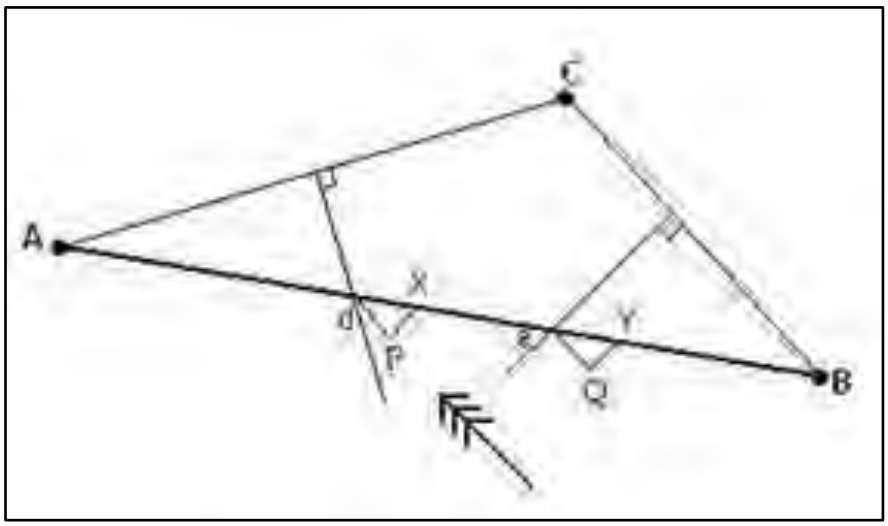


Figure 8.1 Equitime (Critical Point) calculation using simple trigonometry. (From PPRuNe)

To find the ETP (CP) on a journey from A to B with an off track alternate C.

Draw a line AC, and also CB.Using a set of dividers and a protractor, find the midpoint of both those lines and draw in lines running at right angles to them (perpendicular bisectors, for the mathematically inclined) – these cut your track at d and e. In nil wind, the job is done, because e, for example, is the equi-time point to go to either C or B. If you have passed e, then it's quicker to go to B.

Wind is fairly easily included. Looking at point e again, all you do is work out the nil wind time from e to B (or C for that matter, same thing). Then, extend a line out into wind using wind speed, for that amount of time. For example, say it's a 20 kt wind and the still air time at your cruise speed from e to B or C was 30 minutes, you would draw a line out from e into wind for 30 minutes worth of 20 kts, or 10 nautical miles.

This gives you point Q.

Now, project a line back to your track parallel to the original perpendicular bisector, which gives you point Y.

Y is the equi-time point for going to C or B taking into account the wind.

Module 8.3

8.3 **Decision Making Methods.** No situation requiring a decision will be the same as another and so the cognitive processes and resources available will always differ, however there are consistent themes in how decisions should be made, whether it be in an aviation environment, a business environment or any high risk activity. All of the DM models listed below cover this similar theme and provide a good framework for making decisions.

8.3.1 **The US Army's Planning Handbook and Decision Making.** The following is from the US Army's planning handbook and helps to provide more detail into many of the concepts which then follow, such as SADIE, GRADE and MIDAS which are outlined below.[188]

8.3.1.1 **Determine the Nature of the Problem.** The problem being faced can fit into one of the following categories:

- **Well Structured** – All required information is available; the problem is well defined; a means of finding a solution is available and easy to use; the solution is a correct and verifiable answer. Example: a mechanical problem associated with an item of machinery and a defined response to that problem that may be located in a technical manual.

- **Medium Structured** – Some information is available; the problem may not be completely defined; routine solutions may not be available for this particular type of problem; in order to solve the problem, the individual or team may need to be creative; assumptions may need to be made about information that is not available and/or future actions or conditions.

- **Ill Structured** – No obvious solution seems available; very little of the required information is available; there are many variables with varying degrees of complexity which are difficult to analyse; it is difficult to predict future conditions; multiple solutions may be required and which may need to be implemented concurrently.

8.3.1.2 **Identify the Problem** – Recognise and define the problem. If multiple problems arise, then prioritise them. Ensure all team members understand the problem and its conditions and ramifications. Identify its root cause and not the effects and symptoms. Identify any hindrances to clearly seeing the root cause of the problem.

8.3.1.3 **Identify What is Necessary to Solve the Problem** – Figure out how the problem will need to be solved. Such things as:

- Time constraints – how much time do I have? Can I get more time?

- Information Sources – where can I get more information to clarify the problem? How do I get it? Who can help?

[188] Army Doctrine Proponency Division, US Army Combined Arms Center, *FM 5-0 Army Planning and Orders Production,* HQ Dept of the Army, 2005.

- Assets – what assets do I have to help solve the problem? Subject matter experts? Team members who can take on extra work and relieve others to work on the plan.

8.3.1.4 **Gather Information** – Consider what information is necessary, especially if the problem is outside the normal scope of the problem solver. Clarify information that may be ambiguous and seek explanation of information where necessary and pass on those explanations if necessary. Discriminate between facts and assumptions when considering the information. Opinions should be weighted depending on the knowledge and experience of the person providing that opinion and if that person has any ulterior motive or bias.

8.3.1.5 **Generate Assessment Criteria** – For complex problems, consider what standards the solution will need to be assessed against. It may be the organisation's standards and SOPs; technical limitations; budget constraints. This will form a benchmark that can be used to validate and discount some solutions.

8.3.1.6 **Analyse Possible Solutions** – Once solutions have been assembled, give critical analysis to each. Be as rational as possible and acknowledge that some internal biases may be present. Weigh up pros and cons and be as ruthless as possible. Ask persons outside the group to analyse the possible solutions to provide an unbiased and unique point of view.

8.3.1.7 **Decide on the Best Course of Action** – Make a decision as early as possible and be prepared to implement it.

8.3.1.8 **Brief the Plan** – Ensure that all relevant persons are informed of the plan and have enough time to implement their part in it. (One third/Two thirds rule where one third of the time available for planning is used by the initial planner and the remaining two thirds for subordinate planners). At this stage, the plan would be implemented.

8.3.1.9 **Review the Plan and Adjust if Necessary** – Not every plan will be perfect, but a sub-optimal plan is better than no plan. A sub-optimal plan often solves some problems and highlights areas where others need further work which is better than a problem not being addressed or, worse still, deteriorating further.

Section

8.3.2 **Decision Making Models.** There are a number of different models to assist with decision making known by their mnemonics, such as:

- SADIE.
- CLEAR.
- GRADE.
- MIDAS.
- (the) OODA (Loop).

It is interesting to note that when looking at business decision making, the steps used in business are the same as in these decision making models which have their origins in aviation and military or emergency services environments. Take the following diagram for example and look at the individual steps. It is easy to see the parallels in all the DM models.

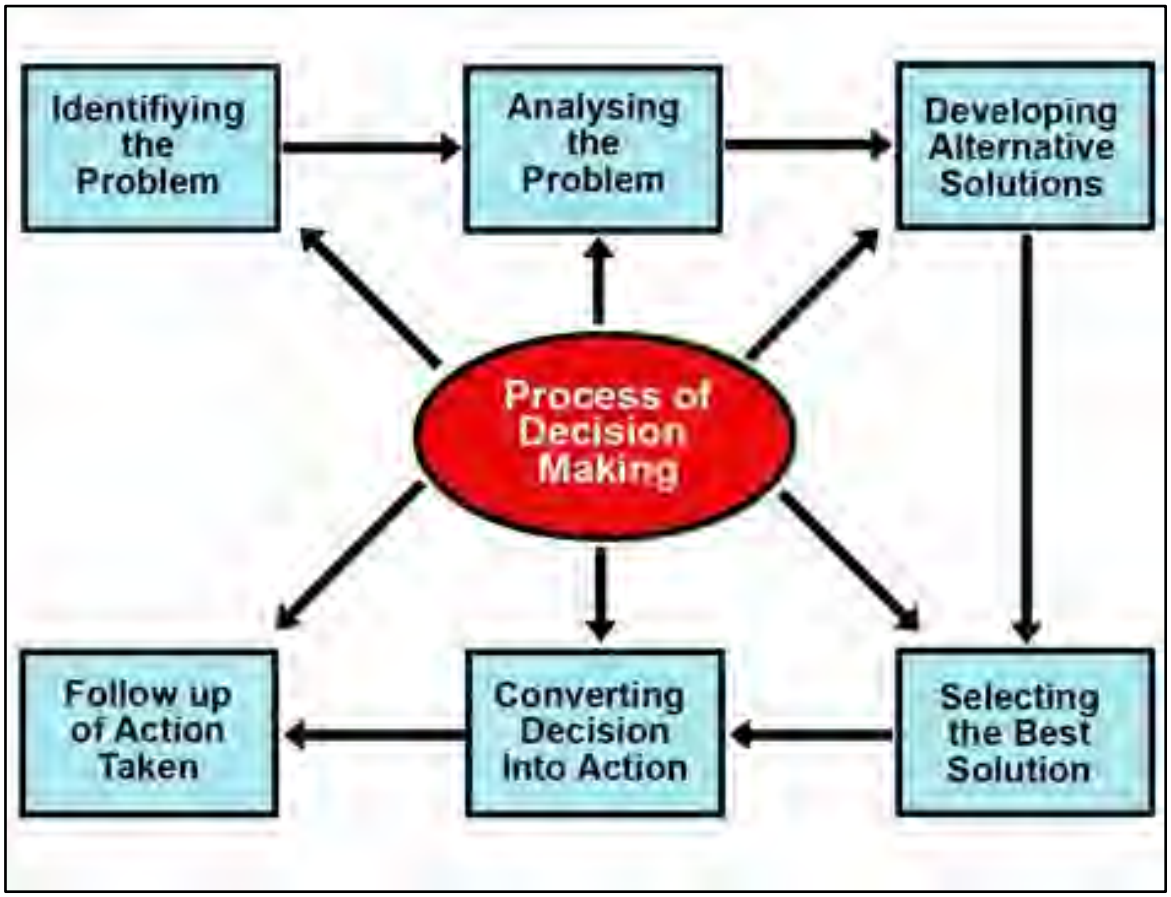


Figure 8.1 The decision making process as part of business training. Note how this process is similar to the following DM models.

8.3.2.1 **SADIE**. This DM model relies on an ordered approach to making a decision.

S – Share the information. This means giving information to others and in return, receiving information. Only in this way can there be relative certainty that all the known factors are being made aware to all members of the team. We say 'relative' certainty because assumptions may be made that a piece of information is known by other members of the team when, in fact, it may not. It is therefore important to ensure that even 'obvious' information is confirmed between all team members.

A – Analyse the information. As stated in the element on Situational Awareness, a failure to comprehend information and assign a level of importance to it is a key factor in the loss of Situational Awareness. The same applies for Decision Making.

D – Decide on the best plan of action to take.

I – Implement your plan of action.

E – Evaluate the outcome of your plan of action and adjust it as necessary if it doesn't fit your needs adequately. If the plan has failed, then go through the process again and re-evaluate the information.

8.3.2.2 **CLEAR.** A similar DM model to SADIE, the basis of which is shown below:

C – Clarify the Problem

L – Look for information from all sources

E – Evaluate all options and choose the best

A – Act on your decision

R – Review the results and adjust the plan where necessary.

8.3.2.3 **GRADE.** A similar DM model to SADIE and CLEAR, the basis of which is shown below:

G – Gather the information

R – Review the information and comprehend its importance

A – Analyse the information and project it

D – Decide on the best plan of action and decide to act on it

E – Evaluate the outcome and adjust the plan as necessary.

8.3.2.4 **MIDAS**. Like the DM models above, MIDAS uses the same principles however it firstly illuminates the first level of DM by establishing the mission and the context. This DM model is used by fire services and is particularly effective for extended incidents that allow for more in-depth planning and may be able to use a larger number of resources. The following is taken from the South Australian Country Fire Service Operations Management Guidelines 2007 and is recreated here for instructional purposes. (Items in parentheses and in italics have been added by the author):

- **Mission**
    - What are your objectives?
    - What outcome is required?
    - Establish the decision making context and assumptions.
- **Information**

- Identify the problem
- Gather information, factors and identify the issues
- Where is the incident now?
- Where is it going?
- What and who is the incident going to impact on?
- How badly?
- Gather information on the most likely and the worst case scenarios

- **Develop Options**
  - Develop your courses of action
  - Most likely *(course of action of the incident)*
  - Worst case *(course of action of the incident)*

- **Analyse Options**
  - Conduct an operational risk assessment
  - Analyse and evaluate your options against the values and principles of operations
  - Consult with other agencies and interested parties.

- **Select Preferred Options**
  - Decide on the best course of action
  - This becomes the plan
  - Brief people on the plan

- Implement the plan

- Monitor progress of the plan and if necessary, review *(and adjust and re-brief)* the plan.

Figure 8.2 [189] South Australia Country Fire Service uses MIDAS to assess a situation and make decisions. (Photo by Mel Mazzone)

[189] CC-BY-SA-3.0 Fire-fighters from the Stirling Country Fire Service test a hose line. Photo taken by Mel Mazzone 2005, http://en.wikipedia.org/wiki/South_Australian_Country_Fire_Service

Section

8.3.3 **The OODA Loop.** The OODA Loop was the brainchild of a US Air Force fighter pilot named Colonel John Boyd. Boyd was a USAF fighter instructor during the '50s and '60s who had such skill in air combat that he was able to out manoeuvre almost any rival. He realised, after observing the tactics of North Korean, Russian and Chinese MiG-15 pilots battling American F-86 Sabre pilots that the American superiority was not in their aircraft, but in their ability to use their superior visibility due to cockpit design to observe and out manoeuvre their enemy.[190] He put this to the test in the air and become a renowned fighter combat instructor. He used the same theory in military planning calling it the OODA loop –

- Observe.
- Orient.
- Decide.
- Act.

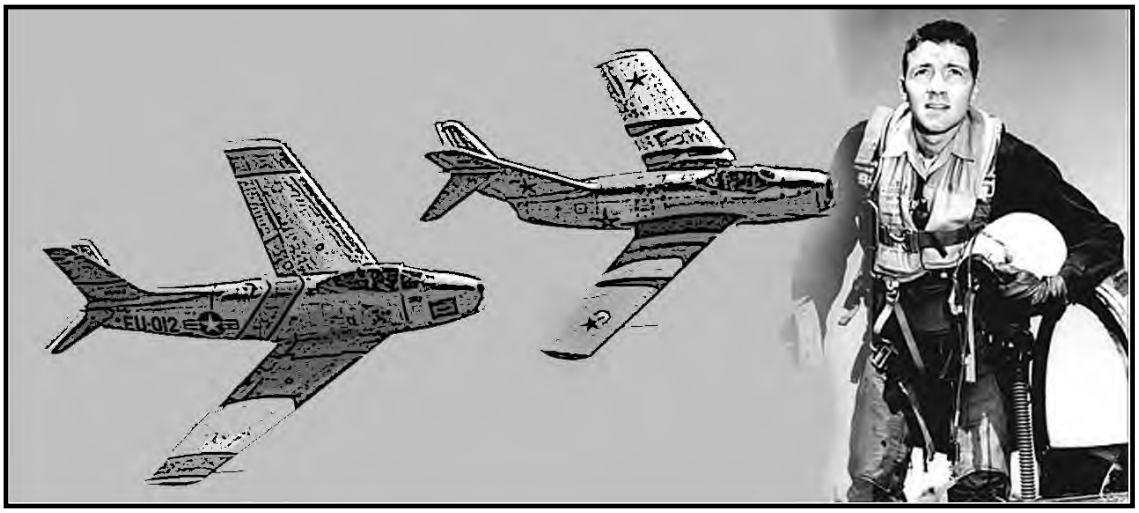


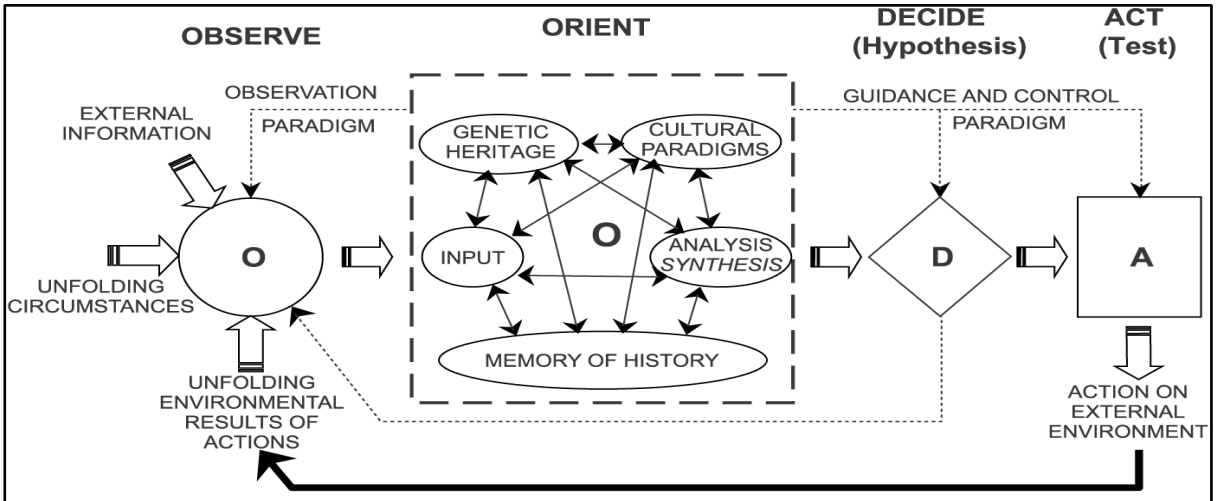
Fig 8.3 The F86 Sabre and the MiG-15 Fishbed. USAF Colonel Boyd – a fighter pilot instructor – saw that a fluid decision making process, which he coined 'The OODA Loop' was instrumental in success in combat, and later in business and any other decision making scenario.

8.3.3.1 According to Boyd, the decision making cycle begins with the **Observation** of the situation which is filtered by the subject, usually implicitly.[191] This information must be processed in order to progress to the next stage of his DM model, the **Orientation** stage. In this stage, understanding – or orienting – the information observed is influenced by a number of factors such as our genetic heritage, cultural tradition and previous experience. These factors also influence how we undertake the next stage, **Decision**. A number of options may be present so the subject must decide on which one to choose whereupon the final stage of the initial loop, **Act**, is then executed. The subject then acts on his/her decision and the

[190] *OODA Loops. Understanding the Decision Cycle,* MindTools, http://www.mindtools.com/pages/article/newTED_78.htm accessed 03 Aug 12

[191] http://en.wikipedia.org/wiki/OODA_loop accessed 03 Aug 12

process repeats in a continuous loop. When compared to the DM models listed earlier, one can see the similarity between them all. The difference with the OODA loop is that it was designed to be used rapidly and is based on previous experience in those cases.



Source: Based on Boyd (1996)

Section

8.3.4 **Ways to Improve Decision Making.** There are many ways to improve DM; some of which are listed in the box below.

Keep up your level of training. Know your job and those of others. Understand what your job entails

Keep healthy. DM is affected by your physical condition.

When confronted with a situation:

Stabilise the situation. Keep yourself out of high-stress or dangerous situations by making your environment safer (eg. If driving, pull over. If flying, gain altitude and stabilise the aircraft).
Buy time, sell stress. Give yourself more time to analyse and decide. Make a decision to act in a certain way at a certain point. This will remove a degree of stress and give you a better psychological condition to make decisions.

Assess the situation. Decide exactly what the root cause of the problem is. Gather the information which is Level 1 of Situational Awareness. This includes getting input from members of the team and external agencies. Use appropriate tools for assessment such as checklists (eg SITCHECK).

Is a solution known? Determine if there is already a solution to the problem. Use SOPs and Checklists to confirm.

Assess time factors. Consider what time constraints and restraints apply.

Use an appropriate DM model to work through the problem.

Task specific discussion. Keep all discussions relevant to the task at hand. Discuss options with other team members and other agencies that may assist.

Allocate priorities. Prioritise the tasks according to importance and time.

Manage workload. Use leadership and management techniques. Delegate duties and monitor their progress.

Consider contingencies. Have alternate plans of action ready to be used.

Keep everyone in the loop. Ensure that everyone in the team knows what's going on as well as external agencies who need to know as well.

Execute the Plan. Implement the plan as you have briefed

Review and adjust the Plan. Not all plans work as expected. Monitor the plan and ascertain if adjustments need to be made.

GROUP 4 – THE OPERATIONAL CONTEXT

The Element/s in this Group relate to the Human Being and how (s)he works in the operational environment.

ELEMENT 9 – Task Planning, Briefing and De-briefing

Contents:

Module 9.1

9.1 **Task and Mission Planning.** There are a myriad of sayings about planning. Perhaps one of the better known ones in Australia is the rather uncouth old British Army saying known as the 'Seven Ps':

> *"Proper Prior Planning Prevents Piss-Poor Performance." – Anon.*

Another is about failing to plan being akin to planning to fail, but the original saying by one of America's founding fathers was:

> *"By failing to prepare, you are preparing to fail."* – Benjamin Franklin

On the battlefield planning is paramount even if sometimes the battle doesn't go according to it. Take the quote from a famous US General and President:

> *"In preparing for battle I have always found that plans are useless, but planning is indispensable."* – Dwight D. Eisenhower.

In the aviation environment however, probably one of the more poignant is a quote by one of the greatest American Baseball players of all time and the former coach of the New York Yankees and Mets:

> *"If you don't know where you're going, you'll end up somewhere else."* – Lawrence 'Yogi' Berra

Aviation and similar high risk activities cannot be undertaken without a significant skill level and sufficient planning. Both are complementary and compensatory to some degree. A lack of adequate planning may be compensated for with significant skill in being able to assess a situation that poses a problem, attach values to it and come up with a solution. In other cases where there is a lack of skill and experience, good planning and preparation will help a great deal. Yogi Berra was famous for his quotes which were oftentimes illogical paradoxes… but these Yogiisms, as they came to be known, often held deep insight into the human condition. His saying that if one doesn't know where he or she is going then perhaps that person may end up somewhere else is illogical on one hand, but totally logical on the other. Having a plan is the only way to provide a degree of certainty that you will end up where you expect to.

The following section details considerations for planning including the associated briefing and de-briefing. Most organisations concerned with high risk activities will already have procedures in place for planning which have been derived and revised over time and through

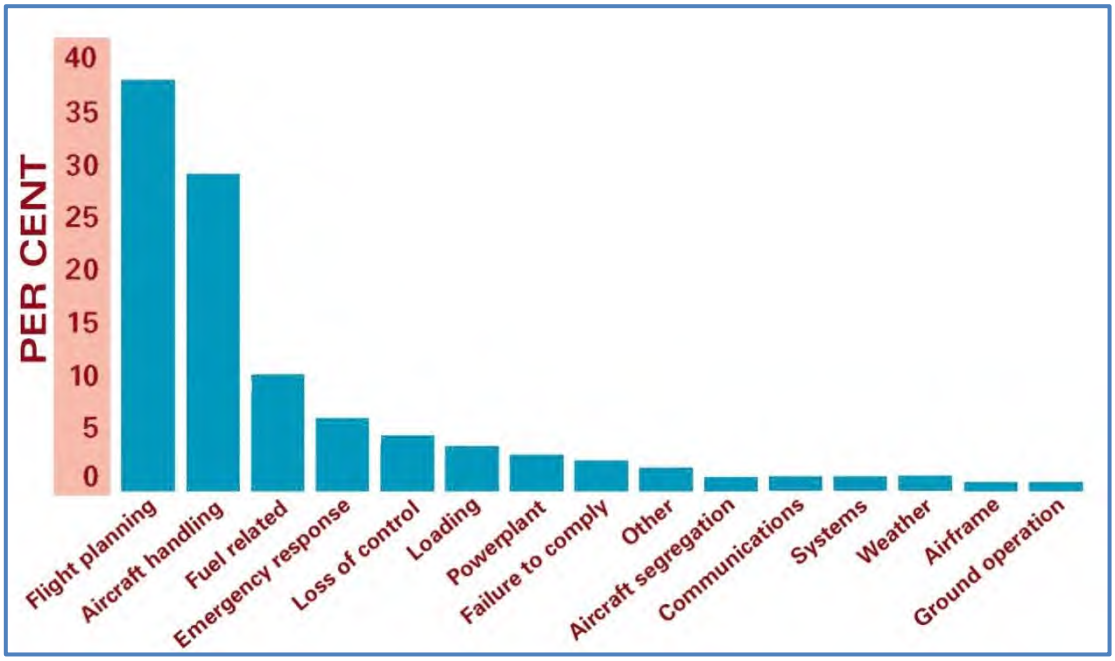
experience. This section does not aim to produce a 'be all and end all' solution to task and mission planning, but rather it will discuss the concepts behind them and how some organisations view planning. It also provides a sample of a Crew Brief which can be used as a planning tool, a briefing tool and a de-briefing tool.

Section

9.1.1 **Defining Planning.** The US Army Field Manual 5.0 defines what a plan is succinctly. It states:[192]

> *Planning is the means by which the commander envisions a desired outcome, lays out effective ways of achieving it, and communicates to his subordinates his vision, intent, and decisions, focusing on the results he expects to achieve. The outcome of planning is a plan or an order that –*
>
> - *Fosters mission command by clearly conveying the commander's intent.*
> - *Assigns tasks and purposes to subordinates.*
> - *Contains the minimum coordinating measures necessary to synchronise the operation.*
> - *Allocates or reallocates resources.*
> - *Directs preparation activities and establishes times or conditions for the execution.*

In many group and team scenarios, this description would be apt. In a one-person scenario it merely means that the allocation of tasks falls to that one person… however the concepts remain valid.



[192] Army Doctrine Proponency Division, US Army Combined Arms Center, *FM 5-0 Army Planning and Orders Production,* HQ Dept of the Army, 2005.

Figure 9.1 A breakdown of causal factors in fatal general aviation accidents in Australia during the period 1991 to 2000. Of all the factors listed, flight planning rates as the most significant causal factor.[193]

9.1.1.1 **Enhancing SA and DM by Effective Planning.** The graph above shows the causal factors for all general aviation accidents in Australia over an 11 year span. More than a third of the accidents can be attributed directly to insufficient flight planning with another 10 per cent attributed to the related factor of fuel planning and about three per cent to weather. In all, about 50 per cent of GA accidents were influenced by flight planning. One of the most important aspects of effective planning, whether it be aviation oriented or any high risk activity, is the enhancement of situational awareness and the fostering of good decision making.

9.1.1.2 **Situational Awareness and Effective Planning.** Situational Awareness is the ability to perceive what is happening in the environment around you, comprehending its meaning and projecting that meaning into the future and how it will impact on mission objectives. By planning effectively, the individual or team is able to predict many likely scenarios and environmental or operational conditions and reduce the need for cognitive interpretation of that information. A situation that is expected is much easier to deal with than one that is not. If the weather report said that there was a probability of thunderstorms, then the flight planner would have given it some thought at the least and planned for a diversion and alternate at best. In either case, this is better than being confronted with unexpected thunderstorms en route which can only result in increased anxiety and the resultant reduction in good decision making as options need to be considered, weighed and explored.

9.1.1.3 The aviation scenario has many variables which need to be considered. Many of these are listed in the Crew Brief checklist below and include such things as:

- Weather (en route, after landing, etc).
- Fuel (amount required, availability en route and at destination).
- Mission requirements.
- Destination and alternates (suitability, facilities, services).
- Administration (company and aviation services requirements).
- Crew (capabilities, currencies, etc).

… to name just a few.

[193] Derived from Flight Safety Australia magazine, March-April 2004. Weeks, R., *Four Fatal Factors,* Flight Safety Magazine, Mar – Apr 2004, Civil Aviation Safety Authority, Canberra, 2004.

Figure 9.2 A pilot gives a pre-flight brief to passengers before a task for FEMA in the US. (Public Domain)

In the ground environment, say on the battlefield, some of the variables are harder to determine, such as the likely enemy course of action. On the fireground, the variables are also harder to determine and are usually related to weather and terrain and vegetation as well as the number of assets available. In all cases, the successful mission planner will try and determine what is likely to occur depending on various situations. This is vital in enhancing operational situational awareness.

9.1.1.4. **Decision Making and Effective Planning.** As has been said in previous Elements; good decisions are based on good situational awareness. Also, good decisions are also based on good planning. Event decisions and contingency decisions are based on good and thorough planning. The components of Decision Making are:

- Evaluating alternatives;
- Selecting a course of action; and
- Assessing.

Of those components, the first and second benefit greatly from good, thorough planning and reduce the need to evaluate conditions or deciding which is the best course of action to select.

Section

9.1.2 **Planning Procedures.** Like risk management, a plan is usually bound by the level that is appropriate to it. The three key levels of planning – just as the three key levels of risk management – are Strategic, Operational and Tactical.[194] For the most part, a team

[194] Army Doctrine Proponency Division, US Army Combined Arms Center, *op. cit.*

involved in high risk activities will usually fall into the latter category; the tactical planning situation.

9.1.2.1 **Tactical Planning.** Within a military environment, tactical planning centres around small units and how they are employed in order to achieve objectives assigned to those units. In an emergency services environment, such as fighting wild fires or conducting civil defence operations, it would be equivalent to how ground units would be employed in order to achieve the small unit mission objectives such as controlling a fire or securing a town from flood or evacuating its residents. Tactical level planning emphasizes flexibility and options.[195] One concept to tactical planning is the development of sound branches and sequels… in other words; developing various courses of action based on the best assessment of what is likely to occur and then subsequent courses of action. In a single aircraft aviation environment, tactical planning is equivalent to how the PIC and/or MC assesses the mission's requirements, the operational and tactical environments (ie company requirements and environmental/task related requirements) and then applies his/her knowledge and expertise to ensure the end state is met based on the information available on the environment s/he expects to encounter and any environments that may be encountered. This last aspect can be considered under Contingency Planning.

9.1.2.2 **Contingency Planning.** A contingency is a possible future event or circumstance that is possible but cannot be predicted with certainty. By conducting thorough planning, possible contingencies arise allowing for appropriate contingency planning. With more experience, contingency planning becomes easier. By planning for contingencies, many variables can be considered and their risk (likelihood of impacting a mission's objectives) assessed.

9.1.2.3 **IF THEN Logic Loops.** As cited in previous elements, using an IF THEN logic loop helps with decision making. Contingency planning allows for IF THEN Logic loops to be established well in advance of contingencies arising. Here is an example of contingency planning using an IF THEN logic loop.

[195] Ibid. P 1-7.

A pilot is flying his aircraft from Start City to Finishville on a business trip. The pilot sees what seems to be bad weather ahead which was listed on the on the flight forecast as a possibility. Because the pilot has conducted good flight planning, his flight has been accurate with respect to fuel calculations and navigation… but he knew the weather would be the key variable. The forecast looked fine, but there was a probability of bad weather indicated, but now he has doubts about whether he can safely fly through the deteriorating weather. Fortunately, the pilot took into consideration the weather variable and has already a contingency plan in place. He thinks about the situation and says to himself aloud:

> *"I will continue on my current flight path and follow my current flight plan until I get closer to that bad weather in about ten miles whereupon I can make a more accurate decision as to how it will affect my flight before I get too close to it. If I decide that the weather won't impact on my flight path, then I shall continue with my current flight plan. If it does or there is a reasonable chance that it does, then I shall make an early decision to turn back or divert to Halfwaytown where I know there is fuel and accommodation. I know that flying sometimes has unexpected delays so the business meeting can be postponed which is a possibility I have already planned for. In the meantime, I shall get the current weather for Halfwaytown, prepare for the diversion, set up my GPS and charts and be ready."*

In the above scenario, the pilot was flying his planned flight but made the assessment that a variable (the weather) may impact on his plan. He had already considered what he would do if he couldn't make the business meeting (postpone it) and/or if the weather turned bad such that he couldn't continue with the flight. He also decided to make an early decision once he was able to gather more information (in ten miles and before he got too close to it). He then came up with two IF THEN scenarios which gave him two choices depending on his evaluations. The first was:

> ***If*** *it doesn't impact on my flight path,* ***then*** *I shall continue with my current flight plan.*

The second was:

> ***If*** *it does or there is a reasonable chance that it does,* ***then*** *I shall make an early decision to turn back or divert to Halfwaytown where I know there is fuel and accommodation. I know that flying sometimes has unexpected delays so the business meeting can be postponed which is a possibility I have already planned for. In the meantime, I shall get the current weather for Halfwaytown, prepare for the diversion, set up my GPS and charts and be ready."*

The Situational Awareness is enhanced with his planning. Perceiving the environment through the forecast and through what he can see; comprehending the impact on his mission and projecting it into the future.

His Decision Making is enhanced with his planning. He has evaluated the various options and will choose the most appropriate course of action and assess.

9.1.2.4 **Mind Mapping.** This is a term used to describe a method of analysing a problem in a non-linear method. Instead, it uses a graphically based process whereby many different 'branches' to the problem and considered and analysed. Mind Mapping is useful when there

is sufficient time to spend doing an analysis and for problems that can be quite complex. It is often used as a planning tool for any project including academic assignments, researching, project management, problem solving, etc. There are many different resources available online to assist with mind mapping, but here are the basic points.

- Use a large piece of paper and coloured pens/pencils.
- Establish the key purpose or goal or problem you are trying to solve and place that in the centre. Use diagrams if necessary to help with cognition.
- From that central theme, start drawing lines from it with each line a particular aspect of that central theme such as a subordinate problem that needs to be solved or a potential solution that needs to be worked.
- Each line becomes a branch and then allow that branch to branch out further with other ideas related to that aspect or problem.
- The result is a tree like diagram with many positive and negative aspects surrounding the central problem. In this way, the human brain can see and analyse these aspects quickly in a non-linear way that helps with lateral thinking.

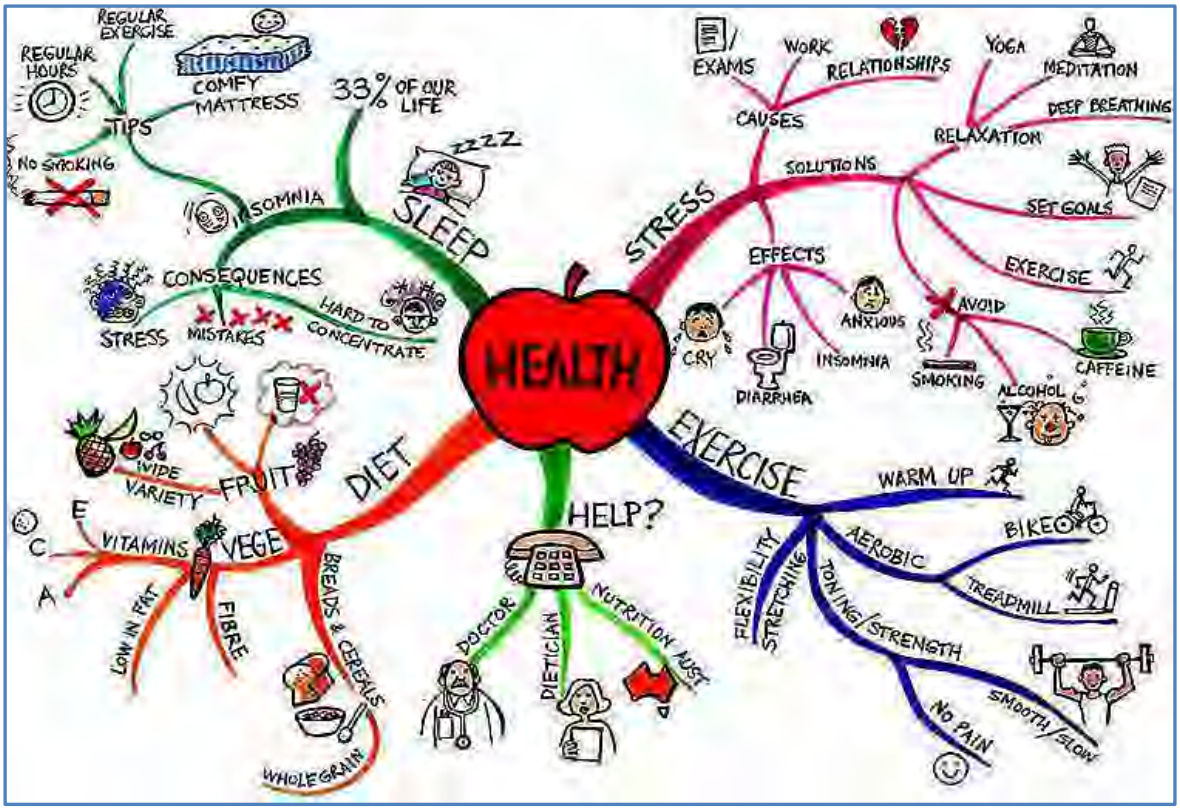


Figure 9.3[196] An example of a diagrammatic mind map related to planning for better health.

Section

9.1.3 **Using Planning Checklists.** Many organisations will already have standard planning SOPs for the operator to use. In other cases, there may be no such document. Within the aviation industry, it is mandatory to have certain information prior to a flight such

[196] Derived from Learning Fundamentals, http://learningfundamentals.com.au/resources/, accessed 12 Sep 12.

as weather forecasts, fuel calculations, details on airfields and maps and charts and merely acquiring these items assists in planning and assessing a flight or mission. It is worthwhile using any planning checklists to ensure completeness of planning activities. If no such checklist is available, the creating one is a wise step. In the briefing section below and in the element entitled Decision Making, there are a couple of examples of checklists for various organisations which, if adjusted, will assist the individual in creating his/her own planning checklist. The SA Country Fire Service's MIDAS model is reproduced here as an example of an assessment and planning checklist used for where emergency services workers arrive at a critical incident and need to do a rapid assessment and formulate a plan. Review it carefully and see where you may be able to use some of its elements in your high risk environment. (For a greater range of decision making models including MIDAS, go to Element 8 Judgement and Decision Making).

- **Mission**
    - What are your objectives?
    - What outcome is required?
    - Establish the decision making context and assumptions.
- **Information**
    - Identify the problem
    - Gather information, factors and identify the issues
    - Where is the incident now?
    - Where is it going?
    - What and who is the incident going to impact on?
    - How badly?
    - Gather information on the most likely and the worst case scenarios
- **Develop Options**
    - Develop your courses of action
    - Most likely *(course of action of the incident)*

- Worst case *(course of action of the incident)*

- **Analyse Options**
  - Conduct an operational risk assessment
  - Analyse and evaluate your options against the values and principles of operations
  - Consult with other agencies and interested parties.

- **Select Preferred Options**
  - Decide on the best course of action
  - This becomes the plan
  - Brief people on the plan
  - Implement the plan
  - Monitor progress of the plan and if necessary, review *(and adjust and re-brief)* the plan.

Section

9.1.4 **Task Delegation and Using Briefs.** One of the roles of a team leader – as pointed out in the element on Teamwork – is that of allocating tasks and managing time. In many instances, the mission planner spends too much of the time available developing his/her plan and does not leave enough time for other members of the team to develop their own in response. By not providing enough time, this leads to temporal stress and can lead to mistakes and delays to the mission or even mission failure. One concept is the 'one third / two thirds' rule whereby the mission planner uses no more than one third of the time available to plan the mission and allocates the remaining two thirds to other team members so that they may plan their own components.

Module 9.2

9.2 **Briefing.** If we were to define briefing versus de-briefing in a succinct manner, it would be to say that in the former, information flows from one person to many persons and in the latter, from many persons to one person. This is a very simplistic explanation so it may be better to give some examples and clarify definitions.

- Briefing – presenting information from one party that has access to that information to another party or parties in order to facilitate a task or achieve an aim. Examples are:
    - Mission or Task Briefings (eg military, emergency services, groups involved in high risk activities such as surgery, etc).
    - Media conferences.
    - Concept briefs to artists.
    - Task briefs to workers (eg construction sites).
    - Briefs by subject matter experts to a group or groups of interested persons.
- De-briefing – gathering information from one or more parties in order to learn from or clarify the circumstances surrounding an incident or activity, so that the information can be used in improving capabilities or apportioning responsibiity. Examples are:
    - Police investigations (eg gathering witness statements).
    - Post mission debriefs in high risk activities, the military or aviation, including after check and training flights, etc.
    - Critical incident analysis such as after a death from surgery.
    - Critical incident management such as counselling after a traumatic event.
    - (On a wider scale) Government, coronial and other official enquiries.

9.2.1 **Types of Briefings and Briefing Procedures.** The US Army defines some specific types of briefings that serve the CRM purpose well[197]. They are:

- **The Information Briefing** - This type of briefing delivers information in a manner that the recipients can understand and which is of use to the task at hand. It

[197] US Army, *Effective Army Briefing,* http://www.uc.edu/armyrotc/ms2text/MSL_201_L08a_Effective_Army_Briefing.pdf, accessed 19 Sep 12.

normally does not contain conclusions and recommendations but it may be used to make decisions.

- **The Decision Briefing** - This type of briefing usually explains a decision and how it was reached and the resulting course of action. It provides the recommended solution after analysis of a specific problem. The efficacy and relevance of a decision briefing is directly related to the expertise of the person/s conducting the analysis and making the recommendations.

- **The Mission Briefing** - The Mission Briefing is the one most familiar to groups involved in high risk activities. Its aim is to ensure a coordinated effort to achieving team goals by exchanging information; providing guidance; issuing instructions; and coordinating activities. It will normally involve an hierarchical chain of command.

Figure 9.4 A Mission Brief by members of the crew of a US Coast Guard Cutter. (Public Domain)

- **The Staff Briefing** - The Staff Briefing, whilst explained in a military context, has its equivalent in civilian organisations. The purpose of the staff briefing is to coordinate the organisation's efforts by informing the chain of command and subordinates (eg staff) of the current situation and the way ahead. The agenda is normally set by the person who convened the meeting and usually involves representatives from different functional areas (eg departments or sections) providing information to the meeting and the head of the meeting to inform and to permit decisions to be made; guidance given and instructions issued.

Section

9.2.2 **Effective Briefing Techniques.** Giving a good brief is perhaps more complicated than giving a good speech to the public. For one thing, the briefer must be very conversant with the subject and must be prepared to answer questions, often of a technical nature. The

average public speaker may not. But like public speaking, there are a number of techniques that can be used to assist with giving a good brief. (In the next paragraph, we discuss using checklists and standard operating procedures to conduct briefings, both of which serve good purpose in conducting effective briefs). Like most tasks, and as stated in the above paragraphs on planning, there are four key elements to effective planning and briefing:

- Plan.
- Prepare.
- Execute.
- Assess/Follow Up.

In the examples that follow, the brief being described is a deliberate and considered brief that may require significant prior planning. In a well-trained and prepared organisation, the requirements of a brief may be already stipulated in Standard Operating Procedures and so much of the planning and formatting for the brief will have already been completed. In this situation, the briefer will normally follow the SOP or checklist as will be discussed below in the next section. The paragraphs below are designed for the more deliberate and complex situations.

- **PLAN: Analyse the Situation** – In order for a briefing to be effective, the following aspects need to be considered:
    - What is the situation I am trying to communicate?
    - What is the knowledge base of the recipients (eg are they trained in this topic or will I have to speak in layman's terms and 'dumb it down?')
    - What are the expectations of me as the briefer?
    - What are the important elements of information that need to be briefed?
    - What time pressures are involved?
    - Who can assist with preparation and presentation
    - Where is the venue and what equipment is available to me?

- **PREPARE: Construct the Brief's Elements** – After analysing the situation, then it is a matter of capturing this knowledge. The following steps should be followed:

  - **Research:**
    - Collect the material required.
    - Ensure the subject is known thoroughly.
    - Ensure that enough information is provided but do not swamp yourself with excessive data.
  - **Organise:**
    - Consider what the essential elements are (key points).
    - Arrange the key points in a logical order.
    - Provide supporting data for the key points.
    - Select your visual aids to assist with getting the message across.
  - **Draft:**
    - Create words and visuals based on the information in such a manner that a script is NOT required.
    - Make sure your key ideas are the main focus of your message.
    - Use speech that is appropriate for the audience (ie pitch it at the right level).
  - **Revise/Proof/Rehearse:**
    - Allow the brief to 'cool' for a while if possible, and then return to it.
    - Proof it for tone, content and style, both in the written words and the spoken words. Check if jargon is appropriate for the audience.
    - Rehearse the brief and check for timings, knowledge, cues, A/V and venue suitability.

- **EXECUTE: Deliver the Briefing** – Being an effective briefer is also about being an effective public speaker. There are a number of techniques that are very useful in both situations, and even moreso for the briefer:

    - **Assess Effectiveness During Delivery:**

        - Maintain eye contact and assess body language.

        - If appropriate (eg giving a lecture) ask questions to ensure understanding.

    - **Manage Time:**

        - Keep the brief brief!

        - Don't allow deviations from the timings to eat into the time allowed.

    - **Be Effective:**

        - Endeavour to express the points not impress the audience.

        - Use A/V effectively and appropriately.

        - Consider when it is appropriate to field questions.

- **ASSESS/FOLLOW UP: Answering Questions and Capturing Information** – When the brief is over, the briefer may be required to conduct follow up such as answering questions either immediately after the brief or some time later when information is disseminated. Furthermore, it may be necessary to capture and disseminate information gathered during the brief. An example of this would be the minutes of a staff briefing and meeting.

    - **Clarification:**

        - Any information that was not received well or any requests for further information should be provided at the earliest convenience.

    - **Record and Disseminate:**

        - In some briefs, it is appropriate that the persons present, their names and any input provided or any tasks distributed, be recorded and disseminated.

Section

9.2.3 **Using Checklists and SOPs to conduct Briefings and Debriefings** – The paragraphs above outlined how a deliberate brief would be conducted where there were many variables to be considered and analysed and then that information formatted into a logical order for delivery. In many organisations, that order is already contained in standardised documents such as checklists, SOPs and the like. Some examples of checklists and standardised briefings include:

- Pre-Flight Briefing – the member of aircrew conducting the flight planning will obtain pre-flight briefing from the authorised agency or agencies or from an authorised person. The information gathered will then be used to plan and brief other members of the team. This will include such things as:
    - Weather en route and at destinations and alternates.
    - Location information relevant to the mission (eg requirements for parking or such administrative things as customs requirements for international operations or specific task requirements).
- Task Related Briefings – These sorts of briefings are more often than not SOP briefings in a checklist fashion and involve briefing members of the crew/team on important items necessary during the task. Some examples are:
    - Take Off or Landing Brief – During this type of task related brief, the PIC will brief the approach or departure and actions during normal or abnormal operations (eg engine failure after take off). See below for an example of a Take Off brief for a light aircraft.
    - Approach Brief – In this brief, one member of the aircrew will brief the pertinent points of an instrument approach to the other members of the crew or, in single pilot operations, to him/herself.
    - Mission/Task/Sortie Brief or Orders – This type of brief will usually involve an outline of the task or mission; what end state is being sought and the manner in which it is to be achieved. Examples could be a set of orders to soldiers on the ground; a specific task brief to firefighters to coordinate efforts or a PIC's or MC's brief to the crew.
    - Briefing from the Mission Commander as to the specifics of the task. (Examples of MCs are persons on board coordinating the task using sensors; electricity linesmen conducting infrastructure survey; Air Attack Supervisors or Air Observers conducting aerial fire fighting; police observers conducting Aerial Law Enforcement, etc)
    - Safety Briefs – These briefs provide information to ensure safety of persons in a particular situation. Examples include an on-site induction brief, say at a construction site, or a pre-take off safety brief conducted by members of the crew for the information of passengers.

"This is a take-off on runway 09 for a departure to the north, climbing to 5500'. Wind is 045 degrees at 15 knots. Rotation speed is 85 knots with Vy of 95 knots. Departure will be from crosswind intercepting the 010 VOR radial. VOR has been tuned and identified. If I have any critical emergencies before 85 knots, I will reject the take-off, throttles to idle and brakes applied. If I have any critical emergencies above 85 knots, I will continue with the departure, control the aircraft, conduct the required Immediate Actions such as power, flaps up and gear up and then secure the emergency. Once safely airborne and at a safe altitude, I will request assistance from ATC aiming for a return to landing on runway 09."

Table 9.1 An example of a Take Off brief for the pilot of a light twin engined aircraft. In this case, the brief may have been given to a co-pilot or to the PIC himself. Articulating a brief to one's self can be quite re-assuring and assists with planning and executing.

Module 9.3

9.3 **The SMEACS Brief Format** – The term SMEAC is very well known in the military environment and is becoming very well known in the emergency services environment. SMEAC is an acronym and describes a briefing format that was devised by the US Army and US Marine Corps with some minor variations between them. It was known in that context as the 'Five Paragraph Field Order' and had its origins in the German Army of the 19th Century before Lieutenant Colonel Eben Swift of the US Cavalry introduced a variant into the US Army.[198] As warfare changed, the contents changed somewhat however the format remained relatively intact. The format is designed to encompass the major components of a mission or task and allow for flexibility within each component for elements to be added or removed. It also allows for a logical progression to the brief or orders. It can also be used as a checklist when planning a mission or task. The extra 'S' on the end of the acronym is one found in the Australian emergency services realm and stands for "Safety". The full acronym SMEACS stands for:

- **SITUATION** – The current situation related to the mission. It includes such things as weather; topography; environmental conditions; political situation; location of other relevant assets such as supporting units or agencies; the intention of higher commands or authorities; the location of important elements to the mission such as the enemy or survivors or offenders or the fire or flood or other similar considerations (depending on the type of mission being followed). The Situation component of a SMEACS brief is designed to set the scene for everyone about to be briefed.

- **MISSION** – The mission is the exact task required of the people being briefed. Within the military environment it contains two specific elements that are always included: '…in order to… ' and the second is a repeat of the full mission description. The '…in order to…' phrase is included in the mission as part of the concept of 'directive control'. This means that if everyone understands what the mission is trying to achieve – the 'in order to' phrase – then if the mission doesn't go according to plan, those involved will have enough information to adjust their own plans accordingly in order to achieve the desired end state. For example, if the following mission was given in a set of orders:

  "Mission: AeroRescue is to conduct a search of sector A in order to locate and report suspected illegal entry vessels."

  In the above case, AeroRescue has been given a specific task and a specific area but has not been told how to do the job. That part may be left to the next part of the SMEACS format, the Execution. However, because the mission's end state has been articulated, if the method outlined in the Execution can't work for some reason (eg the weather), then the company/aircrew can consider other ways of achieving the end state. The Execution may call for a line search, but if that cannot be done, then the company/aircrew may decide a grid search is the best way or an expanding point search will achieve the same result. The mission provides the end state: "locate and report suspected illegal entry vessels". The

[198] Smith, MAJ Matthew L., *The Five Paragraph Field Order: Can a better format be found to transmit combat information to small tactical units?* School of Advanced Military Studies, US Army Command and General Staff College, Ft Leavenworth, KS, 1988 as accessed http://cgsc.cdmhost.com/utils/getfile/collection/p4013coll3/id/1980/filename/1981.pdf

Execution provides, or **may** provide, guidance on how to do it. In some cases, the Execution may be very prescriptive on exactly how it is to be done. This may be valid in certain tasks where precise coordination is necessary.

- **EXECUTION** – This component of the SMEACS format provides guidance on how the mission or task is to be performed. It can often be appended with such terms as 'General Outline' and then 'Specific Tasks' or 'Scheme of Manoeuvre' or similar. In this section, any specific guidance is provided to each subordinate unit or person as the case may be. In some scenarios, it may be required to be quite specific; in other scenarios it may be quite general allowing the subordinate to determine the best means of achieving the end state. (See Mission paragraph above).

- **ADMIN(ISTRATION) AND LOG(ISTICS)** – In this component, the methods used to administer the whole task and the means by which it is to be supported logistically are outlined. Examples of considerations are such things as rations, water supply, fuel and oil, accommodation, special equipment and supplies, etc.

- **COMMAND AND SIG(NALS)** – This component outlines what the status of command is and who is responsible for various duties both inside the immediate team and outside it. Such things as who is the point of contact at the tasking agency; who is issuing the tasks; who is giving the orders higher up the chain and who is responsible further down the chain. Signals is a military term used to describe communications and can be translated to such things as radio frequencies to be used; contact details by phone, email, etc; type of equipment that will be used (eg GRN or Aviation VHF or HF, etc). This section provides information so that anyone who receives the orders knows who to speak to, and how to speak to them, in order to get further information if the need arises.

- **SAFETY** – This is an addition to the SMEAC format that gained popularity in civilian emergency services agencies and is especially relevant in the era of workplace health and safety and its associated components such as risk management. It allows for the briefer to describe how WHS issues have been addressed and any special considerations.

Section

9.3.1 **An example of using a SMEACS brief –** Below is the author's version of a SMEACS briefing format used for powerline patrol. It was also used – with some variations – for airborne law enforcement operations with the Australian Customs Service. In essence, the briefing format remains more or less the same, with individual elements adjusted depending on the nature of the task and the equipment used. It is also a useful tool for planning and becomes a checklist to make sure that all the important items are considered and planned for prior to the mission and then used as a briefing checklist when giving the brief immediately before boarding the aircraft.

9.3.1.2 The SMEACS brief is very thorough and can be shortened depending on the situation. For example, if a crew is flying together for several days in a row… and the nature of the task remains the same, then many of the items do not need to be articulated as part of the brief and can be replaced with such expressions as "no change" or "as per SOPs" or "not applicable" etc.

CREW BRIEF	
1	**Situation, Preliminary Info (includes MC's brief to PIC) and Mission**
	Task/Mission – Confirmation on task to be undertaken and why.
	Topography – Area to be worked / transited identified.
	Key hazards/Assets – Power Lines, terrain, PRDs, FNs, Asset locs
	Meteorology – Forecasts / Obs done / Sun / Wind / Obscurations
	NOTAMS – ASA for area/airfields to be worked, Company NOTAMs
	Notifications – SAR, Flt Plan/Company/Client/Permits/Authorities/PR
2	**Execution – General outline of the activities**
	Timings – Arrive, STTO, Endurance per refuel
	Routes and altitudes, en route replenishment or operational stops
	On station – Off station timings
	Tasks – Pilot/ Obs / Crew / Gnd Spt, Other
	Scan & Duties- Traffic, obstacles, nav, radios.
	Special Considerations Perf IGE/OGE, Wind, Sun, Sling Loads, LZs
	CG – Within limits Long/Lat. Ballast
3	**Contingencies – Actions on unexpected events**
	Emergencies – SOPs, Crew Duties, Indications
	Weather – Contingencies in flight / after flight
	Unserviceabilities – Maint / Recovery Plan
	Risk Mangt Plan – Risks ID'd, Controls instigated. Go/No Go criteria
4	**Administration and Logistics**
	Mission Equipment – Checked / secured / ready
	Personal and Survival Equipment – Checked / secured / ready
	Accommodation and Transport – Checked and booked
	Dangerous Goods – Checked, paperwork, loaded, carried
	Maint Release – Checked / signed / AD s / Hrs left til next servicing
	Fuel / Oil – Location / type / refuellers ready / method of payment
	Acft Maint – Compressor Rinse, Eng Checks, Maintenance Plan
	Rations – Lunch / Drink breaks, locations, timings
	Briefings – Crew, Gnd Spt, Pax briefed. Briefing cards avail.
	Personnel – Qualified, Current, physical / psych issues
5	**Command and Communications**
	Mission Comd – Allocation of duties
	Acft Comd – Allocation of duties
	Company – Requirements of sortie/task, Client POC details
	Comms – Freqs checked, eqpt serv, radios allocated to crew
	Emergency Comms – ICS failure, hand signals, radios, phone, ELT, SOPs
6	**Safety, Questions and Additional Points**
	Safety – Risk Management Plans in place. Special Safety consids & eqpt
	Debrief – Location and time
	Final Questions?
	Pre-flight Insp and Fuel Check – Complete
	Final Walkaround – Complete, hatches and latches checked before boarding

Figure 9.5 A variation of the SMEACS format for a Powerline Patrol sortie in a helicopter where the Pilot In Command gives the brief in conjunction with the Mission Commander's input.

- **Situation, Preliminary Information and Mission** gives an overall view of the situation and mission and the key hazards, terrain, weather, etc. This would include the MC's brief to the pilot on the task required after which the PIC will conduct his/her brief on how it can be achieved. Notifications include any SAR plan or flight following but also any notifications that may be reqd by the organisation to authorities or the media as required or for any appropriate work/landing permits.

Figure 9.6 US Army soldiers conduct a final briefing before commencing operations. The SMEAC format was developed by a US Cavalry officer from and similar system used in Germany. Now, over 120 years later, the same basic format is still being used. (Public Domain)

- **Execution** starts with key timings and routes and an overall outline of how the mission will be executed. It also introduces each person's tasks for the mission. Scan indicates what area of the sky/terrain each individual will be responsible for and other duties. Special considerations allows the PIC to discuss any limitations of the acft so the MC understands what is possible and what is not.

- **Contingencies** allows everyone to receive a mental model on what actions will be taken in the event the mission does not go according to plan. Risks are also identified and Go/No Go criteria established. This is not normally a part of the Execution section of a SMEACS format, but the SMEACS format is a guide to ensure thoroughness. In this brief, the author decided that contingencies should be briefed immediately after the Execution general plan.

- **Administration and Logistics** is basically housekeeping that must be considered as supporting the mission. Things like equipment that is needed or

needs to be carried and if it's approved to do so. Maintenance paperwork and how and when the aircraft will be looked after and how the crew will be looked after with regard to food and accommodation. These items should be taken care of early so that they are not a worry during flight. Finish off with a check of each crew member's preparedness for the mission.

- **Command and Comms** allows everyone to understand roles and responsibilities and allows the PIC and MC to delineate specific roles before the mission commences. This is important in mixed team environments. Comms are also checked before departure and which radios are allocated to whom. Also included are any points of contact with regard to the mission who may need to be contacted if circumstances require it.

- **Safety, Questions and Additional Points** is the final component of this particular SMEACS style brief. The safety related aspects of the mission are briefed including any specific Risk Management Plans or safety equipment that is necessary. Also included is the time for the debrief after the mission and finally, an opportunity for any member of the team to ask questions. In the small aircraft scenario, the PIC would confirm that the aircraft has been prepared and checked for flight including the daily/pre-flight inspection and fuel check; that any paperwork has been signed and, finally, one last walk around the aircraft to confirm that all latches and hatches are secure before boarding and strapping in.

9.3.1.3 **Using a SMEACS brief as a planning tool –** Because this style of brief is so thorough, it can also be used as a planning tool prior to a task. Each item provides a memory jogger for the planner to seek information so that it can be briefed. The beauty of the SMEACS format is that it is flexible enough to change depending on the organisation and mission type. It is up to the individual to tailor the format to his/her own organisation's needs and the mission type and then add or subtract information as need be.

Module 9.4

9.4 **De-briefing.** As cited in paragraph 9.2 above and then shown in the final section of the SMEACS briefing format, debriefing is a vital part of any mission or any important activity. A debriefing is a means of acquiring information to be used later. In a crew environment, it is also an opportunity for people to give opinions and raise concerns.

Section

9.4.1 **Debriefing uses.** There are many uses for de-briefs. Below are some examples:

- **After a task or a mission or project**. This type of debrief is the most common and is used in order to gain the facts and check processes to ensure expectations were met and procedures followed. It is used as part of an effort to learn from the experiences of those involved to capture and reinforce good effects and to improve on those that were not so good.

- **After a critical incident.** The debrief may be part of an investigation held by an external agency (eg police) or by personnel within the organisation (eg safety manager) to clarify the facts and circumstances surrounding the incident for reporting purposes.

- **After a critical incident for psychological purposes.** This is often a form of counselling but unlike the situation above, this type of de-briefing seeks to gain emotional insights rather than just the facts. It allows individuals involved to articulate feelings and emotions and is one step towards providing psychological assistance to those who may require it.

- **After an assessment or test.** This type of de-brief involves two way communication whereby the subject matter expert / assessor provides a de-brief to the assessed on his/her performance and allows the assessed to make comment.

Section

9.4.2 **De-briefing Methodology.** De-briefing often involves sensitive information or opinions or reviews of performance. This being the case, de-briefs are often better handled in private where people are able to express views more readily and/or embarrassment is avoided especially in front of peers. A de-brief may be as simple as recounting what happened in a mission to ensure standards have been met and the job completed according to plan or it may be as complex as a multi-faceted mission where there are many moving parts and many elements involved such as after air to air combat. The following are some tools to assist with effective de-briefing.

- **Use the mission plan as a basis for the de-brief.** The pre mission plan and its associated brief provides a good template for conducting the de-brief. If the plan has been done in a standard chronological order, then this makes a logical de-brief format. Go through each point that was planned and briefed and compare it to what happened during the mission and task. Check for any deviations or departures from what was required and verify the reasons why. In some cases it may have been due to a misunderstanding in the brief; in others it may have been unforeseen circumstances that may be addressed in future planning.

- **Allow every element the opportunity to contribute.** In some missions, certain crew or team members may play a minor role. This does not mean that they have not got important input into the de-brief. In many cases, a team member who plays a minor role often has the capacity to view other team members who have a major role and be able to critically analyse their conduct from a third party perspective. Often this is the most accurate analysis and can contribute greatly to understanding a person's actions in high stress situations.

- **Verify recollections.** It is well known that two people who witness the same event, rarely provide the same details of it when asked. Viewpoints can be skewed for a number of reasons; the amount of information provided; expectations and preconceptions; biases; ulterior motives; the amount of stress involved; etc. A de-brief is a chance to check all the aspects of a story to find that the truth lies somewhere within. It is important to remember that people may give different accounts of a story quite innocently and without any ulterior motive.

- **Choose an appropriate time and place.** For simple missions, the de-brief may occur whilst waiting for the engines to cool down prior to shutting them down and be conducted on the intercom. For more complex situations, it is often more appropriate to have a specific venue and time to get all the key players together to conduct a de-brief. It should be as soon as possible after the mission, however, to ensure that memories are fresh and to also ensure that collusion does not occur that may change an opinion. If the de-brief is associated with some sort of assessment such as a check ride or flight test or after a critical incident, then a de-brief in private is more appropriate. This allows a more free exchange of information and avoids embarrassing people, especially in front of their peers.

- **Ascertain if a third party is required.** In some cases, it may be necessary to have a witness or an advocate in attendance, especially after a critical incident or if the de-brief may give rise to further action. Legal representation may be necessary or some sort of support or someone from the chain of command. Ensure that if you are conducting the de-brief, that the person being de-briefed is made aware of the reason for the third party's presence.

- **Record information.** De-briefs are designed to acquire information for use later. For a check ride or other such assessment, the individual will be served well by having the assessment recorded in order to improve performance later. For more simple tasks, it may be a 'lessons learnt' situation where the crew can improve performance from things that happened well and things that did not happen well. For sensitive de-briefs, records of conversation may be vital during subsequent legal proceedings. If a record of conversation is deemed to be necessary, ensure that all parties present have a chance to review the record of conversation and sign and date it. All parties should be provided with a copy.