SHA-SHIB GROUP OF INSTITUTIONS

Training Notes

Module 09- Human Factors

SHA-SHIB GROUP

EMPOWERING KNOWLEDGE THROUGH VISION

FOREWORD

UNCONTROLLED COPY

- The information in this book is for study/ training purposes only and no revision service will be provided to the holder.
- While carrying out a procedure/ work on aircraft/ aircraft equipment you must always refer to the relevant Aircraft Maintenance Manual or Equipment Manufacturer's Handbook.
- For health and safety in the workplace you should follow the regulations/ Guidelines as specified by the Equipment Manufacturer, your company, National Safety Authorities and National Governments.

Knowledge Levels – Category A, B1, B2, B3 and C Aircraft Maintenance Licence

Basic knowledge for categories A, B1, B2 and B3 are indicated by the allocation of knowledge levels indicators (1, 2 or 3) against each application subject. Category C applicants must meet either the category B1 or the category B2 basic knowledge levels.
The knowledge level indicators are defined as follows:

LEVEL 1

- A familiarization with the principal elements of the subject.

Objectives: The applicant should be familiar with the basic elements of the subject.

- The applicant should be able to give a simple description of the whole subject, using common words and examples.
- The applicant should be able to use typical terms.

LEVEL 2

- A general knowledge of the theoretical and practical aspects of the subject.
- An ability to apply that knowledge.

Objectives: The applicant should be able to understand the theoretical fundamentals of the subject.

- The applicant should be able to give a general description of the subject using, as appropriate, typical examples.
- The applicant should be able to use mathematical formulae in conjunction with physical laws describing the subject.
- The applicant should be able to read and understand sketches, drawings and schematics describing the subject.
- The applicant should be able to apply his knowledge in a practical manner using detailed procedures.

LEVEL 3

- A detailed knowledge of the theoretical and practical aspects of the subject.
- A capacity to combine and apply the separate elements of knowledge in a logical and comprehensive manner.

Objectives: The applicant should know the theory of the subject and interrelationships with other subjects.

- The applicant should be able to give a detailed description of the subject using theoretical fundamentals and specific examples.
- The applicant should understand and be able to use mathematical formulae related to the subject.
- The applicant should be able to read, understand and prepare sketches, simple drawings and schematics describing the subject.
- The applicant should be able to apply his knowledge in a practical manner using manufacturer's instructions.
- The applicant should be able to interpret results from various sources and measurements and apply corrective action where appropriate.

-: DGCA MODULARISATION :-

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CAR – 66 ISSUE II R 2

(LICENSING OF AIRCRAFT MAINTENANCE ENGINEERS)

DIRECTORATE GENERAL OF CIVIL AVIATION

TECHNICAL CENTRE, OPP SAFDURJUNG AIRPORT, NEW DELHI

Modules	Subject	A or B1 Aero plane with		A or B1 Helicopter with		B2
		Turbine Engine (s)	Piston Engine (s)	Turbine Engine (s)	Piston Engine (s)	Avionics
1	Not Applicable					
2	Not Applicable					
3	ELECTRICAL FUNDAMENTALS	X	X	X	X	X
4	ELECTRONIC FUNDAMENTALS	X	X	X	X	X
5	DIGITAL TECHNIQUES ELECTRONIC INSTRUMENT SYSTEMS	X	X	X	X	X
6	MATERIALS AND HARDWARE	X	X	X	X	X
7A	MAINTENANCE PRACTICES	X	X	X	X	X
7B	MAINTENANCE PRACTICES					
8	BASIC AERODYNAMICS	X	X	X	X	X
9A	HUMAN FACTORS	X	X	X	X	X
9B	HUMAN FACTORS					
10	AVIATION LEGISLATION	X	X	X	X	X
11A	TURBINE AEROPLANE AERODYNAMICS, STRUCTURES AND SYSTEMS	X				
11B	PISTON AEROPLANE AERODYNAMICS, STRUCTURES AND SYSTEMS		X			
11C	PISTON AEROPLANE AERODYNAMICS, STRUCTURES AND SYSTEMS					
12	HELICOPTER AERODYNAMICS, STRUCTURES AND SYSTEMS			X	X	
13	AIRCRAFT AERODYNAMICS, STRUCTURES AND SYSTEMS					X
14	PROPULSION					X
15	GAS TURBINE ENGINE	X		X		
16	PISTON ENGINE		X		X	
17A	PROPELLER	X	X			
17B	PROPELLER					

TRAINING NOTES
MODULE: 09

SUBJECT NAME: HUMAN FACTORS

UNIT NO.	OBJECTIVE	LEVEL	
		B1	B2
9.1	**9.1 General** The need to take human factors into account; Incidents attributable to human factors/human error; 'Murphy's' law.	2	2
9.2	**9.2 Human Performance and Limitations** Vision; Hearing; Information processing; Attention and perception; Memory; Claustrophobia and physical access.	2	2
9.3	**9.3 Social Psychology** Responsibility: individual and group; Motivation and de-motivation; Peer pressure; 'Culture' issues; Team working; Management, supervision and leadership	1	1
9.4	**9.4 Factors Affecting Performance** Fitness/health; Stress: domestic and work related; Time pressure and deadlines; Workload: overload and underload; Sleep and fatigue, shift work; Alcohol, medication, drug abuse.	2	2
9.5	**9.5 Physical Environment** Noise and fumes; Illumination; Climate and temperature; Motion and vibration; Working environment.	1	1
9.6	**9.6 Tasks** Physical work; Repetitive tasks; Visual inspection; Complex systems.	1	1
9.7	**9.7 Communication** Within and between teams; Work logging and recording; Keeping up to date, currency; Dissemination of information.	2	2
9.8	**9.8 Human Error** Error models and theories; Types of error in maintenance tasks; Implications of errors (i.e accidents) Avoiding and managing errors.	2	2
9.9	**9.9 Hazards in the Workplace** Recognising and avoiding hazards; Dealing with emergencies.	2	2

Module 09: Enabling Objectives and Certification Statement

Certification Statement

These Study Notes comply with the syllabus of DGCA, CAR – 66 (Appendix I) and the associated Knowledge Levels as specified.

REVISION LOG

Sr. No.	Issue / Revision No.	Issue / Revision Date	Pages Revised	Signature

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Sub Module 9.1 GENERAL

This chapter introduces human factors and explains its importance to the aviation industry. Human factors directly cause or contribute to many aviation accidents. It is universally agreed that at least 80 percent of maintenance related incidents involve human factors. If they are not prevented, and their causes detected, they can cause injuries, wasted time, and even accidents. It examines the relationship between human factors and incidents largely in terms of human error and "Murphy's Law" (i.e. if it can happen, one day it will).

9.1.1 THE NEED TO TAKE HUMAN FACTORS INTO ACCOUNT

Aviation safety relies heavily on maintenance. When it is not done correctly, it contributes to a significant proportion of accidents and incidents. Some examples of maintenance errors may include parts installed incorrectly, missing parts, or necessary checks not being performed. In comparison to many other threats to aviation safety, the mistakes of an Aircraft Maintenance Engineer (AME) can be more difficult to detect. Often times, these mistakes are present but not visible and have the potential to remain latent, affecting the safe operation of aircraft for long periods of time.

AME s are confronted with a set of human factors unique within aviation. Often, they are working in the evening or early morning hours, in confined spaces, on platforms that are up high, and in a variety of adverse temperature/humidity conditions. The work can be physically strenuous, yet it also requires attention to detail. Because of the nature of the maintenance tasks, AME s commonly spend more time preparing for a task than actually carrying it out. Proper documentation of all maintenance work is a key element, and AME s typically spend as much time updating maintenance logs as they do perform the work.

Human factors awareness can lead to improved quality, an environment that ensures continuing worker and aircraft safety, and a more involved and responsible work force

An understanding of the importance of human factors to aircraft maintenance engineering is essential to anyone considering a career as a licensed aircraft engineer. This is because human factors will impinge on everything, they do in the course of their job in one way or another.

What is "Human Factors"?

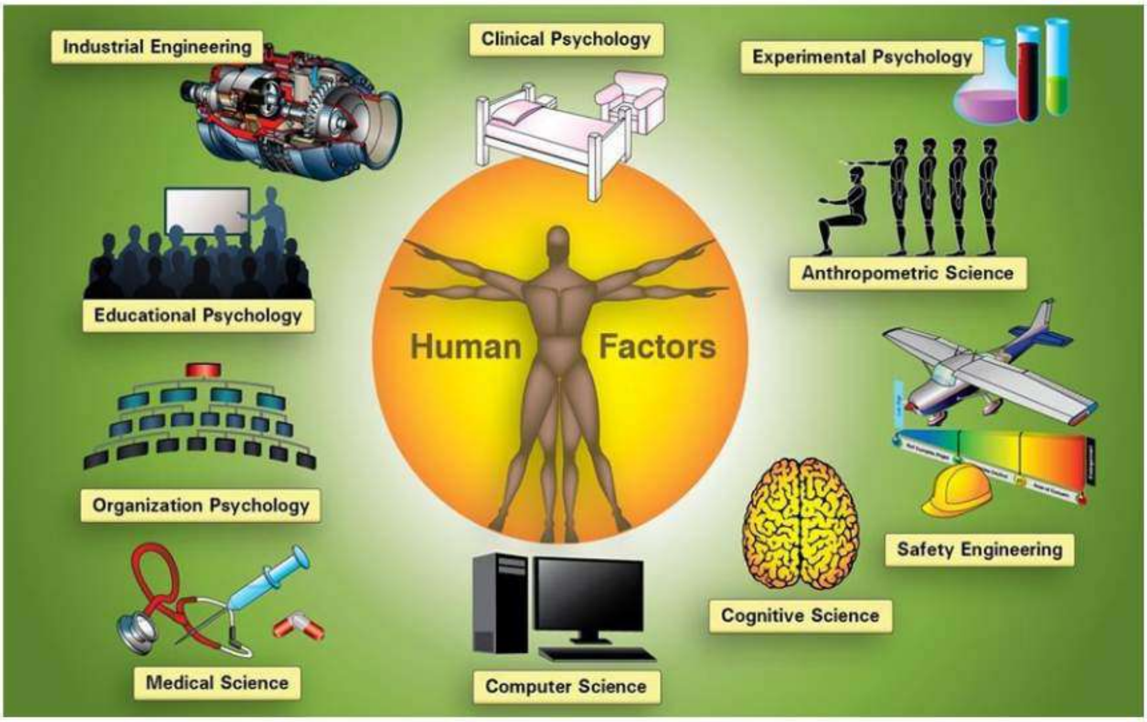
The term human factors has grown increasingly popular as the commercial aviation industry realize that human error, rather than mechanical failure, underlies most aviation accidents and incidents. It is a term that covers the science of understanding the properties of human capability, the application of this understanding to the design, development, and deployment of systems and services, and the art of ensuring successful application of human factor principles into the maintenance working environment.

The use of the term "human factors" in the context of aviation maintenance engineering is relatively new. Aircraft accidents such as that to the Aloha aircraft in the USA in 1988 and the BAC 1-11 windscreen accident in the UK in June 1990 brought the need to address human factors issues in this environment into sharp focus. This does not imply that human factors issues were not present before these dates nor that human error did not contribute to other incidents; merely that it took an accident to draw attention to human factors problems and potential solutions.

Before discussing how these accidents were related to human factors, a definition of human factors is required. There are many definitions available. Some authors refer to the subject as "human factors" and some as "ergonomics". Some see "human factors" as a scientific discipline and others regard it as a more general part of the human contribution to system safety. Although there are simple definitions of human factors such as: "Fitting the man to the job and the job to the man", a good definition in the context of aviation maintenance would be: "Human factors" refers to the study of human capabilities and limitations in the workplace. Human factors researchers study system performance. That is, they study the interaction of maintenance personnel, the equipment they use, the written and verbal procedures and rules they follow, and the environmental conditions of any system. The aim of human factors is to optimize the relationship between maintenance personnel and systems with a view to improving safety, efficiency and well-being".

Elements of Human Factors

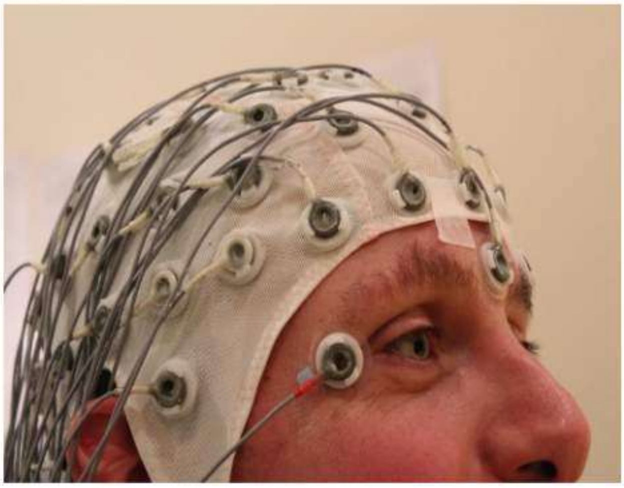
Human factors are comprised of many disciplines. This section discusses ten of those disciplines: Clinical Psychology, Experimental Psychology, Anthropometrics, Computer Science, Cognitive Science, Safety Engineering, Medical Science, Organizational Psychology, Educational Psychology, and Industrial Engineering



By understanding each of the disciplines and applying them to different situations or human behaviors, we can correctly recognize potential human factors and address them before they develop into a problem or create a chain of problems that result in an accident or incident.

Clinical Psychology

It focuses on the mental well-being of the individual. Clinical psychology can help individuals deal with stress, coping mechanisms for adverse situations, poor self-mage, and accepting criticism from coworkers.

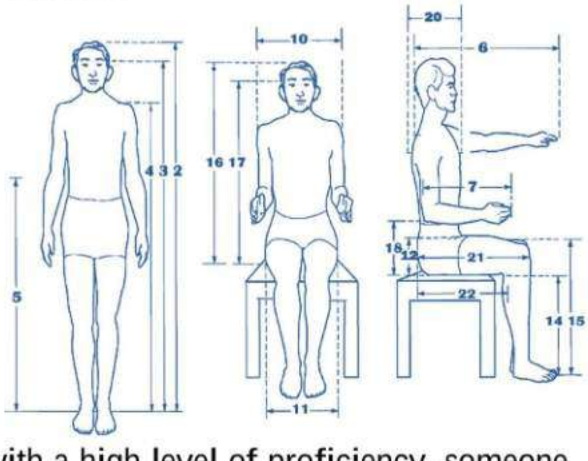


Experimental Psychology

Experimental psychology includes the study of a variety of basic behavioral processes, often in a laboratory environment. These processes may include learning, sensation, perception, human performance, motivation, memory, language, thinking, and communication, as well as the physiological processes underlying behaviors, such as eating, reading, and problem solving. In an effort to test the efficiency of work policies and procedures, experimental studies help measure performance, productivity, and deficiencies.

Anthropometrics

Anthropometry is the study of the dimensions and abilities of the human body. This is essential to aviation maintenance due to the environment and spaces that AMTs have to work with. For example, a man who is 6 feet 3 inches and weighs 230 pounds may be required to fit into a small crawl space of an aircraft to conduct a repair. Another example is the size and weight of equipment and tools.



Men and women are generally on two different spectrums of height and weight. Although both are equally capable of completing the same task with a high level of proficiency, someone who is smaller may be able to perform more efficiently with tools and equipment that is tailored to their size.

Computer Science

AME s spend as much time documenting repairs as they do perform them. It is important that they have computer workstations that are comfortable and reliable. Software programs and computer-based test equipment should be easy to learn and use, and not intended only for those with a vast level of computer literacy.

Cognitive Science

Cognitive science is the interdisciplinary scientific study of minds as information processors. It includes research on how information is processed (in faculties such as perception, language, reasoning, and emotion), represented, and transformed in a nervous system or machine (e.g., computer).

AME s must possess a great ability to problem solve quickly and efficiently. They constantly have to troubleshoot a situation and quickly react to it. This can be a viscous cycle creating an enormous amount of stress. The discipline of cognitive science helps us understand how to better assist AME s during situations that create high levels of stress so that their mental process does not get interrupted and effect their ability to work.

Safety Engineering

Safety engineering assures that a life-critical system behaves as needed even when the component fails. Ideally, safety engineers take an early design of a system, analyze it to find what faults can occur, and then propose safety requirements in design specifications up front and changes to existing systems to make the system safer. Safety cannot be stressed enough when it comes to aviation maintenance, and everyone deserves to work in a safe environment. Safety engineering plays a big role in the design of aviation maintenance facilities, storage containers for toxic materials, equipment used for heavy lifting, and floor designs to ensure no one slips, trips, or falls. In industrial work environments, the guidelines of the Occupational Safety and Health Administration (OSHA) are important.

Medical Science

Medicine is the science and art of healing. It encompasses a variety of health care practices evolved to maintain and restore health by the prevention and treatment of illness. Disposition and physical well-being are very important and directly correlated to human factors.

Organizational Psychology

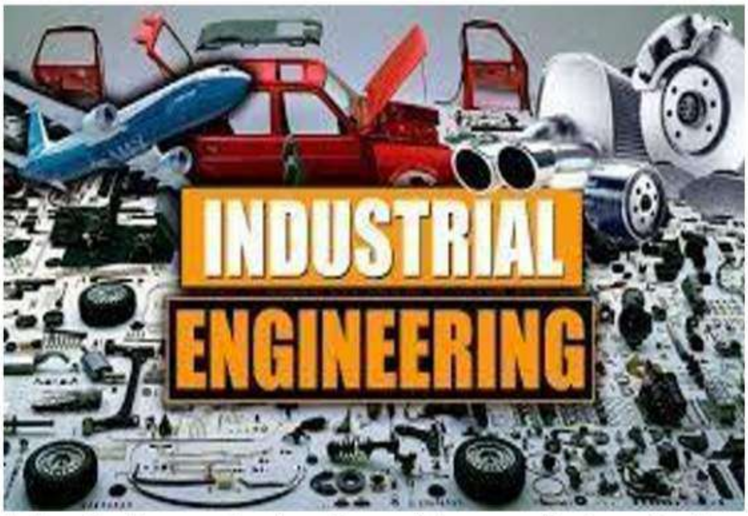
Organizational psychologists are concerned with relations between people and work. Understanding organizational psychology helps aviation maintenance supervisors learn about the points listed below that, if exercised, can enhance the work environment and productivity.

- Rewards and compensations for workers with good safety records.
- Motivated workers that want to do well and work safely.
- Unified work teams and groups that get along and work together to get the job done right.
- Treat all workers equally.

Educational Psychology

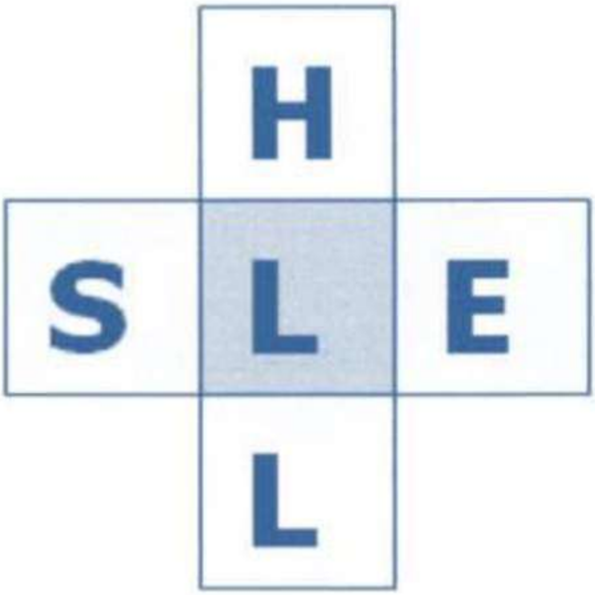
Educational psychologists study how people learn and design the methods and materials used to educate people of all ages. Everyone learns differently and at a different pace. Supervisors should design blocks of instruction that relate to a wide variety of learning styles.

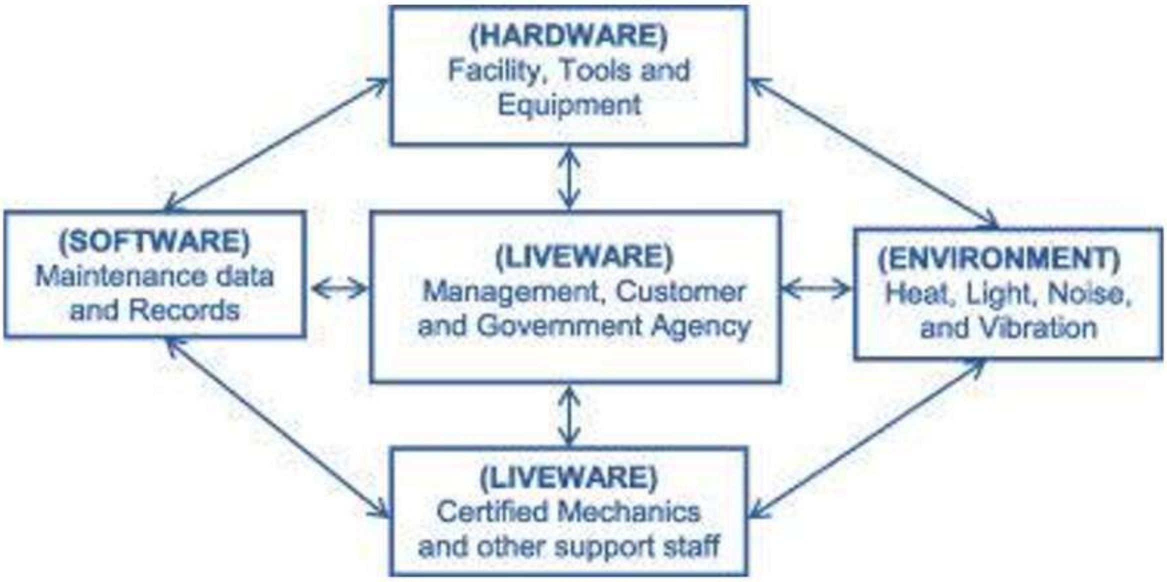
Industrial Engineering



Industrial engineering is the organized approach to the study of work. It is important for supervisors to set reasonable work standards that can be met and exceeded. Unrealistic work standards create unnecessary stressors that cause mistakes. It is also beneficial to have an efficient facility layout so that there is room to work. Clean and uncluttered environments enhance work performance. Another aspect of industrial engineering that helps in the understanding of human factors is the statistical analysis of work performance. Concrete data of work performance, whether good or bad, can show the contributing factors that may have been present when the work was done.

The SHEL Model





It can be helpful to use a model to aid in the understanding of human factors, or as a framework around which human factors issues can be structured. A mode which is often used is the SHEL model, a name derived from the initial letters of its components:

- Software (e.g. maintenance procedures, maintenance manuals, checklist layout etc.);
- Hardware (e.g. tools, test equipment, the physical structure of aircraft, design of flight decks, positioning and operating sense of controls and instruments, etc.);
- Environment (e.g. physical environment such as conditions in the hangar, conditions on the line, etc. and work environment such as work patterns, management structures, public perception of the industry etc.)
- Live ware (i.e. the person or people at the Centre of the model, including maintenance engineers, supervisors, planners, managers etc.).

Human factors concentrates on the interfaces between the human (the 'L' in the centre box) and the other elements of the SHEL model and from a safety viewpoint - where these elements can be deficient, e.g.:

S: misinterpretation of procedures, badly written manuals, poorly designed checklists, untested or difficult to use computer software

H: not enough tools, inappropriate equipment, poor aircraft design for maintainability

E: uncomfortable workplace, inadequate hangar space, extreme temperatures, excessive noise, poor lighting

L: relationships with other people, shortage of manpower, lack of supervision, lack of support from managers

As will be covered in this document, **man, the "Live ware"** - can perform a wide range of activities. Despite the fact that modern aircraft are now designed to embody the latest self- test and diagnostic routines that modern computing power can provide, one aspect of aviation maintenance has not changed: maintenance tasks are still being done by human beings.

However, man has limitations. Since Live ware is at the centre of the model, all other aspects (Software, Hardware and Environment) must be designed or adapted to assist his performance and respect his limitations. If these two aspects are ignored, the human- in this case the maintenance engineer - will not perform to the best of his abilities, may make errors, and may jeopardize safety.

Thanks to modern design and manufacturing, aircraft are becoming more and more reliable. However, it is not possible to re-design the human being: we have to accept the fact that the human being is intrinsically unreliable. However, we can work around that unreliability by providing good training, procedures, tools, duplicate inspections, etc. We can also reduce the potential for error by improving aircraft design such that, for example, it is physically impossible to reconnect something the wrong way round.

9.1.2 INCIDENTS AND ACCIDENTS ATTRIBUTABLE TO HUMAN FACTORS

In 1940, it was calculated that approximately 70% of all aircraft accidents were attributable to **man's performance, that is to say human error**. When the International Air Transport Association (IATA) reviewed the situation 35 years later, they found that there had been no reduction in the human error component of accident statistics.

A study was carried out in 1986, in the USA by Sears3, looking at significant accident causes in 93 aircraft accidents. These were as follows:

Causes/ major contributory factors	% of accidents in which this was a factor
Pilot deviated from basic operational procedures	33
Inadequate cross-check by second crew member	26
Design faults	13
Maintenance and inspection deficiencies	12
Absence of approach guidance	10
Captain ignored crew inputs	10
Air traffic control failures or errors	9
Improper crew response during abnormal conditions	9
Insufficient or incorrect weather information	8
Runways hazards	7
Air traffic control/crew communication deficiencies	6
Improper decision to land	6

Examples of Incidents and Accidents

There have been several „high profile incidents and accidents which have involved maintenance human factors problems.

These are:

1. Accident to Boeing 737, (Aloha flight 243), Maui, Hawaii, April281988; https://youtu.be/POXjwIJk14U

2. Accident to BAC One-Eleven, G-BJRT (British Airways flight 5390), over Did cot, Oxford shire on 10 June1990.
https://youtu.be/ofKnuM0UXcE; https://youtu.be/9vbpdPo8c7k

3. Incident involving Airbus A320, G-KMAM at London Gatwick Airport, on 26 August1993;
4. Incident involving Boeing 737, G-OBMM near Daventry, on 23 February1995.

1. The accident involving Aloha flight 243 in April 1988 involved 18 feet of the upper cabin structure suddenly being ripped away in flight due to structural failure. The Boeing 737 involved in this accident had been examined, as required by US regulations, by two of the engineering inspectors. One inspector had 22 years" experience and the other, the chief inspector, had 33 years" experience. Neither found any cracks in their inspection. Post- accident analysis determined there were over 240 cracks in the skin of this aircraft at the time of the inspection. The ensuing investigation identified many human-factors-related problems leading to the failed inspections.

As a result of the Aloha accident, the US instigated a program of research looking into the problems associated with human factors and aircraft maintenance, with particular emphasis upon inspection.

2. On June 10th 1990 in the UK, a BAC1-11 (British Airways flight 5390) was climbing through 17,300 feet on departure from Birmingham International Airport when the left windscreen, which had been replaced prior to flight, was blown out under the effects of cabin pressure when it overcame the retention of the securing bolts, 84 of which, out of a total of 90, were smaller than the specified diameter. The commander was sucked halfway out of the windscreen aperture and was restrained by cabin crew whilst the co-pilot flew the aircraft to a safe landing at Southampton Airport. The Shift Maintenance Manager (SMM), short-handed on a night shift, had decided to carry out the windscreen replacement himself. He consulted the Maintenance Manual (MM) and concluded that it was a straightforward job. He decided to replace the old bolts and, taking one of the bolts with him (a 7D), he looked for replacements. The store man advised him that the job required 8Ds, but since there were not enough 8Ds, the SMM decided that 7Ds would do (since these had been in place previously). However, he used “sight and touch” to match the bolts and, erroneously, selected 8Cs instead, which were longer but thinner. He failed to notice that the countersink was lower than it should be, once the bolts were in position. He completed the job himself and signed it off, the procedures not requiring a pressure check or duplicated check.

There were several human factors issues contributing to this incident, including perceptual errors made by the SMM when identifying the replacement bolts, poor lighting in the stores area, failure to wear spectacles, circadian effects, working practices, and possible organizational and design factors.

3. An incident in the UK in August 1993 involved an Airbus 320 which, during its first flight after a flap change, exhibited an un- demanded roll to the right after takeoff. The aircraft returned to Gatwick and landed safely. The investigation discovered that during maintenance, in order to replace the right outboard flap, the spoilers had been placed in maintenance mode and moved using an incomplete procedure; specifically the collars and flags were not fitted. The purpose of the collars and the way in which the spoilers

Function was not fully understood by the engineers. This misunderstanding was due, in part, to familiarity of the engineers with other aircraft (mainly 757) and contributed to a lack of adequate briefing on the status of the spoilers during the shift handover. The locked spoiler was not detected during standard pilot functional checks.

4. In the UK in February 1995, a Boeing 737-400 suffered a loss of oil pressure on both engines. The aircraft diverted and landed safely at Lurton Airport. The investigation discovered that the aircraft had been subject to bore scope inspections on both engines during the preceding night and the high pressure (HP) rotor drive covers had not been refitted, resulting in the loss of almost all the oil from both engines during flight. The line engineer was originally going to carry out the task, but for various reasons he swapped jobs with the base maintenance controller. The base maintenance controller did not have the appropriate paperwork with him. The base maintenance controller and a fitter carried out the task, despite many interruptions, but failed to refit the rotor drive covers. No ground idle engine runs (which would have revealed the oil leak) were carried out. The job was signed off as complete.

In all three of these UK incidents, the engineers involved were considered by their companies to be well qualified, competent and reliable employees.
All of the incidents were characterized by the following:

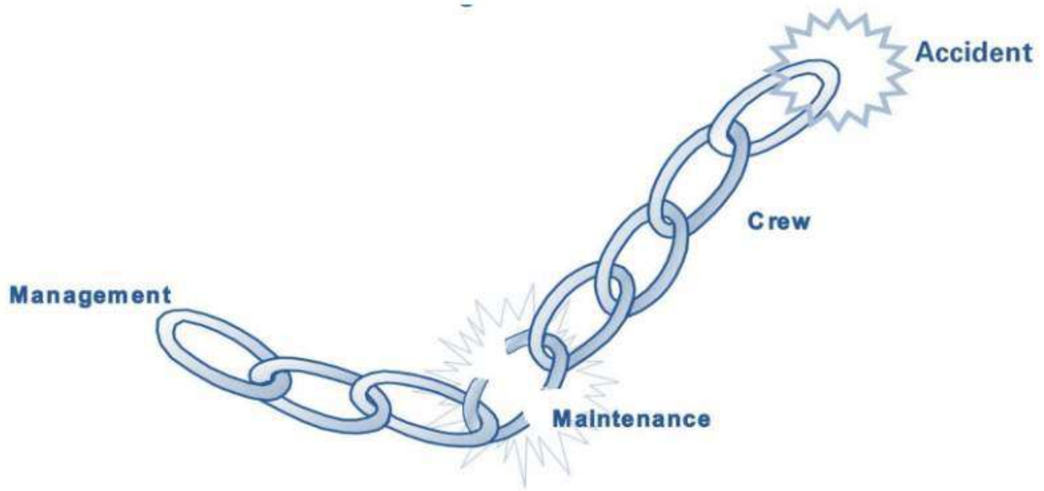
- There were staff shortages;
- Time pressures existed;
- All the errors occurred at night;
- Shift or task handovers were involved;
- They all involved supervisors doing long hands-on tasks;

- There was an element of a "can-do "attitude;
- Interruptions occurred;
- There was some failure to use approved data or company procedures;
- Manuals were confusing;
- There was inadequate pre-planning, equipment or spares.

Incidents and Accidents - A Breakdown in Human Factors

In all of the examples above, the accident or incident was preventable and could have been avoided if any one of a number of things had been done differently. In some cases, a number of individuals were involved and the outcome could have been modified if any one of them had reacted or queried a particular action.

In each situation however, the individuals failed to recognize or react to signs of potential hazards, did not react as expected of them, or allowed themselves to be diverted from giving their attention to the task in hand, leaving themselves open to the likelihood of committing an error.



If we can break just one link of the chain, the accident does not happen

As with many incidents and accidents, all the examples above involved a series of human factors problems which formed an error chain If any one of the links in this 'chain' had been broken by building in measures which may have prevented a problem at one or more of these stages, these incidents may have been prevented.

9.1.3MURPHY'S LAW

https://youtu.be/YdnYUpK4mqc

There is a tendency among human beings towards complacency The belief that an accident will never happen to "me " or to "my Company " can be a major problem when attempting to convince individuals or organizations of the need to look at human factors issues, recognize risks and to implement improvements, rather than merely to pay "lip- service" to human factors.

"Murphy's Law" can be regarded as the notion: **"If something can go wrong, it will'**.

If everyone could be persuaded to acknowledge Murphy's law, this might help overcome the "it will never happen to me" belief that many people hold. It is not true that accidents only happen to people who are irresponsible or sloppy. The incidents and accidents described show that errors can be made by experienced, well-respected individuals and accidents can occur in organizations previously thought to be "safe".

As can be seen from the list, maintenance and inspection deficiencies are one of the major contributory factors to accidents.

Failures in aviation and space exploration can be extremely costly. Because of costly failures, designers have installed **"fail safes". Fail safes are referred to as "idiot proof"**. But Murphy's Law always seems to strike, even when precautions have been put in place; resulting in **"Grave's Law"**, which states, if you make something idiot proof, the world will create a better **idiot".**

9.2 HUMANPERFORMANCE &LIMITATIONS

INTRODUCTION

This chapter provides an overview of physical and mental human performance factors which affect an Aircraft Maintenance Technicians working environment, such as vision, hearing, information processing, attention and perception, memory, judgment and decision making.

THE POTENTIAL FOR HUMAN ERROR

In our study of human factors we will be mostly concerned with identifying those aspects of behavior that can result in people making mistakes or errors which could result in accidents.

Our capacity to perceive what is going on in our working environment by sight, touch, feel, smell, hearing etc.: together with our capacity to remember, process information and act upon it are all relevant in the context of human error.

Factors which can contribute towards mistakes leading to accidents are incalculable. However, some of them will fall into one or more of the following:

1) Inadequate information - be it visual or verbal can, does and will lead to people making mistakes, if you think the information you have is inadequate or insufficient to do something about it.

2) Lack of understanding - possibly stemming from inadequate information or maybe lack of training can lead to people making presumptions as to how a particular process or procedure is carried out. This can and does lead to accidents. If you're not sure…ask.

3) Poor design - which can result in the best of intentions turning out wrong. Remember Murphy. If there's a wrong way to do it that's the way you'll do it! If you recognize a Murphy do something about it if it's only telling others about it.

4) Lapses of attention - can and will allow errors to creep in, especially if it's a simple straightforward repetitive task. The lesson here is that the more expert you become at a particular task the more likely you are to make a mistake because, you think you can afford to allocate less attention to it. Beware the "expert" both in yourself and in others.

5) Mistaken actions - brought about by the classic situation of doing the wrong thing under the impression that its right. A classic example of this is the 'short cut' wherein the engineer knows what has to be done but chooses his own method of doing it. Don't take shortcuts.

6) Misperceptions - meaning the capacity we have to see what we want to see, hear what we want to hear, feel what we want to feel etc.: This factor is particularly relevant to the work of an aircraft engineer in as much as a great many tasks are of a repetitive nature. The lesson here is to be vigilant and on guard against it.

7) Vision

Vision can be adversely affected by certain medications or drugs, alcohol excess, oxygen shortage (hypoxia), injury (e.g. a blow to the head), etc. It can also be affected either temporarily or permanently by medical conditions (e.g. migraine, cataracts, inflammation, corneal problems or refractive surgery) or by dirty or dehydrated contact lenses or even very dirty spectacles.

8) Noise

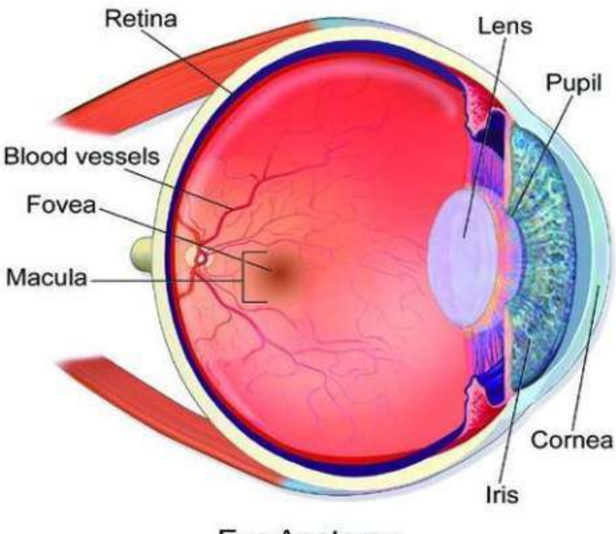
Noise can detrimentally affect human performance in terms of damaging hearing, interfering with speech communication, and affecting concentration and performance. It can also be fatiguing. Effects vary between individuals, and noise of a certain type and level may be good for one individual but bad for another. Noise
can affect motivation, reduce tolerance for frustration and reduce levels of aspiration. There may be an impact upon the individual's ability to think. It is almost certainly likely to affect inspection troubleshooting activities where the strategy used is left to the individual, being primarily assessment - rather than activity-based, possibly reducing the likelihood of successfully thinking laterally under such circumstances. How many of us can recall, when concentrating hard on a task, shouting "Stop that noise; I can't think straight!"?

9.2.1 VISION

The Function and Structure of the Eye

https://youtu.be/BEtdh-G8wFE

In order to understand vision, it is useful first to know a little about the anatomy of the eye. The basic structure of the eye is similar to a simple camera with an aperture (the iris), a lens, and a light sensitive surface (the retina). Light enters the eye through the cornea, then passes through the iris and the lens and falls on the retina. Here the light stimulates the light-sensitive cells on the retina (rods and cones) and these pass small electrical impulses by way of the optic nerve to the visual cortex in the brain. Here, the electrical impulses are interpreted and an image is perceived.



Eye Anatomy

The Cornea: Light enters the eye through the cornea, a clear window at the front of the eyeball. The focusing is achieved by the shape of the cornea bending the incoming light rays. The cornea is responsible for between 70% and 80% of the total focusing ability (refraction) of the eye.

The Iris: The iris (the coloured part of the eye) controls the amount of light that is allowed to enter the eye. It does this by varying the size of the pupil (the dark area in the centre of the iris).

The Pupil: The amount of light allowed to fall on the retina is governed by the size of the pupil, the clear centre of the iris. The size of the pupil can change rapidly to cater for changing light levels.

Note: The amount of light allowed to enter the eye can be adjusted by a factor of five to one by the pupil. This 5:1 factor is not sufficient to cope with the different light levels experienced between full daylight and a dark night and a further mechanism is required. In reduced light levels a chemical change takes place in the light sensitive cells on the retina (cones and rods). This dark adaptation does take time, about 7 minutes for the cones and 30 minutes for the rods. When complete the chemical change can cope with large changes in luminance level (of the order of 150,000: 1 for the cones).

The Lens

After passing through the pupil, the light passes through the lens. Its shape is changed by the muscles (cillary muscles) surrounding it which results in the final focusing adjustment to place a sharp image onto the retina. The change of shape of the lens is called accommodation. In order to focus clearly on a near object, the lens is thickened. To focus on a distant point, the lens is flattened. The degree of accommodation can be affected by factors such as fatigue or the ageing.

When a person is tired accommodation is reduced, resulting in less sharp vision (sharpness of vision is known as visual acuity).

The Retina: The retina is a light sensitive screen lying at the back of the eyeball. On this screen are light sensitive cells. The cells are of two types; cones and rods. The cones can only detect colors; the rods can only detect black and white but are much more sensitive at low light levels. This means that in poor light we see only in black or white or varying shades of grey. When light falls on these cells a small electrical charge is generated which is passed onto the brain by the optic nerve.

Cones function in good light and are capable of detecting fine detail and are colour sensitive. This means the human eye can distinguish about 1000 different shades of colour

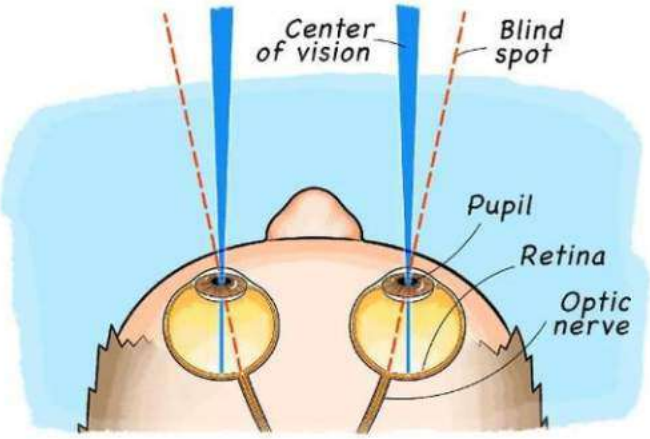
Rods cannot detect colour. They are poor at distinguishing fine detail, but good at detecting movement in the edge of the visual field (peripheral vision). They are much more sensitive at lower light levels. As light decreases, the sensing task is passed from the cones to the rods. This means in poor light levels we see only in black and white and shades of grey.

The Optic Nerve: The optic nerve enters the back of the eyeball along with the small blood cells needed to carry oxygen to the cells of the eye.

The Fovea: The central part of the retina, the Fovea, is composed only of cone cells and only at this part of the retina is vision 20/20 or 6/6. The figures are a means of measuring visual acuity, the ability to discriminate at varying distances. An individual with 20/20 vision should be able to see at 20 feet that which the so- called normal person is capable of seeing at this range. Any resolving power at the fovea drops rapidly as the angular distance from the fovea increases. At as little as 5° from the fovea the acuity drops to 20/40 that is half as good as at the fovea. When the angular displacement increases to 20° the visual acuity will only be one tenth of that at the fovea, that is 20/200. Anything that needs to be examined in detail is automatically brought to focus on the fovea. The rest of the retina fulfils the function of attracting our attention to movement and change.

The Blind Spot:

The point on the retina where the optic nerve enters the eyeball has no covering of light detecting cells. Any image falling at this point will not be detected. This has great significance when considering the detection of objects which are on a constant bearing from the observer. If the eye remains looking straight ahead it is possible for example for a closing aircraft to remain on the blind spot until a very short time before impact. Safe visual scanning demands frequent eye movement with minimal time spent looking in any direction.



This is not evident when viewing things with both eyes (binocular vision), since it is not possible for the image of an object to fall on the blind spots of both eyes at the same time. Even when viewing with one eye (monocular vision), the constant rapid movement of the eye (saccades) means that the image will not fall on the blind spot all the time. It is only when viewing a stimulus that appears very fleetingly (e.g. a light flashing), that the blind spot may result in something not being seen. In maintenance engineering, tasks such as close visual inspection or crack detection should not cause such problems, as the eye or eyes move across and around the area of interest (visual scanning).

Factors Affecting Clarity of Sight

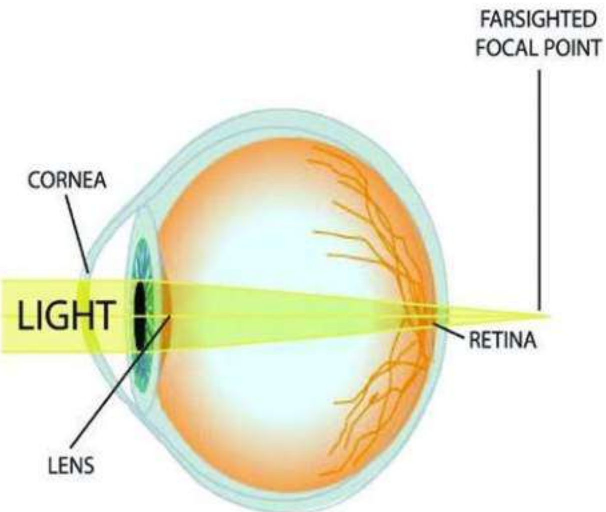
The eye is very sensitive in the right conditions (e.g. clear air, good light, etc.). In fact, the eye has approximately 1.2 million nerve cells leading from the retinas to the area of the brain responsible for vision, while there are only about 50,000 from the inner ears - making the eye about 24 times more sensitive than the ear.

Visual acuity is the ability of the eye to discriminate sharp detail at varying distances

An individual with an acuity of 20/20 vision should be able to see at 20 feet that which the so-called 'normal' person is capable of seeing at this range. It may be expressed in metres as 6/6 vision. The figures 20/40 mean that the observer can read at 20 feet what a 'normal' person can read at 40 feet.

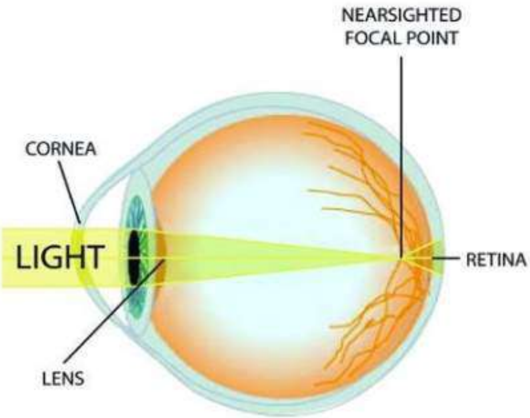
Various factors can affect and limit the visual acuity of the eye. These include

Physical Factors



Hypermetropia: Hyperopia (farsightedness) also known as Hypermetropia, is caused by a shorter than normal eyeball along the visual axis results in the image being formed behind the retina and unless the combined refractive index of the cornea and the lens can combine to focus the image in the correct plane a blurring of the vision will result when looking at close objects. A convex lens will overcome this refractive error.

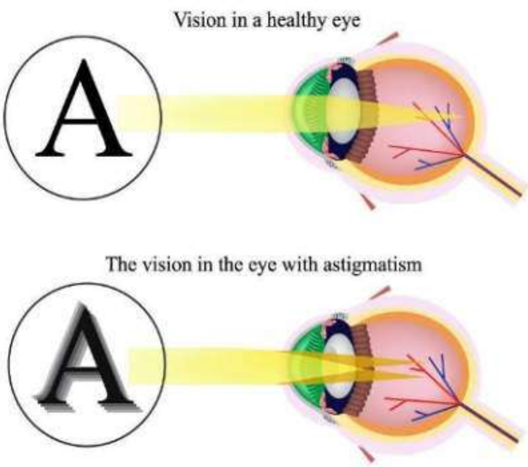
Myopia: Myopia (nearsightedness) the problem is that the eyeball is longer than normal and the image forms in front of the retina. If accommodation cannot overcome this then distant objects are out of focus whilst close up vision may be satisfactory. A concave lens will correct the situation.



Other visual problems include:

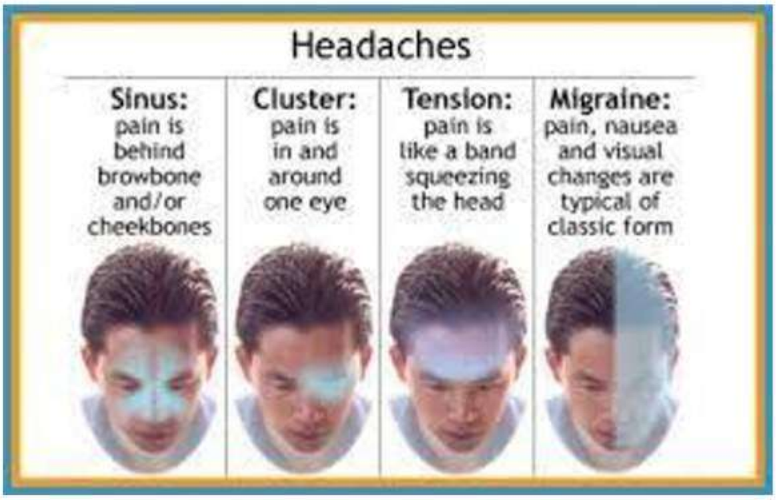
- Cataracts - clouding of the lens usually associated with ageing;

- Astigmatism - This condition is usually caused by a misshapen cornea. Objects will appear irregularly shaped. Modern surgical techniques can reshape the cornea with a scalpel or more easily with laser beams

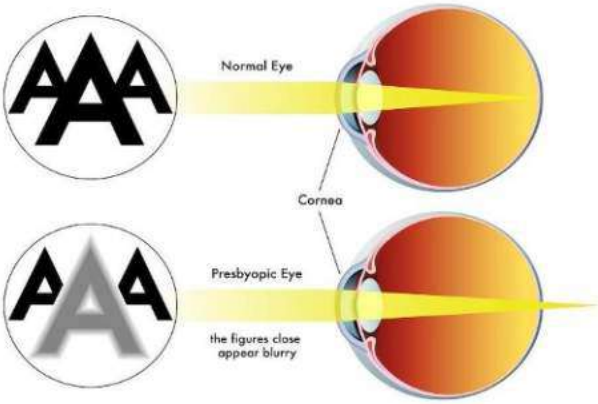


- Glaucoma - a buildup in pressure of the fluid within the eye which can cause damage to the optic nerve and even blindness.

- Migraine - severe headaches that can cause visual disturbances.



As a person grows older, the lens becomes less flexible meaning that it is unable to accommodate sufficiently. This is known as presbyopia and is a form of far- sightedness.



Consequently, after the age of 40, spectacles may be required for near vision, especially in poor light conditions. Fatigue can also temporarily affect accommodation, causing blurred vision for close work.

Foreign Substances

Vision can be adversely affected by the use of certain drugs and medications, alcohol, and smoking cigarettes. With smoking, carbon monoxide which builds up in the bloodstream allows less oxygen to be carried in the blood to the eyes. This is known as hypoxia and can impair rapidly the sensitivity of the rods. Alcohol can have similar effects, even hours after the last drink.

Environmental Factors

Vision can be improved by increasing the lighting level, but only up to a point, as the law of diminishing returns operates. Also, increased illumination could result in increased glare.

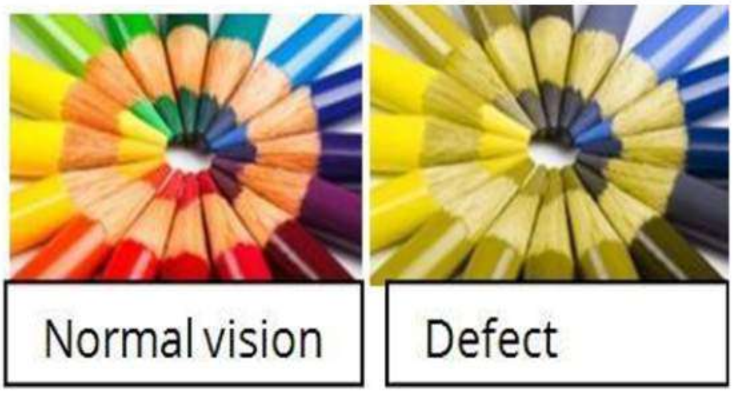
Older people are more affected by the glare of reflected light than younger people. Moving from an extremely bright environment to a dimmer one has the effect of vision being severely reduced until the eyes get used to less light being available. This is because the eyes have become light adapted. If an engineer works in a very dark environment for a long time, his eyes gradually become dark adapted allowing better visual acuity. This can take about 7 minutes for the cones and 30 minutes for the rods. As a consequence, moving between a bright hanger (or the inside of an aircraft) to a dark apron area at night can mean that the maintenance engineer must wait for his eyes to adjust (adapt). In low light conditions.

Any airborne particles such as dust, rain or mist can interfere with the transmission of light through the air, distorting what is seen. Engineers who wear contact lenses (especially hard or gas-permeable types) should take into account the advice from their optician associated with the maximum wear time - usually 8 to 12 hours - and consider the effects which extended wear may have on the eyes, such as drying out and irritation.

Many factors associated with the object being viewed can also influence vision. We use information from the objects we are looking at to help distinguish what we are seeing. These are known as visual cues. Visual cues often refer to the comparison of objects of known size to unknown objects. An example of this is that we associate small objects with being further away. Similarly, if an object does not stand out well from its background (i.e. it has poor contrast with its surroundings), it is harder to distinguish its edges and hence its shape. Movement and relative motion of an object, as well as distance and angle of the object from the viewer, can all increase visual demands.

Colour Defective Vision

Affecting about 8% of men and 0.5% of women "color blindness" is usually associated with the inability to differentiate between reds and greens. Other more rare types may involve blues and yellows.



There are degrees of colour defective vision, some suffering more than others and, ageing of individuals will change their colour perception. Care should be taken not to discriminate personnel from tasks merely because they are "color blind". Tasks that require positive colour perception must however be carried out by personnel who have been tested to an appropriate standard.

Conclusion

Ultimately, what is important is for the individual to recognise when his vision is adversely affected, either temporarily or permanently and to carefully consider the possible consequences should they continue to work if the task requires good vision. AWN47 states:

"Organisations should identify any specific eyesight requirements and put in place suitable procedures to address these issues". General human factors advice would be to stress the joint moral responsibility upon both the individual to admit to poor vision and upon the Organisation to create an environment whereby engineers will not be penalised if they do so.

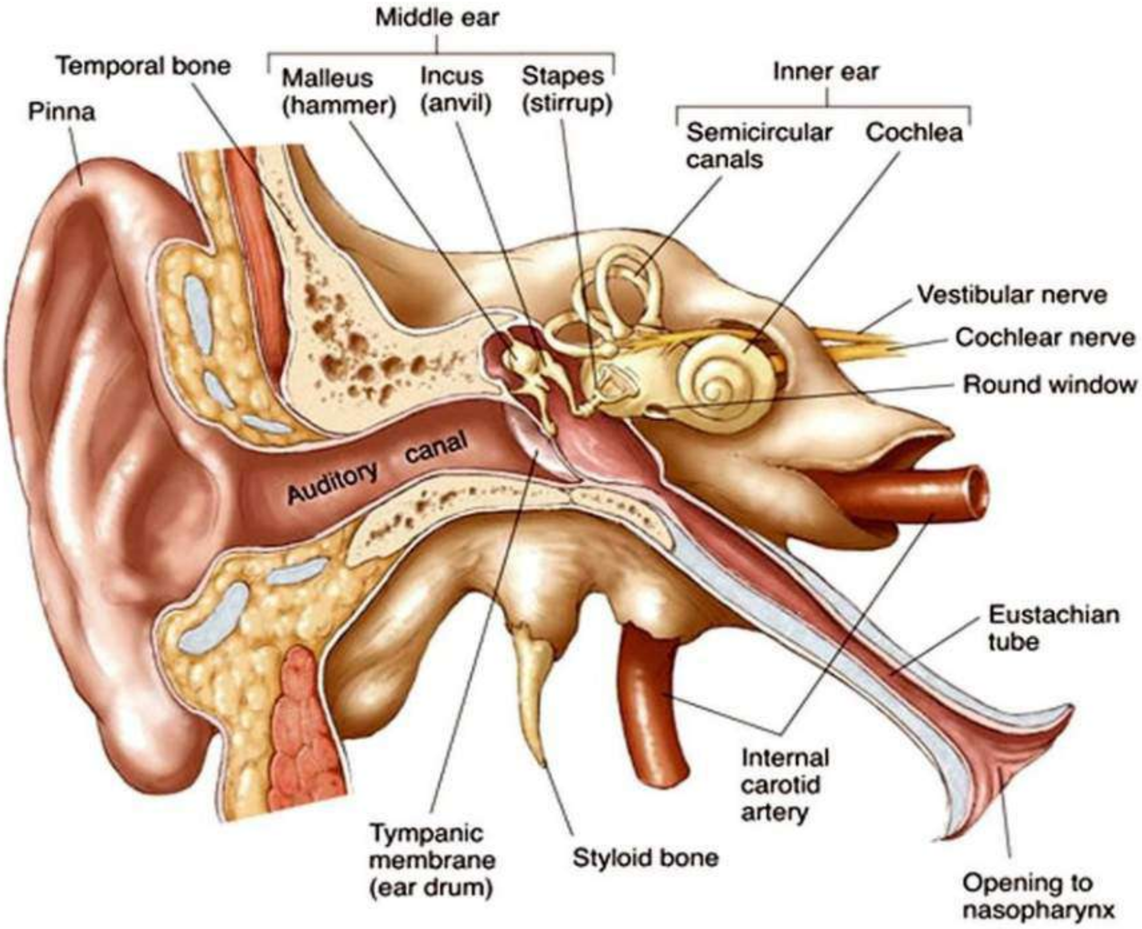
9.2.2 HEARING

The ear performs two quite separate functions: firstly it is used to receive vibrations in the air (sounds), and secondly it acts as a balance organ and acceleration detector.

The ear is divided into three sections, the outer, middle, and inner ear: Outer

Ear

The outer part of the ear pinna directs sounds down the auditory canal, and on to the eardrum. The sound waves will cause the eardrum to vibrate.



Structure of the Ear

Middle Ear

Beyond the eardrum is the middle ear which transmits vibrations from the eardrum by way of three small bones known as the ossicles (Malleus, Incus, stapes) to the fluid of the inner ear. The middle ear also contains two muscles which help to protect the ear from sounds above 80 dB by means of the acoustic or aural reflex, reducing the noise level by up to 20 db. However, this protection can only be provided for a maximum of about 15 minutes and does not provide protection against sudden impulse noise such as gunfire. It does explain why a person is temporarily 'deafened' for a few seconds after a sudden loud noise.

The middle ear is usually filled with air which is refreshed by way of the eustachian tube which connects this part of the ear with the back of the nose and mouth. However, this tube can allow mucus to travel to the middle ear which can build up, interfering with normal hearing.

The Inner Ear:

The vibrating membrane causes the fluid in the Cochlea to vibrate. Inside the cochlea there is a fine membrane (the basilar membrane) covered with tiny hair like cells which are sensitive to movement in the fluid. Any vibrations they detect cause neural impulses to be transmitted to the brain via the auditory nerve. Note the Eustachian tube which allows the pressure in the middle ear to equalise with the atmospheric pressure. The amount of vibration detected in the cochlea depends on the volume and pitch of the original sound.

Performance and Limitations of the Ear

The performance of the ear is associated with the range of sounds that can be heard - both in terms of the pitch (frequency) and the volume of the sound.

The audible frequency range that a young person can hear is typically between 20 and 20,000 cycles per second (or Hertz), with greatest sensitivity at about 3000 Hz.

Volume (or intensity) of sound is measured in decibels (dB). Table shows intensity levels for various sounds and activities

Activity	Approximate Intensity level (Decibels)
Rustling of leaves / Whisper	20
Conversation at 2m	50
Typewriter at 1m	65
Car at 15m	70
Lorry at 15m	75
Power Mower at 2m	90
Propellor aircraft at 300m	100
Jet aircraft at 300m	110
Standing near a propellor aircraft	120
Threshold of pain	140
Immediate hearing damage results	150

Impact of Noise on Performance

Noise can have various negative effects in the workplace. It can:

- be annoying (e.g. sudden sounds, constant loud sound, etc.
- interfere with verbal communication between individuals in the workplace.
- cause accidents by masking warning signals or messages.
- be fatiguing and affect concentration, decision making, etc.
- damage workers' hearing (either temporarily or permanently

Hearing Impairment:

High and low tone deafness

The normal human ear is sensitive to frequencies between about 20 Hz and 20 000 Hz, being particularly sensitive in the range 1000 Hz to 4000 Hz and progressively less sensitive at higher and lower frequencies. This is very important when measuring noise since two sounds of equal intensity, but of different frequency, may appear subjectively to be of different loudness. In the cochlea there are 23 000 nerve cells, and each has about 100 sensory hairs These hairs sense the vibration of the ossicles. There are two sizes of hair; long; which detect low frequencies, and short; which detect high frequencies. Deterioration of the sensory hairs occurs with over exposure to high levels of noise.

Noise Induced Hearing Loss (NIHL):

Hearing loss can result from exposure to even relatively short duration noise. The degree of impairment is influenced mainly by the intensity of the noise. Such damage is known as Noise Induced Hearing Loss (NIHL).

The hearing loss can be temporary lasting from a few seconds to a few days or permanent. Temporary hearing loss may be caused by relatively short exposure to very loud sound, as the hair-like cells on the basilar membrane take time to 'recover'. With additional exposure, the amount or recovery gradually decreases, and hearing loss becomes permanent. Thus, regular exposure to high levels of noise over a long period may permanently damage the hairlike cells in the cochlea, leading to irreversible hearing impairment.

Activity	Approximate Intensity level (Decibels)
Rustling of leaves /Whisper	20
Conversation at 2m	50
Typewriter at 1m	65
Car at 15m	70
Truck at 15m	75
Power Mower at 2m	90
Propeller aircraft at 300m	100
Jet aircraft at 300m	110
Standing near a propeller aircraft	120
Threshold of pain	140
Immediate hearing damage results	150

Typical sound levels for various activities

The UK 'Noise at Work' regulations (1989) impose requirements upon employers.
They stipulate three levels of noise at which an employer must act:

a) 85 decibels (if normal speech cannot be heard clearly at 2 metres), employer must:
- assess the risk to employees' hearing,
- tell the employees about the risks and what precautions are proposed,
- provide their employees with personal ear protectors and explain their use.

b) 90 decibels (if normal speech cannot be heard clearly at 1 metre) employer must:

- do all that is possible to reduce exposure to the noise by means other than by providing hearing protection,
- mark zones where noise reaches the second level and provide recognised signs to restrict entry

.

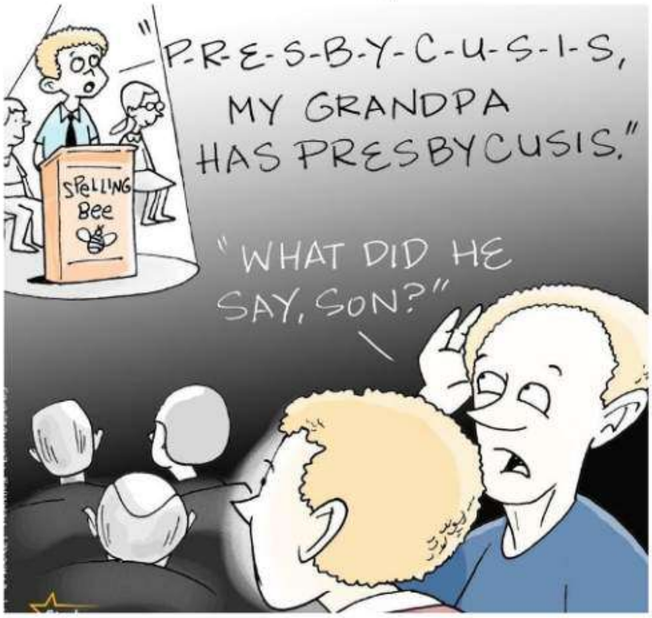
c) 140 decibels (noise causes pain).

The combination of duration and intensity of noise can be described as noise dose. Exposure to any sound over 80 dB constitutes a noise dose, and can be measured over the day as an 8-hour Time Weighted Average sound level (TWA).

For example, a person subjected to 95 decibels for 3.5 hours, then 105 decibels for 0.5 hours, then 85 decibels for 4 hours, results in a TWA of 93.5 which exceeds the recommended maximum TWA of 90 decibels.

Permanent hearing loss may occur if the TWA is above the recommended maximum. It is normally accepted that a TWA noise level exceeding 85 dB for 8 hours is hazardous and potentially damaging to the inner ear. Exposure to noise in excess of 115 decibels without ear protection, even for a short duration, is not recommended.

Hearing deteriorates naturally as one grows older. This is known as presbycusis. This affects ability to hear high pitch sounds first, and may occur gradually from the 30's onwards. The loss of some hearing is natural as one grows older but if combined with some NIHL there may be a chance of increased impairment.



HEARING PROTECTION

Hearing protection is available, to a certain extent, by using ear plugs or ear defenders. Noise levels can be reduced (attenuated) by up to 20 dB using ear plugs and 40 dB using earmuffs. However, using ear protection will tend to adversely interfere with verbal communication. Despite this, it must be used consistently and as instructed to be effective. As stated before if you are wearing headsets or ear protectors, exercise caution and pay attention.

Ear muff

Ear plug

It is good practice to reduce noise levels at source, or move noise away from workers. Often this is not a practical option. Hearing protection should always be used for noise, of any duration, above 115 dB. you will almost always need to use some form of hearing protection when in reasonably close proximity (about 600 - 1 000ft or 200-300m) to aircraft whose engines are running.

Hearing and the Aircraft Maintenance Engineer

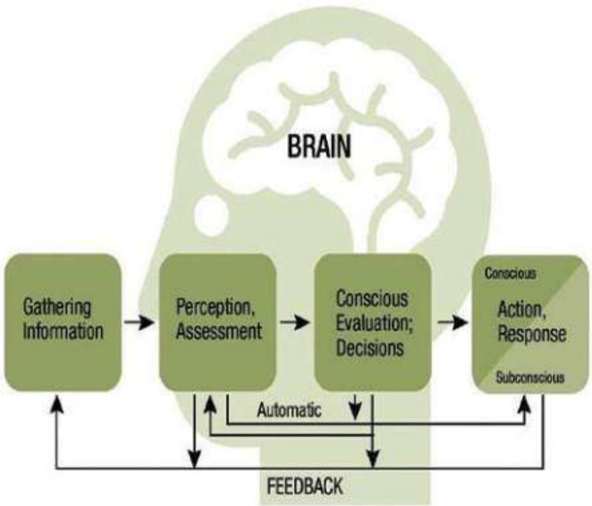
"The ability to hear an average conversational voice in a quiet room at a distance of 2 metres (6 feet) from the examiner is recommended as a routine test. Failure of this test would require an audiogram to be carried out to provide an objective assessment. If necessary, a hearing aid may be worn but consideration should be given to the practicalities of wearing the aid during routine tasks demanded of the individual."

It is very important that the aircraft maintenance engineer understands the limited ability of the ears to protect themselves from damage due to excessive noise. Even though engineers should be given appropriate hearing protection and trained in its use, it is up to individuals to ensure that they actually put this to good use. It is a misconception that the ears get used to constant noise: if this noise is too loud, it will damage the ears gradually and insidiously

Conclusion

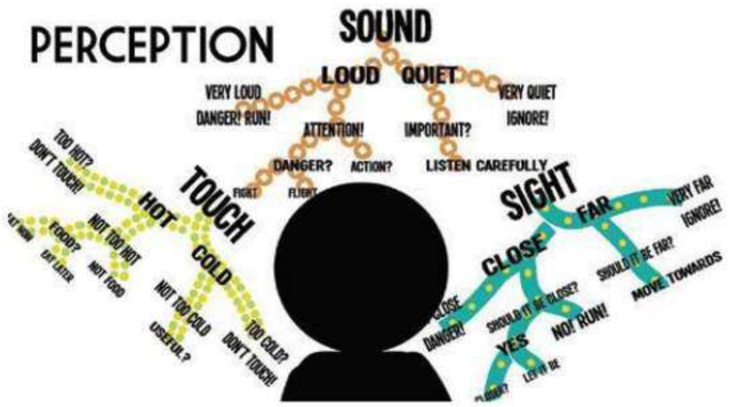
The effects of noise on performance are extremely complex, with no clear guidance emerging as to what noise levels are likely to adversely affect performance in relation to aviation safety. As a rule of thumb and in the absence of more detailed guidelines, if noise levels are kept within the bounds to protect against hearing damage, this should also avoid situations where noise is likely to have a significantly detrimental effect on performance in general terms. This may not, however, be sufficient to avoid breaking someone's concentration.

9.2.3 INFORMATION PROCESSING



Information processing is the process of receiving information through the senses, analysing it and making it meaningful. The way the information gathered by the senses is processed by the brain. The limitations of the human information processing system are also considered.

Stage 1: Gathering information
First we must gather information. We do this by using our senses (sight, hearing, touch or smell), to collect information using receptors, which transform this information (about temperature, for example) into sensations (feels hot). Stimuli can either originate from an external source such as sound, or from an internal one, such as thirst or hunger



Stage 2: Perception or assessment
Once we have gathered this information, we must make sense of it. This involves perception and assessment, and it is the most important stage in the whole process. Our brain gives the information an initial review to see whether it is meaningful. At this point we must satisfy our human need to understand our environment. To do so we rapidly create an internal model (like a pattern) with which we are comfortable. The resulting model or pattern is influenced in two ways: by the raw sensory information we perceive; and either by previous experience, or our current expectations. Here is where we are most vulnerable to being fooled either by the information itself, or by our own expectations; meaning our own eagerness to make the input fit what we have seen before. So, depending on our interpretation, our brain takes preliminary steps to work out how the information is to be dealt with.

Stage 3: Evaluation and decision making

If the information is complex or new, our brains will deal with it by giving it full and conscious attention. We may make the decision immediately or store the information for a later decision. This will require the use of memory. Our initial evaluation may show that the input is familiar, so we can deal with it using a well-known procedure or method that has worked before. On the other hand, our initial evaluation might be that this new information is complex or unfamiliar. When this occurs, we have to think more deeply to resolve the situation. Quite often this will require such a level of concentration and brainpower that our ability to attend to other matters will be reduced, or even disappear. An example is trying to understand a previously unknown electrical wiring fault or dealing with an unfamiliar engine running emergency.

Stage 4: Action/response

Our action or response occurs either consciously, with full awareness, or subconsciously using our automatic programs. If it is performed consciously, we act and/or speak with full attention. If it is performed subconsciously, we act as if we are on 'automatic pilot'.

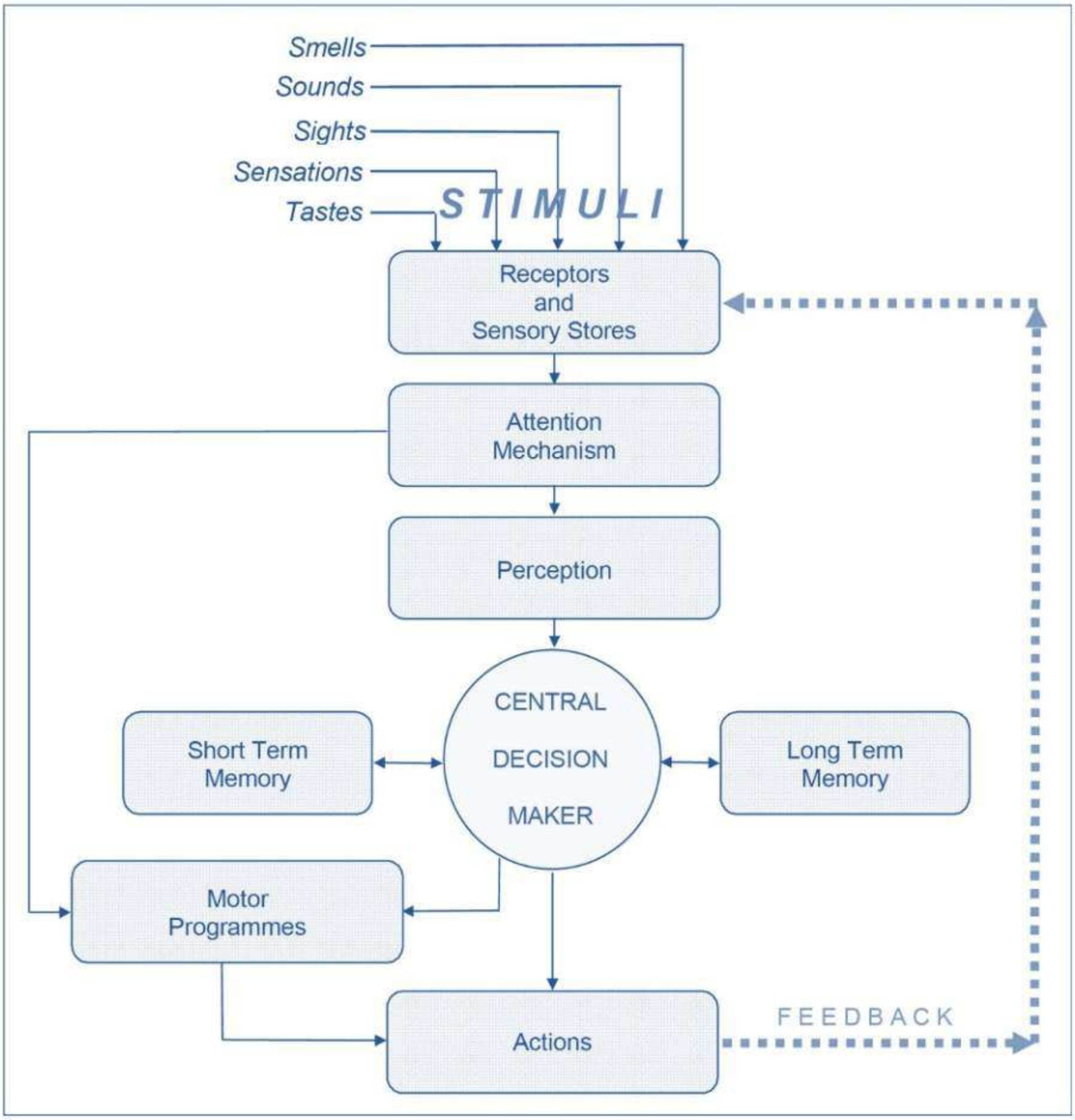
Visualize an automatic task you can perform while doing other things; for example, driving a car while maintaining a conversation. But if the driving task becomes more difficult, such as attempting to parallel park in a particularly tight spot, our brain will revert to the 100 percent full attention requirement, and we stop our conversation. So while we can do more than one thing at a time, our brain is limited by being able to process only one thing at a time!

Stage 5: Feedback

The final stage is feedback, which allows us to confirm that what we are getting is what we are expecting. Feedback is not just a onetime event. It occurs continuously throughout the various stages of information processing to ensure the information we are receiving continues to fit our expectations. The feedback stage provides the opportunity for:

- Clarifying details of the information
- If need be, seeking out additional information
- Refining the information
- Making small or large corrections with our actions and/or responses

When performing any skilled task like opening the cowling to check fluids, we continuously monitor both the environment and the consequences of our action to form a closed loop feedback system. This provides us with valuable opportunities to assess both emerging errors and hazards. Identifying errors in a timely manner means that corrections can be made, and ensures the action continues as intended. In the fluid check, we must be sure that we checked fluids, but also have properly closed the cowling.
However, in the maintenance workplace, incorrect actions may not give instant feedback - under torqued bolts, or omitted locking devices (split pins etc.), may not provide feedback for months after the -error.



A functional model of human information processing

Sensory Receptors and Sensory Stores

Physical stimuli are received via the sensory receptors (eyes, ears, etc.) and stored for a very brief period of time in sensory stores (sensory memory). Visual information is stored for up to half a second in iconic memory and sounds are stored for slightly longer (up to 2 seconds) in echoic memory. This enables us to remember a sentence as a sentence, rather than merely as an unconnected string of isolated words, or a film as a film, rather than as a series of disjointed images.

9.2.4 ATTENTION AND PERCEPTION

Having detected information, our mental resources are concentrated on specific elements - this is attention.

Attention can be thought of as the concentration of mental effort on sensory or mental events.

Although attention can move very quickly from one item to another, it can only deal with one item at a time. Attention can take the form of:

- Selective attention,
- Divided attention,
- Focused attention
- Sustained attention.

Selective attention occurs when a person is monitoring several sources of input, with greater attention being given to one or more sources which appear more important. A person can be consciously attending to one source whilst still sampling other sources in the background. Psychologists refer to this as the 'cocktail party effect 'whereby you can be engrossed in a conversation with one person but your attention is temporarily diverted if you overhear your name being mentioned at the other side of the room, even though you were not aware of listening in to other people's conversations. Distraction is the negative side of selective attention.

Divided attention is common in most work situations, where people are required to do more than one thing at the same time. Usually, one task suffers at the expense of the other, more so if they are similar in nature. This type of situation is also sometimes referred to as timesharing.

Focused attention is merely the skill of focusing one's attention upon a single source and avoiding distraction.

Sustained attention as its name implies, refers to the ability to maintain attention and remain alert over long periods of time, often on one task. Most of the research has been carried out in connection with monitoring radar displays, but there is also associated research which has concentrated upon inspection tasks.

Attention is influenced by arousal level and stress. This can improve attention or damage it depending on the circumstances.

Perception involves the organization and interpretation of sensory data in order to make it meaningful, discarding non-relevant data, i.e. transforming data into information.

Perception can be defined as the process of assembling sensations into a useable mental representation of the world. Perception creates faces, melodies, works of art, illusions etc. out of the raw material of sensation.

Examples of the perceptual process:

• the image formed on the retina is inverted and two dimensional, yet we see the world the right way up and in three dimensions.

• if the head is turned, the eyes detect a constantly changing pattern of images, yet we perceive things around us to have a set location, rather than move chaotically.

Decision Making

Decision making is the generation of alternative courses of action based on available information, knowledge, prior experience, expectation, context, goals, etc. and selecting one preferred option. It is also described as thinking, problem solving and judgement.

This may range from deciding to do nothing, to deciding to act immediately in a very specific manner. A fire alarm bell, for instance, may trigger a well-trained sequence of actions without further thought (i.e. evacuate). We are not usually fully aware of the processes and information which we use to make a decision. Tools can be used to assist the process of making a decision.

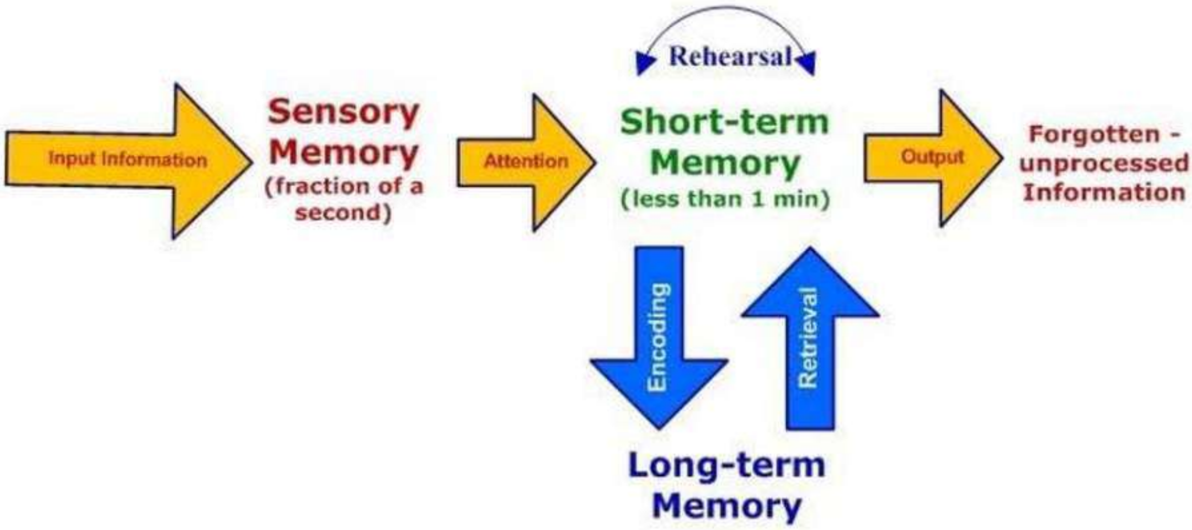
For instance, in aircraft maintenance engineering, many documents (e.g. maintenance manuals, fault diagnosis manuals), and procedures are available to supplement the basic decision-making skills of the individual. Thus, good decisions are based on knowledge supplemented by written information and procedures, analysis of observed symptoms, performance indications, etc. It can be dangerous to believe that existing knowledge and prior experience will always be sufficient in every situation.

9.2.5MEMORY

Memory can be considered to be the storage and retention of information, experiences and knowledge, as well as the ability to retrieve this information. It is, essentially, the storage facility of the human system.

Memory depends on three processes:

• registration - the input of information into memory.
• storage - the retention of information.
• retrieval - the recovery of stored information.



It is possible to distinguish between three forms of memory:

a) ultra-short-term memory (or sensory storage).
b) short term memory (often referred to as working memory)
c) long term memory.

Ultra short-term memory has already been described when examining the role of sensory stores. It has a duration of up to 2 seconds (depending on the sense) and is used as a buffer, giving us time to attend to sensory input

Short term memory receives a proportion of the information received into sensory stores, and allows us to store information long enough to use it (hence the idea of 'working memory'). It can store only a relatively small amount of information at one time, i.e. 5 to 9 (often referred to as 7 ±2) items of information, for a short duration, typically, 10 to 20 seconds. As the following example shows, capacity of short term memory can be enhanced by splitting information in to 'chunks' (a group of related items).

Eg: A telephone number, e.g. 01222555234, can be stored as 11 discrete digits, in which case it is unlikely to be remembered. Alternatively, it can be stored in chunks of related information, e.g. in the UK, 01222 may be stored as one chunk, 555 as another, and 234 as another, using only 3 chunks and therefore, more likely to be remembered.

The duration of short-term memory can be extended through rehearsal (mental repetition of the information) or encoding the information in some meaningful manner

Long-term memory: The capacity of long-term memory appears to be unlimited. It is used to store information that is not currently being used, including:
• knowledge of the physical world and objects within it and how these behave
• personal experiences
• beliefs about people, social norms, values, etc.
• motor programmes, problem solving skills and plans for achieving various activities
• abilities, such as language comprehension.

Information in long-term memory can be divided into two types:

(i) semantic and

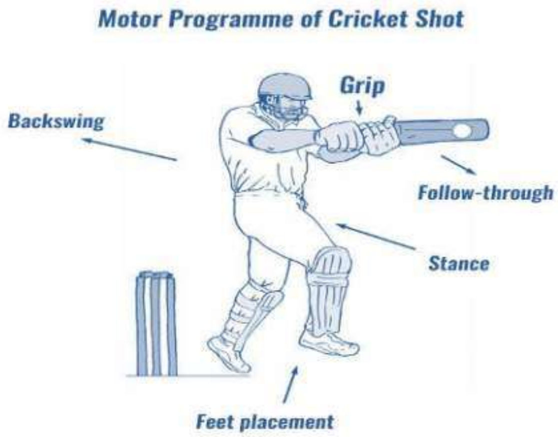
(ii) episodic.

Semantic memory refers to our store of general, factual knowledge about the world, such as concepts, rules, one's own language, etc. It is information that is not tied to where and when the knowledge was originally acquired.

Episodic memory refers to memory of specific events, such as our past experiences (including people, events and objects). We can usually place these things within a certain context. It is believed that episodic memory is heavily influenced by a person's expectations of what should have happened, thus two people's recollection of the same event can differ.

Motor Programmes

If a task is performed often enough, it may eventually become automatic and the required skills and actions are stored in long term memory. These are known as motor programmes and are ingrained routines that have been established through practice. The use of a motor programme reduces the load on the central decision maker. An often-quoted example is that of driving a car: at first, each individual action such as gear changing is demanding, but eventually the separate actions are combined into a motor programme and can be performed with little or no awareness. These motor programmes allow us to carry out simultaneous activities, such as having a conversation whilst driving.



Situation Awareness

Situation awareness is the synthesis of an accurate and up to date 'mental model' of one's environment and state, and the ability to use this to make predictions of possible future states

In the maintenance engineering context, it refers to:

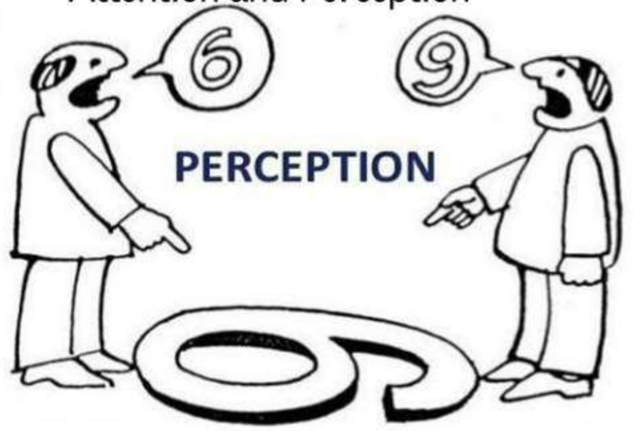
- the perception of important elements, e.g. seeing loose bolts or missing parts, hea information passed verbally.
- the comprehension of their meaning, e.g. why is it like this? Is this how it should be?
- the projection of their status into the future, e.g. future effects on safety, schedule, airworthiness

An example is an engineer seeing (or perceiving) blue streaks on the fuselage. His comprehension may be that the lavatory fill cap could be missing or the drain line leaking. If his situation awareness is good, he may appreciate that such a leak could allow blue water to freeze, leading to airframe or engine damage.

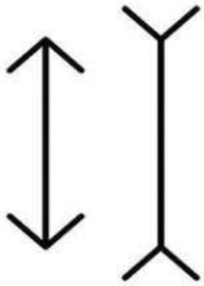
Situation awareness for the aircraft maintenance engineer can be summarised as:
- the status of the system the engineer is working on
- the relationship between the reported defect and the intended rectification
- the possible effect on this work on other systems
- the effect of this work on that being done by others and the effect of their work on this work.

Information Processing Limitations

Attention and Perception

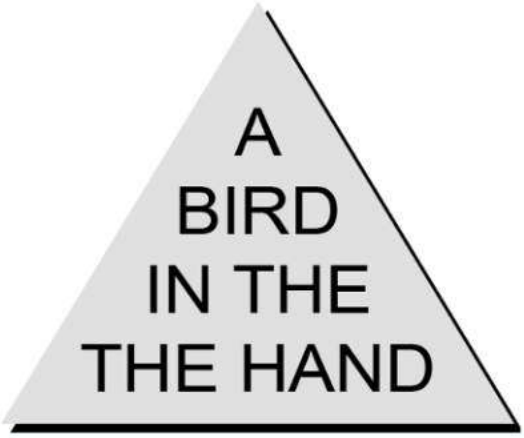


A proportion of 'sensed' data may be lost without being 'perceived'. An example with which most people are familiar is that of failing to perceive something which someone has said to you, when you are concentrating on something else, even though the words would have been received at the ear without any problem. The other side of the coin is the ability of the information processing system to perceive something (such as a picture, sentence, concept, etc.) even though some of the data may be missing. The danger, however, is that people can fill in the gaps with information from their own store of knowledge or experience, and this may lead to the wrong conclusion being drawn.



There are many well-known visual **'illusions'** which illustrate the limits of human perception. Figure shows how the perceptual system can be misled into believing that one line is longer than the other, even though a ruler will confirm that they are exactly the same.

This figure illustrates that we can perceive the same thing quite differently (i.e. the letter "B" or the number "13"). This shows the influence of context on our information processing.



In aviation maintenance it is often necessary to consult documents with which the engineer can become very familiar. It is possible that an engineer can scan a document and fail to notice that subtle changes have been made. He sees only what he expects to see (expectation). To illustrate how our eyes can deceive us when quickly scanning a sentence, read quickly the sentence in Figure

9.2.6 CLAUSTROPHOBIA, PHYSICAL ACCESS AND FEAR OF HEIGHTS

Claustrophobia: Claustrophobia is defined as "abnormal fear of being in an enclosed space". This is the extreme case.

However, there are many circumstances where people may experience various levels of physical or psychological discomfort when in an enclosed or small space, which is generally considered to be quite normal.
When this discomfort becomes extreme, it is known as claustrophobia.
Most people have no difficulty in entering a lift, for instance, but would not consider going pot-holing under any circumstances! In this text, claustrophobia is reserved for the extreme case where a person is extremely uncomfortable, often to the extent of experiencing

panic, in circumstances which most people would not consider a problem. It is unlikely that someone suffering from claustrophobia would take up aircraft maintenance engineering as a career, but it may be the case, however, that susceptibility to claustrophobia is not apparent at the start of employment but comes about because of an incident when working within a confined space, e.g. panic if unable to extricate oneself from a fuel tank.

If an engineer feels that they suffer from this problem, they should make their colleagues and supervisors aware so that if tasks likely to generate claustrophobia cannot be avoided, at least colleagues may be able to assist in extricating an engineer from the confined space quickly and sympathetically.

Physical Access: Problems associated with physical access are not uncommon in aircraft maintenance engineering. Maintenance engineers and technicians often have to access, and work in, very small spaces (e.g. in fuel tanks), cramped conditions (such as beneath flight instrument panels, around rudder pedals), elevated locations (on cherry-pickers or staging), sometimes in uncomfortable climatic or environmental conditions (heat, cold, wind, rain, noise). This can be aggravated by aspects such as poor lighting or having to wear breathing apparatus.

Fear of Heights: Work at high levels can also be a problem, especially when doing 'crown' inspections (top of fuselage or top wing engine). Some engineers may be quite at ease in situations like these whereas others may be so uncomfortable that they are far more concerned about the height, and holding on to the access equipment than they are about the job in hand.

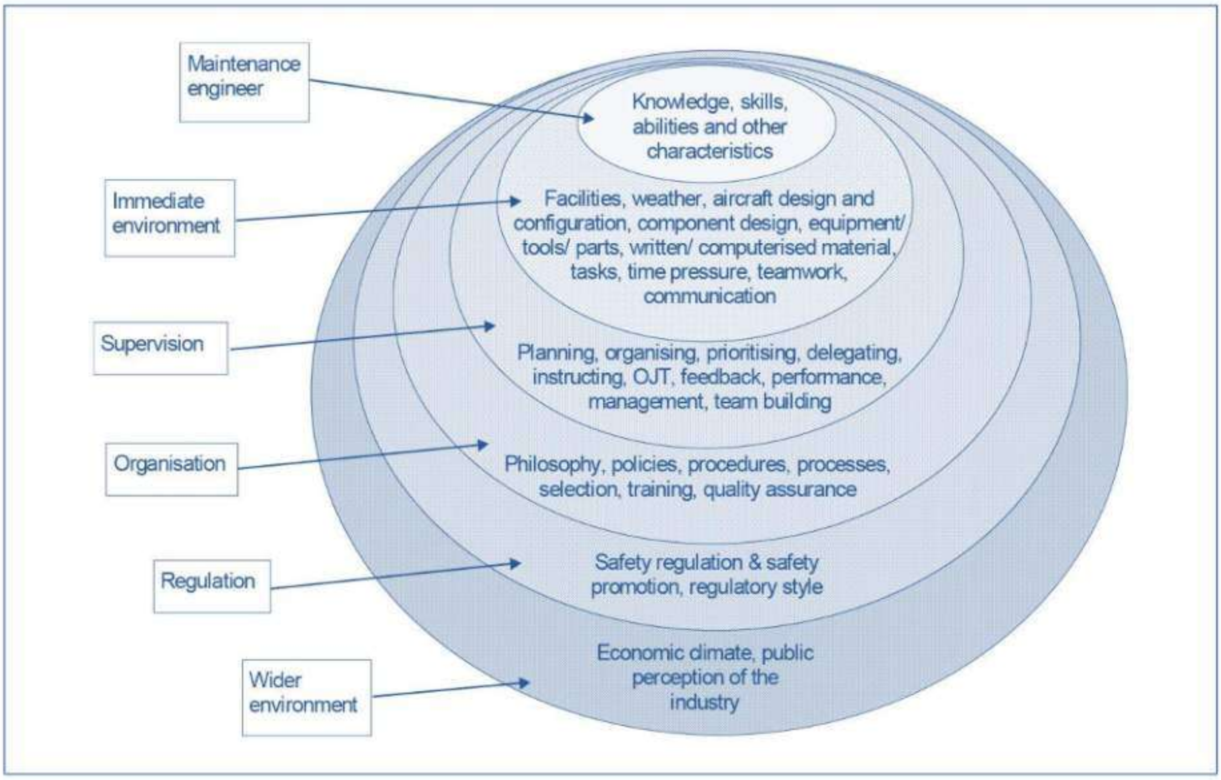
Conclusion

If a person is working in uncomfortable conditions, he may be inclined to get out of that situation as soon as possible, possibly resulting in checks not being carried out quite as diligently as they might be. Although there is no formal evidence of this, there is anecdotal evidence of situations where this has occurred. Engineers should be aware of this and guard against it. Managers and supervisors should attempt to make the job as comfortable and secure as reasonably possible (eg providing knee pad rests, ensuring that staging does not wobble, providing ventilation in enclosed spaces, etc.) and allow for frequent breaks if practicable.

9.3 SOCIAL PSYCHOLOGY

9.3.1 THE SOCIAL ENVIRONMENT

Aircraft maintenance engineers work within a "system". As indicated in Figure, there are various factors within this system that impinge on the aircraft maintenance engineer, ranging from his knowledge, skills and abilities (discussed in the previous chapter), the environment in which he works to the culture of the organisation for which he works. Even beyond the actual company he works for, the regulatory requirements laid down for his trade clearly impact on his behaviour.



Culture

Most aircraft maintenance engineers work for a company, either directly, or as contract staff. It is important to understand how the organisation in which the engineer works might influence him. Every organisation or company employing aircraft maintenance engineers will have different "ways of doing things". This is called the organisational culture. They will have their own company philosophy, policies, procedures, selection and training criteria, and quality assurance methods. It is difficult to point where the culture of an organisation is driven from. It is not necessarily always generated or driven from the top, as one might think, but this is the best point from which to influence the safety culture.

The culture of an organisation can best be judged by 'what is done' rather than by 'what is said'. Organisations may have grand 'mission statements' concerning safety but this does not indicate that they have a good safety culture unless the policies preached at the top are actually put into practice at the lower levels. It may be difficult to determine the safety culture of an organisation by auditing the procedures and paperwork; a better method is to find out what the majority of the staff actually believe and do in practice.

A method for measuring attitudes to safety has been developed by the Human Factors in Reliability Group (HFRG) violations sub- group, utilizing a questionnaire approach. The questionnaire takes the form of statements to which respondents are asked the extent to which they agree.

Examples include:

- It is necessary to bend some rules to achieve target
- Short cuts are acceptable when they involve little or no risk
- I often come across situations with which I am unfamiliar
- I sometimes fail to understand which rules apply
- I am not given regular break periods when I do repetitive and boring jobs
- There are financial rewards to be gained from breaking the rules

The results are scored as outlined in the methodology and results are given which give an indication of the safety culture of the organization, broken down according to safety commitment, supervision, work conditions, logistic support, etc. In theory, this enables one organisation to be objectively compared with another.

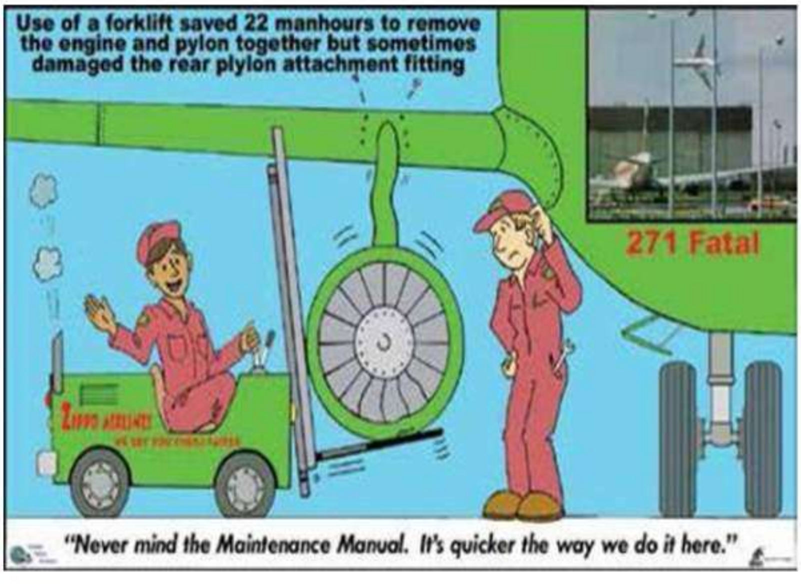
The impact of the organisation may be positive or negative, At times, individuals may feel that these conflict with their ability to sustain the quality of their work. These organisational stresses may lead to problems of poor industrial relations, high turnover of staff, increased absenteeism, and most importantly for the aviation industry, more incidents, and accidents due to human error

9.3.2 RESPONSIBILITY: INDIVIDUAL AND GROUP

Individual: Being an aircraft maintenance engineer is a responsible job. Clearly, the engineer plays a part in the safe and efficient passage of the travelling public when they use aircraft.

All aircraft maintenance engineers are skilled individuals having undertaken considerable training. They work in a highly professional environment and generally have considerable pride in their work and its contribution to air safety. All individuals, regardless of their role, grade or qualifications should work in a responsible manner. This includes not only Licensed Aircraft Engineers (LAEs), but non-licensed staff. The certifying engineer shall be responsible for ensuring that work is performed and recorded in a satisfactory manner. Likewise, non-certifying technicians also have a responsibility in the maintenance Process. If someone is considered responsible, they are liable to be called to account as being in charge or control of, or answerable for something.

All tasks require attention to detail, as well as adherence to duty and procedures to ensure they are done accurately. Occasionally one may be challenged by normal behaviors also called "norms", where methods used have become the accepted practice at the workplace. “I did it this way because this is how it is always done around here.” AMTs need to recognize this behavior and decide if the task is being performed as safety requires, or as it “normally gets done”. This is where personal standards become important



Personal integrity should thus empower the AME to check that the work is done correctly while combining the promotion of safety, integrity, professionalism, and above all else, a resistance to risky behavior.

Group or Team Responsibility: Group responsibility has its advantages and disadvantages. The advantages are that each member of the group ought to feel responsible for the output of that group, not just their own output as an individual, and ought to work towards ensuring that the whole 'product' is safe. This may involve cross-checking others' work (even when not strictly required), politely challenging others if you think that something is not quite right, etc.

The disadvantage of group responsibility is that it can potentially act against safety, with responsibility being devolved to such an extent that no-one feels personally responsible for safety (referred to as diffusion of responsibility). Here, an individual, on his own, may take action but once placed within a group situation, he may not act if none of the other group members do so, each member of the group or team assuming that 'someone else will do it.

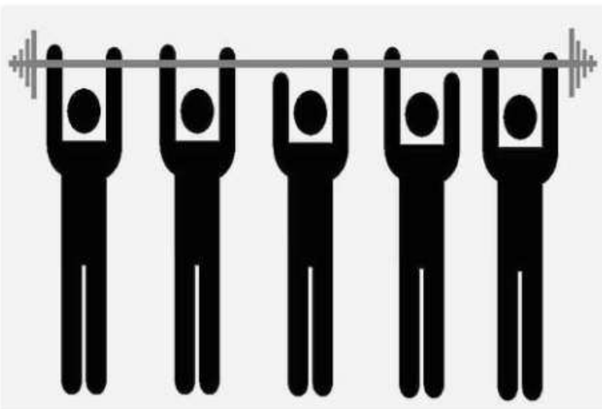
Other recognized phenomena associated with group or team working and responsibility for decisions and actions which aircraft maintenance engineers should be aware of are:

Intergroup conflict

in which situations evolve where a small group may act cohesively as a team, but rivalries may arise between this team and others (e.g. between engineers and planners, between shifts, between teams at different sites, etc) This may have implications in terms of responsibility, with teams failing to share responsibility between them. This is particularly pertinent to change of responsibility at shift handovers, where members of the outgoing shift may feel no 'moral' responsibility for waiting for the incoming shift members to arrive and giving a verbal handover in support of the written information on the work cards or task sheets, whereas they might feel such responsibility when handing over tasks to others within their own shift.

Group polarisation

is the tendency for groups to make decisions that are more extreme than the individual members' initial positions. At times, group polarization results in more cautious decisions. Alternatively, in other situations, a group may arrive at a course of action that is riskier than that which any individual member might pursue. This is known as risky shift. Another example of group polarisation is groupthink in which the desire of the group to reach unanimous agreement overrides any individual impulse to adopt proper, rational (and responsible) decision making procedures.



Social loafing has been coined to reflect the tendency for some individuals to work less hard on a task when they believe others are working on it. In other words, they consider that their own efforts will be pooled with that of other group members and not seen in isolation.

9.3.3 MOTIVATION AND DE-MOTIVATION

Motivation can be thought of as a basic human drive that arouses, directs, and sustains all human behavior. Generally we say a person is motivated if they take action to achieve something

Motivated behavior is goal directed purposeful behavior. No human behavior occurs without some kind of motivation behind it. In aircraft maintenance, technicians are trained to carry out the tasks within their expertise. However, it is largely their motivation which determines what they actually do in any given situation. Thus, "motivation reflects the difference between what someone can do and what they will do".

Motivation is usually considered to be a positive rather than a negative force in that it stimulates one to achieve various things. However, just because someone is motivated, they still might not do the right thing. Many criminals are highly motivated.

With respect to safety, being motivated is vital. AMTs ought to be motivated to work safely and efficiently. However, many factors may conflict with this ideal. For instance, the motivation of some financial bonus, or demotivation of working outdoors in extreme cold might lead to less consideration of safety and an increase in the likelihood of risk taking, corner cutting, and violating procedures and so on. In Aviation, you can be motivated to take risks It is important to associate motivation with the right type of actions, i.e. point it in the right direction.

External and Internal Motivation

External: System rewards & punishments
Internal: Do it because we want to

Internal motivation (doing things because you want to rather than because someone else has told you to) is far more effective than external sticks and carrots.

Punishing (or rewarding inappropriately) people who are internally motivated can be counterproductive.

Reward and punishment: effects on behavior

	Immediate	Delayed
Reward	Positive effects	Doubtful effects
Punishment	Doubtful effects	Negative effects

Rewards are the most powerful means of changing behavior, but they are only effective if delivered close in time and place to the behavior that is desired. Delayed punishments have negative effects: they don't lead to improved behavior and they make people resentful.

Maslow's Hierarchy of Needs

Maslow considered that humans are driven by two different sets of motivational forces:

- those that ensure survival by satisfying basic physical and psychological needs.
- those that help us to realise our full potential in life known as self-actualisation needs (fulfilling ambitions, etc.).

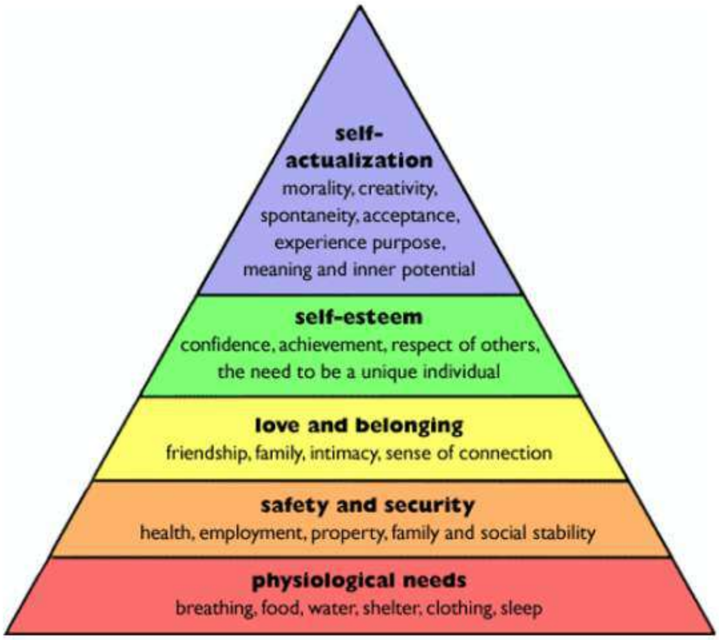


Figure shows the hypothetical hierarchical nature of the needs we are motivated to satisfy. The theory is that the needs lower down the hierarchy are more primitive or basic and must be satisfied before we can be motivated by the higher needs. For instance, you will probably find it harder to concentrate on the information in this document if you are very hungry (as the lower level physiological need to eat predominates over the higher level cognitive need to gain knowledge). There are always exceptions to this, such as the mountain climber who risks his life in the name of adventure. The higher up the hierarchy one goes, the more difficult it becomes to achieve the need. High level needs are often long-term goals that have to be accomplished in a series of steps.

An aircraft maintenance engineer will fulfil lower level needs by earning money to buy food pay for a home and support a family. They may well be motivated by middle level needs in their work context (e.g. social groups at work, gaining status and recognition). It is noteworthy that for shift workers, tiredness may be a more powerful motivator than a higher order need (such as personal satisfaction to get the job done in time or accurately).

People will act differently if they know they are being Observed. Its also known as ***Observer effect.***

Hawthorne effect

An interesting experiment on motivation was carried out in 1924 at the Hawthorne Works of the Western Electric Company in Chicago. Here, the management altered various factors such as rest periods, lighting levels, working hours, etc. and each time they did so, performance improved, even when the apparent improvements were taken away! This suggested that it was not the improvements themselves which were causing the increased production rates, but rather the fact that the staff felt that management were taking notice of them and were concerned for their welfare. This phenomenon is known as the Hawthorne effect.

Motivation

Highly motivated people tend to show the following characteristics:

- high performance and results being consistently achieved
- the energy, enthusiasm, and determination to succeed
- unstinting co-operation in overcoming problems
- willingness to accept responsibility
- willingness to accommodate change.

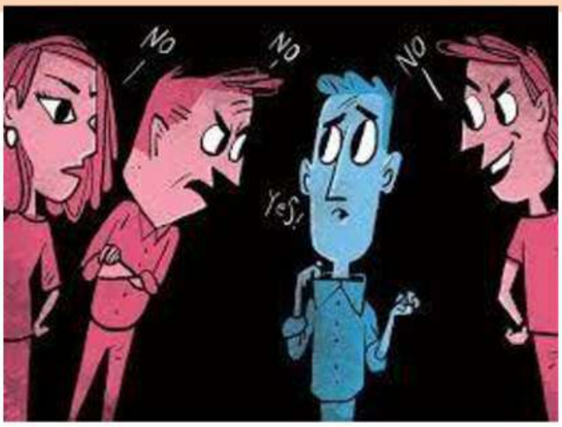
De-motivation

People who are de-motivated lack motivation, either intrinsically or through a failure of their management to motivate the staff who work for them.

De-motivated people tend to demonstrate the following characteristics:

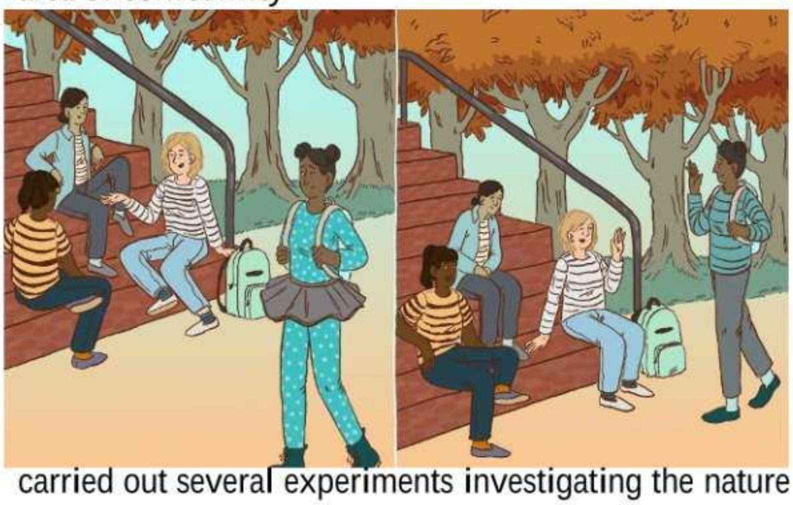
- apathy and indifference to the job, including reduced regard for safety whilst working
- a poor record of time keeping and high absenteeism
- an exaggeration of the effects/difficulties encountered in problems, disputes and grievances
- a lack of co-operation in dealing with problems or difficulties
- unjustified resistance to change.

9.3.4 Peer Pressure and Conformity



Peer pressure is the actual or perceived pressure which an individual may feel, to conform to what he believes that his peers or colleagues expect.

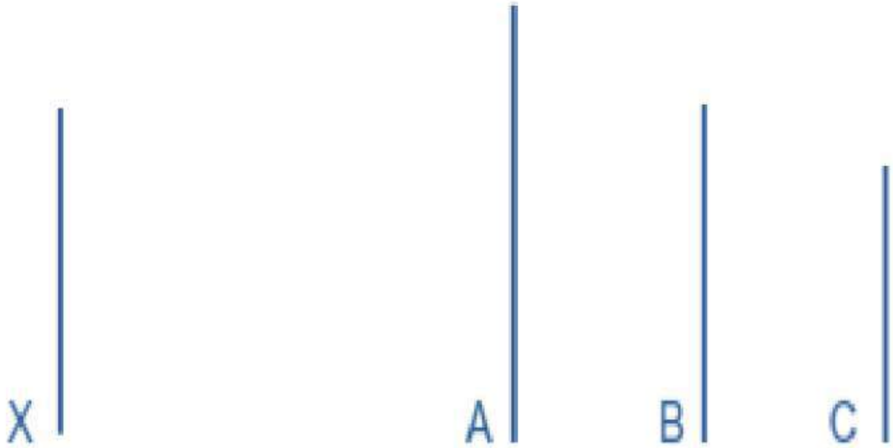
For example, an individual engineer may feel that there is pressure to cut corners in order to get an aircraft out by a certain time, in the belief that this is what his colleagues would do under similar circumstances. There may be no actual pressure from management to cut corners, but subtle pressure from peers, e.g. taking the form of comments such as "You don't want to bother checking the manual for that. You do it like this…" would constitute peer pressure. Peer pressure thus falls within the area of conformity



Conformity is "the tendency to allow one's opinions, attitudes, actions and even perceptions to be affected by prevailing opinions, attitudes, actions and perceptions".

A researcher named Solomon Asch carried out several experiments investigating the nature of conformity, one of the better known experiments being where he asked people to judge which of lines A, B & C was the same length as line X.

An experiment to illustrate conformity



(B is the same length as X)

He asked this question under different conditions, one where the individual was asked to make the judgment on his own, without being influenced, and the other where the individual was asked to judge last, after a series of 'stooges' had all judged that line A was the correct choice. In the latter condition, about 25% of people yielded to group pressure and agreed with the incorrect 'group' finding.

As already mentioned, peer pressure can be good or bad, depending on the context and on whether the group view is the correct one. As far as safety is concerned, if the group (or shift) view is one which believes that safety is very important, then peer pressure will have a positive effect in influencing others to conform to this attitude. Too often, however, it works in reverse, with safety standards gradually deteriorating as shift members develop practices which might appear to them to be more efficient but which erode safety, placing pressure, albeit possibly unwittingly, upon new engineers joining the organisation, to do likewise. need to periodically exchange or replace team members for a variety of reasons as suggested above.

9.3.5 CULTURE ISSUES

There can be a degree of mistrust of anything new in the workplace, (e.g. an individual joining a company whose expertise has not yet been proven, or contracting out maintenance to another company, etc.). There may be a tendency for groups within organisation and the organization itself to think that their own methods are the best and that others are not as good. This viewpoint is known as the group's or organisation's culture.
The culture of an organisation can be described as 'the way we do things here'. It is a group or company norm.

Safety Culture

Safety culture basically involves the attitudes coworkers hold about the company's approach to safety, their perceptions of the magnitude of the risks, and their belief in the necessity, practicality and effectiveness of measures to control risk. In this way, safety culture can be considered an enabler for safety.

Safety culture is made up of those shared beliefs, values, and practices affecting the safety of the environment. Think about how culture affects the way one thinks and acts

How do you recognize an organization with a good safety culture?

An organization with a good safety culture is one where safe and professional behaviour is fully internalized as the way personnel think and act. It is one where safety is seen as a required outcome of all operations, and where safe and professional practices are not only endorsed by management but are proactively demonstrated. We are not simply talking about the number of safety posters around the workspace, but a realistic demonstration of support for safe and professional operations at all levels of the organization. In a safe culture each worker can define their specific role in safety.

The key components of a safety culture, summarised as follows:

• The 'engine' that continues to propel the system towards the goal of maximum safety health, regardless of the leadership's personality or current commercial concerns

• Not forgetting to be afraid

• Creating a safety information system that collects, analyses and disseminates information from incidents and near-misses as well as from regular proactive checks on the system's vital signs

• A good reporting culture, where staff are willing to report near-misses

• A just culture - an atmosphere of trust, where people are encouraged, even rewarded, for providing essential safety related information - but in which they are clear about where the line must be drawn between acceptable and unacceptable behaviour

• A flexible culture

• Respect for the skills, experience and abilities of the workforce and first line Supervisors

• Training investment

• A learning culture - the willingness and the competence to draw the right conclusions from its safety information system, and the will to implement major reforms when their need is indicated.

9.3.6 TEAM WORKING

Teams require interdependence; members working together in ways to achieve one or more common goals. A team could be a group of engineers working on a specific task or the same aircraft, a group working together on the same shift, or a group working in the same location or site. There are natural teams within the aircraft maintenance environment. The most obvious is the supervisor and the engineers working under his supervision. A team could also be a Licensed Aircraft Engineer (LAE) and unlicensed engineers working subject to his scrutiny. A team may well comprise engineers of different technical specialties (e.g. sheet/metal structures, electrical/electronic/avionics, hydraulics, etc.).

Successful teamwork is achieved when the output of the team is greater than what the output would be by the combined efforts of the individual members in isolation. This is a process known as synergy. Synergy occurs when each individual team member is empowered and encouraged to contribute in the most effective way to the overall task of the team. Interaction between team members creates a positive environment, increasing efficiency and productivity. Sound teamwork in aviation maintenance is also a vital error management tool. There are many examples where maintenance team failures have been found to be major factors in aviation accidents.

Some Advantages and Disadvantages of Team Working

The discussion on motivation suggests that individuals need to feel part of a social group. In this respect, team working is advantageous. However, the work on conformity suggests that

they feel some pressure to adhere to a group's views, which may be seen as a potential disadvantage.

Working as part of a team has a number of potential benefits which include:

- individuals can share resources (knowledge, tools, etc.).
- they can discuss problems and arrive at shared solutions.
- they can check each other's work (either "officially" or "unofficially").

Important Elements of Team Working

For teams to function cohesively and productively, team members need to have or build up certain interpersonal and social skills. These include communication, cooperation, co- ordination and mutual support

Conditions for effective teamwork

- Share and understand a common goal
- Have effective and balanced leadership
- Have effective followership (or team) skills
- Have a shared mental model
- Practice clear and effective communication
- Have clear delegation/role definition
- Have clear operating procedures
- Allocate workload appropriately
- Have an appropriate authority gradient
- Resolve conflict effectively

9.3.7 MANAGEMENT, SUPERVISION AND LEADERSHIP

Managers and supervisors have a key role to play in ensuring that work is carried out safely. It is no good instilling the engineers and technicians with 'good safety practice' concepts, if these are not supported by their supervisors and managers.

The Management Role

Line Managers, particularly those working as an integral part of the ' front line' operation, may be placed in a situation where they may have to compromise between commercial drivers and 'ideal' safety practices (both of which are passed down from 'top management' in the organization). For example, if there is a temporary staff shortage, he/ she must decide whether maintenance tasks can be safely carried out with reduced manpower, or whether an AMT volunteering to work a "back to back shift" will be able to perform adequately. The adoption of Safety Management Principles may help by providing managers with techniques whereby they can carry out a more objective assessment of risk.

The Supervisory Role

Supervision may be a formal role or post (i.e. a Supervisor), or an informal arrangement in which a more experienced engineer 'keeps an eye on' less experienced staff. The Supervisor is in a position not only to watch out for errors which might be made by engineers and technicians, but will also have a good appreciation of individual engineer's strengths and weaknesses, together with an appreciation of the norms and safety culture of the group which he supervises. It is mainly his job to prevent unsafe norms from developing, and to ensure that good safety practices are maintained. There can be a risk however, that the Supervisor becomes drawn down the same cultural path as his team without realising. It is good practice for a Supervisor to step back from the day-to-day work on occasion and to try to look at his charges' performance objectively.

It can be difficult for supervisory and management staff to strike the right balance between carrying out their supervisory duties and maintaining their own skills and knowledge (and appropriate authorizations), and they may thus get out of practice. Also, there is unlikely to be anyone monitoring or checking the supervisor, because:

- The supervisor's seniority. Supervisors are generally authorized to sign for their own work.
- They need to step in when there are staff shortages and therefore there is no spare staff to monitor or check their task.
- The supervisor may be more sensitive to any commercial pressures which may exist, or may perceive that pressure to a greater extent than other staff

Leadership

A leader in a given situation is a person whose ideas and actions influence the thought and the behaviour of others.

There are potentially two types of leader in aircraft maintenance: the person officially assigned the team leader role (possibly called the Supervisor), an individual within a group that the rest of the group tend to follow or defer to (possibly due to a dominant personality, etc.). Ideally of course, the official team leader should also be the person the rest of the group defer to.

Characteristics of a Leader

A good leader in the maintenance engineering environment needs to possess a
number of qualities:

• Motivating his team
• Reinforcing good attitudes and behaviour
• Demonstrating by example
• Maintaining the group
• Fulfilling a management role

What leadership is not

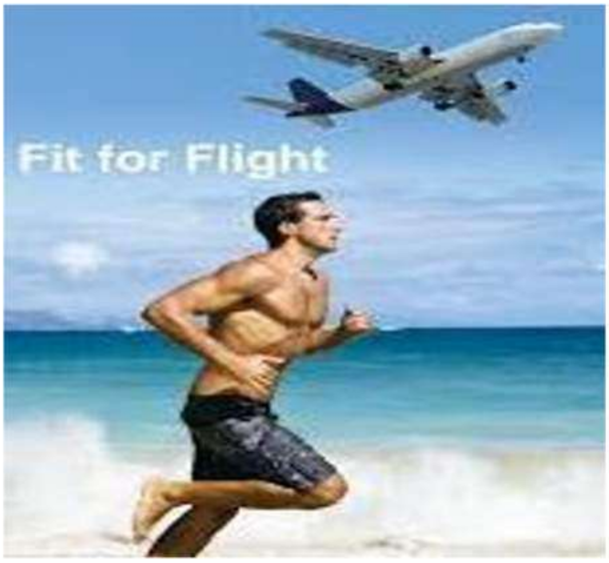
- Leadership is not power. The thug who sticks a gun in your back has power, but not leadership.
- Leadership is not status. Some may have status or position, yet do not have a shred of leadership.
- Position is assigned from above ... leadership is conferred from below.
- Leadership is not authority. Bosses will naturally have subordinates, but if bosses do not lead, they will not have followers.
- Leadership is not management. Managing is a planned activity: leadership is more spontaneous.
- Managers do things right. Leaders do the right things.

9.4 FACTORS AFFECTING PERFORMANCE

9.4.1 Fitness and Health

There are many factors that adversely affect an Aircraft Maintenance Engineer (AME). Some of the main human factors include fitness and health, stress, time pressures and deadlines, workload, fatigue, shift work, and the effects of alcohol and drugs.

The job of an aircraft maintenance engineer can be physically demanding. In addition, his work may have to be carried out in widely varying physical environments, including cramped spaces, extremes of temperature, etc.



There are two aspects to fitness and health: The disposition of the AME prior to taking on employment and the day to day wellbeing once employed.

Pre-employment physical

Some employers may require a medical pre-employment physical. This allows the employer to judge the fitness and health of the applicant. There is an obvious effect upon an AMEs ability

to perform his or her job if through poor physical fitness or health, the applicant is constrained in some way (such as freedom of movement). In addition, an airworthiness authority when considering issuing a license, will consider these factors and may judge the condition to be of such significance that a license could not be issued. This would not, however, affect the individual's possibility of obtaining employment in an alternative post within the industry where fitness and health requirements are less stringent.

Day-to-Day Fitness and Health

Fitness and health can have a significant effect upon job performance (both physical and cognitive). Day to day fitness can be reduced through illness (physical or mental) or injury EASA Part-66.50 imposes a requirement that "certifying staff must not exercise the privileges of their certification authorization if they know or suspect that their physical or mental condition renders them unfit".

Responsibility often falls upon the individuals to determine whether they are well enough to work on a particular day. Alternatively, team members or supervisors may intervene.

Many conditions can impact on the health and fitness of an individual, such as:

- Minor physical illness (such as colds, flu, etc.)
- More significant physical illness (such as cancer, heart conditions, etc.)
- Mental illness (such as depression, anxiety, etc.)
- Minor injury (such as a sprained wrist, etc.)
- Major injury (such as a broken arm, etc.)
- Latent Medical and Environmental Conditions (LMECs) such as ongoing deterioration, possibly associated with the aging such as hearing loss, visual defects, obesity, heart problems, etc.)
- Effects of toxins and other foreign substances (such as carbon monoxide poisoning, alcohol, illicit drugs, etc.).

There is no hard and fast guidelines as to what constitutes 'unfit for work'. This is a complex issue dependent upon the nature of the illness or condition, its effect upon the individual, the type of work to be done, environmental conditions, etc. Instead, it is important that the AME is aware that his/her performance, and consequently the safety of aircraft he/she works on, might be affected adversely by illness or lack of fitness.

An engineer may consider that he is letting down his colleagues by not going to work through illness, especially if there are on- going manpower shortages. However, he should remind himself that, in theory, management should generally allow for contingency for illness. Hence the burden should not be placed upon an individual to turn up to work when unfit if no such contingency is available. Also, if the individual has a contagious illness (e.g. flu), he may pass this on to his colleagues if he does not absent himself from work and worsen the manpower problem in the long run. There can be a particular problem with some contract staff due to loss of earnings or even loss of contract if absent from work due to illness. They may be tempted to disguise their illness or may not wish to admit to themselves or others that they are ill. This is of course irresponsible, as the illness may well adversely affect the contractor's standard of work.

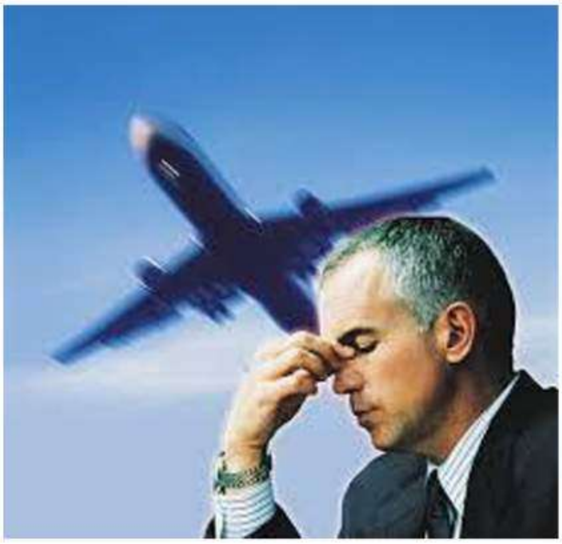
Positive measures

There are many things AMEs can do to help maintain fitness and health. These include:

- Eating regular meals and a well-balanced diet.
- Regular exercise (exercise sufficient to double the resting pulse rate for 20 minutes, three times a week is often recommended)
- Stop smoking.
- Sensible alcohol intake.

9.4.2 STRESS

Stress is the high level of emotional arousal typically associated with an overload of mental and/or physical activity. Stress is often associated with anxiety, fear, fatigue, and hostility. It can also arise because of feelings of inadequacy, where we may feel we do not have the appropriate experience, knowledge, or capability to complete our allocated tasks. All these feelings can have a direct and negative impact on performance.



Stress is an inevitable and necessary part of life. It can motivate us and heighten our response to meeting the challenges we face. In fact, our performance will generally improve with the onset of stress but will peak and then begin to degrade rapidly as stress levels exceed our adaptive abilities to handle the situation.
High levels of stress are a problem for any individual or team since the effects of stress are often subtle and difficult to assess. Although complex and difficult maintenance activities can generate stress, there is also both physical and mental stress that a team member may bring to the situation and which others may not be able to detect.

Causes and Symptoms

Stress is usually something experienced due to any changes in personal circumstances such as marital separation, bereavement, difficult family affairs, or financial concerns and affect our emotional state. There is also work related stress, which may include real or imagined commercial pressures, such as the need to juggle deadlines to get an aircraft on line, and balance economic considerations with the understanding that lives depend on the quality of our work. From these, we get acute stress (typically intense but of short duration) and chronic stress (frequent recurrence or of long duration) respectively.

Different stressors affect different people to varying extents. Stressors may be:

- Physical, such as heat, cold, noise, or the onset of fatigue.
- Psychological, such as worries about real or imagined problems (e.g. financial problems, ill health, etc.)
- Reactive, such as events occurring in everyday life (e.g. working under unrealistic time pressure, bullying, encountering unexpected situations, etc.).

Symptoms/signs of stress

The symptoms of stress can include:

- Physiological symptoms, such as sweating, dryness of the mouth etc.
- Health effects, such as nausea, headaches, sleep problems, stomach upsets.
- Behavioral symptoms, such as restlessness, shaking, nervous laughter, taking longer over tasks, changes to appetite, excessive drinking or smoking etc.
- Cognitive effects, such as poor concentration, indecision, forgetfulness etc.
- Subjective effects, such as anxiety, irritability, depression, moodiness, aggression etc.

Domestic Stress

When aircraft maintenance engineers go to work, they cannot leave stresses associated with home behind. Pre-occupation with a source of domestic stress can play on one's mind during the working day, distracting from the working task. Inability to concentrate fully may impact on the engineer's task performance and ability to pay due attention to safety.

Domestic stress typically results from major life changes at home, such as marriage, birth of a child, a son or daughter leaving home, bereavement of a close family member or friend, marital problems, or divorce.

Work Related Stress

Aircraft maintenance engineers can experience stress for two reasons at work: because of the task or job they are undertaking at that moment, or because of the general organisational environment. Stress can be felt when carrying out certain tasks that are particularly challenging or difficult. This stress can be increased by lack of guidance in this situation, or time pressures to complete the task or job (covered later in this chapter). This type of stress can be reduced by careful management, good training, etc.

9.4.3 TIME PRESSURE AND DEADLINES

There is probably no industry in the commercial environment that does not impose some form of deadline, and consequently time pressure, on its employees. Aircraft maintenance is no exception. It was highlighted in the previous section that one of the potential stressors in maintenance is time pressure. This might be actual pressure where clearly specified deadlines are imposed by an external source (e.g. management or supervisors) and passed on to engineers, or perceived where engineers feel that there are time pressures when carrying out tasks, even when no definitive deadlines have been set in stone. In addition, time pressure may be self-imposed, in which case engineers set themselves deadlines to complete work (e.g. Completing a task before a break or before the end of a shift).

management has contractual pressures associated with ensuring an aircraft is released to service within the time frame specified by their customers. striving for higher aircraft utilization means that more maintenance must be accomplished in fewer hours, with these hours frequently being at night. failure to do so can impact on flight punctuality and passenger satisfaction. thus, aircraft maintenance engineers have two driving forces: the deadlines handed down to them and their responsibilities to carry out a safe job. the potential conflict between these two driving pressures can cause problems.

Stress and time pressure in shift and task handovers

Ironically, one of the busiest times in the maintenance environment is during shift and task handovers. Generally during this time, paperwork is being completed (in a rush) and a briefing prepared for the oncoming shift. Often, shifts and supervisors do not get the opportunity for a face to face handover.

The quality of information in shift and task handover notes varies from organization to organization, and sometimes is of a very poor standard. Where possible, it is best to have an overlap between shifts to ensure a face to face handover. In all cases, however, provide a written handover to the oncoming shift, team, or individual taking over a specific task. All organizations should have a formal process of providing clear information for task/ shift handover to the incoming team.

Managing shift handovers?

Manage stress and time pressure during the shift handover by planning appropriately and communicating. Before the shift ends, identify any obvious and appropriate points in the maintenance process needed to complete the work. The outgoing supervisor also needs to allow adequate time for all tasks (including completing any outstanding documentation) and for a comprehensive written shift handover log to be completed before the incoming shift's arrival. An example of a shift/task handover log is included in below:

SHIFT – TASK HANDOVER SHEET	
COMPANY	
SHIFT/TASK	
TIME/DATE	
Aircraft registration	
Maintenance procedure reference	
Task details	
Steps completed	
Steps required	
Power restrictions	
Items/equipment disconnected for access	
Test equipment in use	
Equipment/tooling/GSE deficiencies identified	
Fault finding conducted	
Additional information/comments	
NAME	**TRADE/POSITION**

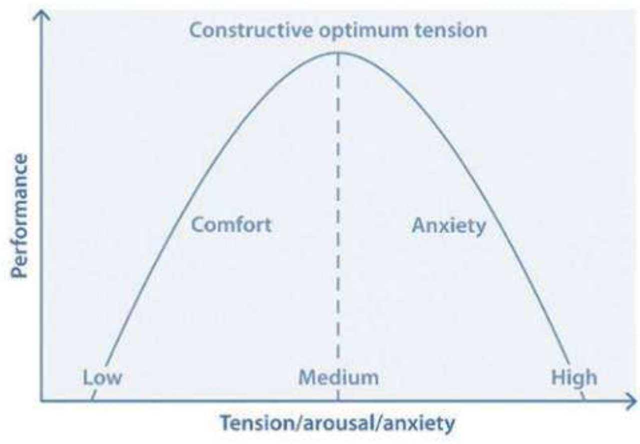
Shift/task handover log

The Effects of Time Pressure and Deadlines

As with stress, it is generally thought that some time pressure is stimulating and may actually improve task performance. However, it is almost certainly true that excessive time pressure (actual or perceived, external, or self-imposed), is likely to mean that due care and attention when carrying out tasks diminishes, and more errors will be made. Ultimately, these errors can lead to aircraft incidents and accidents.

9.4.4 WORKLOAD - OVERLOAD AND UNDER LOAD

Both arousal and alertness are necessary for us to achieve our optimum performance, however, too much, or too little arousal can adversely affect our ability to function effectively. It is therefore important for us to be aware of the symptoms of stress in ourselves and others as well as to understand the effect of stress on team performance as a whole.



The Yerkes Dodson curve demonstrates that our performance is directly related to the level of arousal. The graph below shows that there is typically a level of arousal which aligns with the optimum level of performance. At very low levels of arousal (complacency and boredom) and very high levels of arousal (stress, anxiety and overload) our performance is very much degraded.

Work overload

Work overload occurs when there is a lot of work to be done and the individual's or team's workload exceeds their ability to cope. As performance deteriorates, we are forced to shed tasks and focus on key information. In these situations, error rates may also increase. As we carry out our assigned tasks, over a given time, the normal effects of fatigue will also produce a decline in our mental and physical capacity. This will mean that tasks that we consider easy at the beginning of our work period feel more difficult later on. Added to this, momentary workload spikes within a shift may strain our individual (or team) capacity, increasing the risk of errors.

Work overload can occur for a wide range of reasons and may happen suddenly or gradually. It is good practice to plan maintenance tasks so that individuals (or the team as a whole) are not expected to perform at an unacceptable level to complete their tasks within the allocated time. Specific task allocation between team members can reduce the likelihood of one person within the team being overloaded.

Maintenance personnel under excessive workload (often associated with unrealistic time pressures) can exhibit or experience the following issues:

Table 4.3: HIGH WORKLOAD	
Omission and filtering	Ignoring some signals or responsibilities that are not seen as immediately relevant or necessary
Reduced ability to think logically	Limited capability for the consideration of other possibilities, or to process information correctly
Queuing	Delaying required actions/responses in the hope that you will be able to catch up as the task progresses
Confirmation bias	The tendency to automatically confirm a decision we have made, ignoring other information to the contrary
Approximation	Near enough becomes good enough
Regression	Reverting to a previously well learned procedure or action which may or may not be appropriate for the current task

Work overload and effects of fatigue

Work underload

Although rare in the maintenance environment, work under load does occur. Work under load can result from menial, simple or very repetitive tasks that are boring, or indeed from a lack of tasks to do. We are likely to be less attentive when carrying out repetitive tasks; boredom may

set in and may begin to raise the level of mental stimulation by thinking about things not related to the task, (e.g. what to do at the weekend). Under these conditions, situational awareness is degraded, and errors and omissions will increase.

9.4.5SLEEP, FATIGUE AND SHIFT WORK

What Is Sleep?

Sleep is a natural state of reduced consciousness involving changes in body and brain physiology which is necessary to man to restore and replenish the body and brain.

Sleep can be resisted for a short time, but various parts of the brain ensure that sooner or later, sleep occurs. When it does, it is characterized by five stages of sleep

Stage 1: This is a transitional phase between waking and sleeping. The heart rate slows and muscles relax. It is easy to wake someone up.

Stage 2: This is a deeper level of sleep, but it is still fairly easy to wake someone.

Stage 3: Sleep is even deeper, and the sleeper is now quite unresponsive to external stimuli and so is difficult to wake. Heart rate, blood pressure and body temperature continue to drop.

Stage 4: This is the deepest stage of sleep and it is very difficult to wake someone up.

- Rapid Eye Movement or REM sleep: Even though this stage is characterised by brain activity similar to a person who is awake, the person is even more difficult to awaken than stage 4. It is therefore also known as paradoxical sleep. Muscles become totally relaxed and the eyes rapidly dart back and forth under the eyelids. It is thought that dreaming occurs during REM sleep. https://youtu.be/H0DJzFDOgzg

Stages 1 to 4 are collectively known as non-REM (NREM) sleep. Stages 2-4 are categorised as slow-wave sleep and appear to relate to body restoration, whereas REM sleep seems to aid the strengthening and organisation of memories. Sleep deprivation experiments suggest that if a person is deprived of stage 1-4 sleep or REM sleep he will show rebound effects. This means that in subsequent sleep, he will make up the deficit in that particular type of sleep. This shows the importance of both types of sleep.

Typically, the first REM sleep will occur about 90 minutes after the onset of sleep. The cycle of stage 1 to 4 sleep and REM sleep repeats during the night about every 90 minutes.

What is fatigue?

We use the word fatigue all the time, but what exactly does it mean? There are several different meanings of the word:

- Tiredness after hard physical work
- Emotional fatigue
- Short term effects of intense concentration on a task
- An overwhelming need to sleep.

Fatigue can have a major effect on your safety and the quality of your work when you are maintaining aircraft.

We can distinguish between two types of sleep related fatigue:

Acute—this is generally only short term and can be remedied with a good night's sleep
Chronic—a longer term problem, as there is usually a buildup of sleep deprivation.

Fatigue can act like a toxin accumulating in our body. We can generally deal with a small amount of it, and work it out of our system by catching up on a night's sleep, but chronic fatigue accumulates

The effects of fatigue

One obvious hazard of fatigue is that the fatigued person loses the fight to stay awake while at work.

Clearly this is most dangerous when the person is operating equipment or driving a vehicle. A sleep episode can take the form of a micro sleep, which is a brief moment (generally between 2-30 seconds) when the person starts to enter the first stage of sleep, possibly with their eyes still open; sometimes for less than a few seconds before regaining consciousness. The person is typically unaware that they have experienced a micro sleep and may continue to perform simple repetitive tasks while asleep. When truck drivers volunteered to wear sleep monitoring equipment while they worked, researchers were amazed to find that some drivers were showing signs of the first stage of sleep while driving on interstate highways.

Memory failures

Fatigued AMTs are more likely to forget to perform routine actions, such as replacing oil caps and are more susceptible to distraction and resulting memory lapses.

Failures to notice defects or problems

Fatigued AMTs have more difficulty detecting defects during inspections and may be less likely to notice problems as a result of inattention or poor concentration.

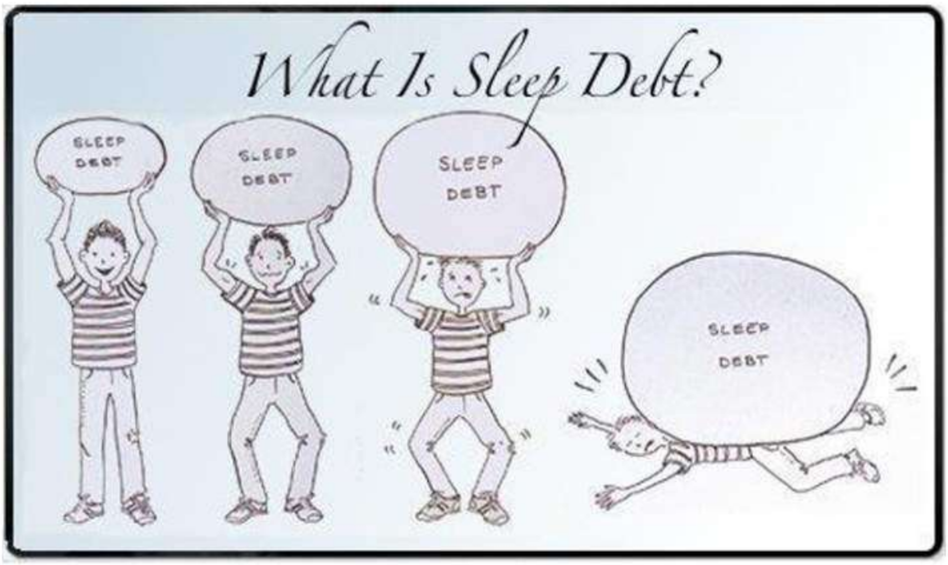
The reduced performance caused by fatigue imposes a burden on the aviation industry not only in terms of flight safety, but also in financial costs through delays, the need for rework, and other inefficiencies.

The causes of fatigue

Fatigue is caused by a combination of two processes— sleep debt and circadian rhythms Sleep

debt

Adults generally sleep between seven and eight hours per night, although the need for sleep varies with some individuals needing up to 10 hours to remain alert. A century ago, before the widespread use of electric lighting, people typically slept around nine hours per night. Today, family demands, work commitments, and even television habits combine to limit the opportunities for nighttime sleep. In our busy world, many people are suffering from sleep deprivation without being aware of it. Extreme sleep deprivation has severe health effects, but even mild sleep deprivation can affect health and our ability to perform tasks in our work and personal lives.

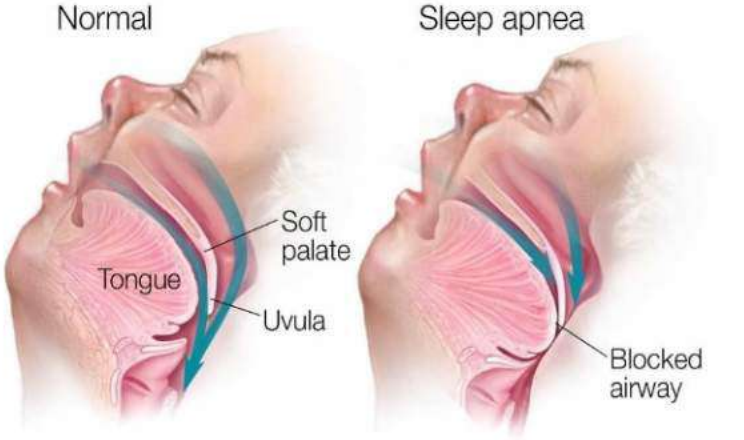


If we obtain less sleep than we need, we build up a sleep debt. Each successive night of inadequate sleep adds to the debt. Even reducing our sleep by just one hour each night over several nights (getting seven hours when we really need eight) can reduce our mental efficiency. Shift workers, who sleep during daylight hours, also build up a sleep debt because daytime sleep tends to be briefer and of poorer quality than sleep obtained at night.

But sleep debts can also occur when sleep is disrupted by alcohol, drugs, and medical conditions. Medical conditions that can cause sleep disruption include the following:
Insomnia – An inability to get to sleep, or a difficulty staying asleep. In many cases, insomnia is a symptom of another problem, such as medical conditions, side effects of medicines, or sleep disorders. Insomnia can also be caused by worry or emotional upsets.
Restless legs syndrome (RLS) – A disorder that causes a strong urge to move your legs. This urge to move often occurs with strange and unpleasant feelings such as creeping, tingling, or burning. Moving your legs relieves the urge and the unpleasant feelings.
Periodic limb movements (PLM) – Involuntary leg movements while asleep. The movements often disrupt sleep and may cause the person to wake up.
Sleep apnea – A disorder in which breathing pauses or becomes shallow during sleep

Sleep apnea

Sleep apnea is one of the more common medical conditions related to sleep disturbance. It is a condition in which breathing stops for ten seconds or longer during sleep. This reduces the level of oxygen to the brain and results in disturbed sleep. The condition is often associated with snoring. During a typical episode of sleep apnea snoring stops as the person ceases breathing. After a period of silence, they wake up, gasp or snort, and then return to snoring.



Sleep apnea affects between two and

five per cent of the population. However, the condition is more common in men who are overweight and/or have a large neck size.

Sleep apnea typically results in excessive daytime sleepiness. It also causes forgetfulness, clumsiness on tasks requiring careful movements, and may lead to reduced sex drive and/or impotence.

The good news is that effective treatments are available for sleep apnea. As well as weight loss, your doctor may recommend surgery, or the use of a device that will keep your airway open while you sleep.

When to see a doctor

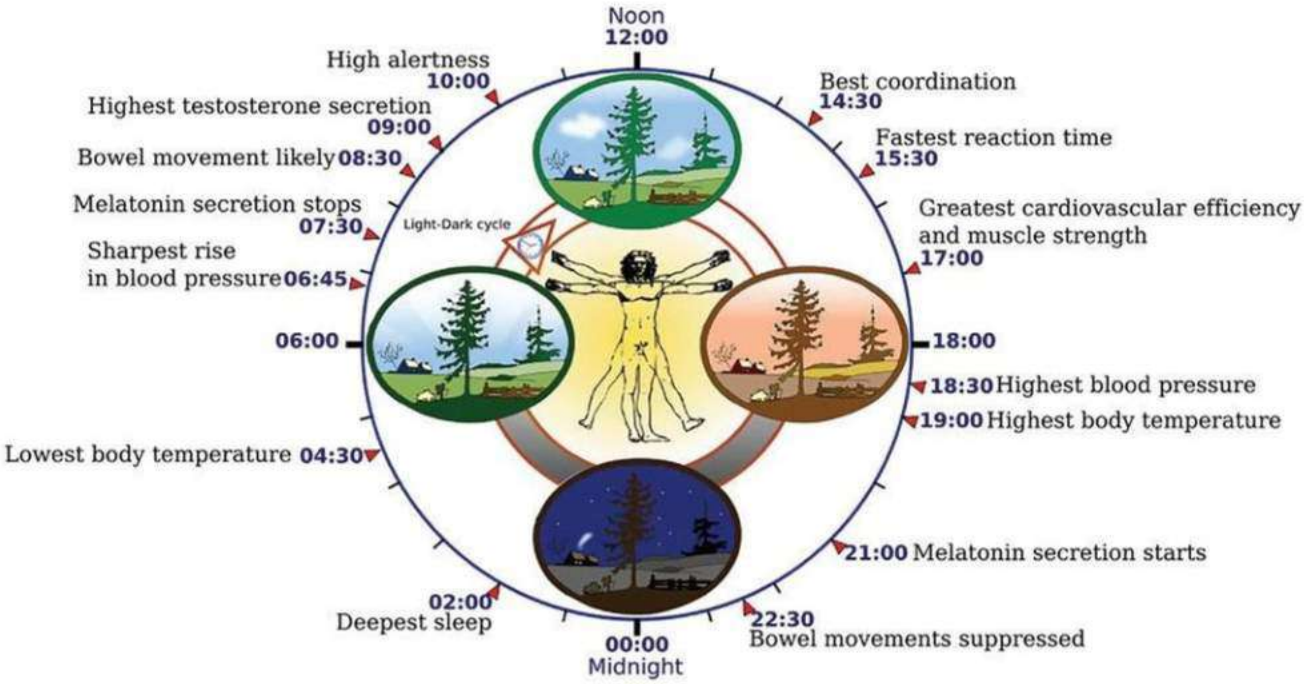
Consult a medical professional if you experience, or if your partner observes the following:

- Snoring loudly enough to disturb the sleep of others or yourself
- Shortness of breath that awakens you from sleep
- Intermittent pauses in your breathing during sleep
- Excessive daytime drowsiness, which may cause you to fall asleep while you're working, watching television, or even driving.

Circadian rhythms

Our bodies have very steady 24-hour rhythms in their physiology, biochemistry, and behavior. Alertness, body temperature, sleep tendency, and human error have also been shown to follow a 24-hour pattern. This is known as circadian rhythms. Our body's internal clock is kept on correct time by exposure to light, particularly early morning light. Our circadian rhythms are so reliable that even if we are removed from the 24-hour rhythm of night and day (such as wintering in Antarctica) the rhythms continue to run. Without regular exposure to a daily cycle of light and dark, circadian rhythms eventually begin to 'free run' and will no longer align closely with the 24-hour day.

An example of disrupting circadian rhythms would be taking a flight that crosses time zones. This will interfere with the normal synchronisation with the light and dark (day/ night). This throws out the natural link between daylight and the body's internal clock, causing jet lag, resulting in sleepiness during the day, etc. Eventually however, the circadian rhythm readjusts to the revised environmental cues.



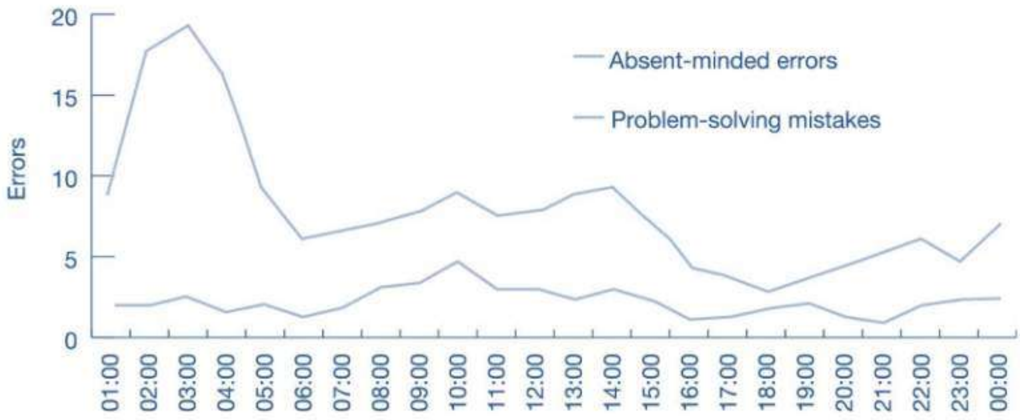
Circadian Rhythms

Circadian rhythms have an important role in regulating sleep patterns. Chemical changes occur in the body as it prepares for sleep, typically between 8pm and midnight. Body temperature reaches a low point at around 3am, and then begins rising steadily as our body gets ready for the day ahead, even before we are naturally awake.

Beware the WOCL!

The period from around 2am–5am when we would normally be asleep is often referred to as the Window of Circadian Low (WOCL) and is a time when mental functioning is generally at its worst. The WOCL is a high risk time for human error. Even people without a sleep debt find that their work performance is affected by fatigue during the WOCL, but a sleep debt will intensify the negative effects of the WOCL.

Studies of thousands of industrial errors have shown that although they can occur at any time of day or night, a large proportion of errors occur at around 3am. There is often a second, although smaller risk period at around 3pm. That afternoon period is sometimes called the 'post lunch dip', but it happens regardless of whether people eat lunch or not.



Airline maintenance errors throughout the 24 hour day

Sleep inertia ('sleep drunkenness')

In the few minutes after waking up, we may experience a brief period of confusion, poor memory and grogginess. This effect, which can last up to 15 minutes, is known as sleep inertia. It can be an issue in workplaces where people have to wake up shortly before they get to work, for example pilots who sleep in onboard crew rest facilities. It can also be an issue in maintenance if you are on call during the night. Be aware that after waking from a deep sleep it might take 15 minutes or so before you are alert enough to get to work.

Fatigue cannot be eliminated, but the risks associated with it can be managed through a partnership between employer and employee. Some of the causes of fatigue originate with company policies; for example, hours of work, the extent to which work is performed during the night, and the predictability of work schedules. Other causes stem from the employee's personal situation, including commuting time, family responsibilities, and the demands of second jobs.

Responsibilities of the employer

- schedule work hours and time off to give the employee sufficient opportunity for restorative sleep.
- manage workload and breaks.

Responsibilities of the employee

- manage personal time to make sure you are rested and fit for duty.
- when reporting incidents, note if fatigue was a factor.

Strategies to deal with fatigue

Get more sleep!

The first and most obvious way to prevent fatigue is to get more good quality sleep. this is easier said than done, particularly if you work irregular hours, have a second job, or have young children. Here are some tips on getting better sleep:

Tips for better sleep

- set, and stick to, a sleep
- schedule as much as possible. try to go to bed and wake up at the same time each day.
- expose yourself to bright light in the morning but avoid it at night. exposure to bright morning light energizes and prepares you for a productive day. alternatively, dim your lights when it is close to bedtime.
- exercise regularly. exercise in the morning can help you get the light exposure you need to set your biological clock. avoid vigorous exercise close to bedtime if having problems sleeping.
- establish a relaxing bedtime routine. allow enough time to wind down and relax before going to bed
- create a cool comfortable sleeping environment free of distractions.
- treat your bed as your sanctuary from the stresses of the day. if you find yourself still lying awake after 20 minutes, get up and do something relaxing in dim light until sleepy.
- keep a 'worry book' next to your bed. if you wake up because of concerns, write them down with an action plan, then forget about them until morning
- avoid caffeinated drinks, chocolate, and tobacco at night.
- avoid large meals and beverages before bedtime.
- no nightcaps—drinking alcohol before bed can rob you of deep sleep and cause you to wake up too early.
- avoid medicines that delay or disrupt your sleep. if you have trouble sleeping, ask your doctor if your medications might be contributing to your sleep problem.
- no late afternoon or evening naps unless you work nights. if you must nap, keep it under 45 minutes and before 3.00pm.
- place a 'do not disturb' sign on your door. ask all family members to be as quiet as possible while you are sleeping.
- make sure that your room is dark. blackout curtains can help.

Controlled naps

Numerous research studies have shown that even a brief nap can result in performance improvements. Napping used to be widely discouraged by employers, but now pilots, air traffic controllers and others are being allowed to take brief controlled naps when workload permits.

There are two types of naps:
Preventative nap—a brief sleep before you report for work, particularly before starting a night shift
Restorative nap—a brief sleep during a break at work can sharpen your performance for the next couple of hours.

There are two problems to watch out for with naps:

- Avoid taking naps in the hours before you go to bed so as not to interfere with your main sleep period.
- Naps lasting more than about 40 minutes may produce sleep inertia, (a feeling of grogginess that may persist after awakening). the best nap duration appears to be about 20-25 minutes.

Caffeine

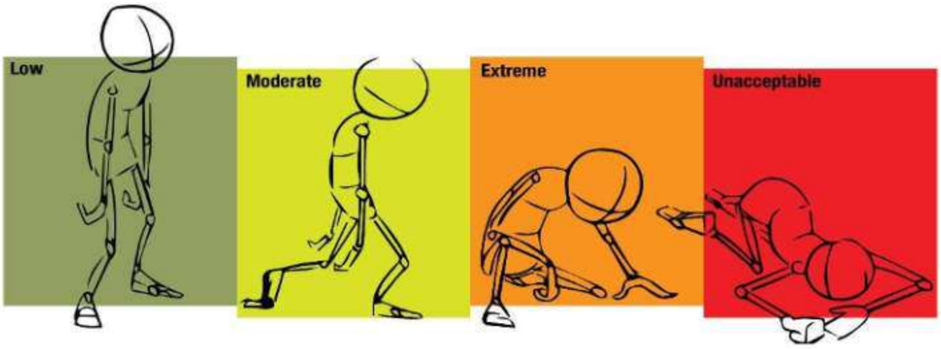
Caffeine is one of the most widely used stimulants, and if used carefully and in moderation can be part of an overall fatigue management strategy. Caffeine has a half-life in the body of around five hours, so shift workers should be careful to avoid caffeine in the hours leading up to sleep. If you use caffeine to stay alert at work, use it selectively, and cut down on caffeinated drinks at other times. If you develop a tolerance to caffeine, it will not be as effective in keeping you alert.

Breaks

If the situation allows a brief break or a stretch can help to focus your attention and provide temporary relief from fatigue. Do not be afraid to call time out for a few minutes to clear your head. Breaks however, only provide a short-term benefit. The only real remedy for fatigue is sleep.

Progressive restrictions

One way to deal with fatigue in maintenance is to keep those who are most fatigued away from the most critical tasks, an approach sometimes called 'progressive restrictions. Some companies have internal policies progressively limiting the tasks an AMT can perform the longer they have been at work.
For example, an AMT who has been on duty for longer than 12 hours might not be permitted to certify the work of others or may not be permitted to perform engine runs or other critical tasks.



Level of fatigue: example of the progressive restriction approach

Shift work

Most aircraft movements occur between 6am and 10pm to fit in with the requirements of passengers. AMEs are required when aircraft are on the ground such as during turn arounds. However, this scheduling means that aircraft are available for more significant maintenance overnight. Thus, aircraft maintenance is clearly a 24-hour business and it is inevitable, to fulfill commercial obligations, that AMEs usually work shifts. Some permanently work the same shift, but the majority cycle through different shifts.

Advantages and disadvantages of shift work

There are pros and cons to working shifts

Advantages include:

- more days off
- avoiding peak traffic times when travelling to work.

Disadvantages include:

- working unsociable hours meaning that time available with friends and family will be disrupted
;
- working when human performance is known to be poorer (i.e. between 4am and 6am)
;
- problems associated with disturbance of the body's various rhythms (principally sleeping patterns).

Rolling shift patterns

When an AME works rolling shifts and changes from one shift to another (e.g. 'day shift' to 'night shift'), the body's internal clock is not immediately reset. It continues its old wake sleep cycle for several days. However, by this time, the AMT may have moved onto the next shift. Generally, it is now accepted that shift rotation should be to later shifts (i.e. early shift - late shift - night shift or day shift - night shift) instead of rotation towards earlier shifts.

9.4.6 ALCOHOL, MEDICATION AND DRUG ABUSE

It should come as no surprise to the aircraft maintenance engineer that his performance will be affected by alcohol, medication or illicit drugs. Under the legislation it is an offence for safety critical personnel to carry out their duties whilst under the influence of alcohol or drugs

"The holder of an aircraft maintenance engineer's licence shall not, when exercising the privileges of such a licence, be under the influence of drink or a drug to such an extent as to impair his capacity to exercise such privileges."

The current law which does not prescribe a blood/alcohol limit, is soon to change. There will be new legislation permitting police to test for drink or drugs where there is reasonable cause, and the introduction of a blood/alcohol limit of 20 milligrams of alcohol per 100 millilitres of blood for anyone performing a safety critical role in civil aviation (which includes aircraft maintenance engineers).

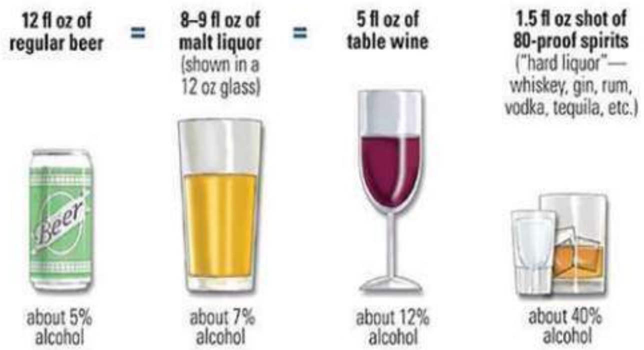
Despite an individual's belief that he can still work effectively after drinking alcohol, such behaviour will not be tolerated within aviation maintenance activities. Consumption of even relatively small amounts of alcohol is unacceptable since, in combination with a number of other factors such as fatigue, illness or medication, there may still be a distinguishable impairment of judgement and decision making. Organisations may have an alcohol and drug policy, including random testing for such substances. Even where such policy is not defined by the organisation, it does not absolve the individual from complying with the relevant legislation.

Whilst it is acceptable to take prescribed drugs, such as generic or trade-marked medicines, to address medical conditions or short- term illness, it should be noted that many of these may have side effects. These may affect individuals in different ways and even differently on separate occasions. Maintenance personnel should therefore be aware of potential side effects, as advised by the manufacturer of the medicine.

Alcohol

The term alcohol describes a series of organic chemicals, but only one type, ethyl alcohol or ethanol, is found in drinks intended for human consumption. Alcohol is a central nervous system depressant as illustrated in the Table below summarizing the stages of intoxication

Alcohol has similar effects to tranquillizers and sleeping tablets and may remain circulating in the blood for a considerable time, especially if taken with food. It may be borne in mind that a person may not be fit to go on duty even 8 hours after drinking large amounts of alcohol. Individuals should therefore anticipate such effects upon their next duty period. Special note should be taken of the fact that combinations of alcohol and sleeping tablets, or anti histamines, can form a highly dangerous and even lethal combination.



As a general rule, aircraft maintenance engineers should not work for at least eight hours after drinking even small quantities of alcohol and increase this time if more has been drunk.

Standard drink sizes are considered

12 ounces of regular beer
5 ounces of wine
1.5 ounces of 80 proof distilled spirits

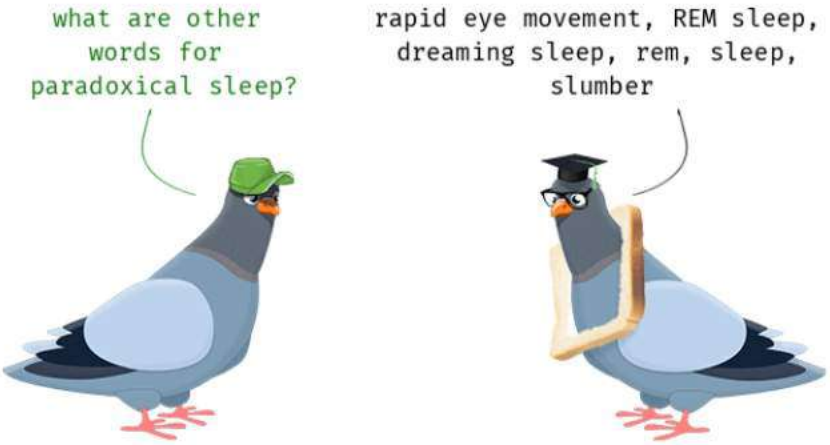
Alcohol and safety

Alcohol is a depressant drug, even though it may feel stimulating at first. Within minutes of drinking, some alcohol will be absorbed into the bloodstream. Certain things, such as eating, affect the alcohol absorption rate; eating slows down absorption. Even a small amount of alcohol affects decision making skills. Your ability to perform certain tasks, such as trouble shooting is quickly affected.

Alcohol and sleep

Disturbance of paradoxical (rem) sleep/slow wave sleep cycle

Alcohol has a harmful effect on both the quality of sleep and on daytime attention.



Alcohol seems to accelerate falling asleep, at least in subjects who do not tend to fall asleep immediately. The negative effects arise later and affect the quality and duration of sleep. Sleep is a complex phenomenon. There are alternating phases of deep sleep, called paradoxical or REM sleep during which the subject dreams, and slow wave sleep. Undisturbed progression of these two phases of sleep is essential.

Alcohol disturbs or interrupts this sequence. Thus alcoholics, and some people who have stopped drinking, complain about disturbed and fragmented sleep, frightening dreams, and insomnia.

Alcohol and attention

The sedative action of alcohol has variable effect on attention, reducing it and producing diminished performance.

Drugs

What is a drug?

A drug is any substance (solid, liquid or gas) that brings about physical and/or psychological changes. The drugs of most concern in the community are those affecting the central nervous system. They act on the brain and can change the way you think, feel, or behave. These drugs are known as psychoactive drugs.

When we use drugs our capacity to think and move is generally impaired. The changes may be slight, but when involved in safety sensitive activities, drug use can lead to dangerous errors.

The effects of alcohol and other drugs include:

- Slowed processing of information
- Slowed perception
- Longer reaction time. Responses to

hazards are slower, and the number of inappropriate avoidance manoeuvres increases

- Reduced coordination and ability to track or follow movement
- Reduced ability to concentrate
- Reduced ability to see alternative solutions, to think flexibly
- Attention problems affecting:

  a. Focused attention—concentrating on a single task
  b. Divided attention—coping with a number of sources of information at once
  c. Sustained attention—concentrating on one thing for some time
  d. Memory (including short term memory, and memory for visual and spatial information)
  e. Increased risk taking.

How are drugs classified?

Drugs are commonly classified according to their legal status, and their effects on the central nervous system.

Legal drugs

Laws control the availability, quality, and price of legal drugs. For example, in the United States, alcohol may not be sold to persons under the age of 21.

Illegal drugs

Because they are illegal, there is no quality control on illicit drugs such as heroin and ecstasy. This means that users can never be sure that the drug they are taking is what they think it is.

Central nervous system

There are three main types of drug affecting the central nervous system: depressants, stimulants, and hallucinogens.

1. Depressants slow down the functions of the central nervous system. Depressant drugs do not necessarily make a person feel depressed. In small quantities, depressants can cause the user to feel more relaxed and less inhibited. In larger quantities they can cause unconsciousness, vomiting, and even death. Depressants affect concentration and coordination. They slow down the ability to respond to unexpected situations.

They incl

- Alcohol
- Cannabis
- Barbiturates, including Seconal, Tuinal and Amytal
- Benzodiazepines (tranquilizers), such as Rohypnol, Valium, Serepax, Mogadon, Normison and Eupynos
- GHB (gammahydroxybutrate), or Fantasy
- Opiates and opioids, including heroin, morphine, codeine, and methadone

- Some solvents and inhalants, many of which are common household products.

2. Stimulants on the other hand, act on the central nervous system to speed up the messages to and from the brain. They can make the user feel more awake, alert, or confident. Stimulants increase heart rate, body temperature, and blood pressure. Other effects include reduced appetite, dilated pupils, talkativeness, agitation, and sleep disturbance.

Large quantities of stimulants can "over stimulate" the user, causing anxiety, panic, seizures, headaches, stomach cramps, aggression, and paranoia. Prolonged use of strong stimulants can mask some of the effects of depressant drugs, such as alcohol, making it difficult for a person to judge their effects.

Mild stimulants include:

- Ephedrine (used in medicines for bronchitis, hay fever, and asthma)
- Caffeine (in coffee, tea, and cola drinks)
- Nicotine (in tobacco).

Stronger stimulants include:

- Methamphetamines,
- Cocaine
- MDMA/Ecstasy
- Slimming tablets (such as Duromine, Tenuate, Dospan and Ponderax).

3. Hallucinogens affect perception. People who have taken them may believe they see or hear things that are not really there, or what they do see may be distorted in some way. The effects of hallucinogens vary a great deal, so it is impossible to predict how they will affect a particular person at a particular time.

Some effects of hallucinogens include dilation of pupils, loss of appetite, increased activity, talking or laughing, emotional euphoria and wellbeing, jaw clenching, sweating, panic, paranoia, loss of contact with reality, irrational or bizarre behavior, stomach cramps, and nausea.

Hallucinogens include:

- Datura
- Ketamine
- LSD
- Magic mushrooms

- Cannabis is a hallucinogen as well as a depressant. Ecstasy can also have hallucinogenic qualities.

How do drugs affect people?

The effects of a drug depend on the type of drug, how much is used, how it is taken, the characteristics of the person taking it (body type and mood), and the situation or place at which the drug is taken.

Legal drugs – prescription and over the counter

The following are some of the over the counter and prescription types of medication in common use and how they may affect you. This list is not exhaustive. You should take care to find out the likely effects of any prescribed drug before you take it. Always seek advice from your doctor and pharmacist, and in particular declare what kind of work you do so they can take that into account when prescribing medication.

Analgesics are used for pain relief and to counter the symptoms of colds and 'flu. Paracetamol, aspirin and ibuprofen are the most common, and are generally considered safe if used as directed. They can be taken alone but are often used as an ingredient of a 'cold relief' medicine. It is always worth bearing in
mind that the pain or discomfort that you are attempting to treat with an analgesic (e.g. headache, sore throat, etc.) may be the symptom of some underlying illness that needs proper medical attention.

Sleeping tablets (often antihistamine based) tend to slow reaction times and generally dull the senses. The duration of effect is variable from person to person. Individuals should obtain expert medical advice before taking them.

Melatonin (a natural hormone) deserves a special mention. Although not available without a prescription it is classed as a food supplement in the USA (and is readily available in health food shops). It has been claimed to be effective as a sleep aid, and to help promote the resynchronisation of disturbed circadian rhythms. Its effectiveness and safety are still yet to be proven and current best advice is to avoid this product.

Antidepressants: these can depress the alerting system and have contributed to errors, in turn leading to fatal accidents. You should stop work when starting antidepressants and only return when it is clear that there are no adverse side effects. It is recommended that individuals seek medical advice from their appropriate medical specialist before returning to work.

Antibiotics: penicillin and the various mycins and cyclines and sulphur drugs may have short term or delayed effects which can affect work performance. Their use indicates that a fairly severe infection may well be present and, apart from the effects of these substances themselves, the side effects of the infection will almost always render a person unfit forwork.

Antihistamines: such drugs are widely used in cold cures and in the treatment of hay fever, asthma, and allergic conditions. Many easily obtainable nasal spray and drops containantihistamines. Most antihistamines tend to make the user feel drowsy, making operation of equipment or vehicles not recommended. Admittedly, very mild states of hay fever may be adequately controlled by small doses of anti-allergic drugs, but a trial period to establish the absence of side effects is essential before going on duty. When individuals are affected by allergic conditions requiring more than the absolute minimum, and in all cases of asthma, you should seek medical advice.

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'Pep' pills: (e.g. containing caffeine, Dexedrine, Benzedrine) used to maintain wakefulness can be habit forming. Individuals vary in their susceptibility to each drug, but all of them can create dangerous overconfidence. Over dosage may cause headaches, dizziness and mental disturbances. The use of 'pep' pills while working cannot be permitted. If tea or coffee is insufficient, you are not fit for work.

Drugs for the relief of high blood pressure: these are proving to be very effective in controlling this condition. However, antihypertensive agents all have some side effects, and should not be administered before adequate assessment of the need for treatment. Your doctor should be able to advise of any side effects you should consider.

Antimalarial drugs: prescribed in normally recommended doses do not usually have any adverse effects.

Oral contraceptive tablets: in the standard dose do not usually have adverse effects, although regular supervision is required.

Sudafed is the trade name of a preparation containing pseudoephedrine hydrochloride. Your doctor may prescribe this for relief of nasal congestion. Side effects reported are anxiety, tremor, rapid pulse, and headache. The preparation does not contain antihistamines, which could sedate and cause drowsiness, but it can nevertheless affect skilled performance. Sudafed or similar medications, therefore, should not be taken when making maintenance decisions or performing safety critical tasks.

Medication and Drugs -

Although these are common groups of drugs, which may have adverse effects on performance, it should be pointed out that many forms of medication, which although not usually expected to affect efficiency, may do so if the person concerned is unduly sensitive to a particular drug. Therefore no drugs or medicines, or combinations, should be taken before or during duty unless the taker is completely familiar with the personal effects of the medication and the drugs or medicines have been medically prescribed for the individual alone.

9.5 PHYSICAL ENVIRONMENT

Aviation maintenance has many features in common with other industries. The physical facilities in which aircraft maintenance engineer work, however, are unique. The aircraft maintenance engineer can expect to work in a variety of different environments, from 'line' (generally outside the hangar) to 'base' (usually inside a hangar or workshop), in all types of weather and climatic conditions, day and night. No other industry uses quite the combination of facilities, including exposed aprons, aircraft hangars, workshops, offices, inspection rooms, etc. The primary reason for using hangars is obvious, of course. Aviation maintenance technicians work on aircraft, and hangars are often needed to shelter aircraft and workers from the elements for certain maintenance activities.

Aircraft hangars present a range of human factors issues. They are generally quite large and are built so that most of the floor area is unobstructed by structural support members. This design allows large aircraft to be moved and parked in the building. Their vast areas and high ceilings make hangars difficult to light properly. Their large, unobstructed volume makes public address systems difficult to hear. Large, open doors make controlling temperature and humidity problematic. The use of extensive and elevated, multi-level access platforms is common due to the sizes of today's aircraft and the varying heights of component locations. Access requirements vary according to the nature of the work being carried out. In some cases, the close proximity of different pieces of equipment to each other brings its own problems. Individual workspaces tend to be clustered around certain areas of the aircraft, e.g. undercarriage bays and engines.

9.5.1 NOISE

Noise can be thought of as any unwanted sound, especially if it is loud, unpleasant, and annoying. Noise in the workplace can have both short term and long-term negative effects: it can be annoying, can interfere with verbal communication and mask warnings, and can damage workers' hearing (either temporarily or permanently). The ear is sensitive to sounds between certain frequencies (20 HZ to 20 KHz). The intensity of sound is measured in decibels (dB), where exposure in excess of 115 dB without ear protection even for a short duration is not recommended. This equates to standing within several hundred feet of a moving jet aircraft.

General background noise can be 'filtered out' by the brain through focused attention. For more problematic noise, some form of hearing protection (e.g. ear plugs and earmuffs), is commonly used by technicians, both on the line and in the hangar to help with concentration. The noise environment can vary considerably. For instance, the airport ramp or apron area is clearly noisy, due to running aircraft engines or auxiliary power units (APUs), moving vehicles and so on. It is not unusual for this to exceed 85 dB - 90 dB which can cause hearing damage if the time of exposure is prolonged. The hangar area can also be noisy, usually due to the use of various tools during aircraft maintenance.

It is very important that Aircraft Maintenance Engineers (AMEs) remain aware of the extent of the noise. Some form of hearing protection should be carried at all times and used when remaining in an area where normal speech cannot be heard clearly at 2 yards.

Select appropriate hearing protection devices

Hearing Protection Devices (HPD) include earmuffs that cover the ear, ear plugs that insert into the ear canal and canal caps which cover the entrance to the ear canal.

9.5.2 FUMES, CHEMICALS, TOXIC METALS AND SOLVENTS

Fumes

Maintenance of aircraft involves working on a variety of systems. It involves working with a variety of hydraulic fluids, paints, cleaning compounds, and solvents. Other chemical compound and gases are to be found in greases, protective coatings, lubricants or aircraft components themselves. Where any chemical compound is involved it is likely that, at some time, fumes will be produced. For some substances, fumes will always be detectable, e.g. fuel, hydraulic oil. For others it may require a particular set of circumstances to produce fumes, e.g. overheated grease or oils, smoldering insulation. Chemicals in isolation may be relatively harmless but in combination with others may give rise to fumes, which may even be toxic by nature.

Gasoline engine exhaust (Carbon monoxide)

Carbon Monoxide (CO) is both odourless and colourless. Symptoms of CO exposure are not immediately apparent, but no matter how small, any amount of exposure severely affects the function of sensitive tissues like the brain.

Moderate CO poisoning results in headache, rapid breathing, nausea, weakness, confusion, and discoloration of the lips and nail beds. High exposures result in the loss of consciousness without other symptoms. Headache, nausea and vomiting start with lower exposures; while confusion and collapse, followed by death may occur with high exposure.

Survivors of CO poisoning often show delayed effects, the most frequently reported symptoms are mental deterioration including apathy, disorientation, amnesia, and irritability. Other symptoms include mood disorders, unusual behaviors, irrational speech content, and gait movement disorders.

Kerosene based fuel

Kerosene based fuels include jet and diesel fuels.

Respiratory exposures to jet fuel are low for most AMEs, but symptoms include:

- Transient memory deficit (difficulty recalling even common items such as your phone number)
- Disturbances in consciousness (slow thinking, sense of drunkenness, lightheaded, slurring words)
- Irritation to eyes and nose (sneezing, runny nose)
- Nausea and vomiting
- Headache
- Staggering

Symptoms can persist for a time, but no published reports describe human deaths associated with a single jet fuel exposure.
Skin Absorption symptoms such as:
Erythema – reddening of the skin
Eczema – scaling and flaking of the skin
Dermatitis – thinning of the skin with redness and inflammation

Common sense strategies to reduce exposure to fuels are:

Skin

- Use impervious gloves
- Wipe hands clean of fuel
- Wash with a good quality nonabrasive soap
- Do not wash your skin with another solvent

Lungs/respiration

- Ventilate room
- Use air supplied respirator

Clothing

- Change clothing as soon as possible
- Separate soiled clothing from household laundry
- Wash soiled clothing as soon as possible

Toxic metals

Toxic metals include antimony, arsenic, barium, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, and thallium.

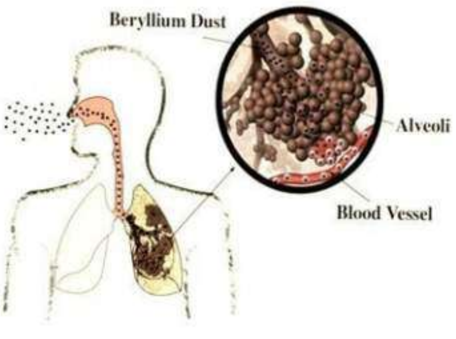
Cadmium

In 1989 the Atlanta, Georgia office of the Occupational Safety and Health Administration (OSHA) had just inspected the landing gear shop of Eastern Airlines. Due to unventilated grinding activities, employees had exposures up to eighty-five times the ceiling level for cadmium. Inhalation of cadmium has both acute and chronic effects. Acute effects following inhalation from welding fumes or dust from grinding causes Metal Fume Fever (MFF). Within one day of exposure the AMT develops chills, a fever, shortness of breath, and tiredness. The symptoms look like a viral infection but actually represent a lung reaction. Fortunately, the symptoms of MFF resolve after two days, but severe exposures may progress to more serious disease. At this stage hospitalization is essential.

Chronic low-level exposure to cadmium may not immediately produce MFF, but the metal still passes through the lungs into the blood. The red blood cells carry the metal to the liver, kidney, and muscles.

Beryllium

Beryllium, unlike aluminum, is not commonly associated with aircraft. Exposure to beryllium seems unlikely, but review of exposure inspections indicates otherwise. This alloy is present in landing gear bushings and bearing sleeves on aircraft such as the B737. Beryllium exposure is possible even when the metal is a small component of the aircraft.



Beryllium targets the lungs, lymph nodes, and skin either directly or by effecting the immune system. Direct toxicity results from breathing beryllium dust or by skin injuries from handling the ores or metal. The result is pneumonia or dermatitis. Treatment involves removing the individual from the exposure. Few will experience the direct toxicity of this metal. But unlike other metals, Chronic Beryllium Disease (CBD) can develop years after exposure has ceased.

Preventative actions for toxic metal exposure

- Substitute a less toxic material for the one in use. (For most AMEs this is not practical).
- Implement controls such as local exhaust ventilation to control dust and fumes.
- Do not eat or drink in the workplace.
- Use proper respirators, protective eyewear, and coveralls.
-

Paints and primers

Painting can cause a condition known as Occupational Asthma (OA). The culprit is a chemical called diisocyanates which is found in some paints.

Spray painting produces finely atomized particles of paint in the air (over spray), which does not adhere to the object being sprayed. Breathing brings these particles into the lung. The chemicals (diisocyanates) enter the lungs and combines with other proteins forming heavy molecules that affect the body's immune system. The body is now sensitized, but symptoms do not occur, and blood tests do not record any change. In other words, there is no evidence of any symptoms or disease. The next time a painter is exposed (weeks, months, or even years), the immune system recognizes the molecule and produces a variety of chemicals that cause an inflammatory reaction. The result is occupational asthma

Personal protective equipment (PPE) is the last step to protect from exposures. Some examples of protective equipment are:

Negative Pressure Respirators – for use with primers, dopes and water-based paints
Positive Pressure Air Line Respirator – for use with paints containing diisocyanates
Covering – Tyvek spraying suit with gloves
Goggles – When mixing and spraying

Hydraulic fluids

Phosphate ester based hydraulic fluids used in ground equipment and aircraft are available under the trade names Skydrol and Hyjet.

Skydrol is fire resistant hydraulic fluid with a flash point that is much higher than other petroleum-based fluid. Passenger airline aircraft must use the fire-resistant fluid, while military and general aviation aircraft can use red oil.

Exposure to Skydrol produces a burning sensation in the eyes and skin. Eye exposure occurs when a geyser of fluid erupts after opening a hydraulic line that is still under pressure. After eye exposure, first aid involves flushing the eye with water.

What are solvents?

Solvents are liquids or gases that can dissolve or extract other substances. They are used to dissolve grease, oil, and paint; to thin or mix pigments, paint, glue, and epoxy resins; to clean electronics, airplane parts, tools, and engines; and to make other chemicals.

In general, solvents can irritate and damage the skin, eyes, and respiratory system. They cause a narcotic effect on the nervous system and damage internal organs such as the liver and kidneys. These kinds of damage can be acute (from single heavy exposures) or chronic (from repeated low dose exposures over months or years). In addition, some solvents are especially hazardous to specific organs or can cause specific diseases such as cancer.

9.5.3 **ILLUMINATION**

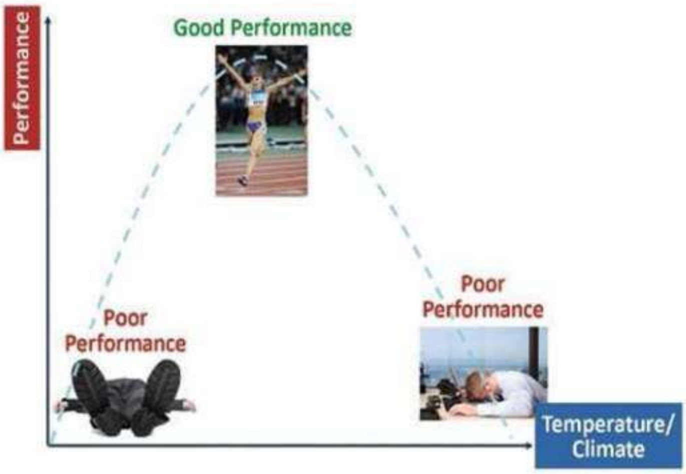
Illumination refers to the lighting both within the general working environment and also in the locality of the engineer and the task he is carrying out. It can be defined as the amount of light striking a surface.

When working outside during daylight, the engineer may have sufficient natural light to see well by. It is possible however that he may be in shadow (possibly caused by the aircraft) or a building. Similarly, cramped equipment compartments will not be illuminated by ambient hangar lighting. In these cases, additional local artificial lighting is usually required (known as task lighting).

At night, aerodromes may appear to be awash with floodlights and other aerodrome lighting, but these are unlikely to provide sufficient illumination for an engineer to be able to see what he is doing when working on an aircraft. These lights are not designed and placed for this purpose. Again, additional local artificial lighting is needed, which may be nothing more than a good torch (i.e. one which does not have a dark area in the centre of the beam). However, the drawback of a torch, is that it leaves the engineer with only one hand available with which to work. A light mounted on a headband gets round this problem.

The type of lighting used can also affect colour perception, various type of lighting strengthening some colors but subduing others. This may not be overly important for aircraft exterior maintenance tasks but may be relevant for visual discrimination between different coloured wiring, or other work where colour differences are important.

9.5.4 CLIMATE AND TEMPERATURE



Humans can operate within quite a wide range of temperatures and climatic conditions; but performance is adversely affected at extremes and is best within a fairly narrow range of conditions. Although this text refers mainly to maintenance carried out in hangars, it is realized that some work must take place outside hangars, often in extreme heat, cold, wind, snow, rain or humidity. This may be unavoidable, but engineers and managers should be aware of the effects of extremes in temperature and climatic conditions upon their performance, both within and outside the hangar.

Human Performance at various temperatures		
Temperature (°F) /	(°C):	Performance Effect:
90	32	Upper limit for performance
80	28	Maximum acceptable upper limit
75	25	Optimum with minimal clothing
70	21	Optimum for typical clothing and tasks
65	18	Optimum for winter clothing
60	15	Hand and finger dexterity begins to deteriorate
55	12	Hand dexterity reduced by 50%

On summer days the structure of the airplane can magnify heat and its effects. Environmental factors that influence the body's heat load include the ambient temperature, radiant heat, and air velocity. Hot tarmacs will also radiate heat.

Small work areas within the fuselage, wing area, and other structures create a microenvironment much different from the outside. Taken to extremes, this heat load can kill.

The body's response to heat

To function efficiently, the body needs a stable internal temperature which is a balance between heat production and loss. Under normal circumstances 65% of the body's heat loss is by passive transfer (radiation) and 20% by evaporation. Passive heat loss is entirely sufficient to remove this heat load, and the body's temperature remains constant.

The body's primary defense against overheating is sweating which produces heat loss through evaporation. Simultaneously, vessels in the skin dilate to bring more blood from the inner body to the skin; the effect is similar to a radiator. Dilation and evaporation can prevent the elevation of the body's core temperature.

As temperature increases, both radiation and evaporation become less effective. With temperatures exceeding 99°F, (37.2° C) the body gains radiant heat from the environment. At 100% humidity, evaporation is ineffective. High humidity occurs not only because of climatic changes, but when clothes absorb sweat and prevent evaporation. Under these circumstances, it is difficult to maintain a stable body temperature.

Heat stress and major disorders

Five major disorders arise from excessive heat exposure. The first and most serious is heat stroke. Fortunately, aviation maintenance activities rarely lead to heat stroke. Closely related to heat stroke is heat exhaustion, caused by prolonged exposure to heat without adequate salt and water intake. Thirst, nausea, weakness, and confusion are common symptoms. Treatment usually involves intravenous hydration. One day in the hospital should be expected because without proper treatment heat exhaustion can lead to stroke.

The other three disorders, heat cramps, heat syncope, and heat rash are less serious but more common.

Heat cramps are painful muscle spasms that occur after performing strenuous activities and create severe spasms (lasting one to three minutes) among the muscles employed. While the skin is moist and cool, the underlying muscles feel like hard stony lumps. Treatment requires moving to a cool environment and drinking a salt solution. Drinking commercially available electrolyte replacement liquids is effective in replenishing the lost sodium that causes the cramps. It is advised to miss one to three days of work after such an event.

Heat syncope e is the sudden loss of consciousness due to dilation of blood vessels in the skin, but does not involve the loss of blood flow to the brain that occurs in heat stroke. The skin is cool and moist and the pulse is weak, with a systolic blood pressure of less than 100mm HG. Treatment involves moving the victim to a cool environment and having him/her lie down. In this reclined position, the victim of heat syncope rapidly regains consciousness and can take liquids by mouth. It is advised to miss one day of work following such an event.

Heat rash, commonly called prickly heat, is a common skin problem in hot environments. Manifestation of heat rash are red papules which usually appear in the trunk and groin (not the palms and soles) where sweat cannot evaporate. The papules itch and can become infected. Treatment involves reducing sweat production by moving to cool environments, where the person should remain for about one week.

Heat Index (HI) is the temperature that the body feels when heat and humidity combine. The HI is a good predictor of when heat stress will produce a heat related illness

Working in the cold

The popular concept is that aviation people work in warm, comfortable hangars. In fact, hangars are poorly heated and draughty, and repairs are sometimes outside on the flight line. Add the chilly winds of winter and conditions are ideal for producing adverse effects on the body. The medical term for low body temperature is hypothermia. Hypothermia is a medical emergency that occurs when your body loses heat faster than it can produce heat, causing a dangerously low body temperature. Since normal body temperature is 98.6 °F (37°C) and outside temperatures usually are lower, hypothermia is a relative term. Hypothermia can occur at temperatures above freezing. It is evident that cold (or cool) airplanes set the stage for hypothermia.

The body's response to cold

To function effectively, the body's metabolic processes maintain a constant temperature of approximately 98.6 °F (37°F) with minor variation. Heat loss originates from three processes. The first is evaporation of sweat, causing cooling. The second is conductive heat loss, or the transfer of heat from a warm object (the hand) to a cold object (a tool). The third source of heat loss is convection, also known as wind chill. Protecting against the cold involves limiting the loss of body heat by these processes.

The body's first response to heat loss is generation of more heat through a violent and uncontrolled muscle contraction called shivering. This sign is an early indication of heat loss. As body temperature continues to drop, the shivering becomes less violent and eventually stops. The next response is constriction of the blood vessels, called vasoconstriction which reduces blood flow to the extremities. The net effect is the shunting of blood from the extremities, such as the fingers and toes, to the warmer organs of the body's core. A significant temperature difference now exists between the extremities and the core.

The physiological response to cold results in observable symptoms most notably in the fingers and toes. Vasoconstriction results in redness, or in some areas paleness. Prolonged cold exposure can result in an extremity becoming swollen or blistered, forcing movement to become clumsy. Sloughing and scaling of skin in the exposed area occurs with numbness and tingling.

In the extreme situation, continued loss of heat can be greater than the body's ability to replace it. Not only are the extremities cold, but core temperature begins to drop. Heart rate slows down, reducing distribution of warm body fluids to tissues, and the extremities become numb. When ambient temperatures are below freezing, frostbite (actual freezing of tissues) starts at the tip of the nose or fingers. Tissue injury becomes irreversible, and eventual death results from cardiac arrest.

9.5.5 MOTION AND VIBRATION

Aircraft maintenance engineers often make use of staging and mobile access platforms to reach various parts of an aircraft. As these get higher, they tend to become less stable. For example, when working at height on a scissors platform or „cherry picker", applying force to a bolt being fixed to the aircraft may cause the platform to move away from the aircraft. The extent to which this occurs does not just depend on the height of the platform, but its design and serviceability. Any sensation of unsteadiness may distract an engineer, as he may concentrate more on keeping his balance than the task. Furthermore, it is vitally important that engineers use mobile access platforms properly in order to avoid serious injury.

Vibration in aircraft maintenance engineering is usually associated with the use of rotating or percussive tools and ancillary equipment, such as generators. Low frequency noise, such as that associated with aircraft engines, can also cause vibration. Vibration between 0.5 Hz to 20 Hz is most problematic, as the human body absorbs most of the vibratory energy in this range. The range between 50-150 Hz is most troublesome for the hand and is associated with Vibratory-induced White Finger Syndrome (VWF). Pneumatic tools can produce troublesome vibrations in this range and frequent use can lead to reduced local blood flow and pain associated with VWF. Vibration can be annoying, possibly disrupting an engineer's concentration.

9.5.5 WORKING ENVIRONMENT

Various factors that impinge upon the engineer's physical working environment have been highlighted in this chapter. Apart from those already discussed, other physical influences include:

- Workplace layout and the cleanliness and general tidiness of the workplace (e.g. storage facilities for tools, manuals and information, a means of checking that all tools have been retrieved from the aircraft, etc.);
- The proper provision and use of safety equipment and signage (such as non-slip surfaces, safety harnesses.);
- The storage and use of toxic chemical and fluids (as distinct from fumes) (e.g. avoiding confusion between similar looking canisters and containers by clear labelling or storage in different locations,etc.).

To some extent, some or all of the factors associated with the engineer's workplace may affect his ability to work safely and efficiently. EASA Part-145.25(c) - Facility Requirements states:

"The working environment must be appropriate for the task carried out and in particular special requirements observed. Unless otherwise dictated by the particular task environment, the working environment must be such that the effectiveness of personnel is not impaired."

Confined Spaces

The entry of personnel into any space, with limited means of entry or exit, which is not intended for normal use or designed for continuous occupancy, needs to be managed, e.g. fuel tank access. Such activities will benefit from the availability of written control procedures, prior safety training and the possession of adequate and appropriate safety equipment. These should address the likely risks to be encountered. For example, attaching only a safety rope to someone is no good if there is likelihood that they will be overcome with fumes in any case.

Using breathing apparatus could well prevent the need for the rope to be used. Some confined spaces have other hazards present, such as toxic gases or fumes, electricity, machinery, etc. A recent report delineated the risks associated with fuel cell repair as an example. Confined spaces are considered inherently hazardous even without being associated with other hazards.

Anyone entering a confined space should:

- Receive appropriate training in entering such spaces and in using any safety equipment.
- Secure a written entry permit before entering the space if it contains any hazards that could cause death or serious physical harm.
- Test the space for sufficient oxygen and for dangerous gases or vapours.
- Ventilate the space before and during entry.
- Lock out any connecting lines.
- Have the appropriate safety equipment and trained assistance present during entry.

9.6 TASKS

9.6.1 PLANNING

Most aircraft maintenance involves replacing and repairing unserviceable parts, AMEs cannot always plan for every situation, but most activities do involve prior knowledge so that parts, materials, tools and other equipment can be prearranged before the task is started.

Planning is critical to making good decisions. It ensures there are qualified personnel, tools, equipment, material, maintenance data, and facilities at the right place, at the right time, for the scheduled and, (as much as possible) unscheduled tasks.

Planning should therefore include having knowledge about what relevant resources are available in case they are required. Decisions made in a maintenance environment may be influenced by access to replacement parts and support equipment, or at least being able to obtain them in a timely manner.

AMEs sometimes find that a part may need further attention but may decide to defer it if they knew a replacement is not readily available.

Sometimes AMEs may find themselves in a situation where task completion is perceived as the prime objective, but a lack of required supporting data, facilities, tooling, and equipment may mean it is not possible to complete the task by the book. In these situations, violations or workaround are more likely to occur particularly when the manufacturers' required spares are not available to perform the task. Routine violations may become the norm within an organization, or even the habits of an individual, usually because people believe that the rules are too rigid or unnecessary. These routine violations typically occur during the performance of simple maintenance tasks.

9.6.2 **PHYSICAL WORK**

People vary in the strength they can bring to bear on a task; they also differ in their capacities to perform different types of work over time. Many studies have attempted to describe the acceptable range of energy usage over different periods of time and in different environments. As with other basic physical variables, one's ability to perform work is affected by a number of different factors.

From a biomechanical perspective, the human body is a series of physical links (bones) connected at certain points (joints) that allow various movements. Muscles provide the motive force for all movements, both fine and gross. This is known as the musculoskeletal system. The force that can be applied in any given posture is dependent on the strength available from muscles and the mechanical advantage provided by the relative positions of the load, muscle connections, and joints.

As the AME gets older the musculoskeletal system stiffens and muscles become weaker, injuries become more likely and take longer to heal. Obesity limits the physical spaces that can be accessed. Staying in shape will minimize the effects of aging and can help make sure that normal weight can be maintained.

Excessive physical work over a period can result in fatigue. Fatigue generated as a result of physical effort is normally not a problem if there is adequate rest and recovery time between work periods. It can, however, become a problem if the body is not allowed to recover, possibly leading to illness or injuries.

9.6.3 **REPETITIVE TASKS**

Repetitive tasks in aircraft maintenance engineering typically refer to tasks that are performed several times during a shift, or a number of times during a short time period, e.g. in the course of a week. An example of this would be the checking life jackets on an aircraft during daily inspections

The main danger is that engineers may become so practiced at such tasks that they may cease to consult the manual or to use work cards and, if something about the tasks is changed, the engineer may not be aware of the change. complacency is also a danger that an engineer may skip steps or fail to give due attention to steps in the procedure, especially if it is to check something which is rarely found to be wrong, damaged or out of tolerance. This applies particularly to visual inspection.

Repetitive tasks, such as the detailed inspections of rivets along a lap joint, are tedious, boring and lead to errors being made (missed defects).

9.6.4 VISUAL INSPECTION

Visual inspection can be described as the process of using the eye, alone or in conjunction with various aids to examine and evaluate the condition of systems or components of an aircraft.

AMEs may use magnifiers and boroscopes to enhance their visual capabilities. Visual inspection may be assisted by examining the element using other senses (touch, hearing, smell, etc.). Also manipulating the element being inspected helps to make further judgments about its condition. For instance, feeling a surface for unevenness, or pushing against an object to look for any unanticipated movement.

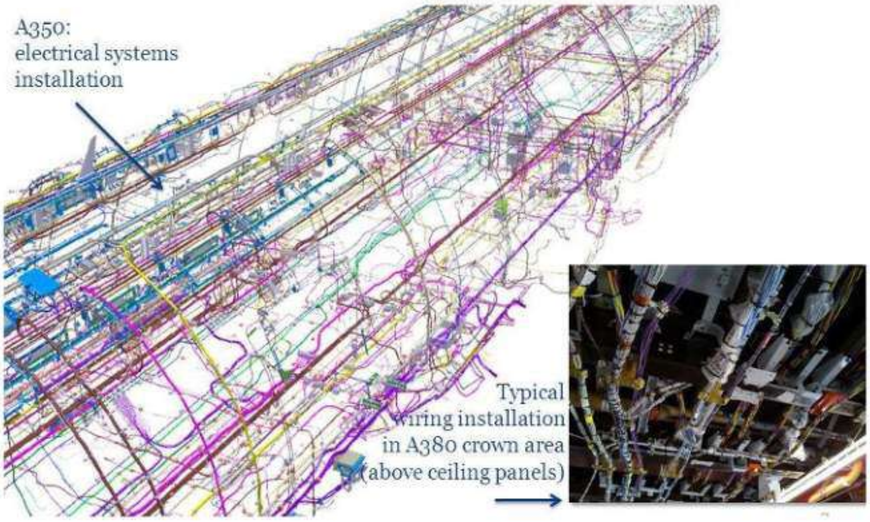
Visual inspection requires a considerable amount of concentration. Long spells of continuous inspection can be tedious and result in low arousal. An engineer's low arousal or lack of motivation can contribute to a failure to spot a potential problem or a failure in recognising a defect during visual inspection. The effects are potentially worse when an inspector has a very low expectation of finding a defect, e.g. on a new aircraft.

Good eyesight is of prime importance in visual inspection. This calls for glasses or contact lenses to be used where prescribed and regular eyesight checks to be scheduled. It is however one of the primary methods employed during maintenance to ensure the aircraft remains in an airworthy condition. The majority of inspection is visual (80% to 99%, depending on circumstances); 1% to 20% is Non-Destructive Testing (NDT).

Non-destructive Testing (NDT) includes an element of visual inspection, but usually permits detection of defects below visual thresholds. Various specialist tools are used for this purpose, such as the use of eddy currents and fluorescent penetrant inspection (FPI).

9.6.4 COMPLEX SYSTEMS

The main difference between simple systems and complex systems, from a maintenance point of view, is that the degree of complexity of the latter, and the interface between systems, is such that it is not (usually) possible for one person to have the knowledge and skills to maintain the system without support. This support may be achieved by distributing the workload among individuals or specialists who have an expertise in a particular trade discipline.



Alternatively it may be provided by the manufacturer in the form of well defined, comprehensive and prescriptive maintenance manuals and documentation.

With complex systems and aircraft, written procedures become more important as a source of reference rather than just as a reminder.

The reference material may describe comprehensively the method of performing maintenance tasks, the related tasks, inspections, adjustments and tests, the relationship to other systems and often, most importantly, provide cautions or bring attention to specific areas of design or criticality. As a result of the complexity, the system has to be broken down, conceptually or even physically, into smaller parts which one person, or a small group of people, can work upon. It is vital to ensure that all the separated activities occur in concert and that dependencies are addressed.

A single modern aircraft is complex enough, but many engineers are qualified on several types and variants of aircraft. If an engineer works on several different types of aircraft, this will usually mean that he has less time to become familiar with one type, making it even more important that he sticks to the prescribed procedures and refers to the manual wherever necessary. There is a particular vulnerability where tasks are very similar between two different aircraft (e.g. spoiler systems on the A320, B757 and B767), and may be more easily confused if no reference is made to the manual. Continuation or refresher training is important to keep this knowledge topped up.

9.7 COMMUNICATION

Communication can be defined as achieving shared meaning, and to be effective requires four elements working together.

The individual sending the message must present that message clearly, with the necessary detail, and should have credibility.

The person receiving the message must be prepared to, and decide to, listen, ask questions if they do not understand something, and trust the person sending the message.

The delivery method chosen must suit the circumstances and needs of both sender and receiver.

The content of the message must resonate and connection some level with the already held beliefs of the receiver.

If communication is to be effective, therefore, it must be worked upon and refined.

9.7.1 MODES OF COMMUNICATION

We are communicating almost constantly, whether consciously or otherwise. An aircraft maintenance engineer might regularly communicate:

- information.
- ideas.
- feelings.
- attitudes and beliefs

As the sender of a message, he will typically expect some kind of response from the person he is communicating with (the recipient), which could range from a simple acknowledgement that his message has been received (and hopefully understood), to a considered and detailed reply. The response constitutes feedback.

As can be seen in the above definition, communication can be:
- verbal/spoken - e.g. a single word, a phrase or sentence, grunt.
- written/textual - e.g. printed documents, words and/or numbers on paper or on a screen, handwritten notes;
- non-verbal - gestures, facial expressions, tone of voice, and body language.

Physical cues

Maintenance also relies on physical cues to communicate information between maintenance personnel and to pilots. Some objects such as placards, tags or streamers attached to lockout pins have been designed specifically to communicate information.

As noted in previous chapters, aircraft maintenance engineers often work as teams. Individuals within teams exchange information and need to receive instructions, guidance, etc. Moreover, one team will have to pass on tasks to another team at shift handover. An engineer needs a good understanding of the various processes of communication, as without this, it is impossible to appreciate how communication can go wrong

9.7.2 WITHIN AND BETWEEN TEAMS

Effective communication is a complex process. Some have simplistically summarized the process in these four steps:

1. Someone transmits information.
2. Someone else receives that information.
3. That receiver understands the information, and finally.
4. Confirms to the transmitter that they have received, and understood, the information.

For maintenance teams to work effectively, anyone passing on information to the team needs to ensure that the individual team members understand the meaning and context of what is being conveyed.

Regular, effective communication is vital to forming and maintaining a shared mental model and ensuring everyone is on the same page. Good communication is also necessary for maintaining a high level of situational awareness—and having high levels of situational awareness will help teams to be more effective.

Communication between teams usually occurs at shift handover. The information conveyed usually includes:

- Tasks that have been completed.
- Tasks in progress.
- Tasks to be carried out.

Communication between teams will involve passing on written reports of tasks from one shift supervisor and, where appropriate, individuals. This means that, wherever necessary, outgoing personnel personally brief their incoming replacements. The written reports (maintenance cards, procedures, work orders, logs, etc.) and placards provide a record of work completed and yet to be completed and they provide traceability. Communication during shift handover provides continuity.

Shift handover

During shift change, the need for effective communication between the outgoing and incoming personnel in maintenance is extremely important. The absence of such effective communication has been evident in many accident reports from various industries, not just aircraft maintenance.

Effective shift handover depends on three basic elements:

The outgoing person's ability to understand and communicate the important elements of the job or task being passed over to the incoming person.

The incoming person's ability to understand and assimilate the information being provided by the outgoing person.

A formalized process for exchanging information between outgoing and incoming people and a place for such exchanges to take place.

Aids to effective communication at shift handover

There are certain processes, practices and skills aids that have been found to be effective communication at shift handover.

People have to physically transmit information in written, spoken or gestured (nonverbal or body language) form. If only one medium is used there is a risk of erroneous transmission. The introduction of redundancy, by using more than one way of communicating i.e. written, verbal or nonverbal, greatly reduces this risk.

For this reason, information should be repeated via more than one medium. For example, verbal and one other method such as written or diagrams etc.

The availability of feedback, to allow testing of comprehension etc. during communication increases the accuracy. The ability for two-way communication to take place is therefore important at shift handover

A part of the shift handover process is to facilitate the formulation of a shared mental model of the maintenance system, aircraft configuration, tasks in work etc. This is particularly true when deviations from normal working has occurred such as having the aircraft in the flight mode at a point in a maintenance check when this is not normally done.

Other considerations are when people have returned following a lengthy absence (the state of things could have changed considerably during this time) and when handovers are carried out between experienced and inexperienced personnel (experienced people may make assumptions about their knowledge that may not be true of inexperienced people). In all these cases handovers can be expected to take longer and time should be allowed for.

Written communication is helped by the design of the documents, such as the handover log, which consider the information needs of those people who are expected to use it.

Barriers to effective communication at shift handover

Key information can be lost if the message also contains irrelevant, unwanted information. We also only have a limited capability to absorb and process what is being communicated to us. It is important that only key information is presented, and irrelevant information excluded.

The language we use in everyday life is inherently ambiguous. Effort, therefore, needs to be expended to reduce ambiguity by:

- Carefully specifying the information to be communicated e.g. by specifying the actual component, tooling or document,
- Facilitating two-way communication which permits clarification of any ambiguity (e.g. do you mean the inboard or out board wing flap?)

To identify, minimize and repair misunderstandings communication has to be two way, with both participants taking responsibility for achieving full and accurate communication

Basic rules of thumb to help aircraft maintenance engineers minimize poor communication are:

• think about what you want to say before speaking or writing.
• speak or write clearly.
• listen or read carefully.
• seek clarification wherever necessary.

Four ways to improve shift handover

Following recommendations to improve handovers:

1. Use the handover as a chance to catch errors, not just communicate information. Critically check the work of the previous shift.
2. Improve shift handover documentation. In some cases, there is a reluctance to produce written records beyond the minimum requirements. However, temporary sources of information such as whiteboards can still be an important source of task handover information.
3. Have direct verbal briefings between incoming and outgoing technicians. Face-to-face handovers are standard operating procedure in many high-risk industries such as nuclear power, offshore oil and air traffic control.
4. Communicate 'next steps,' not just 'work accomplished'. A good handover not only covers the work that has been accomplished, but also captures problems, possible solutions and future intentions.

9.7.3 **WORK LOGGING AND RECORDING**

This is one of the most critical aspects of communication within aviation maintenance, since inadequate logging or recording of work has been cited as a contributor to several incidents.

Even if AMEs think they are going to complete a job, it is always necessary to keep the record of work up to date just in case the job has to be handed over.

Scheduled task cards

The paperwork normally associated with scheduled tasks are the task cards that are issued at the beginning of the maintenance input. These may have been written by the manufacturer, maintenance organization or the operator of the aircraft. In all cases associated task breakdown is written on the card and assumes that the same person will start and finish the job. It was not designed to be used as a handover document.

Task cards break down jobs into discrete stages, and ideally jobs should always be stopped at one of these stages so that the last sign off on the card is the exact stage of the job reached. In this case the card is the handover. However, a job is sometimes stopped at a point which is between the stages identified on the card, the stage sequencing has not been followed, or a deviation from normal working has occurred. When this occurs, additional written information must be used to clearly identify the point of exit from the task and what is required to complete the job and restore serviceability. Non routine cards or sheets should then be used to record and transmit the relevant information necessary

GO FAST AIRWAYS			
A/C type: B737 MP ref: MS/B737/668 Aircraft Reg: G-OFST			
Flight Controls			
Additional work card raised: Yes/NO			
27-00-56	Flap synchronizing system	Mechanic	Inspector
	a) Check the cable tensions are correct (mm 27-50-02)	B Bloggs	T. Stamp
	b) With the flaps selected up, disconnect the operating link from one transmitter gearbox only.	B Bloggs	T. Stamp
	c) Pressurize the hydraulic system and select flaps down	B Bloggs	T. Stamp
	d) Make sure that the flaps start to move and then the system cuts out.	B Bloggs	T. Stamp
	e) Depressurize the hydraulic system and connect the transmitter operating link.		
	f) Pressurize the hydraulic system and make sure that the flaps operate correctly.		

Typical Task Card

Non-scheduled tasks

Complex or lengthy nonscheduled tasks should always be broken down into a number of discrete steps using stage or process sheets (the terminology will vary from one company to another). Many incidents have occurred when people have started a straightforward job but had to exit the task part way through without anybody to handover the task to. These situations by their nature are unplanned and are normally associated with time pressure or emergency situations. It is vital that time is taken by the person leaving the job to comprehensively record what activities have taken place and what is required to complete the job. This would be recorded on stage sheets and should emphasize any deviations from the normal or expected way of working. Management and supervisors have a responsibility to ensure that adequate time is given to maintenance staff to record their work if they require tasks to be suspended for any reason.

9.7.4 KEEPING UP-TO-DATE, CURRENCY

Aircraft maintenance engineers undertake an approved course to obtain the knowledge and basic skills to enter the profession. This training is followed by instruction in more specific areas, such as maintenance of individual aircraft and specific systems However, the aviation industry is dynamic: operators change their aircraft, new aircraft types and variants are introduced, new aircraft maintenance practices are introduced. As a consequence, the engineer needs to keep his knowledge and skills up to date.

To maintain his currency, he must keep abreast of pertinent information relating to:

- new aircraft types or variants;
- new technologies and new aircraft systems;
- new tools and maintenance practices;
- modifications to current aircraft and systems he works on;
- revised maintenance procedures and practices.

Engineers are likely to keep up to date by:

- undertaking update courses;
- reading briefing material, memos and bulletins;
- studying maintenance manual amendments

Responsibility for maintaining currency lies with both the individual engineer and the maintenance organisation for which he works. The engineer should make it his business to keep up to date with changes in his profession (remembering that making assumptions can be dangerous). The organisation should provide the appropriate training and allow their staffs time to undertake the training before working on a new aircraft type or variant. It should also make written information easily accessible to engineers and encourage them to read it. It is, of course, vital that those producing the information make it easy for engineers to understand (i.e. avoid ambiguity).

9.7.4 DISSEMINATION OF INFORMATION

Good dissemination of information within an organisation forms part of its safety culture. Typically, the maintenance organisation will be the sender and the individual engineer will be the recipient.

Part of this process should be checking that all information relating to the task has been gathered and understood. This includes checking to see if there is any information highlighting a change associated with the task (e.g. the way something should be done, the tools to be used, the components or parts involved).

It is imperative that engineers working remotely from the engineering base (e.g. on the line) familiarize themselves with new information (on notice boards, in maintenance manuals, etc.) on a regular basis.

There should normally be someone within the maintenance organisation with the responsibility for disseminating information. Supervisors can play an important role by ensuring that the engineers within their team have seen and understood any communicated information.

Poor dissemination of information was judged to have been a contributory factor to many accidents.

Tips for improving communication and avoiding errors

When you are the sender:

- Provide information as required;
- Deliver information clearly and concisely;
- Verbalize plans—surprises belong at birthday parties, not in hangars;
- Use appropriate non verbal communication;
- Provide relevant information without being asked;
- Ask for confirmation that message is understood ("what did you hear me say").

When you are the receiver:

- Be an active listener;
- Acknowledge and repeat information as required;
- Paraphrase what you have heard ("repeat what I heard");
- Pay attention to non verbal as well as verbal communication;
- Clarify uncertainties, ask questions as necessary;
- Provide useful feedback.

Both sender and receiver

- Never assume;
- Don't let the conversation end with unresolved ambiguities;
- If a disagreement exists, take the most conservative action until more information is available.

9.8 **HUMAN ERROR**

It has long been acknowledged that human performance is at times imperfect. Nearly two thousand years ago, the Roman philosopher Cicero cautioned "It is the nature of man to err". It is an unequivocal fact that whenever men and women are involved in an activity, human error will occur at some point.

Human error can be seen as a natural threat that must be managed in the same way. An understanding of the risk factors for human error can help us reduce its frequency. We can also take appropriate precautions to limit its effects. The one difference is that unlike hazards in nature, human error is a constantly

evolving threat, as it stems from human beings' infinite adaptability and capabilities. The maintenance errors that occur this year, with current procedures and equipment, may be different than those that will occur next year. The solutions that work today may need to be revised and updated to continue to work in 12 months' time.

Errors may be buried deep inside aircraft systems. Once maintenance is complete and the aircraft is returned to service, the chances of detecting the error before the next scheduled maintenance may be slight.

Errors can lie dormant for months or even years before causing a problem. A loosely secured nut may take months to vibrate free, and a fatigue crack caused by improper maintenance may grow slowly over years.

Given the high probability of human error, it is remarkable that relatively few serious maintenance errors occur each year. Credit is due to the systems in place and the professionalism of maintenance personnel. Nevertheless, industries that rely on accurate and consistent human performance must be designed to deal with the inevitability of human error.

9.8.1 ERROR MODELS AND THEORIES

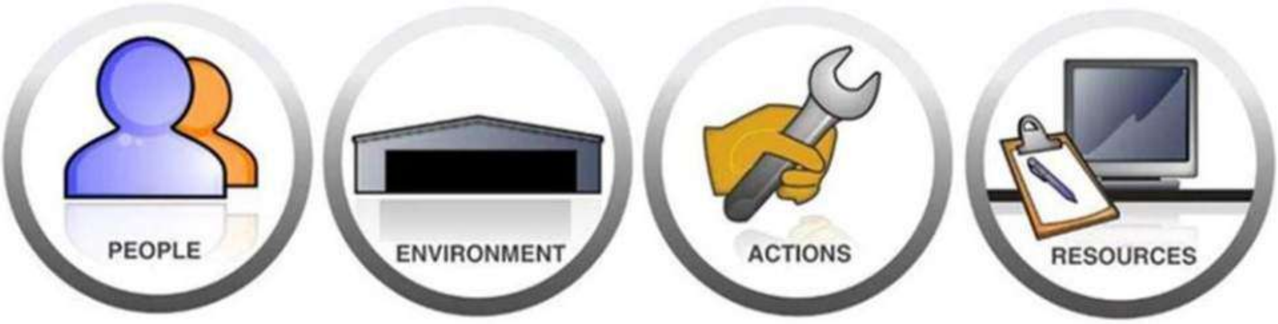
There are many published models and theories explaining why and how accidents occur. The PEAR model was addressed fully under the General section Developed by Dr. William Johnson and Dr. Michael Maddox, PEAR is not an error model as much as a way to consider Human Factors as a whole.

Other models that will be briefly addressed are the SHEL Model and HFAC. The Dirty Dozen, developed by Gordon Dupont for Transport Canada, was very briefly referenced in order to list some of the factors specific to the incidents related to Human Factors.

The PEAR model of human factors in maintenance

Application of the mnemonic 'PEAR' makes recognition of Human Factors (HF) even easier. It prompts recall of the four important considerations for HF programs: People who do the job; Environment in which they work; Actions they perform; Resources necessary to complete the job.

PEAR was developed by Dr. Michael Maddox and Dr. Bill Johnson, specifically with maintenance in mind, as an easy way for aviation maintenance personnel to identify human factors and relate to tasks and conditions within the maintenance environment.



P stands for People (the humans in the system), with all our capabilities and limitations. It includes senses such as vision and hearing; physical characteristics such as strength and reach; as well as capabilities such as memory, communication styles, decision making, supervision and teamwork skills (leadership/followership etc.).

	DOING	THINKING	INTERACTING
People	• Physical capabilities	• Knowledge	• Team structure
	• Sensory Capabilities	• Experience	• Role definition
	• Health	• Attitude	• Leadership
	• Training	• Motivation	• Followership
	• Current	• Confidence	• Supervision skills/needs
	• Competent	• Workload	• Interpersonal relationships
	• Authorized	• Fatigue	• Communication
	• Briefed	• Stress	• Conflicts

People relates to the suitability (physical, cognitive and social) of the selected personnel for a particular task. Suitability not only covers technical training but also human factors considerations such as fatigue, stress and motivations. It guides the review of the competency, supervision abilities, briefing needs, leadership skills and requirements of individuals against the task demands.

E stands for the Environment in which the work is done, not just the physical environment, but also the organization itself. The physical environment includes lighting, temperature, noise level and time of day. The organizational environment covers issues such as supervision (quality and ratios), pressures (time, commercial and production etc.), organization and safety culture and existing organizational norms and how these will affect individual and team performance and the potential for error. The organizational environment also covers the leadership shown and the effectiveness of management in supporting positive safety behaviors.

Environment

PHYSICAL

- Weather
- Location (inside/outside)
- Workspace
- Lighting
- Noise
- Distractions
- Housekeeping
- Hazards
- Shift (day/night/late)

ORGANIZATIONAL

- Management style
- Leadership
- Staffing levels
- Size/complexity
- Priorities
- Pressures
- Morale
- Norms
- Culture

A represents the Actions people perform. Actions list the requirements of a job to help to identify any specific areas that might increase the risk of error, such as ambiguous information, or complex tasks that need specialist skills and knowledge.

Actions

- Getting Information
- Preparation
- Briefing/debriefing
- Steps/sequence of activity
- Application of Knowledge
- Application of skill
- Communication requirements
- Task management
- Supervision requirements
- Inspection requirements
- Documentation
- Certification requirements

The list of actions is aligned with a Job Task Analysis (JTA) process which is the standard human factors approach to identifying the knowledge, skills and attitudes necessary to perform each task in a given job. The JTA also helps identify what instructions, preparation and task management are necessary.

This may include

- Accessing / finding task specific information required
- Preparation and briefing requirements
- Identifying procedures to be followed
- Are those procedures clear and easy to follow?
- Task complexity and application of skill and knowledge
- Communication requirements (headsets required?)
- The level of supervision and inspection required (is a dual inspection needed?)
- The certification and documentation, including the complexity or user-friendly nature of the aircraft maintenance documentation.

R is for the Resources necessary to perform the work. Resources are the broadest component of PEAR. They can be defined as anything that the maintenance technician needs to get the job done. Resources details both the tangible items required and available, such as personnel, spares, technical manuals, tooling, and personnel protective equipment (PPE), as well as less tangible (but equally important) elements such as time and training availability.

Resources

- Procedures/workcards
- Test equipment
- Paperwork/signoffs
- Fixtures
- Training
- Interpersonal relationships
- Competence
- Technical manuals
- Tools
- Ground handling equipment
- Materials
- Quality system
- Confidence
- Workload
- Personnel
- Computers/software
- Workstands and lifts
- Task lighting
- Personal Protective Equipment
- Supervision skills/needs
- Interpersonal relationships

An important resources element is focusing on identifying the areas where resources are deficient including:

- Design (work stands, tools etc.)
- Application (e.g. available, accurate procedures)
- Where additional resources (time, personnel, training, lighting, PPE and consumables) are required.

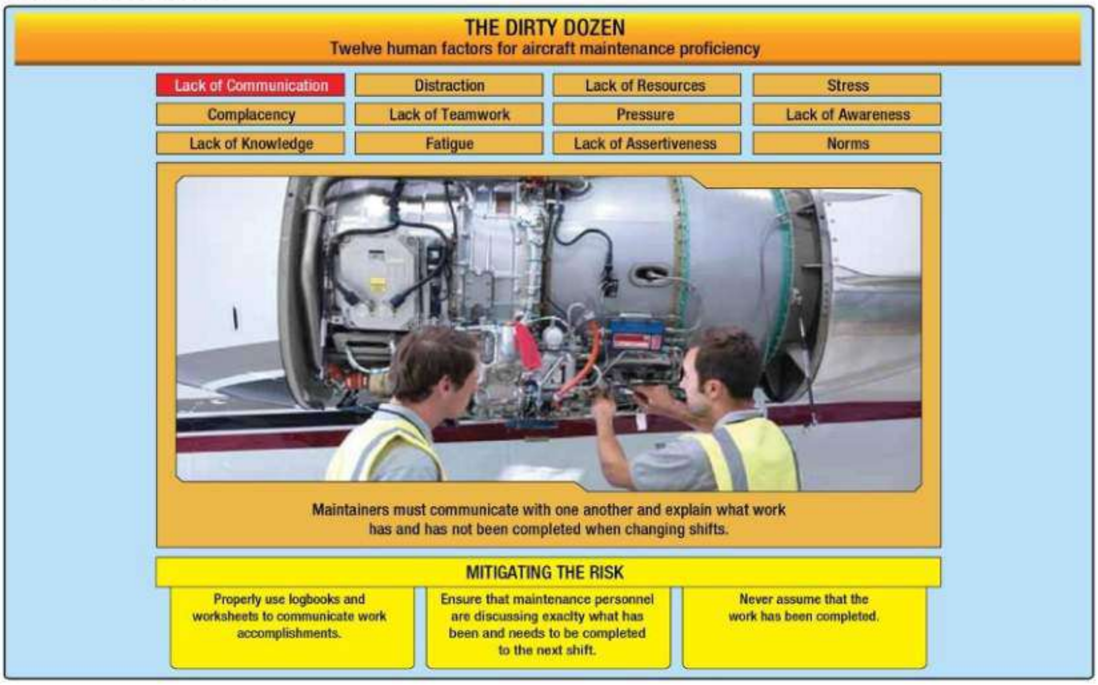
The dirty dozen

Introduction

Due to a large number of maintenance related aviation accidents and incidents that occurred in the late 1980s and early 1990s, Transport Canada identified twelve factors that degrade people's ability to perform effectively and safely, thus leading to maintenance errors. These twelve factors, known as the "dirty dozen," were eventually adopted by the aviation industry as a straightforward means to discuss human error in maintenance. It is important to know the Dirty Dozen, how to recognize their symptoms, and most importantly, know how to avoid or contain errors produced by the Dirty Dozen. Understanding the interaction between organizational, work group, and individual factors that may lead to errors and accidents. Aircraft Maintenance Engineers (AMEs) can learn to prevent or manage them proactively in the future.

1. Lack of communication
2. Distraction
3. Lack of resources
4. Stress
5. Complacency
6. Lack of teamwork
7. Pressure
8. Lack of awareness
9. Lack of knowledge
10. Fatigue
11. Lack of assertiveness
12. Norms

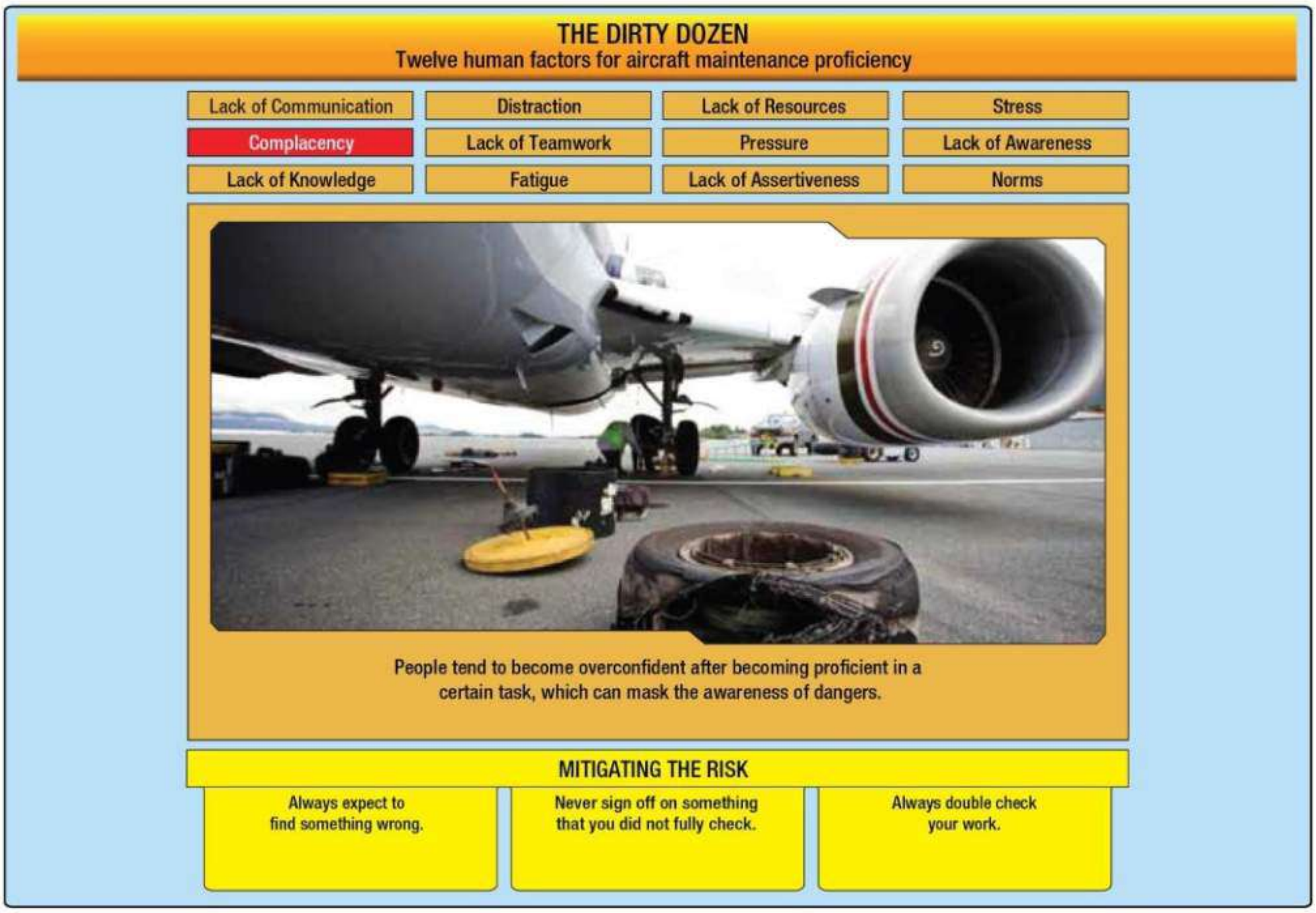
Lack of communication



Lack of communication is a key human factor that can result in suboptimal, incorrect, or faulty maintenance. Communication between AMTs may be the most important of all. Lack of communication between technicians could lead to a maintenance error and result in an aircraft accident. This is especially true during procedures where more than one technician performs the work on the aircraft. It is critical that accurate and complete information be exchanged to ensure that all work is completed without any step being omitted. Knowledge and speculation about a task must be clarified and not confused. Each step of the maintenance procedure must be performed according to approved instructions as though only a single technician did the work.

The technician must see his or her role as part of a greater system focused on safe aircraft operation and must communicate well with all in that system to be effective.

Complacency



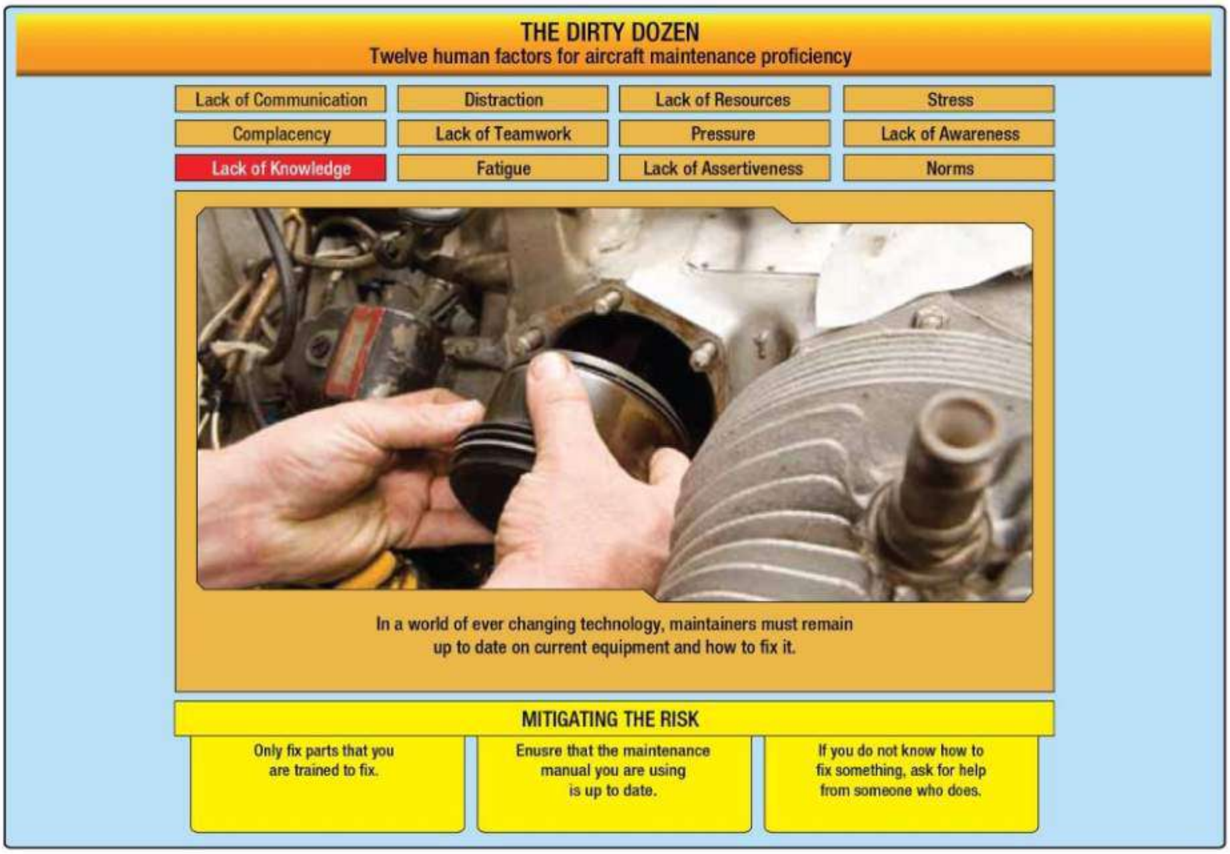
Complacency is a factor in aviation maintenance that typically develops over time. As a technician gains knowledge and experience, a sense of self satisfaction and false confidence may occur. A repetitive task, especially an inspection item, may be overlooked or skipped because the technician has performed the task a number of times without ever finding a fault. The false assumption that inspection of the item is not important may be made.

Approved written maintenance procedures should be followed during all maintenance inspections and repairs. Executing the proper paperwork draws attention to a work item and reinforces its significance.

To combat complacency, a technician must train oneself to expect to find the fault that created the inspection item in the first place. He or she must stay mentally engaged in the task being performed. All inspection items must be treated with equal importance, and it must never be assumed that an item is acceptable when it has not been inspected. A technician should never sign for any work that has not been performed.

Prior to the pen touching the paper for a signature, the technician should read the item before signing and confirm it has been performed.

A lack of knowledge



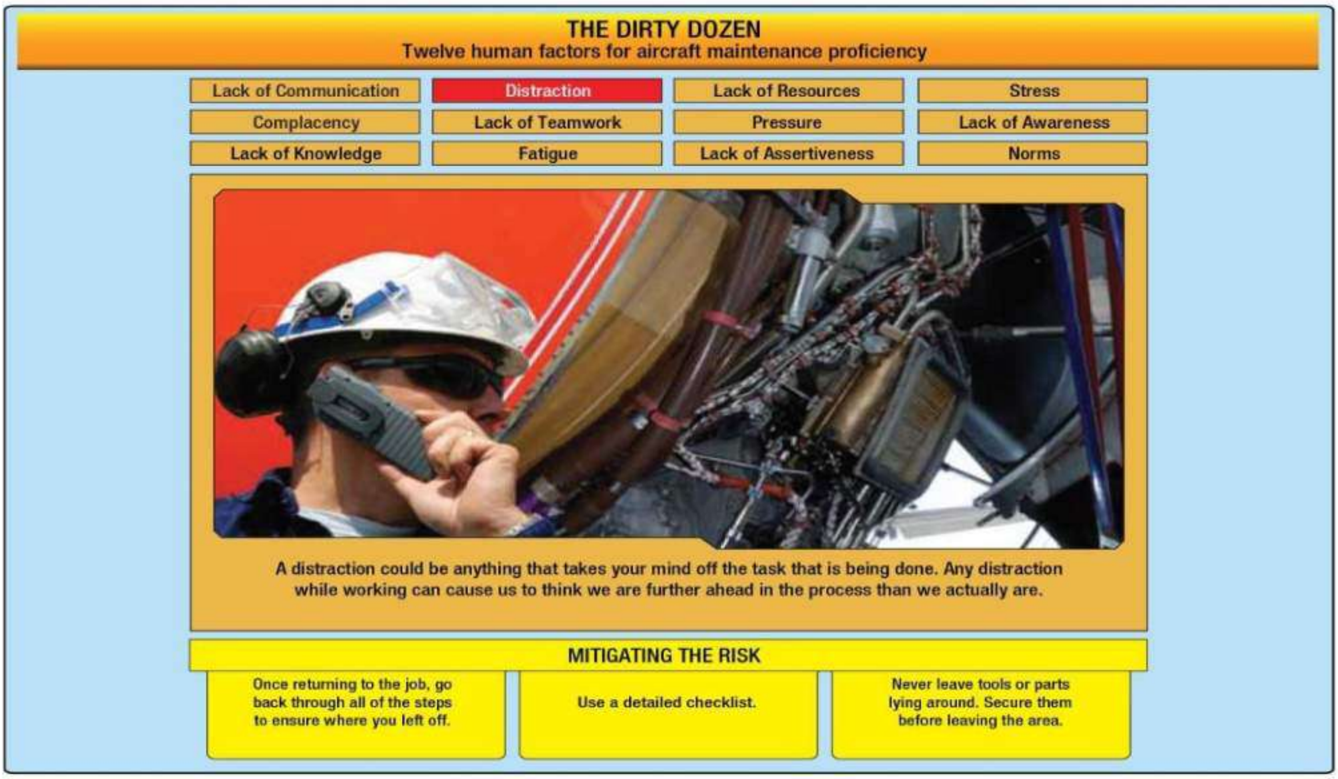
A lack of knowledge when performing aircraft maintenance can result in a faulty repair that can have catastrophic results. Differences in technology from aircraft to aircraft and updates to technology and procedures on a single aircraft also make it challenging to have the knowledge required to perform airworthy maintenance.

AMT's must be remain up to date on current equipment

All maintenance must be performed to standards specified in approved instructions. Technicians must be sure to use the latest applicable data and follow each step

of the procedure as outlined. When in doubt, a technician with experience on the aircraft should be consulted. If one is not available, or the consulted technician is not familiar with the procedure, a manufacturer's technical representative should be contacted. It is better to delay a maintenance procedure than to do it incorrectly and cause an accident.

Distractions



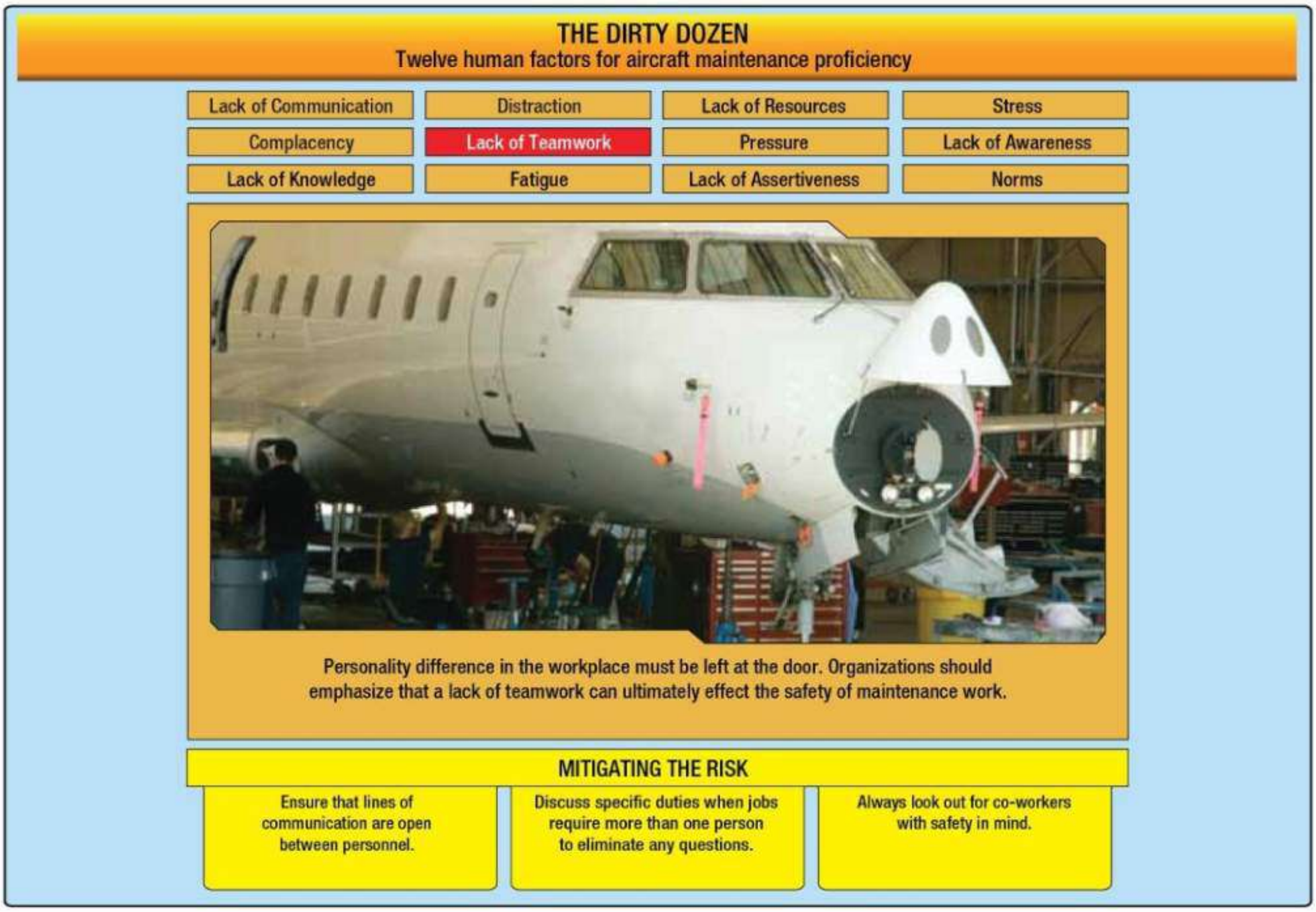
A distraction while performing maintenance on an aircraft may disrupt the procedure. When work resumes, it is possible that the technician skips over a detail that needs attention. It is estimated that 15 percent of maintenance related errors are caused by distractions.

Distractions can be mental or physical in nature. They can occur when the work is located on the aircraft or in the hangar. They can also occur in the psyche of the technician independent of the work environment. Something as simple as a cell phone call or a new aircraft being pushed into the hangar can disrupt the technician's concentration on a job.

Distractions often play a big part in this sort of maintenance errors

Regardless of their nature, numerous distractions may occur during the course of maintaining an aircraft. The technician must recognize when attention to the job at hand is being diverted and assure that work continues correctly. A good practice is to go back three steps in the work procedure when one is distracted and resume the job from that point. Use of a detailed step-by-step written procedure and signing off each step only after it is completed.

Lack of teamwork



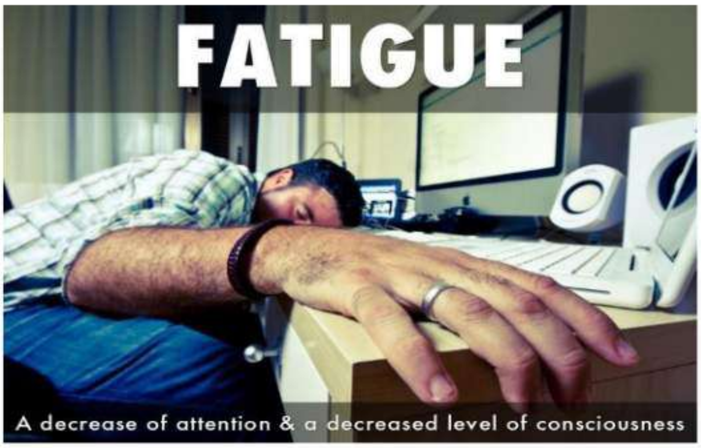
A lack of teamwork may also contribute to errors in aircraft maintenance. Closely related to lack of communication, teamwork is required in aviation maintenance. Teamwork involves everyone understanding and agreeing on actions to be taken.

The technician primarily deals with the physical aspect of the aircraft and its airworthiness. Others in the organization perform their roles and the entire company functions as a team. Teams can win or lose depending on how well everyone in the organization works together toward a common objective.

Fatigue

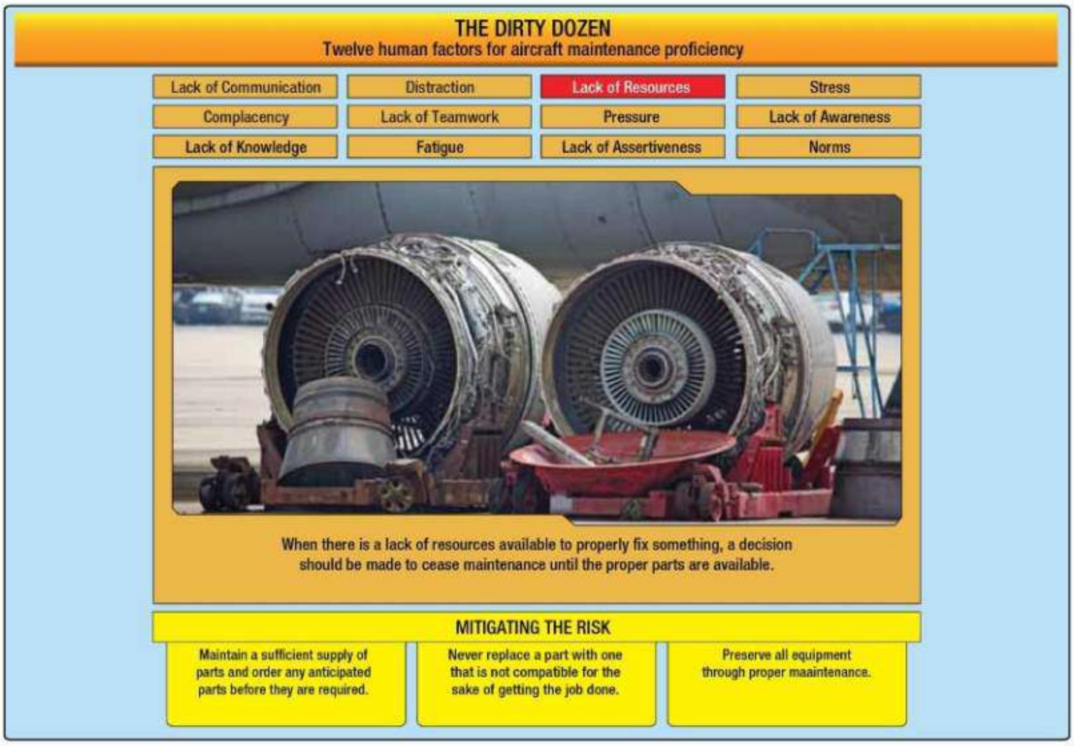
Fatigue is a major human factor that has contributed to many maintenance errors resulting in accidents. Fatigue can be mental or physical in nature. Emotional fatigue also exists and effects mental and physical performance. A person is said to be fatigued when a reduction or impairment in any of the following occurs: cognitive ability, decision making, reaction time, coordination, speed, strength, and balance. Fatigue reduces alertness and often reduces a person's ability to focus and hold attention
on the task being performed.

A person's mental and physical state cycles through various levels of performance each day. Variables such as body temperature, blood pressure, heart rate, blood chemistry, alertness, and attention, rise and fall in a pattern daily.
This is known as one's circadian rhythm.



A person's ability to work (and rest) rises and falls during this cycle. Performance counter to circadian rhythm can be difficult.

Shift work alone is a cause of fatigue that can degrade performance and also lead to errors. Shift work requires technicians to work during low cycles of their natural circadian rhythm. It also makes sleep more difficult when not on the job.
Each technician must monitor and control his or her sleep habits to avoid fatigue



Lack of resources

A lack of resources can interfere with one's ability to complete a task because there is a lack of supply and support. Low quality products also affect one's ability to complete a task. Aviation maintenance demands proper tools and parts to maintain a fleet of aircraft. Any lack of resources to safely carry out a maintenance task can cause both non-fatal and fatal accidents.

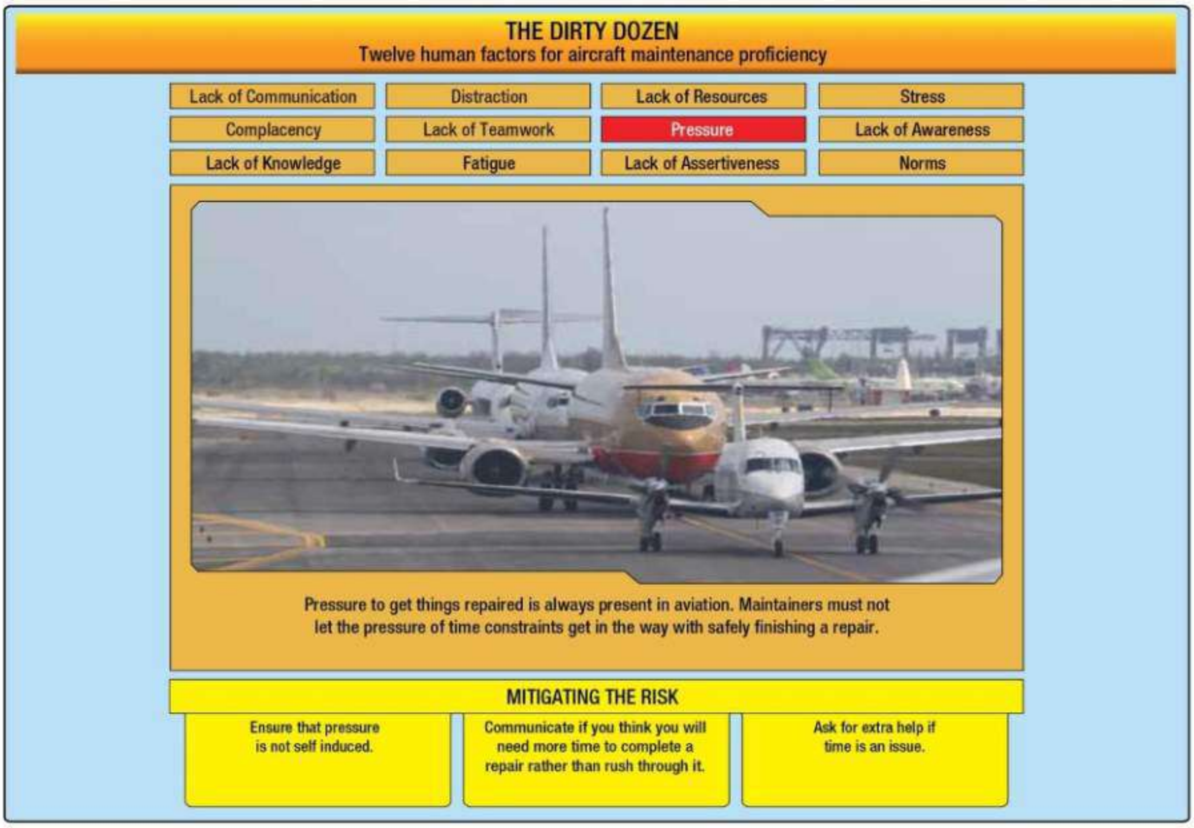
Parts are not the only resources needed to do a job properly, but all too frequently parts become a critical issue. AMEs can try to be proactive by checking suspected areas or tasks that may require parts at the beginning of the inspection.

Within an organization, making sure that personnel have the correct tools for the job is just as important as having the proper parts when they are needed.

Technical documentation is another critical resource that can lead to problems in aviation maintenance. When trying to find out more about the task at hand or how to troubleshoot and repair a system, often the information needed cannot be found because the manuals or diagrams are not available.

If the correct resources are not available, make the necessary arrangements to get them in a timely manner. The end result saves time, money, and enables organizations to complete the task knowing the aircraft is airworthy.

Pressure



Aviation maintenance tasks require individuals to perform in an environment with constant pressure to do things better and faster without making mistakes and letting things fall through the cracks. Unfortunately, these types of job pressures can affect the capabilities of maintenance workers to get the job done right.

Organizations must be aware of the time pressures that are put on aircraft mechanics and help them manage all of the tasks that need to be completed so that all repairs, while done in a timely manner, are completed correctly with safety being the ultimate goal.

In an effort to combat self-induced pressure, technicians should ask for help if they feel overwhelmed and under a time constraint to get a repair fixed. Another method is to have someone check the repair thoroughly to ensure that all maintenance tasks were completed correctly.

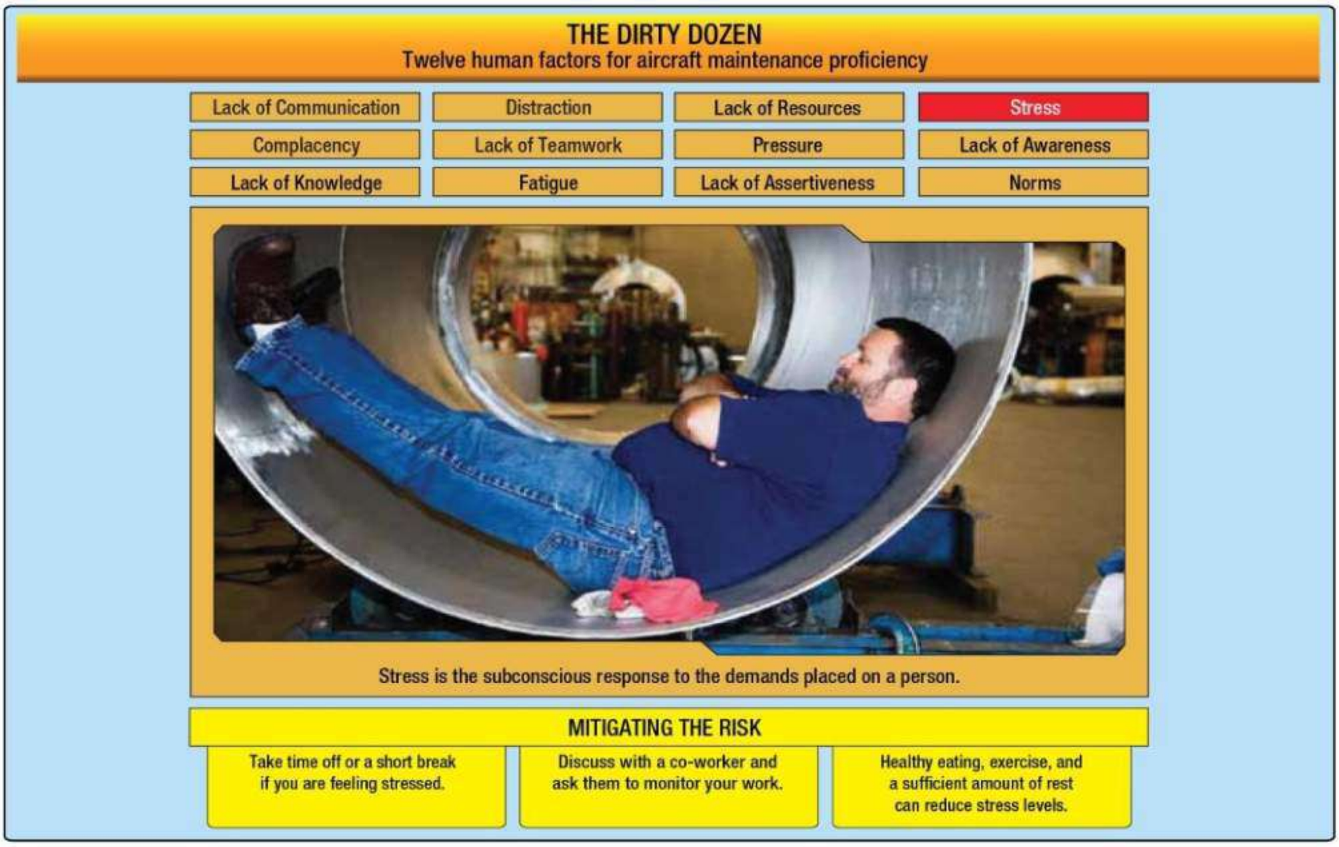
Lastly, if given a repair with a specific time limitation that you do not feel is realistic or compromises safety, bring it to the attention of the organization's management and openly discuss a different course of action.

Lack of assertiveness

Assertiveness is the ability to express your feelings, opinions, beliefs, and needs in a positive, productive manner and should not be confused with being aggressive. It is important for AMEs to be assertive when it pertains to aviation repair rather than choosing or not being allowed to voice their concerns and opinions. The direct result of not being assertive could ultimately cost people their lives.

When being assertive with coworkers or management, deal with one issue at a time rather than trying to tackle a number of problems at once. It is also important to have documentation and facts to back up your argument, which can give people a visual account of what you are trying to explain. A lack of assertiveness in failing to speak up when things do not seem right has resulted in many fatal accidents. This can easily be changed by promoting good communication between coworkers and having an open relationship with supervisors and management. Maintenance managers must be familiar with the behavior style of the people they supervise and learn to utilize their talents, experience, and wisdom. As the employees become aware of behavior styles and understand their own behavior, they see how they unwittingly contribute to some of their own problems and how they can make adjustments.

Stress



Aviation maintenance is a stressful task due to many factors. Aircraft must be functional and flying in order for airlines to make money, which means that maintenance must be done within a short timeframe to avoid flight delays and cancellations. Fast paced technology that is always changing can add stress to technicians. This demands that AMTs stay trained on the latest equipment. Other stressors include working in dark, tight spaces, lack of resources to get the repair done correctly, and long hours. The ultimate stress of aviation maintenance is knowing that the work they do, if not done correctly, could result in tragedy.

The causes of stress are referred to as stressors. They are categorized as physical, psychological, and physiological stressors.

Physical Stressors Physical stressors add to the personnel's workload and make it uncomfortable for him or her in their work environment.

- Temperature —high temperatures in the hangar increases perspiration and heart rate causing the body to overheat. Low temperatures can cause the body to feel cold, weak, and drowsy.

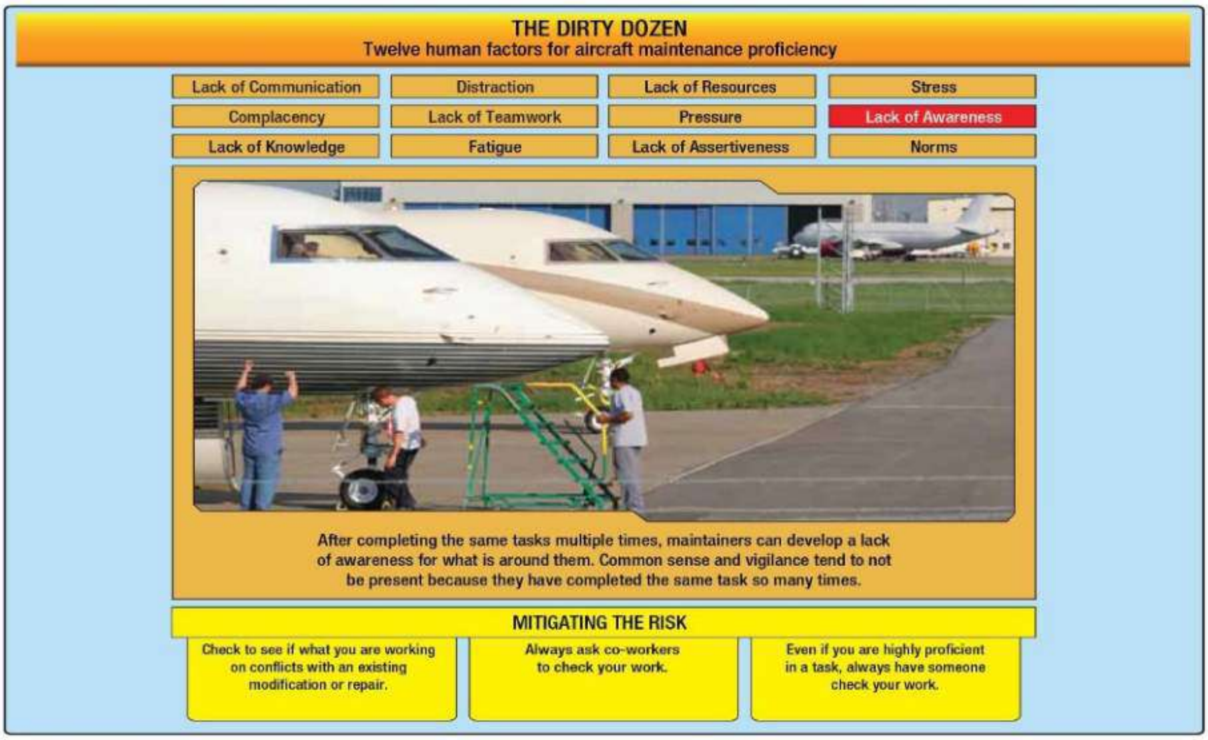
Psychological Stressors

- Psychological stressors relate to emotional factors, such as a death or illness in the family, business worries, poor interpersonal relationships with family, coworkers, supervisors, and financial worries.

• Work related stressors— over anxiousness can hinder performance and speed while conducting maintenance if there is any apprehension about how to do a repair or concerns about getting it done on time, and interpersonal problems—problems with superiors and colleagues due to miscommunication or perceived competition and backstabbing can cause a hostile work environment.

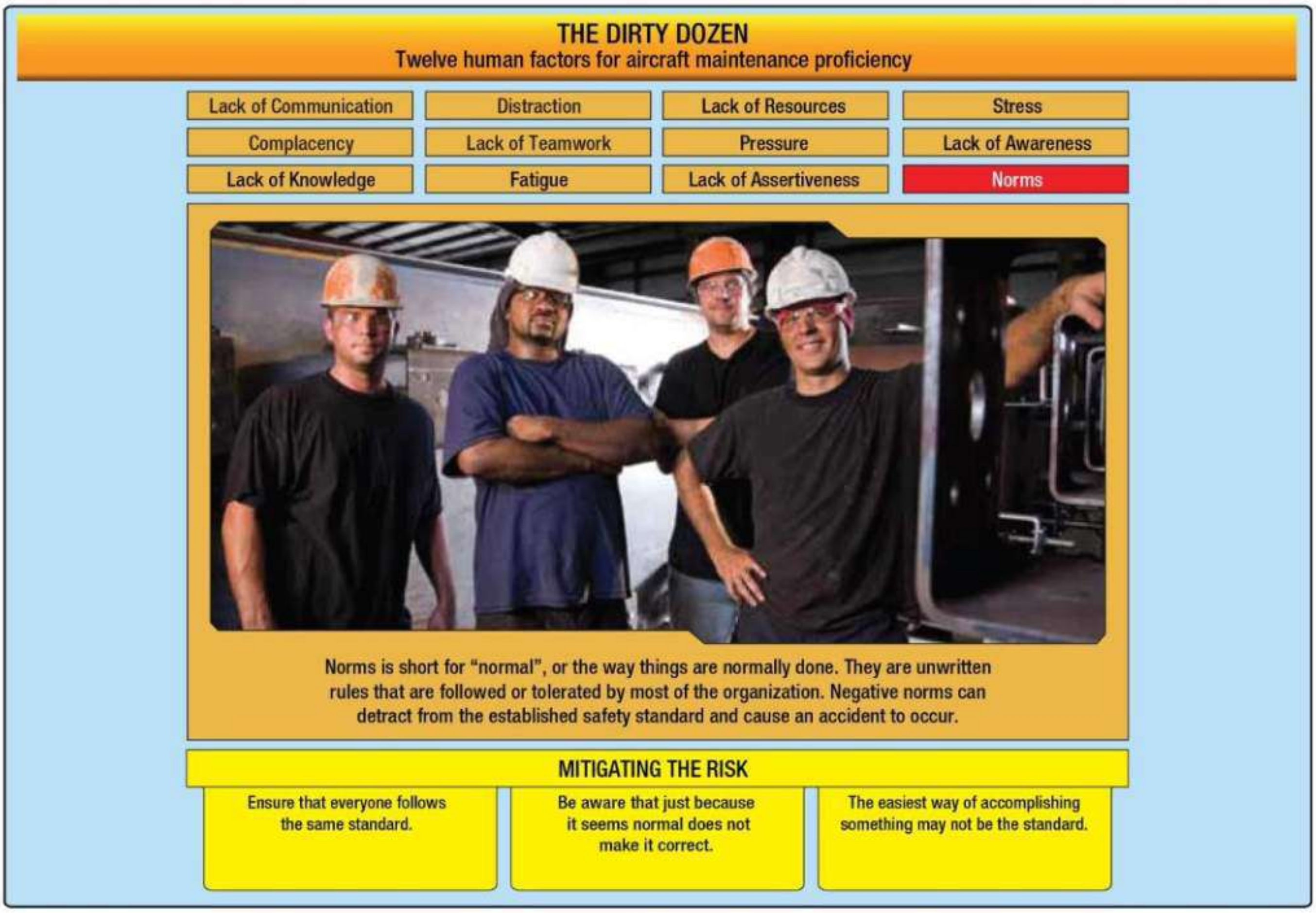
Physiological Stressors Physiological stressors include fatigue, poor physical condition, hunger, and disease.

Lack of awareness



Lack of awareness is defined as a failure to recognize all the consequences of an action or lack of foresight. In aviation maintenance, it is not unusual to perform the same maintenance tasks repeatedly. After completing the same task multiple times, it is easy for technicians to become less vigilant and develop a lack of awareness for what they are doing and what is around them. Each time a task is completed it must be treated as if it were the first time.

Norms



Norms is short for "normal," or the way things are normally done. They are unwritten rules that are followed or tolerated by most organizations. Negative norms can detract from the established safety standard and cause an accident to occur. Norms are usually developed to solve problems that have ambiguous solutions. When faced with an ambiguous situation, an individual may use another's behavior as a frame of reference around which to form his or her own reactions. As this process continues, group norms develop and stabilize. Newcomers to the situation are then accepted into the group based on adherence to norms.

Very rarely do newcomers initiate change in a group with established norms.

Some norms are unsafe in that they are nonproductive or detract from the productivity of the group.

Norms have been identified as one of the dirty dozen in aviation maintenance and a great deal of anecdotal evidence points to the use of unsafe norms on the line. The effect of unsafe norms may range from the

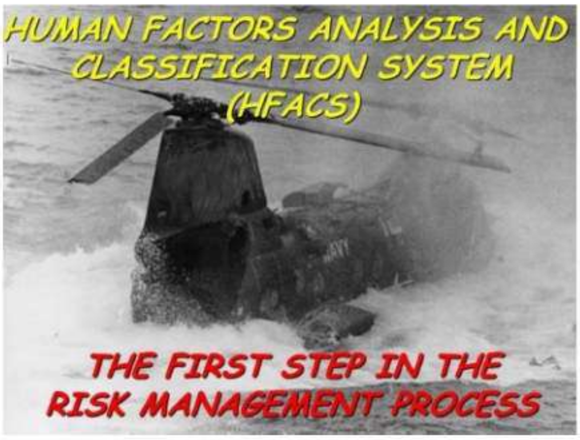
relatively benign, such as determining accepted meeting times, to the inherently unsafe, such as signing off on incomplete maintenance tasks. Any behavior commonly accepted by the group, whether as a standard operating procedure or not, can be a norm. Supervisors need to ensure that everyone adheres to the same standards and not tolerate unsafe norms. AMTs should pride themselves on following procedure, rather than unsafe norms that may have been adopted as regular practice.
https://youtu.be/ogvwV8-Mtro

Additional models/theories

Other well-respected accident models/theories that are widely referred to include the HFACS-ME Model, and the SHEL Model. They classify why human error happens in slightly different ways. A brief synopsis of each model follows:

HFACS-ME MODEL

Human Factors Analysis and Classification System Maintenance Extension (HFACS-ME), developed by the U.S. Naval Safety Center, is designed to identify human error that contributed to aviation maintenance occurrences and to use the information in the development of strategies to prevent such errors.



HFACS-ME categorizes human error into four categories: supervisory conditions; maintainer conditions; working conditions; and maintainer acts. These are used to study the relationships among latent failures and active failures.

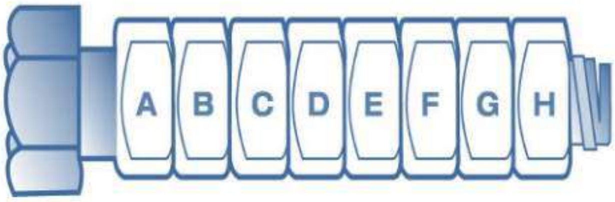
SHEL MODEL

SHEL Model, developed by Elwyn Edwards and modified by Frank Hawkins, describes how the human interacts with the system; SHEL is an acronym for software, hardware, environment and liveware (humans). The SHEL model explains how the liveware interacts with the other three elements, as well as with other human colleagues.

9.8.2 TYPES OF ERRORS IN MAINTENANCE TASKS

Professor James Reason is considered the leading authority on the study of human error.

Professor Reason's Model of Error is a widely used categorization system for human errors shown in Once you have identified the type of error involved in an incident, you can then develop possible solutions.



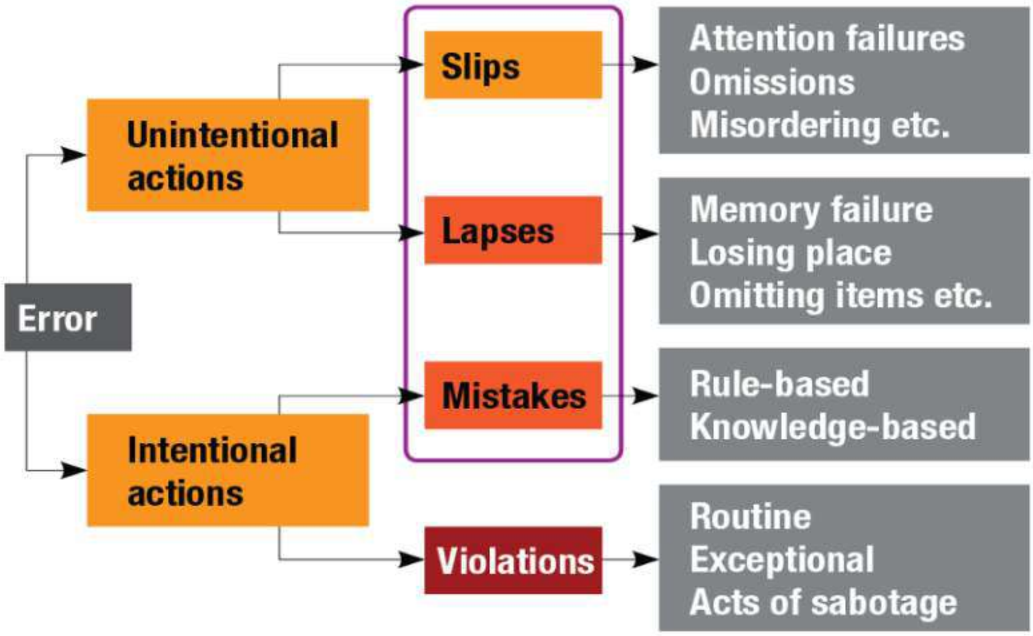
Professor Reason's nuts and bolt example. A bolt fitted with eight nuts can be disassembled one way, but there are over 40,000 ways in which it can be reassembled incorrectly. Consider how many more error opportunities the average general aviation aircraft presents!

Human errors can be divided into two basic categories, unintended actions and intended actions. "unintended action" means that we find ourselves doing a task in a way we never meant to (a slip), or we leave out a step we intended to carryout (a lapse). These errors typically occur when our attention is distracted.

Intended actions can be divided into "mistakes" and violations". When we say that the action was intended, in most cases we do not mean that the person intended harm.

Reason's Model of Error

Basic error types



Professor Reason's model of error

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Unintended errors

Slips

Many people are familiar with the feeling that they have been doing a familiar task on autopilot.

Slips occur when we perform a routine action that was out of place in the situation, usually because we are distracted and habit takes over. For example, in the first week of January, it is not uncommon to write the date with the previous year. Many slips in maintenance are slips of the pen, where a signature is put in the wrong place or a checklist item is missed. Slips also occur when using tools and when activating cockpit controls.

Lapses

A lapse occurs when we forget to complete an action we had been intending to perform. Examples are forgetting to remove tools or rigging devices at the end of a job, forgetting to close hatches, or leaving nuts finger tight when the intention had been to torque them up. One of the most widely reported lapses in maintenance is failing to replace oil caps. Many lapses occur when the AME has been interrupted part way through a task, often when called away to a more urgent job. They may then fail to return to the task, leave out a step, or lose their place in the task.

Intended errors

Mistakes are a type of error where the problem has occurred during thinking rather than doing. The person carries out their actions as planned, except that what they planned to do was not right for the situation. Professor Reason describes two types of these mistakes, rule based and knowledge based.

Rule Based Mistakes

Rule based mistakes occur in familiar situations where an AME has a preexisting "rule" or guideline they use to guide their actions. This need not necessarily be a formal rule; it could be a procedure or work habit that they usually follow in that situation. The mistake happens when the rule no longer fits the situation, or the AME misidentifies the situation. For example, an AME who pushed in a pulled cockpit circuit breaker without first stopping to check the cockpit control settings failed to apply a good rule or work habit to a familiar situation. In another case, an electrician wrongly assumed that a coworker had disconnected the power supply, because this was a standard work practice rule.

Knowledge Based Mistakes Knowledge based mistakes reflect a lack of necessary knowledge, or a lack of awareness of where to find the necessary information. This is most likely to occur when a person is performing an unfamiliar task or is dealing with a non-routine situation. Typically, a person who has made a knowledge-based error will say they did not know about a procedure or were confused by the task.

Violations

Violations are intentional deviations from procedures or good practice. In most cases, the violation occurs because the AME is trying to get the job done, not because they want to break rules. One AME expressed it this way: "Management tells us to follow the procedures to the letter, but then they tell us not to be obstructive and to use common sense".
Professor Reason's error model shows three types of violations "routine", "exceptional" and sabotage". Sabotage will not be dealt with here, as it is an extremely rare event in aircraft maintenance.

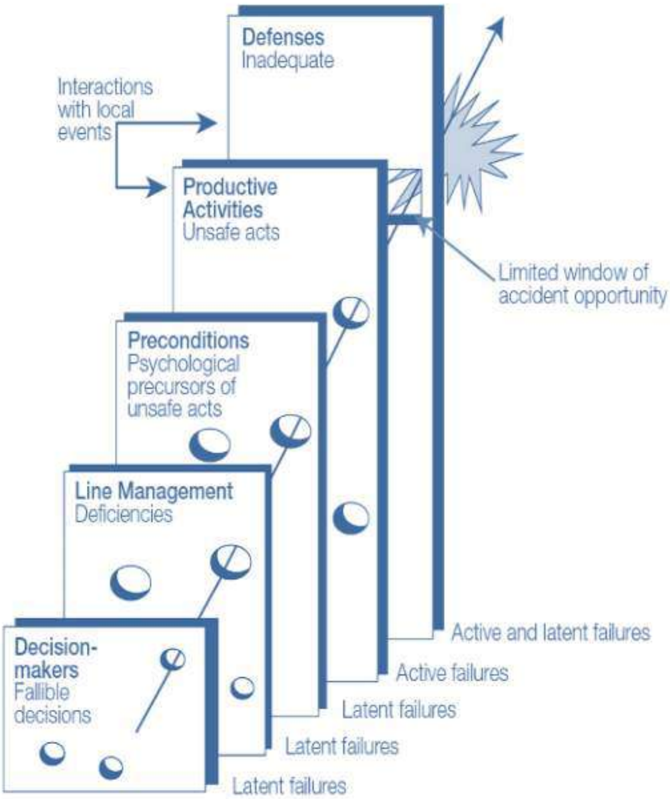
Routine Violations Routine violations are the everyday deviations from procedures made to keep things moving and get the job done efficiently. While not justifying these actions, they are the easiest to understand. Routine violations are frequently so widespread in a company that they become the "normal way" that everyone works. Researchers in Europe found that 34 percent of AMEs acknowledged that they had not strictly followed procedures in their most recent maintenance task. Common reasons for these violations are unworkable procedures and lack of resources, such as specialized tools or spares. In some cases, there is an easier way to perform the task, so that the AME gravitates to that method. Examples are not using a torque wrench but instead judging torque by feel; or referring to a personal source of maintenance data instead of going to the maintenance manual.

Exceptional Violations Exceptional violations are often well-intentioned attempts to get the job done despite problems such as missing documents or a shortage of parts. The AME knows that they are deviating from procedures, but may be able to justify their actions, and usually considers that the risk is minimal. At times, for example, AMEs may be tempted to skip a required engine run to allow an aircraft to depart on time. In many cases, exceptional violations in isolation are not dangerous, yet they do reduce the margin of safety. If another problem occurs, there may be nothing standing in the way of an accident

Professor **Reason's Swiss Cheese Model**, also known as "The Window of Opportunity," is a theoretical model that illustrates how accidents occur in organizations. The model focuses on both organizational hierarchy and human error. It states that the typical accident occurs because several (human) errors have occurred at various levels in the organization in a way that made the accident unavoidable.

https://youtu.be/KND5py-z8yI For example:

- Decision makers may have made poor decisions when purchasing the aircraft (fallible decisions);
- Line management may have pushed for faster turnarounds (line management deficiencies);
- Pilots may have felt pressured by a stressful climate (distraction);
- An unsafe culture of limited rest exists (preconditions;)
- The pilot in the accident may have gotten distracted with other tasks prior to the accident (unsafe act);
- The aircraft systems fail in providing unmistakable warnings of the danger (inadequate defenses).



The Swiss Cheese Model

This example illustrates key concepts in the Accident Causation (Swiss Cheese) Model:

- Active errors (also called unsafe acts) are the central cause of the accident: the pilot got distracted. Had the pilot not been distracted, she/he would have prevented the accident.
- Latent errors are the remaining elements in the organization which contributed to the accident: senior managers purchasing decisions, line management pressures, unsafe climate and culture coupled with fatigue and confusing warnings. Had not any of these latent errors occurred, the accident would have been prevented. https://youtu.be/WWvTpgCAJAM

9.8.3 AVOIDING AND MANAGING ERRORS

Professor Reason believes EMS should include measures that would:

- Minimize the error liability of the individual or team.
- Reduce the error vulnerability of tasks or task elements.
- Discover, assess the eliminate error producing (and violation producing) factors within the workplace.
- Diagnose organizational factors that create error producing factors within the individual, the team, the task or the workplace.
- Enhance error detection.
- Increase the error tolerance of a workplace or system.

- Make latent conditions more visible to those who operate and manage the system.
- Improve organization's intrinsic resistance to human fallibility

In contrast a Comprehensive EMS focuses most of its efforts on:

- Identifying and correcting error prone tasks.
- Improving error producing work situations.
- Identifying and correcting latent organizational conditions

MAINTENANCE ERROR DECISION AID (MEDA)

Maintenance Error Decision Aid (MEDA) is based on three principles: "Mechanics don't intend to make mistakes"; "errors result from a variety of workplace factors, such as unclearly written manuals, poor communication between workers or improperly labeled parts"; and "management can fix the factors that contribute to errors".

Boeing developed the MEDA process to help maintenance organizations identify why these errors occur and how to prevent them in the future. Successful implementation of MEDA requires an understanding of the following:

The MEDA philosophy.
The MEDA processes
Management resolve
Implementing MEDA
The benefits of MEDA

The MEDA philosophy

Traditional efforts to investigate errors are often aimed at identifying the employee who made the error. This usually results in an employee who is defensive and subjected to a combination of disciplinary action and recurrent training. Because retraining often adds little or no value to what the employee already knows, it may be ineffective in preventing future errors. In addition, by the time the employee is identified, information about the factors that contributed to the error have been lost. Because the factors that contributed to the error remain unchanged, the error is likely to recur, setting what is called the "blame and train" cycle in motion. The MEDA philosophy is based on these principles:

- Positive employee intent (maintenance technicians want to do the best job possible and do not make errors intentionally).
- Contribution of multiple factors (a series of factors contributes to an error).
- Manageability of errors (most of the factors that contribute to an error can be managed).

The MEDA processes

To help maintenance organizations achieve the dual goals of identifying factors that contribute to existing errors and avoiding future errors, Boeing initiated the following process to avoid future errors

- Event.
- Decision.
- Investigation.
- Prevention strategies.
- Feedback.

Event

An event occurs, such as a gate return or air turn back. It is the responsibility of the maintenance organization to explore what problem(s) caused the events which should be investigated.

Decision

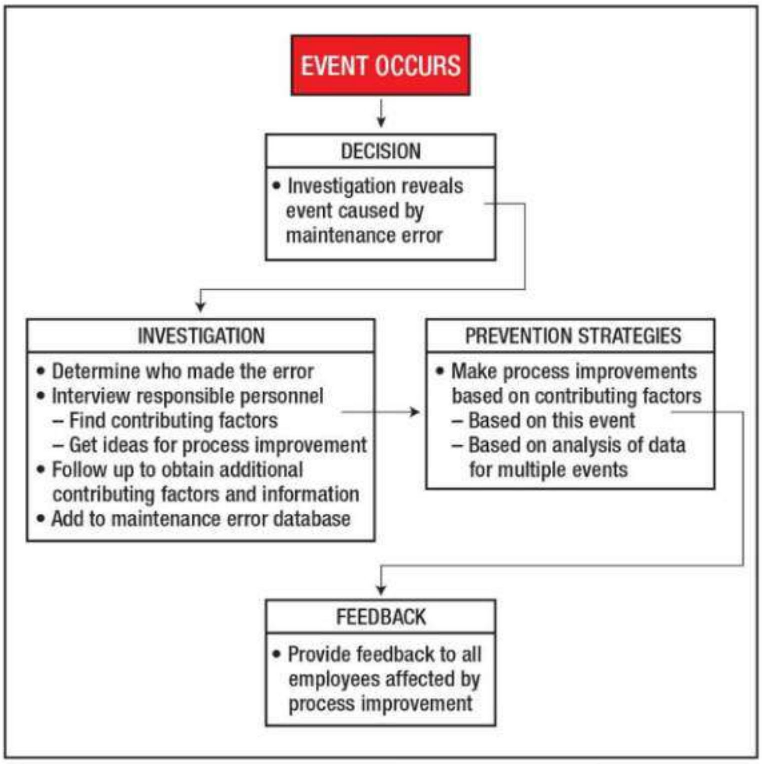
After fixing the problem and returning the airplane to service, the operator makes a decision: Was the event maintenance related? If yes, the operator performs a MEDA investigation.

Investigation

Using the MEDA results form, the operator carries out an investigation. The trained investigator uses the form to record general information about the airplane, when the maintenance and the event occurred, the event that began the investigation, the error that caused the event, the factors contributing to the error, and a list of possible prevention strategies.

Prevention Strategies

The operator reviews, prioritizes, implements, and then tracks prevention strategies (process improvements) in order to avoid or reduce the likelihood of similar errors in the future.



MEDA process flow chart

Feedback

The operator provides feedback to the maintenance workforce, so technicians know that changes have been made to the maintenance system as a result of the MEDA process. The operator is responsible for affirming the effectiveness of employees' participation and validating their contribution to the MEDA process by sharing investigation results with them.

- Event occurs
- Investigation finds that event was caused by mechanic inspector performance
- Find the maintenance mechanic or inspector who did the work
- Interview person

- Find contributing factors
- Get ideas for process improvement

- Carry out follow-up interviews, as necessary, in order to get all relevant contributing factors information
- Add the results form investigation information to a maintenance event database
  - Make process improvements Based on this event
  - Based on data from previous event
- Provide feedback to all employees affected by the process improvements

Implementing MEDA

Many operators have decided to use MEDA initially for investigations of serious, high visibility events, such as in flight shutdowns and air turn backs. It is easy to track the results of such investigations, and the potential "payback" is very noticeable.

9.9 HAZARDS IN THE WORKPLACE

Hazards in the workplace are a health and safety issue dealing with the protection of individuals at work. Although health and safety is somewhat separate from human factors, it does very much overlap; we need to recognize where potential hazards exist and be able to establish systems or procedures that are capable of protecting workers in the same way we strive to maintain the safety of maintenance systems. This is not always possible, and when a potential hazard or accident occurs, it is necessary to have proper steps in place to deal with such emergencies.

It is not always 100% possible to remove hazards from the workplace. In such cases employees should be made aware that they exist and be given a set of procedures of how to avoid them. This can be done through

training; checklists, Personal Protection Equipment (PPE) and warning signs. To be effective, warnings signs must:

- Clearly identify the hazard(s).
- Describe the danger (i.e. electric shock, radiation, etc.);
- Inform employees what to do or not to do (use PPE)

Safety Management system (SMS) https://youtu.be/WLZPNyyAPaw

9.9.1 RECOGNISING AND AVOIDING HAZARDS

https://youtu.be/04bb9JEoHpI

Hazard quite simply is the potential for harm. In practical terms, a hazard often is associated with a condition or activity that, if left uncontrolled, can result in an injury or illness. Identifying hazards and eliminating or controlling them as early as possible will help prevent injuries and illnesses.

Job Hazard Analysis (JHA) is a technique that focuses on job tasks as a way to identify hazards before they occur. It focuses on the relationship between the worker, the task, the tools, and the work environment. Ideally, after you identify uncontrolled hazards, you will take steps to eliminate or reduce them to an acceptable risk level. It can be as simple as asking yourself "Is there anything here that could hurt someone?" However, one of the best ways to determine and establish proper work procedures is to conduct a job hazard analysis.
Supervisors can then use these findings to eliminate and prevent hazards in the workplace.

When first conducting a JHA, priority should go to the following types of jobs:

- Jobs with the highest injury or illness rates.
- Jobs with the potential to cause severe or disabling injuries or illness, even if there is no history of previous accident
- Jobs in which one simple human error could lead to a severe accident or injury;
- Jobs that are new to your operation or have undergone changes in processes and procedures; and
- Jobs complex enough to require written instructions.

Potential Hazards in Aircraft Maintenance Engineering

There are many potential hazards in the aircraft maintenance industry and it is impossible to list them all here. However, a thorough health and safety appraisal will reveal the hazards. Physical hazards may include:

- very bright lights (e.g. from welding).
- very loud sounds (sudden or continuous).
- confined or enclosed areas.
- working at significant heights.
- noxious substances (liquids, fumes, etc.).
- excessive temperature (i.e. too cold or too hot).

9.9.2 DEALING WITH EMERGENCIES

Careful handling of health and safety in the maintenance environment should serve to minimise risks. However, should health and safety problems occur, all personnel should know as far as reasonably practical how to deal with emergency situations.

Emergencies may include:

- An injury to oneself or to colleague;
- A situation that is inherently dangerous, which has the potential to cause injury (such as the escape of a noxious substance, or a fire).

Appropriate guidance and training should be provided by the maintenance organisation. The organisation should also provide procedures and facilities for dealing with emergency situations and these must be adequately communicated to all personnel. Maintenance organizations should appoint and train one or more first aiders.

Preparing for emergencies

Preparing for an emergency requires that you have four things in place:

- planning,
- attitude,
- supplies,
- Emergency contacts and communications.

https://youtu.be/YvltDKg9DcM

Responding to an emergency

Depending on the situation, you may or may not need all the steps listed below, but you should follow this outline in nearly all situations:

1. Get to a safe place.

Regardless of the situation, getting to a safe place after an emergency will help prevent any additional injuries from occurring. This will allow you to assess the situation and proceed.

2. Assess the situation.

Is anyone injured? Has any property been damaged? Do you need to call emergency number? Answering these basic questions will determine your next steps.

3. Call for help.

In any case of injury y, getting professional help immediately will minimize the risks of the situation and prevent injuries from getting worse. Know the address of your workplace - and how to give directions to get there. The emergency responders will need your name and the phone number at your location as well. When called to a large plant, fire fighters or ambulance crews can waste valuable time searching for the exact location of the emergency. It is also a good idea to direct the emergency personnel to a main entrance where someone can take them directly to the incident.

4. Know the location of emergency equipment.

This can include fire extinguishers, alarms, chemical spill control materials and first aid supplies.

5. Learn how to operate any emergency equipment

Different fire extinguishers are used for different types of fires. Know how to use the safety shower and eye wash station.

6. Know your limits.

If anything beyond very simple first aid is required, always get Emergency Medical Personnel or other professionals involved right away.

7. Know where to find the Safety Data Sheets (SDS).

An SDS should be available for all chemicals used in the workplace. These sheets provide valuable information which you will need in case of an accidental chemical exposure or spill.

8. Know How to Find Emergency Exits.

Be aware of where the exits are and know the evacuation routes.

9. Assist the injured.
Provide first aid where possible; stabilize those with major injuries.

10. Get information.
Record the details of the accident while they are fresh in your mind. Time can change the way you view the situation and your memory of it, so write down all information immediately.

11. Keep the evidence.
Never destroy potential evidence, the information can help to prevent further accidents. Always keep people away from potentially hazardous equipment, but do not discard or destroy it.

12. Prevent further accidents.
Following an accident, you and/or your Safety Committee should quickly take action to assess the situation to prevent any further injuries. The Safety Committee may recommend long term changes, but always do what you can to keep others safe in the short term as well.

13. Follow up.
File the appropriate paperwork as required and provide any assistance necessary as requested by your Safety Committee or management.

Possible work-related accidents or emergencies

Breathing emergencies

Call emergency number if:

- The person stops breathing for longer than 15 to 20 seconds.
- Has severe trouble breathing, a person with this problem may:
- Have chest tightness so severe that the person is worried she/he cannot keep breathing.
- Be so short of breath that she/he cannot speak.

- Gasp for breath or have severe wheezing.
- Feel very anxious, afraid, or restless

Rescue breathing and CPR

https://youtu.be/ozzZVQQTvo4


Performing CPR

Doing CPR the wrong way or on a person whose heart is still beating can cause serious harm. Do not do CPR unless:

- An adult is not breathing normally (may be gasping for breath).
- The person does not breathe or move in response to rescue breaths.
- No one with more training in CPR than you is present. If you are the only one there, do your best.

Chemical burns

Call emergency number if:

- A strong chemical such as acid splashes into the eye.
- A large area of skin (more than 25 percent of any body part) or any part of the face is exposed to a strong acid, such as battery acid, or to a caustic substance (solvents).
- A burned eye still hurts after 30 minutes after rinsing in water or wash.
- The eye is very red; has yellow, green, bloody, or watery discharge; or has a gray or white discolored area.
- Vision problems occur.
- The skin is red, blistered or blackened.
-

Burns can occur when a harmful chemical or solvents such as a cleaning solution, gasoline or turpentine splashes into the eyes or skin, or the airways and lungs.

A burned eye may be red and watery and may be sensitive to light. If the damage is severe, the eye may look white.

Chemically burned skin may be red, blistered, or blackened, this depends on how strong the chemical was.

Call emergency number or Poison Control for specific advise. Have the chemical's container or label nearby.

Right away, flush eye or skin with lots of water or eye wash kit. Use the safety shower for skin burns. Keep rinsing with water for 30 minutes or until pain stops, or help arrives.

Head injury

Call emergency number if:

- Unconscious for more than a few seconds.
- Severe bleeding does not slow down or stop after 15 minutes of direct pressure.
- Has a seizure.
- Feels weak or numb on one side of the body.
- Double vision or trouble speaking lasts more than a minute or two.
- Seems confused, does not remember being hurt, or keeps asking the same questions.
- There is bruising around the eyes or behind one ear.
- There is a new "dent" or deformity on the skull.
- The wound needs stitches.

A head injury may be worse than it looks. An injury that doesn't bleed on the outside may still have caused dangerous bleeding and swelling inside the skull. The more force involved, the more likely it is serious.

If the person is unconscious, assume she/he has a spinal injury. DO NOT MOVE without first protecting the neck from movement.

If there is bleeding, put firm pressure directly over the wound with a clean cloth for 15 minutes. If the blood soaks through, put another cloth over the first one.

Check for injuries on other parts of the body. The panic from seeing a head injury may cause you to miss other injuries that need attention.

Hypothermia

Call emergency number if:

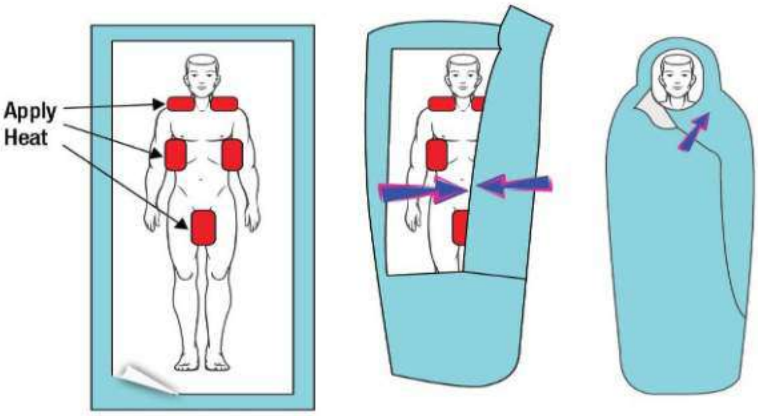
- Very confused, stumbles a lot, or faints, and you suspect hypothermia.
- Hypothermia is below normal body temperature that happens when the body loses heat faster than it can produce heat. It is an emergency that can quickly lead to death.
- It does not have to be that cold to get hypothermia. You can get it at temperatures of 50° F (10° C) or even higher in wet and windy weather. It can happen in water that is 60° F to 70° F (15° C to 21° C).
- Do not ignore early warning signs. If the person starts to shiver fiercely, stumble, or respond strangely

Early warning signs

- Shivering;
- Cold, pale skin;
- Lack of interest or concern;
- Clumsy movement and speech

Advanced warning signs

- A cold belly;
- Stiff, hard muscles. Shivering may stop if temperature drops below 90° F (32.2° C);
- Slow pulse and breathing;
- Weakness or drowsiness;
- Confusion.



Hypothermia Wrap

In the field treatment is to stop heat loss and safely rewarm the person.
Get him/her out of the cold and wind;
Remove cold, wet clothes first, and give them dry or wool clothing to wear;
Give warm fluids and high energy foods, such as candy. Do not give food or drink if confused or has fainted. Do not give alcohol or caffeine;
If at all possible, place in a hypothermia wrap as shown in figure

Spinal injury

It is important to keep the spine, head, neck and shoulders in a single unit if movement is necessary to avoid paralysis.

Call emergency number if you think there might be a spinal injury. Symptoms include:

- Severe pain in the neck or back.
- Bruises on the head, neck, shoulders, or back.
- Weakness, tingling, or numbness in the arms or legs.
- Loss of bowel or bladder control.
- Fainting.

Any accident, injury, or fall that affects the neck or back can damage the spine. It is important to keep the spine from moving and transport right way to prevent permanent loss of movement and feeling (paralysis).

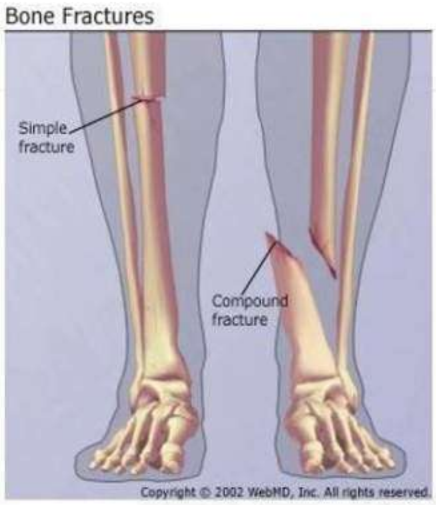
If you suspect spinal injury:

- Do not move the unless there is an immediate threat to life, such as fire.
- If you must move the person to safety, try to move the head, neck and shoulders asa unit.

Strains, Sprains and Broken bones

Call emergency number if:

- A bone is poking through the skin.
- The hurt limb or joint looks odd, is in a strange shape, or is out of its normal position.
- The skin over the site of an injury is broken.
- Signs of nerve or blood vessel damage, such as:
- Skin that is pale, white or blue, or feels colder than the skin on the limb that is not hurt.
- Not being able to move the limb normally because of weakness, not just pain.
- Not being able to bear weight on or straighten a hurt limb.
- Severe pain.
- Swelling within 30 minutes of the injury.



A broken bone is called a fracture

Strain vs. Sprain

Strain – tear in muscles/tendons from excessive use

Sprain – tear in ligaments

A strain is caused by overstretching or tearing a muscle or tendon. Tendons connect muscle and bone.

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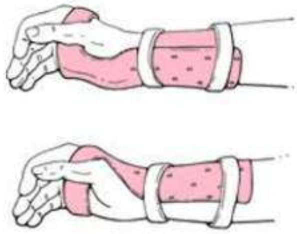
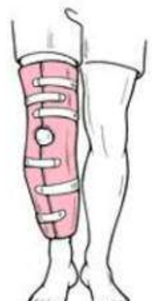
A sprain is an injury to the ligaments or soft tissues around a joint. Ligaments connect one bone to another

A dislocation occurs when one end of a bone is pulled or pushed out of its normal position.
All of these injuries cause pain and swelling. Unless a broken bone is obvious, it may be hard to tell whether the injury is a strain, sprain, break, or dislocation. Rapid swelling often means there is more serious injury.
Most strains and sprains can be treated on site. Bad sprains, broken bones and dislocations need medical care.

Splintering

This is for short term first aid only.
If a bone is broken, you can splint it so that it doesn't move until you can get the employee proper medical help.
There are two ways to splint a limb:


Wrist splint


Knee splint

Method 1: Tie the injured limb to a stiff object, such as rolled up newspapers or magazines, a stick or cane. You can use a rope, belt, or anything else that will work as a tie. Do not tie too tightly. Place the splint so the hurt limb cannot bend. Try to splint from a joint above the suspected break to a joint below it. For example, splint a broken forearm from above the elbow to below the wrist.
Method 2: Tape a broken finger or toe to the next finger or toe, with padding between them. Tie a hurt arm across the chest to keep it from moving.

CONCLUSION

The workplace contains a wide range of hazards, some known, others less so. We have learned to control most of them, sometimes instinctively, sometimes intentionally. Given the ever-increasing complexity of the aviation maintenance workplace, we can no longer rely on instinct alone. Risk must be managed just like any other business function. The negative impacts are so costly in human and financial terms.

Developing a Job Hazard Analysis with or without the help of outside experts is the best tool for avoiding risk. That being said, it is not always possible to avoid risk 100%. When something does happen, preparation and knowledge, proper equipment and drill practice can minimize the damage caused.

REFERENCE BOOKS

- CAP 715 An Introduction to Aircraft Maintenance Engineering Human Factors
- Human Factors Aviation Maintenance Technician Certification Series
- Doc 9683-an/950 Human Factors training manual
- CAP 716 Aviation Maintenance Human Factors
- AMT Handbook Human Factors
- CAP 718 Human Factors in Aircraft Maintenance and Inspection
- Doc 9806-an/763 Human Factors Guidelines for Safety Audits Manual

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