



# AVIATIONLEARNING.NET

FAA/EASA PART 147 AIRCRAFT TYPE TRAINING COMPANY

[www.aviationlearning.net](http://www.aviationlearning.net)



## HUMAN FACTORS IN AVIATION



# AviationLearning.net

FAA/EASA PART 147 AIRCRAFT TYPE TRAINING COMPANY

[www.aviationlearning.net](http://www.aviationlearning.net)



This booklet is the copyright material of AviationLearning.net. and may not be copied or re-sold.



---

Table of Contents

# Contents

## **HUMAN FACTORS - A COMPLETE COURSE**

### **Chapter 1 Introduction**

The Need To Take Human Factors Into Account	2
Incidents and Accidents Attributable To Human Factors /Human Error	4
Murphy's Law	9
Summary	9

### **Chapter 2 Human Performance and Limitations**

Human Performance as Part of the Maintenance Engineering System	12
Vision	12
Hearing	20
Information Processing	21
Claustrophobia, Physical Access and Fear of Heights	29
Summary	31

### **Chapter 3 Social Psychology**

The Social Environment	34
Responsibility: Individual and Group	35
Motivation and De-motivation	39
Peer Pressure	40
Culture Issues	42
Team Working	44
Management, Supervision and Leadership	47
Maintenance Resource Management (MRM)	49
Summary	52

---



## **Chapter 4 Factors Affecting Performance**

Fitness and Health	54
Stress: Domestic and Work Related	56
Time Pressure and Deadlines	58
Workload - Overload and Underload	60
Sleep, Fatigue and Shift Work	63
Alcohol, Medication and Drug Abuse	67
Summary	70

## **Chapter 5 Physical Environment**

Noise	72
Fumes	72
Illumination	73
Climate and Temperature	75
Motion and Vibration	76
Confined Spaces	77
Working Environment	77
Summary	78

## **Chapter 6 Tasks**

Physical Work	80
Repetitive Tasks	81
Visual Inspection	82
Complex Systems	84
Summary	85

## **Chapter 7 Communication**

Within and Between Teams	88
Work Logging and Recording	91
Keeping Up-to-Date, Currency	92
Dissemination of Information	93
Summary	94

## **Chapter 8 Human Error**

Understanding Human Error	96
Error Models and Theories	96
Types of Error in Maintenance Tasks	102
Implications of Errors (i.e. Accidents)	105
Avoiding and Managing Errors	106
Summary	108

## **Chapter 9 Hazards In The Workplace**

Recognizing and Avoiding Hazards	110
Summary	113

---



## Chapter 1



# Introduction

---

This chapter introduces human factors and explains its importance to the aviation industry. It examines the relationship between human factors and incidents largely in terms of human error and "Murphy's Law" (i.e., if something **can** go wrong, it **will**).



## The Need To Take Human Factors Into Account

In the early days of powered flight, the design, construction, and control of aircraft was the predominated focus. The main attributes of the first pilots were courage and the mastery of a whole new set of skills in the struggle to control the new flying machines.

As the technical aspects of flight were overcome, the role of the people associated with aircraft became more important. Pilots were supported initially with mechanisms to help them stabilize the aircraft, and later with automated systems to assist the crew with tasks such as navigation and communication. With the introduction of these highly complex systems the interface between the pilot and technician and the effects of one on the other became very important. The study of human/machine interface is ergonomics and the application of this science is **Human Factors**.

The importance of human factors to the aircraft maintenance technician, supervisors and managers is essential. This is because human factors will affect everything they do in the course of their job in one way or another.

### **What is "Human Factors"?**

The term "human factors" is used in many different ways in the aviation industry. Most people known it in the context of aircraft cockpit design and Crew Resource Management (CRM). However, those activities are only a small part of aviation-related human factors, as broadly speaking it covers all aspects of human involvement in aviation.

The use of the term "human factors" in aviation maintenance engineering is new. Aircraft accidents such as that of the Aloha aircraft in the USA in 1988<sup>1</sup> and the BAC 1-11 windscreens accident in the UK in June 1990<sup>2</sup> focused attention on human factors. This does not mean that human factors issues were not present before these dates or that human error did not contribute to other incidents only that it took an accident to draw attention to human factors problems and potential solutions.

### **A Definition of Human Factors**

Human Factors covers a range of issues including perceptual, physical and mental capabilities, the interaction and effects on individuals of their job and working environments, the influence of equipment and system design on human performance and finally the organizational characteristics which influence safety related behavior at work.

In summary human factors covers three areas of influence on people at work:

- The organization
- The job
- Personal factors

These are affected by the systems of communication within the organization and the training system and procedures in operation all of which are directed at preventing human error and accidents.



Human factors includes:

- Human **physiology**
- **Psychology** (including perception, cognition, memory, social interaction, error, etc.)
- Work place design
- Environmental conditions
- Human-machine interface
- Anthropometrics (the scientific study of measurements of the human body)

### ***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 model 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.)
- Liveware (i.e., the person or people at the center of the model, including maintenance technicians, supervisors, planners, managers, etc.)

The \_\_\_\_\_ offers the following in regards to human factors:

*"As stated before, Human factors refers to the study of human capabilities and limitations in the workplace.*

*Human factors researchers study system performance, the interaction of maintenance personnel with 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."*



**Figure 1** SHEL Model.

Source: Edwards, 1972 (as referenced in ICAO Human Factors Digest No 1, Circular 216 (1989))

Human factors concentrates on the interfaces between the human (the "L" in the center box) and the other elements of the SHEL model<sup>1</sup> (see Figure 1). From a safety standpoint, it examines where these elements can be deficient.

### Deficiencies in Safety

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

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

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

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

Humans, the "Liveware," can perform a wide range of activities. Despite the fact that modern aircraft are now designed to use the latest Built-In Test Equipment (BITE) that modern computers can provide, one aspect of aviation maintenance has not changed: maintenance tasks are still done by human beings. However, humans have limitations. Since Liveware is at the center of the model, all other aspects (Software, Hardware, and Environment) must be designed or adapted to **assist human performance** and **respect human limitations**. If these two aspects are ignored, the human - in this case the maintenance technician - will not perform to the best of his abilities, may make errors, and may compromise safety.

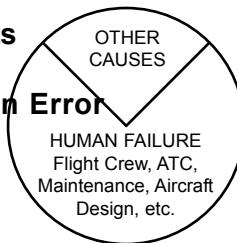
Because of modern design and manufacturing, aircraft are becoming even more reliable. However, it is not possible to re-design the human being: we have to accept the fact that the human being is intrinsically unreliable. We can work around that unreliability by providing good training, procedures, tools, duplicate inspections, etc. We can also



## Introduction

reduce the potential for error by improving aircraft design so that it is physically impossible to reconnect something the wrong way.

### Incidents and Accidents Attributable To Human Factors / Human Error



In 1940, it was calculated that approximately 70% of all aircraft accidents were

**Figure 2** The dominant role played by human performance  
Source: IATA, 1975

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 (Figure 2).

Causes/ major contributory factor	% 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
<b>Maintenance and inspection deficiencies</b>	<b>12</b>
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
Runway hazards	7
Air traffic control/crew communication deficiencies	6
Improper decision to land	6

out in the USA in 1986 looking at significant accident causes in 93 aircraft accidents. The results of this study are highlighted in Table 1.

A study was carried out



One of the main aims of this book is to help all personnel in the maintenance engineering environment (technicians, planners, managers, etc.) to recognize human performance limitations in themselves and others, and to be able to avoid, detect and rectify errors or error prone behavior and practices.

As can be seen from Table 1, the maintenance errors and omissions have a disproportionately high risk level that results in serious failures on the aircraft. More important is the Fatal and Serious Accident Rating FAR/SAR, details of which can be obtained from the Air Accident Investigation Board (AAIB) or the National Aviation Safety Data Analysis Center (NASDAC) or the National Transportation Safety Board (NTSB). Records from 1972 to the present confirm that maintenance errors related to human factors scores over 0.5 FAR/SAR, well above other accident types. This indicates that in these instances there is a greater loss of life. The following accident reports will demonstrate the significant impact of human factors in accidents.

The Civil Aviation Authority (CAA), carried out a similar exercise<sup>1</sup> in 1998 looking at causes of 621 global fatal accidents between 1980 and 1996. Again, the area "maintenance or repair oversight / error / inadequate" featured as one of the top 10 primary causes.

It is clear from these studies that human factors problems in aircraft maintenance engineering are an important issue needing serious consideration.

### ***Examples of Incidents and Accidents***

There have been several 'high profile' incidents and accidents which have involved maintenance human factors problems. The Human Factors in Aviation Maintenance and Inspection (HFAMI) web site ([hfskyway.faa.gov](http://hfskyway.faa.gov)) lists 24 NTSB accident reports where maintenance human factors problems have been the cause or a major contributory factor. In the UK, there have been several major incidents and accidents, details of which can be found on the AAIB web site ([www.dft.gov.uk](http://www.dft.gov.uk)). Some of the major incidents and accidents that will be used as case studies in this book are summarized below. These are:

- Accident to Boeing 737, (Aloha flight 243), Maui, Hawaii, April 28 1988
  - Accident to BAC One-Eleven, G-BJRT (British Airways flight 5390), over Didcot, Oxfordshire on 10 June 1990
  - Incident involving Airbus A320, G-KMAM at London Gatwick Airport, on 26 August 1993
  - Incident involving Boeing 737, G-OBMM near Daventry, on 23 February 1995
- 

### **Aloha Flight 243**



## Introduction

---

*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.*

### **British Airways Flight 5390**

*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 windscreens, 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 storeman 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 corrective lenses, circadian effects, working practices, and possible organizational and design factors.*

### **Airbus A320 at London Gatwick**

*An incident in the UK in August 1993 involved an Airbus 320 which, during its first flight after a flap change, exhibited an undemanded [sic] 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 functioned was not fully understood by*



## Human Factors in Aviation Maintenance

---

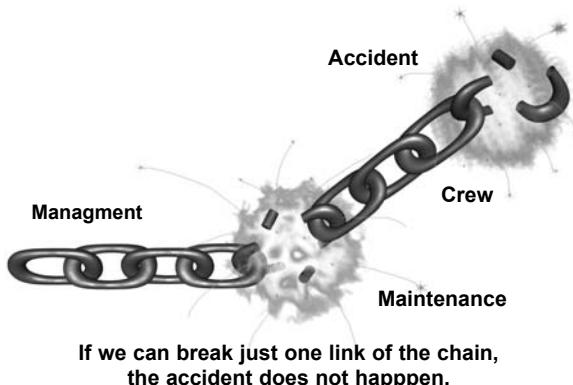
*the technicians. This misunderstanding was due, in part, to familiarity of the technicians with other aircraft (mainly 757) and contributed to a lack of adequate briefing on the status of the spoilers during the shift handover. The locked spoiler was not detected during standard pilot functional checks.*

### Boeing 737 Near Daventry

*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 Luton Airport. The investigation discovered that the aircraft had been subject to borescope 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 technician 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 four of these incidents, the technicians 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 hand overs 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



**Figure 3** The Error Chain. - Source: Boeing<sup>2</sup>

### Incidents and Accidents - A Breakdown in Human Factors



## Introduction

---

In all of the previous examples, 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.

As with many incidents and accidents, all the examples above involved a series of human factors problems which formed an **error chain** (see Figure 3). If any one of the links in this error chain had been broken by built-in measures to intercept a problem at one or more of these stages, these incidents may have been prevented.

Further chapters in this book aim to help the aircraft maintenance technician to identify where the vulnerable areas might be within the maintenance "link," how to identify them, and to provide an introduction to those human factors practices and principles which should prevent the error chain from reaching a catastrophic conclusion.

### Murphy's Law

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

If everyone could be persuaded to acknowledge Murphy's Law, "If something can go wrong, it will," 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 previously show that errors can be made by experienced, well-respected individuals and can occur in organizations previously thought to be "safe."

### Summary

While keeping in mind Murphy's Law may increase our awareness of potential incidents and accidents, there are other human factors to consider that are based on the limitations of the human body and mind.



## Human Factors in Aviation Maintenance

---



## Chapter 2



# Human Performance and Limitations



## Human Factors in Aviation Maintenance

---

This chapter will provide an overview of those key physical and mental human performance characteristics which are likely to affect an Aircraft Maintenance Technician in his working environment, such as his vision, hearing, information processing, attention and perception, memory, judgement and decision making.

---

Page #



## Human Performance as Part of the Maintenance Engineering System

Just as mechanical components used in aircraft maintenance engineering have limitations, technicians themselves have capabilities and limitations that must be considered when looking at the maintenance engineering "system." For instance, rivets used to attach aluminum skin to a fuselage can withstand forces that act to pull them apart. These rivets will eventually fail if enough force is applied to them. The precise range of human capabilities and limitations are not as well-defined as the performance range of mechanical or electrical components but the same principles apply in that human performance is likely to degrade and eventually "fail" under certain conditions (e.g. stress).

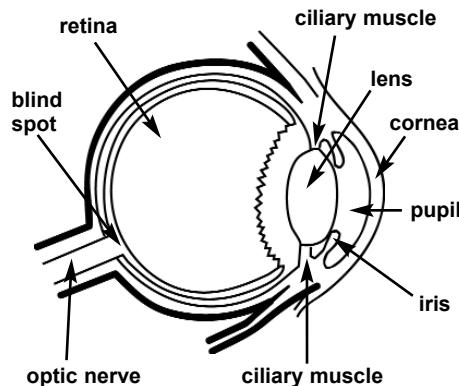
Mechanical components in aircraft can, on occasion, suffer catastrophic failures. Humans can also fail to function properly in certain situations. Physically, humans become fatigued, are affected by the cold, can break bones in workplace accidents, etc. Mentally, humans can make errors, have limited perceptual powers, can exhibit poor judgement due to lack of skills and knowledge, etc. In addition, unlike mechanical components, human performance is also affected by social and emotional factors. Therefore failure by aircraft maintenance technicians can be a detriment to aircraft safety.

The Aircraft Maintenance Technician is the central part of the aircraft maintenance system. It is therefore very useful to have an understanding of how various parts of the body and mental processes function and how performance limitations can influence their effectiveness at work.

## Vision

### ***The Basic Function of the Eye***

In order to understand vision, it is useful first to know a little about the anatomy of the eye (see Figure 4). 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.



**Figure 4** The Human Eye



### **The Cornea**

The **cornea** is a clear "window" at the very front of the eye. The cornea acts as a fixed focusing device. 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 and Pupil**

The **iris** (the colored 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 center of the iris). The size of the pupil can be changed very rapidly to compensate for changing light levels. The amount of light entering the eye can be adjusted by a factor of 5:1.

### **The Lens**

After passing through the pupil, the light passes through the **lens**. Its shape is changed by the muscles (**ciliary 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 aging process.

### **The Retina**

The **retina** is located on the rear wall of the eyeball. It is made up of a complex layer of nerve cells connected to the optic nerve. Two types of light sensitive cells are found in the retina - **rods** and **cones**. The central area of the retina is known as the **fovea** and the receptors in this area are all cones. It is here that the visual image is typically focused. Moving outward, the cones become less dense and are progressively replaced by rods, so that in the periphery of the retina, there are only rods.

At the point at which the optic nerve joins the back of the eye, a "**blind spot**" occurs. 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 strobe 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.



## Human Factors in Aviation Maintenance

---

Before considering factors that can influence and limit the performance of the eye, it is necessary to describe **visual acuity**. When a person is tired accommodation is reduced, resulting in less sharp vision (sharpness of vision is known as visual acuity). Cones function in good light and are capable of detecting fine detail and are color sensitive. This means the human eye can distinguish about 1000 different shades of color. Rods cannot detect color. 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. 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 meters 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 including physical factors, influence of foreign substances, environmental factors, and factors surrounding the object itself.

Physical factors include:

- Physical imperfections in one or both eyes (short sightedness, far sightedness)
- Age

The influence of ingested foreign substances include:

- Drugs
- Medication
- Alcohol
- Cigarettes

Environmental factors include:

- Amount of light available
- Clarity of the air (e.g. dust, mist, rain, etc.)

Factors associated with object being viewed include:

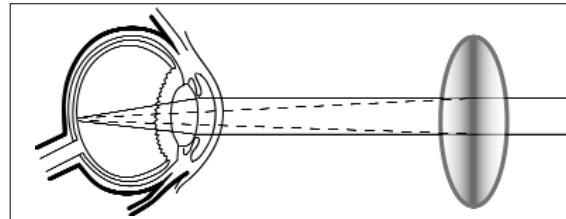
- Size and contours of the object
- Contrast of the object with its surrounding
- Relative motion of the object
- Distance of the object from the viewer
- The angle of the object from the viewer

Each of these factors will now be examined in some detail.



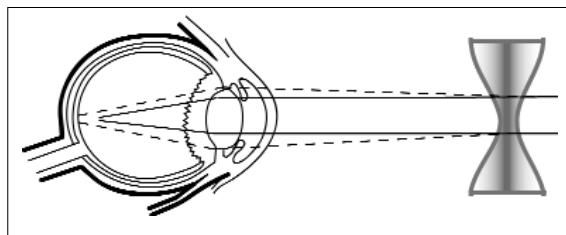
### Physical Factors

Far sightedness, known as **Hypermetropia**, is caused by a shorter than normal eyeball which means that the image is formed behind the retina (Figure 5). If the cornea and the lens cannot use their combined focusing ability to compensate for this, blurred vision will result when looking at close objects.



**Figure 5** A convex lens will overcome long sightedness by bending it before it reaches the cornea.

Short sightedness, known as **Myopia**, is where the eyeball is longer than normal, causing the image to be formed in front of the retina (Figure 6). If the accommodation of the lens cannot counteract this then distant objects are blurred.



**Figure 6** A concave lens will overcome short sightedness by bending light before it reaches the cornea.

Other visual problems include:

- **Cataracts** - clouding of the lens usually associated with aging
- **Astigmatism** - a misshapen cornea causing objects to appear irregularly shaped
- **Glaucoma** - a build up 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

Finally 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, glasses 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, medications, alcohol, and smoking cigarettes. With smoking, carbon monoxide 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 a technician works in a very dark environment for a long time, their 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 technician must wait for their eyes to adjust (adapt). In low light conditions, it is easier to focus if you look slightly to one side of an object. This allows the image to fall outside the fovea and onto the part of the retina which has many rods.

Any airborne particles such as dust, rain or mist can interfere with the transmission of light through the air, distorting what is seen. This can be even worse when glasses are worn, as they are susceptible to getting dirty, wet, misted up or scratched. Technicians 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. This is particularly important if they are working in an environment which is excessively dry or dusty, as airborne particles may also affect contact lens wear. Safety goggles should be worn where necessary.

### ***The Nature of the Object Being Viewed***

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.

### ***Color Vision***

Although not directly affecting visual acuity, inability to see particular colors can be a problem for the aircraft maintenance technician. Amongst other things, good color vision for maintenance technicians is important for:

- Recognizing components
- Distinguishing between wires
- Using various diagnostic tools
- Recognizing various lights on the airfield (e.g., warning lights)



Color defective vision (normally referred to incorrectly as color blindness) is usually hereditary, although may also occur as a temporary condition after a serious illness.

There are degrees of color defective vision, some people suffering more than others. Individuals may be able to distinguish between red and green in a well-lit situation but not in low light conditions. Color defective people typically see the colors they have problems with as shades of neutral grey.

Aging also causes changes in color vision. This is a result of progressive yellowing of the lens, resulting in a reduction in color discrimination in the blue-yellow range. Color defective vision and its implications can be a complex area and care should be taken not to stop a technician from performing certain tasks merely because he suffers from some degree of color deficient vision. It may be that the type and degree of color deficiency is not relevant in their particular job. However, if absolutely accurate color discrimination is critical for a job, it is important that appropriate testing and screening be put in place. Color-defective vision affects about 8% of men but only 0.5% of women. The most common type is difficulty in distinguishing between red and green. More rarely, it is possible to confuse blues and yellows.

### ***Vision and the Aircraft Maintenance Technician***

It is important for a technician, particularly one who is involved in inspection tasks, to have adequate vision to meet the task requirements. As discussed previously, age and problems developing in the eye itself can gradually affect vision. Without regular vision testing, aircraft maintenance technicians may not notice that their vision is deteriorating.

Most National Airworthiness Authorities have produced guidance in regards to vision. The \_\_\_\_\_ states:

*"A reasonable standard of eyesight is needed for any aircraft technician to perform his duties to an acceptable level. Many maintenance tasks require a combination of both distance and near vision. In particular, such consideration must be made where there is a need for the close visual inspection of structures or work related to small or miniature components. The use of glasses or contact lenses to correct any vision problems is perfectly acceptable and indeed they must be worn as prescribed. Frequent checks should be made to ensure the continued adequacy of any glasses or contact lenses. In addition, color discrimination may be necessary for an individual to drive in areas where aircraft maneuver or where color coding is used, (e.g., in aircraft wiring) organizations should identify any specific eyesight requirement and put in place suitable procedures to address these issues."*

Often, airline companies or airports will set the eyesight standards for reasons other than aircraft maintenance safety, (e.g., for insurance purposes, or for driving on the airfield).

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

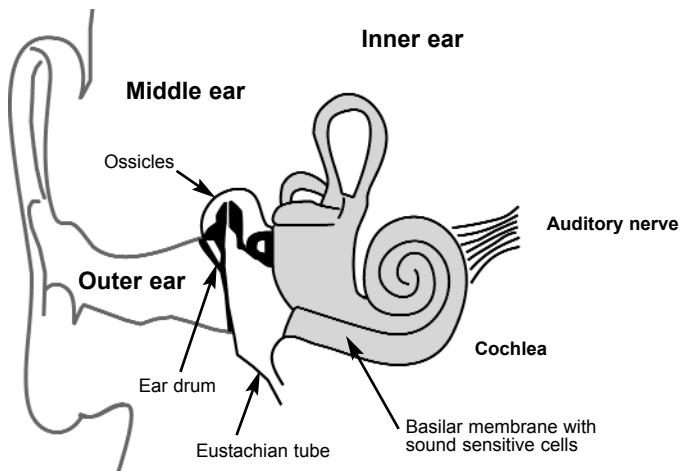


## Hearing

### **The Basic Function of the Ear**

The ear performs two quite different functions. It is used to detect sounds by receiving vibrations in the air, and secondly, it is responsible for balance and sensing acceleration. Of these two, the hearing aspect is more pertinent to the maintenance technician, and thus it is necessary to have a basic appreciation of how the ear works.

As can be seen in Figure 7, the ear has three divisions: **outer ear**, **middle ear**, and **inner ear**. These act to receive vibrations from the air and turn these signals into nerve impulses that the brain can recognize as sounds.



**Figure 7** The human ear

### **Outer Ear**

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

### **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**, 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.



### **Inner Ear**

Unlike the middle ear, the inner ear is filled with fluid. The last of the ossicles in the middle ear is connected to the **cochlea**. This contains a fine membrane (the **basilar membrane**) covered in 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**.

### **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.

Volume (or intensity) of sound is measured in decibels (dB). Table 1 shows intensity levels for various sounds and activities.

Activity	Approximate Intensity level (dB)
Rustling of leaves/Whisper	20
Conversation at 6ft	50
Typewriter at 3ft	65
Car at 45ft	70
Lorry at 45ft	75
Power Mower at 6ft	90
Propeller aircraft at 600ft	100
Jet aircraft at 600ft	110
Standing near a propeller aircraft	120
Threshold of pain	140
Immediate hearing damage results	150

**Table 1** Typical sound levels of various sources

### **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)

The amount of vibration detected in the cochlea depends on the volume and pitch of the original sound. The audible frequency range that a young person can hear is typically between 20 and 20,000 cycles per second, or Hertz (Hz), with greatest sensitivity at about 3000 Hz.



## Human Factors in Aviation Maintenance

---

Intermittent and sudden noise are generally considered to be more disruptive than continuous noise at the same level. In addition, high frequency noise generally has a more adverse affect on performance than lower frequency. Noise tends to increase errors and variability, rather than directly affect work rate. This subject is discussed further in Chapter 5.

### ***Hearing Impairment***

Hearing loss can result from exposure to even a 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 of recovery gradually decreases and hearing loss becomes permanent. Thus, regular exposure to high levels of noise over a long period may permanently damage the hair like cells in the cochlea, leading to irreversible hearing impairment.

The UK "Noise at Work" regulations<sup>1</sup> (1989) impose requirements upon employers to take action if the noise reaches three different levels.

If the noise reaches 85 dB (if normal speech cannot be heard clearly at 2 meters), 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

If the noise reaches 90 decibels (if normal speech cannot be heard clearly at 1 meter) 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 recognized signs to restrict entry

If the noise reaches 115 dB (noise causes immediate damage) for any time duration, employer must:

- Provide hazardous environment protection equipment to be worn at all times

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).

Permanent hearing loss may occur if the TWA is above the recommended maximum.



For example, a person subjected to 95 dB for 3.5 hours, then 105 dB for 0.5 hours, then 85 dB for 4 hours, results in a TWA of 93.5 dB which exceeds the recommended maximum TWA of 90 dB. It is normally accepted that a TWA noise level exceeding 85 dB for 8 hours is hazardous and potentially damaging to the inner ear.

### **Hearing Protection**

Hearing protection is available, to a certain extent, by using ear plugs or ear defenders. It is good practice to reduce noise levels at the source, or move noise away from workers. Often this is not a practical option in the aviation maintenance environment. Hearing protection should always be used for noise, of any duration, above 115 dB. Referring again to Table 1, this means that the aviation maintenance technician will almost always need to use some form of hearing protection when in reasonably close proximity (about 600 - 900ft) to aircraft with its engines running.

### **Presbycusis**

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 age 30 onwards. When this natural decline is made worse by Noise Induced Hearing Loss, it can obviously occur even sooner.

### **Hearing and the Aircraft Maintenance Technician**

The FAA and JAA do not specify the type of hearing test to be carried out for Aircraft Maintenance Technicians, only that the AMT must be capable of carrying out assigned duties. The CAA hearing test recommendation is commonly used worldwide:

*"The ability to hear an average conversational voice in a quiet room at a distance of 2 meters (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 technician understands the limited ability of the ears to protect themselves from damage due to excessive noise. Even though technicians 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 the noise is too loud, it will damage the ears gradually and this is almost unnoticeable until too late. Noise in the workplace is discussed further in Chapter 5.

### **Information Processing**

The previous sections have described the basic functions and limitations of two of the senses used by aircraft maintenance technicians in the course of their work. This

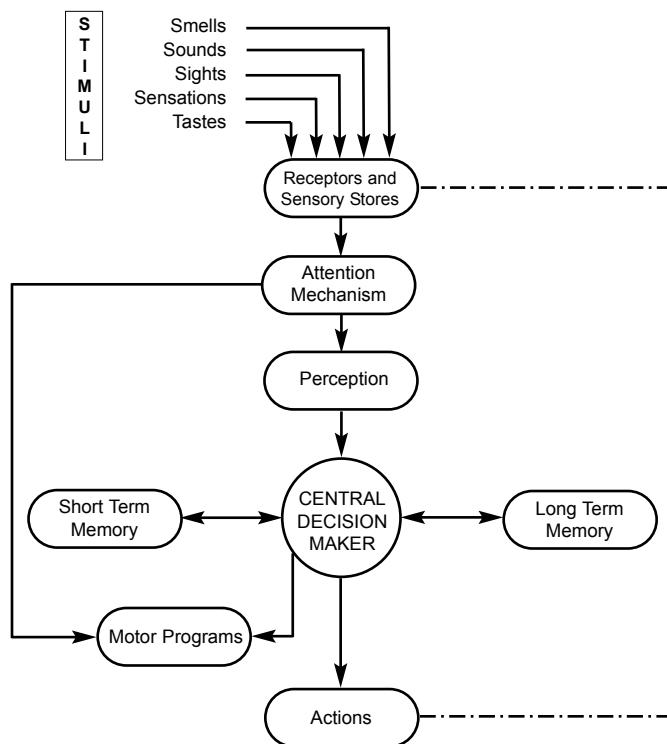


## Human Factors in Aviation Maintenance

section examines the way the information gathered by the senses is processed by the brain. The limitations of the human information processing system are also considered.

### **An Information Processing Model**

Information processing can be represented as a model. This captures the main elements of the process, from receipt of information via the senses, to outputs such as decision making and actions. One such model is shown in Figure 8. Information processing is the process of receiving information through the senses, analyzing it and making it meaningful.



**Figure 8** A functional model of human information processing

### **Sensory Receptors and Sensory Stores**

Physical stimuli are received via the **sensory receptors** (i.e., 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 motion picture, rather than as a series of disjointed images.



### ***Attention and Perception***

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

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 while 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 time sharing.

**Focused attention** is merely the skill of focussing 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.<sup>2</sup>

Attention is influenced by arousal level and stress. This can improve attention or damage it depending on the circumstances. Attention can be thought of as the concentration of mental effort on sensory or mental events.

**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 is a highly sophisticated mechanism and requires existing knowledge and experience to know what data to keep and what to discard, and how to associate the data in a meaningful manner.



### ***Decision Making***

Having recognized coherent information from the stimuli reaching our senses, a course of action has to be decided upon. In other words, **decision making** occurs. 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 (e.g., evacuate); alternatively, an unfamiliar siren may require further information to be gathered before an appropriate course of action can be initiated.

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 as will be shown in the upcoming section entitled "Information Processing Limitations."

Finally, once a decision has been made, an appropriate action can be carried out. Our senses receive feedback of this and its result. This helps to improve knowledge and refine future judgement by learning from experience. 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 to move chaotically

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.

### ***Memory***

Memory is critical to our ability to act consistently and to learn new things. Without memory, we could not capture a "stream" of information reaching our senses, or draw on past experience and apply this knowledge when making decisions.

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:

- Ultra short-term memory (or sensory storage)
- Short term memory (often referred to as working memory)
- 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  $7 \pm 2$  items of information) 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;" or a group of related items.

The duration of short term memory can be extended through **rehearsal** (mental repetition of the information) or **encoding** the information in some meaningful manner (e.g., associating it with something as in the example above). Memory can be considered to be the storage and retention of information, experiences and knowledge, as well as the ability to retrieve this information.

*A telephone number, (e.g., 15853285000,) 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, i.e. in the US, 1585 may be stored as one chunk, 328 as another, and 5000 as another, using only 3 chunks and therefore, more likely to be remembered. In mainland Europe, the same telephone number would probably be stored as 1 58 3 2 85 00 0, using 6 chunks. The size of the chunk will be determined by the individual's familiarity with the information (based on prior experience and context), thus in this example, a person from the UK might recognize 0208 as the code for London, but a person from mainland Europe might not.*

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 programs, problem solving skills, and plans for achieving various activities
- Abilities, such as language comprehension



## Human Factors in Aviation Maintenance

---

Information in long-term memory can be divided into two types: **semantic** and **episodic**. Semantic memory refers to our store of general factual knowledge about the world such as concepts, rules, and 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 Programs***

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 programs** and are ingrained routines that have been established through practice. The use of a motor program 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 program and can be performed with little or no awareness. These motor programs allow us to carry out simultaneous activities, such as having a conversation while driving.

### ***Situation Awareness***

Although not shown explicitly in Figure 8, the process of attention, perception, and judgement should result in awareness of the current situation.

Situation awareness has traditionally been used in the context of the flight deck to describe the pilot's awareness of what is going on around him, (i.e., where he is geographically, his orientation in space, what mode the aircraft is in, etc.) In the maintenance engineering context, it refers to:

- The **perception** of important elements, (e.g., seeing loose bolts or missing parts, hearing information passed verbally)
- The **comprehension** of their meaning, (e.g., Why is it like this? Is this how it should be?)

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.

- The **projection** of their status into the future, (e.g., future effects on safety, schedule, and airworthiness)

As with decision making, feedback improves situation awareness by informing us of the accuracy of our **mental models** and their predictive power. The ability to project system status backward, to determine what events may have led to an observed system state, is also very important in aircraft maintenance engineering, as it allows effective fault finding and diagnostic behavior.



Situation awareness for the aircraft maintenance technician can be summarized as:

- The status of the system the technician 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

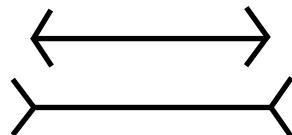
### ***Information Processing Limitations***

The basic elements of human information processing have now been explored. It is important to appreciate that these elements have limitations. As a consequence, the aircraft technician, like other skilled professionals, requires support such as reference to written material (i.e., manuals).

### ***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 9 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. An example is a technician seeing (or perceiving) blue streaks on the fuselage. His comprehension may be that the lavatory fill cap could be missing or the drainline 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. This suggests that in aircraft maintenance engineering, the entire team needs to have situational awareness, not just of what they are doing individually, but of their colleagues' activities as well. Once we have formed a mental model of a situation, we often seek information which will confirm this model and, not consciously, reject information which suggests that this model is incorrect.



**Figure 9** The Muller-Lyer Illusion



## Human Factors in Aviation Maintenance

Figure 10 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.

A, 13, C, D, E, F  
10, 11, 12, 13, 14

Figure 10 The importance of context

In aviation maintenance, it is often necessary to consult documents with which the technician can become very familiar. It is possible that a technician 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 11.

At first, most people tend to notice nothing wrong with the sentence. Our perceptual system sub-consciously rejects the additional "THE."

As an illustration of how expectation can affect our judgement, the same video of a car accident was shown to two groups of subjects. One group were told in advance that they were to be shown a video of a car crash; the other were told that the car had been involved in a "bump." Both groups were asked to judge the speed at which the vehicles had collided. The first group assessed the speed as significantly higher than the second group.

Expectation can also affect our memory of events. The study outlined previously was extended such that subjects were asked a week later whether they recalled seeing glass on the road after the collision (there was no glass). The group who had been told that they would see a crash, recalled seeing glass; the other group recalled seeing no glass.

### **Decision Making, Memory, and Motor Programs**

Attention and perception shortcomings can clearly affect decision making. Perceiving something incorrectly may mean that an incorrect decision is made, resulting in an inappropriate action. Figure 8 also shows the dependence on memory to make decisions.

It was explained earlier that sensory and short-term memory have limitations, both in terms of capacity and duration. It is also important to bear in mind that human memory is fallible, so that information:

- May not be stored

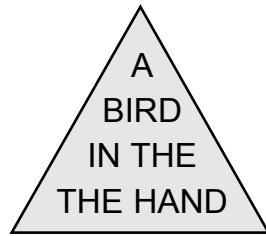


Figure 11 The effects of expectation



- May be stored incorrectly
- May be difficult to retrieve

All these may be referred to as **forgetting**, which occurs when information is unavailable (not stored in the first place) or inaccessible (cannot be retrieved). Information in short-term memory is particularly susceptible to interference, an example of which would be trying to remember a part number while trying to recall a telephone number.

It is generally better to use manuals and **temporary memory aids** rather than to rely upon memory, even in circumstances where the information to be remembered or recalled is relatively simple. For instance, an aircraft maintenance technician may think that they will remember a torque setting without writing it down, but between consulting the manual and walking to the aircraft (possibly stopping to talk to someone on the way), they may forget the setting or confuse it (possibly with a different torque setting appropriate to a similar task with which they are more familiar). Additionally, if unsure of the accuracy of memorized information, an aircraft maintenance technician should seek to check it, even if this means going elsewhere to do so. Noting something down temporarily can avoid the risk of forgetting or confusing information. However, the use of a personal note book to capture such information on a permanent basis can be dangerous, as the information in it may become out-of-date.

In the B737 double engine oil loss incident, the AAIB 1996 report stated:

*"Once the Controller and Fitter had got to T2 and found that this supportive material [Task Cards and AMM extracts] was not available in the workpack, they would have had to return to Base Engineering or to have gone over to the Line Maintenance office to get it. It would be, in some measure, understandable for them to have a reluctance to recross the exposed apron area on a winter's night to obtain a description of what they were fairly confident they knew anyway. However, during the course of the night, both of them had occasion to return to the Base Maintenance hangar a number of times before the task had been completed. Either could, therefore, have referred to or even drawn the task descriptive papers before the job was signed off. The question that should be addressed, therefore, is whether there might be any factors other than overconfidence in their memories, bad judgement or idleness which would dispose them to pass up these opportunities to refresh their memories on the proper and complete procedures."*

### Claustrophobia, Physical Access and Fear of Heights

Although not peculiar to aircraft maintenance engineering, working in restricted space and at heights is a part of the job. Problems associated with physical access are not uncommon. Maintenance technicians often have to access and work in uncomfortable environments. They can include:

- Very small spaces (e.g., in fuel tanks)
- Cramped conditions (such as beneath flight instrument panels, around rudder pedals)



## Human Factors in Aviation Maintenance

---

- Elevated locations (on cherry-pickers, scaffolding, or staging)
- 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. The physical environments associated with these problems are examined further in Chapter 5.

### ***Physical Access and Claustrophobia***

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**.

It is quite possible that susceptibility to claustrophobia is not apparent at the start of employment. It may come about for the first time because of an incident when working within a confined space (e.g., panic if unable to remove yourself from a fuel tank). If a technician suffers an attack of claustrophobia, 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 removing the technician from the confined space quickly and sympathetically. Technicians should work in a team and assist one another, if necessary, making allowances for the fact that people come in all shapes and sizes and that it may be easier for one person to access a space, than another. However, this should not be used as an excuse for a technician to excuse himself from disagreeable jobs.

### ***Fear of Heights***

Working at significant heights can also be a problem for some aircraft maintenance technicians, especially when doing "crown" inspections (top of fuselage, etc.). Some technicians 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 at hand. In such situations, it is very important that appropriate use is made of harnesses and safety ropes. These will not necessarily remove the fear of heights, but will certainly help to reassure the technician and allow them to concentrate on the task in hand. The FAA's HFAMI website ([hfskway.faa.gov](http://hfskway.faa.gov)) provides practical guidance to access equipment when working at heights. Ultimately, if a technician finds working high up brings on phobic symptoms (such as severe anxiety and panic), they should avoid such situations for safety's sake. However, as with claustrophobia, support from team members can be helpful. Please refer to Photograph A.



**Photograph A** - De-Icing an aircraft from a cherry-picker



Managers and supervisors should attempt to make the job as comfortable and secure as reasonably possible (e.g., providing knee pad rests, ensuring that staging does not wobble, providing ventilation in enclosed spaces, etc.) and allow for frequent breaks if possible.

Shortly before the Aloha accident, during maintenance, the Inspector needed ropes attached to the rafters of the hangar to prevent falling from the aircraft when it was necessary to inspect rivet lines on top of the fuselage. Although unavoidable, this would not have been conducive to ensuring that the inspection was carried out meticulously (nor was it, as the subsequent accident investigation revealed). The NTSB investigation report stated:

*"Inspection of the rivets required inspectors to climb on scaffolding and move along the upper fuselage carrying a bright light with them; in the case of an eddy current inspection, the inspectors needed a probe, a meter, and a light. At times, the inspector needed ropes attached to the rafters of the hangar to prevent falling from the airplane when it was necessary to inspect rivet lines on top of the fuselage. Even if the temperatures were comfortable and the lighting was good, the task of examining the area around one rivet after another for signs of minute cracks while standing on scaffolding or on top of the fuselage is very tedious. After examining more and more rivets and finding no cracks, it is natural to begin to expect that cracks will not be found."*

## Summary

The performance of human beings is not a constant. Human error can be introduced into any workplace by changing physical conditions, human biological limitiations, and psychological and sociological factors. In the field of human factors and ergonomics we attempt to "design out" these variations and limitations as much as possible.



## Human Factors in Aviation Maintenance

---



## Chapter 3



# Social Psychology

---

The previous chapter considered the abilities and limitations of the individual. This chapter draws together issues relating to the social context in which the aircraft maintenance technician works. This includes the organization in which they work, how the responsibilities may be delegated, how they are motivated, the aspects of team working, and their supervision and leadership practices.



## The Social Environment

Aircraft maintenance technicians work within a "system". As indicated in Figure 12, there are various factors within this system that effects the aircraft maintenance technician. These range from the knowledge, skills and abilities (discussed in the previous chapter), to the environment in which they work (dealt with in Chapter 5), to the culture of the organization for which they work. Even beyond the actual company they work for, the regulatory requirements laid down for this trade clearly impact on their behavior. As will be seen in Chapter 8 on *Human Error*, all aspects of this system may contribute towards errors that the technician might make.

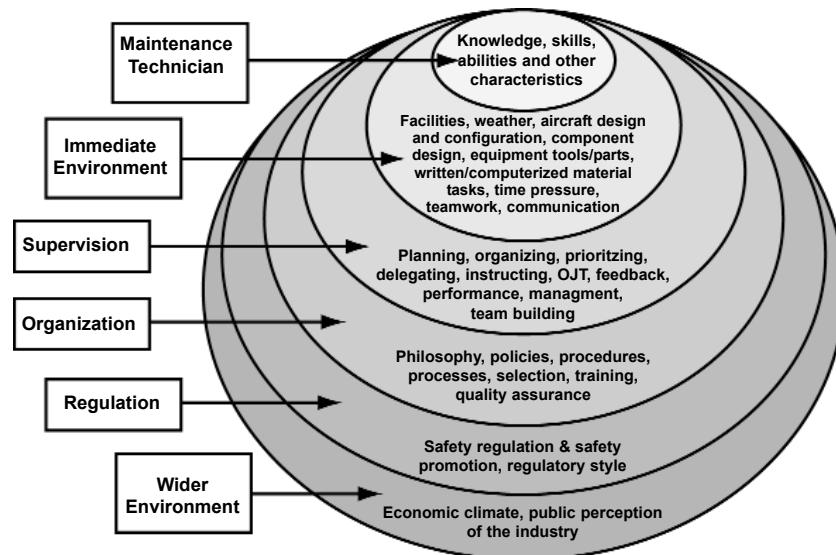


Figure 12 - The maintenance system. Source: Boeing, adapted by Baines, 2001<sup>1</sup>

The vast majority of aircraft maintenance technicians work for a company, either directly, or as contract staff. It is important to understand how the Organization in which the technician works might influence them. Every organization or company employing aircraft maintenance technicians will have different "ways of doing things." This is called the **organizational culture**. They will have their own company philosophy, policies, procedures, selection and training criteria, and quality assurance methods. Culture will be discussed further in a separate section in this chapter.

The impact of the Organization may be positive or negative. On the positive side, Organizations may encourage their employees (both financially and with career incentives), and take notice of problems that their technicians encounter, attempting to learn from these and make changes where necessary or possible. On the negative side, the Organization may exert pressure on its technicians to get work done within certain timescales and within certain budgets. At times, individuals may feel that these conflict with their ability to sustain the quality of their work. These **organizational**



**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.

## **Responsibility: Individual and Group**

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

Within aircraft maintenance, responsibility should be spread across all those who play a part in the activity. This ranges from the accountable manager who formulates policy, through the management that sets procedures, to the supervisors that oversee and mentor the group, to the teams of technicians and individuals within those teams that perform the work. Flight crew also play a part as they are responsible for carrying out preflight checks and walkarounds and highlighting aircraft faults to maintenance personnel.

### ***Working as an Individual or as a Group***

Traditionally, in the maintenance engineering environment, responsibility has been considered in terms of the individual rather than the group or team. This is historical, and has much to do with the manner in which technicians are licensed and the way in which work is certified. This has both advantages and disadvantages. The main advantage to individual responsibility is that a technician understands clearly that one or more tasks have been assigned to them and it is their job to do them (it can also be a strong incentive to a technician to do the work correctly knowing that they will be the one held responsible if something goes wrong). The main disadvantage of any emphasis upon personal responsibility, is that this may overlook the importance of working together as a cohesive team or group to achieve goals.

In practice, aircraft maintenance technicians are often assigned to groups or teams in the workplace. These may be shift teams, or smaller groups within a shift. A team may be made up of various engineering trades, or be structured around aircraft types or place of work (e.g., a particular hangar). Although distinct tasks may be assigned to individuals within a team, the responsibility for fulfilling overall goals would fall on the entire team. Team working is discussed in more detail later in this chapter. If someone is considered responsible, they are liable to be accountable or answerable for something.

### ***Individual Responsibility***

All aircraft maintenance technicians 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 Maintenance Technicians, but also non-licensed staff. The \_\_\_\_\_ states:



## Human Factors in Aviation Maintenance

---

*"The certifying technician shall be responsible for ensuring that work is performed and recorded in a satisfactory manner..."*



**Photograph B** - Certifying engineer checking and signing for completed work

Likewise, non-certifying technicians also have a responsibility in the maintenance process. An Organization approved in accordance with FAA Part 145 or JAR145 must establish the competence of every person, whether directly involved in hands-on maintenance or not. The FAA and CAA has previously ruled that an Organization can make provision on maintenance records or work sheets for the technicians involved to sign for the work, it provides the traceability to those who were involved in the job. The certified technician is then responsible for any adjustment or functional test and the required maintenance records are satisfied before making the legal certification.

### **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), or politely challenging others if you think that something is not quite right.

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 their own may take action, but once placed within a group situation, they 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." This is expanded upon further in the section on peer pressure later in this chapter.

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

- **Intergroup conflict**
- **Group polarization**
- **Free Loading**

**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 technicians 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 hand over in support of the written information on the workcards or task sheets, whereas they might feel such responsibility when handing over tasks to others within their own shift.

**Group polarization** 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 polarization 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.

**Free Loading** is 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.

Responsibility is an important issue in aircraft maintenance engineering and ought to be addressed not only by licensing, regulations, and procedures, but also by education and training and an attempt to encourage a culture of shared, but not diffused, responsibility.

## Motivation and De-motivation

Motivated behavior is goal-directed, purposeful behavior, and no human behavior occurs without some kind of motivation underpinning it. In aircraft maintenance, technicians are trained to carry out the tasks within their capability. However, it is largely their motivation which determines what they actually do in any given situation. Thus, motivation reflects the difference between what a person 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, this does not mean to say that they are doing the right thing. Much 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 are taking action to achieve something. Criminals are highly motivated for instance. Motivation is difficult to measure and predict. We are all motivated by different things, for example, an artist might strive over many months to complete a painting that may never sell, whereas a businessman may forfeit all family life in pursuit of financial success.

With respect to aviation safety, being appropriately motivated is vital. Ideally, aircraft maintenance technicians ought to be motivated to work in a safe and efficient manner. However, many factors may cause conflicting motivations to override this ideal. For instance, the motivation of some financial bonus, or de-motivation of working outdoors in extreme cold weather might lead to less consideration of safety and increase the likelihood of risk taking, corner cutting, violating procedures, and so on. Aircraft maintenance technicians should be aware of conflicting motivations that affect their actions and attempt to examine their motivations for working in a certain way.



## Maslow's Hierarchy of Needs

Possibly one of the most well known theories which attempts to describe human motivation is 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 realize our full potential in life known as self-actualization needs (fulfilling ambitions, etc.)

Figure 13 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 book 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.



**Figure 13** - Maslow's hierarchy of needs. Source: Maslow, 1954<sup>1</sup>



An aircraft maintenance technician will fulfill 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 (For example: 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).

*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**.*

### **De-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

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 while 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

However, care should be taken when associating these characteristics with lack of motivation, since some could also be signs of stress.

There is much debate as to the extent to which financial reward is a motivator. There is a school of thought which suggests that whilst lack of financial reward is a demotivator, the reverse is not necessarily true. The attraction of the extra pay offered to work a moonlighter can be a strong motivator for an individual to ignore the dangers associated with working when tired.



## Human Factors in Aviation Maintenance

---

The motivating effects of job security and the de-motivating impact of lack of job security is also an area that causes much debate. The "hire and fire" attitude of some companies can, potentially, be a major influence upon safety, with real or perceived pressure upon individuals affecting their performance and actions. It is important that maintenance technicians are motivated by a desire to ensure safety, rather than by a fear of being punished and losing their job. It is possible that the "can do" culture, which is evident in some areas of the industry, may be generated by the expectancy that if individuals do not "deliver," they will be punished (or even dismissed) and, conversely, those who do "deliver" (whether strictly by the book or not, finding ways around lack of time, spares, or equipment) are rewarded and promoted. This is not motivation in the true sense but it has its roots in a complex series of pressures and drives and is one of the major influences upon human performance and human error in maintenance engineering.

### Peer Pressure

In the working environment of aircraft maintenance, there are many pressures brought to bear on the individual technician. We have already discussed the influence of the Organization, of responsibility, and motivational drives. In addition to these, there is the possibility that the aircraft maintenance technician will receive pressure at work from those that work with them. This is known as **peer pressure**.

For example, an individual technician 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 their 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.

### ***Experiments in Conformity***

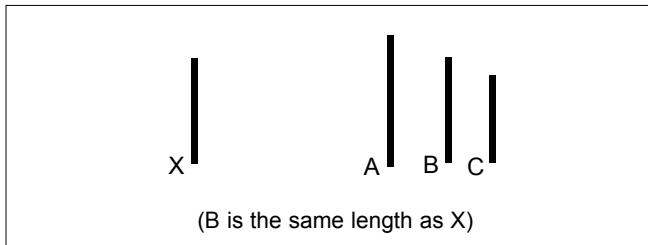
Several experiments have been carried out investigating the nature of conformity in which people were asked to judge which of lines A, B, & C was the same length as line X. (see Figure 14). They were asked this question under different conditions:

- Where the individual was asked to make the judgement on their own
- Where the individual carried out the task after a group of 7-9 others had all judged that line A was the correct choice

In the first condition, very few mistakes were made (as would be expected of such a simple task with an obvious answer). In the second condition, on average, participants gave wrong answers on one third of the trials by agreeing with the conspiring majority. Clearly, participants yielded to group pressure and agreed with the incorrect



"group" finding. However, it is worth mentioning that whether peer pressure is real or not there is a strong tendency to conform with what your colleagues expect.



**Figure 14** An experiment to illustrate conformity. Souce: Asch, 1951

Further research indicated that conformity does not occur with only one conspiring (as then it is a case of "my word against yours"). However, it is necessary to have only three conspirators to one real participant to attain the results found with 7-9 participants.

The degree to which an individual's view is likely to be affected by conformity or peer pressure depends on many factors, including:

- Culture (people from country X tend to conform more than those from country Y)
- Gender (men tend to conform less than women)
- Self-esteem (a person with low self-esteem is likely to conform more)
- Familiarity of the individual with the subject matter (a person is more likely to conform to the majority view if they feel that the other person knows less about the subject matter than they do)
- The expertise of the group members (if the individual respects the group or perceives them to be very knowledgeable he will be more likely to conform to their views)
- The relationship between the individual and group members (conformity increases if the individual knows the other members of the group, that is, a group of peers)

### ***Countering Peer Pressure and Conformity***

The influence of peer pressure and conformity on an individual's views can be reduced considerably if the individual airs their views publicly from the outset. However, this can be very difficult. After the experiments, when asked, many participants said they agreed with the majority as they did not want to appear different or to look foolish.

Conformity is closely linked with "culture" (described in the next section). It is highly relevant in the aircraft maintenance environment where it can work for or against a safety culture, depending on the attitudes of the existing staff and their influence over newcomers. In other words, it is important for an organization to encourage a positive approach to safety throughout their workforce so that peer pressure and

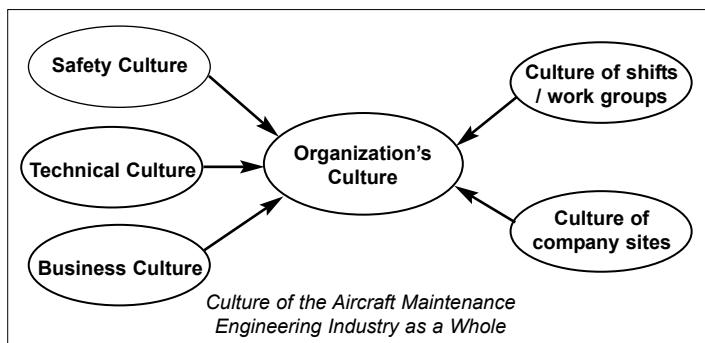


conformity perpetuates this. In this instance peer pressure is clearly a good thing. Too often, however, it works in reverse, with safety standards gradually deteriorating as shift members develop practices which might appear to them to be more efficient but which erode safety. These place pressure, albeit possibly unwittingly, upon new technicians joining the shift to do likewise.

### 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 the Organization and the Organization itself to think that their own methods are the best and that others are not as good. This viewpoint is part of their organizational culture.

Figure 15 indicates that there can be an overall organizational culture, and a number of different "sub-cultures", such as safety culture, professional/technical culture, etc. It is possible for cultural differences to exist between sites or even between shifts within the same organization. The prevailing culture of the industry as a whole also influences individual organizations.



**Figure 15** The influences on an organization's culture

Culture is not necessarily always generated or driven from the top of an organization (as one might think), but this is the best point from which to influence the culture.

### Safety Culture

The ICAO Human factors Digest No. 10, "Human Factors, Management and Organization" (Circular 247), discusses corporate culture and the differences between safe and unsafe corporate cultures.

Gary Eiff from Purdue University discusses safety culture in his paper "Organizational Culture and its Effect on Safety." He suggests that "A safety culture exists only within an organization where each individual employee, regardless of their position, assumes



an active role in error prevention," stressing that "Safety cultures do not ...spring to life simply at the declaration of corporate leaders." The culture of an organization can be described as "The way we do things here." It is a group or company norm.

ICAO HF Digest 10 describes a safety culture as:

*"A set of beliefs, norms, attitudes, roles and social and technical practices concerned with minimizing exposure of employees, managers, customers and members of the general public to conditions considered dangerous or hazardous"*

The culture of an organization can best be judged by what is done rather than by what is said. Organizations 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 organization 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.

Professor James Reason describes the key components of a safety culture<sup>1</sup>, summarized 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, analyzes 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 behavior
- 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

A method for measuring attitudes to safety has been developed by the Health and Safety Executive utilizing a questionnaire approach. Examples of the statements which employees are asked the extent to which they agree are:



## Human Factors in Aviation Maintenance

---

- It is necessary to bend some rules to achieve a target
- Shortcuts 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 and analyzed to give an indication of the safety culture of the Organization. They are broken down according to safety commitment, supervision, work conditions, logistic support, etc. In theory, this enables one organization to be objectively compared to another.

### **Social Culture**

The influence of social culture (an individual's background or heritage) can be important in determining how an individual integrates into an organizational culture. The way an individual behaves outside an organization is likely to have a bearing on how they behave within it. Internal pressures and conflicts within groups at work can be driven by underlying social cultural differences (e.g., different nationalities, different political views, different religious beliefs, etc.). This is an extremely complex subject, however, and an in-depth discussion is beyond the scope of this book.

## **Teamwork**

The responsibility of aircraft maintenance technicians within teams has been discussed in the section "*Responsibility: Individual and Group*" and the influence of peers on the behavior of the individual highlighted in the section titled "*Peer Pressure*." This section looks in more detail at teamwork in aircraft maintenance.

### ***The Concept of a Team***

A lot has been written on the concept of a team, and it is beyond the scope of this book to give anything but a flavor of this.

Teams may comprise a number of individuals **working together** towards one shared goal. Alternatively, they may consist of a number of individuals **working in parallel** to achieve one common goal. Teams generally have a recognized **leader** and one or more followers. Teams need to be built up and their identity as a team needs to be maintained in some way.

While safety culture has been discussed from the organizational perspective, the responsibility of the individual should not be overlooked. Ultimately, safety culture is a combination of the attitude, beliefs and actions of all the individuals working for the Organization. Each person should take responsibility for their own contribution



towards this culture, ensuring that it is a positive contribution rather than a negative one. Whereas individualism encourages independence, teams are associated with interdependence and working together in some way to achieve one or more goals.

A team could be a group of technicians 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 technicians working under their supervision. A team could also be licensed aircraft maintenance technicians and unlicensed technicians working together. A team may also comprise technicians of different technical specialities (e.g., sheetmetal structures, electrical/electronics/avionics, hydraulics, etc.).

There has been a great deal of work carried out on teamwork, in particular "Crew Resource Management (CRM)" in the flight deck context and, more recently, "Maintenance Resource Management (MRM)" in the maintenance context. The ICAO Human Factors Digest No. 12 "Human Factors in Aircraft Maintenance and Inspection" (ICAO Circular 253), includes a Chapter on team working, that is available for further information." MRM is addressed separately since it covers more than just teamwork.

### ***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 others' work (either "officially" or "unofficially")

Teams can be encouraged to take **ownership of tasks** at the working level. This gives a team greater responsibility over a package of work, rather than having to keep referring to other management for authorization, support or direction. However, groups left to their own devices need proper leadership. Healthy competition and rivalry between teams can create a strong **team identity** and encourage pride in the product of a team. Team identity also has the advantage that a group of technicians know one another's capabilities (and weaknesses).

As noted earlier in this chapter, if work has to be handed over to another group or team (i.e., shift handover), this can cause problems if it is not handled correctly. If one team of technicians consider that their diligence (i.e., taking the trouble to do something properly and carefully) is a waste of time because an incoming team's poor performance will detract from it, then it is likely that diligence will become more and more rare over time.



### ***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, coordination, and mutual support.

#### ***Communication***

Communication is essential for exchanging work-related information within the team. For example, a team leader must ensure that a team member has not just heard an instruction, but **understood** what is meant by it. A team member must highlight problems to their colleagues and/or team leader. Furthermore, it is important to listen to what others say. This is covered in greater depth in Chapter 7.

#### ***Cooperation***

"Pulling together" is inherent in the smooth running of a team. **Fairness and openness** within the team encourage cohesiveness and mutual respect. Disagreements must be handled sensitively by the team leader.

#### ***Coordination***

Coordination is required within the team to ensure that the team leader knows what the group members are doing. This includes **delegation** of tasks so that all the resources within the team are utilized. Delegated tasks should be supervised and monitored as required. The team leader must ensure that no individual is assigned a task beyond their capabilities. Further important aspects of coordination are **agreement of responsibilities** (i.e., who should accomplish which tasks and within what timescale), and **prioritization** of tasks.

#### ***Mutual Support***

Mutual support is at the heart of the team's identity. The team leader must encourage this in the team. For instance, if mistakes are made, these should be discussed and corrected constructively.

It is worth noting that in many companies, line technicians tend to work as individuals whereas base technicians tend to work in teams. This may be of significance when a technician who normally works in a hangar, finds themselves working on the line, or vice versa. This was the case in the Boeing 737 incident involving double engine oil pressure loss, where the Base Controller took over a job from the Line Maintenance Technician, along with the line maintenance paperwork. The line maintenance paperwork is not designed for recording work with a view to a hand over, and this was a factor when the job was transferred from the Line Technician to the Base Controller.



## Management, Supervision and Leadership

The previous section made frequent reference to the team leader. Management, supervision, and leadership are all skills that a team leader requires. Of course, management is also a function within an organization (i.e., those managers responsible for policy, business decisions, etc.), as is the supervisor (i.e., in an official role overseeing a team). Managers and supervisors have a key role to play in ensuring that work is carried out safely. It is no good instilling the technicians and repairmen 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, they must decide whether maintenance tasks can be safely carried out with reduced manpower, or they must decide whether a technician volunteering to work as a "moonlighter" to make up the numbers will be able to perform adequately. The adoption of Safety Management Principles<sup>1</sup> 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 technician "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 technicians, but will also have a good appreciation of an individual technician's strengths and weaknesses, together with an appreciation of the norms and safety culture of the group which they supervise. It is mainly their 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 their team without realizing it. It is good practice for a Supervisor to step back from the day-to-day work on occasion and to try to look at their team's 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 engineering skills and knowledge (and appropriate authorizations), and they may get out of practice. In the UK, Air Accidents Investigation Branch (AAIB) investigation reports of the BAC 1-11, A320 and B737 incidents, a common factor was: "Supervisors tackling long duration, hands-on involved tasks." In the B737 incident, the borescope inspection was carried out by the Base Controller, who needed to do the task in order to retain his borescope authorization. Also, there is unlikely to be anyone monitoring or checking the Supervisor because:

- Of his seniority



## Human Factors in Aviation Maintenance

---

- He is generally authorized to sign for his own work (except, of course, in the case where a duplicate inspection is required)
- He may often have to step in when there are staff shortages and, therefore, no spare staff to monitor or check the tasks
- He may be "closer" (i.e., more sensitive to) to any commercial pressures which may exist, or may perceive that pressure to a greater extent than other technicians

It is not the intention to suggest that supervisors are more vulnerable to error; rather that the circumstances which require supervisors to step in and assist tend to be those where several of the "defenses" (see Chapter 8, *Error*) have already failed and which may result in a situation which is more vulnerable to error.

### ***Characteristics of a Leader***

There are potentially two types of leader in aircraft maintenance: The person officially assigned the team leader role (possibly called the Supervisor) and 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.

A good leader in the maintenance engineering environment must possess a number of personal qualities which will assist him in:

- Motivating the team
- Reinforcing good attitudes and behavior
- Demonstrating by example
- Maintaining the group
- Fulfilling a management role

These will now be examined in a little more detail.

### ***Motivating the Team***

Just as the captain of a football team motivates his fellow players, the leader of a maintenance team must do likewise. This can be done by ensuring that the goals or targets of the work which need to be achieved are clearly communicated and manageable. For instance, the team leader would describe the work required on an aircraft within a shift. They must be honest and open, highlighting any potential problems and where appropriate encouraging team solutions.

### ***Reinforcing Good Attitudes and Behavior***

When team members work well (i.e., safely and efficiently), this must be recognized by the team leader and reinforced. This might be by offering a word of thanks for hard work, or making a favorable report to senior management on an individual. A good



leader will also make sure that bad habits are eliminated and inappropriate actions are constructively criticized.

### ***Demonstrating by Example***

A key skill for a team leader is to lead by example. This does not necessarily mean that a leader must demonstrate that they are as skilled at a task as their team (it has already been noted that a supervisor may not have as much opportunity to practice using their skills). Rather, they must demonstrate a personal understanding of the activities and goals of the team so that the team members respect their authority. It is particularly important that the team leader establishes a good safety culture within a team through their attitude and actions in this respect.

### ***Maintaining the Group***

Individuals do not always work together as good teams. It is part of the leader's role to be sensitive to the structure of the team and the relationships within it. They must encourage a "team spirit" where the team members support each other and feel responsible for the work of the team. They must also recognize and resolve disputes within the team and encourage cooperation amongst its members.

### ***Fulfilling a Management Role***

The team leader must not be afraid to lead (and diplomatically making it clear when necessary that there cannot be more than one leader in a team). The team leader is the link between higher levels of management within the organization and the team. A leader in a given situation is a person whose ideas and actions influence the thought and the behavior of other members who actually work on the aircraft. They are responsible for coordinating the activities of the team on a day-to-day basis, which includes allocation of tasks and delegation of duties. There can be a tendency for team members to transfer some of their own responsibilities to the team leader, and he must be careful to resist this.

In terms of the relationship between managers, supervisors and technicians, a "them and us" attitude is not particularly conducive to improving the safety culture of an organization. It is important that managers, supervisors, technicians, and repairmen all work together, rather than against one another, to ensure that aircraft maintenance improves airworthiness. Skilled management, supervision, and leadership play a significant part in the attainment of safety and high quality human performance in aircraft maintenance engineering.

## **Maintenance Resource Management (MRM)**

Maintenance Resource Management (MRM) is included as a specific topic in this book because it is implicit in many of the areas covered in this chapter, such as team working, communication, responsibility, and shift handovers. The discussion of MRM



## Human Factors in Aviation Maintenance

---

in this text is intended only as an introduction to the basic concepts. For more in-depth information concerning MRM is available in the *Maintenance Resource Management Handbook* produced by the FAA.

The term "Maintenance Resource Management" became better known after the Aloha accident in 1988, when researchers took Crew Resource Management (CRM) concepts and applied them to the aircraft maintenance environment. CRM concerns the process of managing all resources in and out of the flight deck to promote safe flying operations. These resources not only include the human element, but also mechanical, computer and other supporting systems. MRM has many similarities to CRM, although the cockpit environment and team is somewhat different from that found in aircraft maintenance. The FAA MRM handbook highlights the main differences between CRM and MRM, and these are summarized in Table 2. MRM is not about addressing the individual human factors of the technician or their manager; rather, it looks at the larger system of human factors concerns involving technicians, managers, and others working together to promote safety.

**Table 2 - Examples of the Differences Between CRM and MRM Highlighted in the FAA Maintenance Resource Management Handbook.<sup>1</sup>**

CRM	MRM
<b>Human error</b>	
Errors tend to be "active" in that their consequences follow on immediately after the error.	The consequences of an engineer's error are often not immediately apparent, and this has implications for training for error avoidance.
<b>Communication</b>	
Much of flight operations are characterised by synchronous, "face-to-face" communications, or immediate voice communications (e.g., with ATC) over the radio.	Maintenance operations tend to be characterised by "asynchronous" communications such as technical manuals, memos, Advisory Circulars, Airworthiness Directives, workcards, and other non-immediate formats. Much of the information transfer tends to be of a non-verbal nature.
<b>"Team" composition</b>	
Flight crews are mostly homogenous by nature, in that they are similar in education level and experience, relative to their maintenance counterparts.	Maintenance staff are diverse in their range of experiences and education and this needs to be taken into account in a MRM program.
<b>Teamwork</b>	
Flight deck crew team size is small - two or three members; although the wider team is obviously larger (i.e., flight deck crew + cabin crew, flight crew + ATC, ground crew, etc.)	Maintenance operations are characterized by large teams working on disjointed tasks, spread out over a hangar. In addition, a maintenance task may require multiple teams (hangar, planning department, technical library, management) each with their own responsibilities. Therefore MRM places equal emphasis on inter-team teamwork skills.

**Situation awareness**

The flight environment is quickly changing, setting the stage for the creation of active failures. Situation awareness in CRM is tailored to avoid these errors; Line Oriented Flight Training (LOFT) simulations provide flight crews with real-time simulations to improve future situation awareness.	The maintenance environment, though hectic, changes slowly relative to flight operations. In terms of situational awareness, engineers must have the ability to extract the consequences of their errors over hours, days or even weeks. To do this, the situational awareness cues that are taught must be tailored to fit the maintenance environment using MRM-specific simulations.
--	---

**Leadership**

Similar to teamwork issues, leadership skills in CRM often focus mainly on intra-team behaviors or "how to lead the team," as well as following skills. Inter-team interaction is somewhat limited during flight.	Because supervisors or team leaders routinely serve as intermediaries among many points of the organization, engineer leaders must be skilled not only in intra-team behaviors, but in handling team "outsiders" (personnel from other shifts, a manager outside the immediate workgroup, etc.) during any phase of the maintenance problem. These outsiders also vary widely in experience, mannerisms, etc. A good MRM program should take these into accounts.
---	---

One of the early MRM training programs was developed by Gordon Dupont for Transport Canada introducing "The Dirty Dozen," which are 12 areas of potential problems in human factors<sup>1</sup>. A series of posters has been produced, one for each of these headings, giving a few examples of good practices or "safety nets" which ought to be adopted. These are summarized in Table 3 and addressed in most maintenance human factors programs.

**Table 3 - Examples of Potential Human Factors Problems from the "Dirty Dozen"**

Problem Example	Potential Solutions
1. Lack of communication	Use logbooks, worksheets, etc. to communicate and remove doubt. Discuss work to be done or what has been completed. Never assume anything.
2. Complacency	Train yourself to expect to find a fault. Never sign for anything you didn't do [or see done].
3. Lack of knowledge	Get training on type. Use up-to-date manuals. Ask a technical representative or someone who knows.
4. Distraction	Always finish the job or unfasten the connection. Mark the uncompleted work. Lockwire where possible or use torque seal. Double inspect by another or self. When you return to the job, always go back three steps. Use a detailed check sheet.
5. Lack of teamwork	Discuss what, who, and how a job is to be done. Be sure that everyone understands and agrees.



## Human Factors in Aviation Maintenance

---

Problem Example	Potential Solutions
6. Fatigue	Be aware of the symptoms and look for them in yourself and others. Plan to avoid complex tasks at the bottom of your circadian rhythm. Sleep and exercise regularly. Ask others to check your work.
7. Lack of parts	Check suspect areas at the beginning of the inspection and AOG the required parts. Order and stock anticipated parts before they are required. Know all available parts sources and arrange for pooling or loaning. Maintain a standard and if in doubt, ground the aircraft.
8. Pressure	Be sure the pressure isn't self-induced. Communicate your concerns. Ask for extra help. Just say "No."
9. Lack of assertiveness	If it's not critical, record it in the journey log book and only sign for what is serviceable. Refuse to compromise your standards.
10. Stress	Be aware of how stress can affect your work. Stop and look rationally at the problem. Determine a rational course of action and follow it. Take time off or at least have a short break. Discuss it with someone. Ask fellow workers to monitor your work. Exercise your body.
11. Lack of awareness	Think of what may occur in the event of an accident. Check to see if your work will conflict with an existing modification or repair. Ask others if they can see any problem with the work done.
12. Norms	Always work as per the instructions or have the instructions changed. Be aware the "norms" don't make it right.

## Summary

No man is an island. We are all products of our genetic make up and social influences. By learning and understanding the internal and external psychological effects on us we can begin to control them.



## Chapter 4



# Factors Affecting Performance

---

The performance abilities and limitations of aircraft maintenance technicians have been described in Chapter 2. Other factors may also affect the technician, potentially rendering them less able to carry out their work and attain the levels of safety required. This chapter discusses factors that affect maintenance technicians performance including fitness and health, stress, time pressures, workload, fatigue, and the effects of medication, alcohol, and drugs.



## **Fitness and Health**

The job of an aircraft maintenance technician can be physically demanding. In addition, their work may have to be carried out in a wide variety of physical environments including cramped spaces, extremes of temperature, etc. (as discussed in the next chapter). There are at present no defined requirements for physical or mental fitness for technicians or maintenance staff. ICAO Annex 11 states:

*"An applicant shall, before being issued with any license or rating [for personnel other than flight crew members], meet such requirements in respect of age, knowledge, experience and, where appropriate, medical fitness and skill, as specified for that license or rating."*

There are two aspects to fitness and health: The disposition of the technician prior to taking on employment and the day-to-day well being of the technician once employed.

### ***Pre-employment Disposition***

Some employers may require a medical exam upon commencement of employment. This allows them to judge the fitness and health of an applicant (and this may also satisfy some pension or insurance related need). There is an obvious effect upon a technician's ability to perform maintenance or carry out inspections if through poor physical fitness or health they are constrained in some way (such as his freedom of movement or impaired vision). In addition, an Airworthiness Authority will consider these factors when issuing a license 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 affect upon job performance (both physical and mental). Day-to-day fitness and health can be reduced through illness (physical or mental) or injury.

Responsibility falls upon the individual aircraft maintenance technician to determine whether they are not well enough to work on a particular day. Alternatively, their colleagues or Supervisor may persuade or advise them to absent themselves until they feel better. The \_\_\_\_\_ states an interesting fact in regards to fitness:

*"In most professions there is a duty of care by the individual to assess his or her own fitness to carry out professional duties. This has been a legal requirement for some time for doctors, flight crew members and air traffic controllers. Licensed aircraft maintenance technicians are also now required by law to take a similar professional attitude. Cases of subtle physical or mental illness may not always be apparent to the individual but as technicians often work as a member of a team any substandard performance or unusual behavior should be quickly noticed by colleagues or supervisors who should notify management so that appropriate support and counselling action can be taken."*



## Factors Affecting Performance

---

Many conditions can impact on the health and fitness of a technician and there is not space here to offer a complete list. However, such a list would include:

- Minor physical illness (colds, flu, etc.)
- More major physical illness (HIV, malaria, etc.)
- Mental illness (depression, etc.)
- Minor injury (sprained wrist, etc.)
- Major injury (broken arm, etc.)
- Ongoing deterioration in physical condition, possibly associated with the aging process (hearing loss, visual defects, obesity, heart problems, etc.)
- Affects of toxins and other foreign substances (carbon monoxide poisoning, alcohol, prescription or illicit drugs, etc.)

This book does not attempt to give 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 technician is aware that their performance, and consequently the safety of aircraft they work on, might be affected adversely by illness or lack of fitness.

A technician may consider that they are letting down their colleagues by not going to work through illness, especially if there are ongoing manpower shortages. However, they should remind themselves that, in theory, management should generally allow for the contingency of 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), an infected employee may pass this on to others if they don't absent themselves from work. 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**

Aircraft maintenance technicians can take common sense steps to maintain their fitness and health. These include:

- Eating regular meals and a well-balanced diet
- Taking regular exercise (exercise sufficient to double the resting pulse rate for 20 minutes, three times a week is often recommended) (always consult a physician before undertaking any exercise program)
- Stopping smoking
- Sensible alcohol intake (for men, this is no more than 3-4 units a day (2-3 for women) or 28 per week, where a unit is equivalent



to half a pint of beer or a 4 oz. glass of wine or 1 oz. of spirit)

Finally, day-to-day health and fitness can be influenced by the use of medication, alcohol and illicit drugs. These are covered later.

## **Stress: Domestic and Work Related**

Stress is an inescapable part of life for all of us. From a human viewpoint, stress results from the imposition of any demand or set of demands which require us to react, adapt or behave in a particular manner in order to cope with or satisfy them. Up to a point, such demands are stimulating and useful, but if the demands are beyond our personal capacity to deal with them, the resulting stress is a problem.

### ***Causes and Symptoms***

Stress is usually something experienced due to the presence of some form of stressor, which might be a one-off stimulus (such as a challenging problem or a punch on the nose), or an on-going factor (such as an extremely hot hangar or a painful divorce). 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** - heat, cold, noise, vibration, presence of something damaging to health (e.g., carbon monoxide)
- **Psychological** - emotional upset (e.g., due to bereavements, domestic problems, etc.), worries about real or imagined problems (e.g., due to financial problems, ill health, etc.)
- **Reactive** - events occurring in everyday life (e.g., working under time pressure, encountering unexpected situations, etc.)

A stress problem can manifest itself by signs of irritability, forgetfulness, sickness absence, mistakes, or alcohol or drug abuse. Management have a duty to identify individuals who may be suffering from stress and to minimize workplace stresses. Individual cases can be helped by sympathetic and skillful counseling which allows a return to effective work and licensed duties.

In brief, the possible signs of stress can include:

- Physiological symptoms - sweating, dryness of the mouth, etc.
- Health effects - nausea, headaches, sleep problems, diarrhea, ulcers, etc.
- Behavioral symptoms - restlessness, shaking, nervous laughter, taking longer over tasks, changes to appetite, excessive drinking, etc.
- Cognitive effects - poor concentration, indecision, forgetfulness, etc.



- Subjective effects - anxiety, irritability, depression, moodiness, aggression, etc.

### **Domestic Stress**

When aircraft maintenance technicians go to work, they cannot leave stresses associated with home behind. Preoccupation 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 technician'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. It should be noted that individuals respond to stressful situations in very different ways. Generally speaking though, people tend to regard situations with negative consequences as being more stressful than when the outcome of the stress will be positive (e.g., the difference between being made redundant at work and being present at the birth of a son or daughter).

### **Work Related Stress**

Aircraft maintenance technicians can experience stress for two reasons related to work: Because of the task or job they are undertaking at that moment or because of the general organizational 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 (covered later in this chapter). This type of stress can be reduced by careful management, good training, and other means.

Within an organization, the social and managerial aspects of work can be stressful. Chapter 3 discussed the impact on the individual of peer pressure, organizational culture and management, all of which can be stressors. In the commercial world that aircraft maintenance technicians work in; shift patterns, lack of control over their own workload, company reorganization, and job uncertainty can also be sources of stress.

### **Stress Management**

Once we become aware of stress, we generally respond to it by using one of two strategies: **defense** or **coping**.

Coping strategies involve dealing with the source of the stress rather than just the symptoms (e.g., delegating workload, prioritizing tasks, sorting out the problem, etc.).

Unfortunately, it is not always possible to deal with the problem if this is outside the control of the individual (such as during an emergency), but there are well-published techniques for helping individuals to cope with stress. Good stress management techniques include:



- Relaxation techniques
- Careful regulation of sleep and diet
- A regime of regular physical exercise
- Counseling - ranging from talking to a supportive friend or colleague to seeking professional advice

There is no magic formula to cure stress and anxiety, merely common sense and practical advice. Defense strategies involve alleviation of the symptoms (taking medication, alcohol, etc.) or reducing the anxiety (e.g., denying to yourself that there is a problem (denial), or blaming someone else). Coping is the process whereby the individual either adjusts to the perceived demands of the situation or changes the situation itself.

### **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 onto technicians, or **perceived** where technicians 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 technicians 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 technicians 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.

#### ***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 (either actual or perceived, external source 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. It is possible that perceived time pressure would appear to have been a contributory factor in the BAC 1-11 accident described in Chapter 1. Although the aircraft was not required the following morning for operational use, it was booked for a wash. The



wash team had been booked the previous week and an aircraft had not been ready. This would have happened again, due to short-staffing, so the Shift Manager decided to carry out the windscreens replacement task himself so that the aircraft would be ready in time.

### **Managing Time Pressure and Deadlines**

One potential method of managing time pressures exerted on technicians is through regulation. For example, FAA research has highlighted the need to insulate aircraft maintenance technicians from commercial pressures. They consider this would help to ensure that airworthiness issues will always take precedence over commercial and time pressures. Time pressures can make "corner-cutting" a cultural norm in an Organization. Sometimes, only an incident or accident reveals such norms (the extract from the Aloha accident above exemplifies this).

Those responsible for setting deadlines and allocating tasks should consider:

- Prioritizing various pieces of work that need to be done
- The actual time available to carry out work (considering breaks, shift hand overs, etc.)
- The personnel available throughout the whole job (allowing a contingency for illness)
- The most appropriate utilization of staff (considering an technician's specialization, and strengths and limitations)
- Availability of parts and spares

An extract from the NTSB report on the Aloha accident refers to time pressure as a possible contributory factor in the accident:

*"The majority of Aloha's maintenance was normally conducted only during the night. It was considered important that the airplanes be available again for the next day's flying schedule. Such aircraft utilization tends to drive the scheduling, and indeed, the completion of required maintenance work. Mechanics and inspectors are forced to perform under time pressure. Further, the intense effort to keep the airplanes flying may have been so strong that the maintenance personnel were reluctant to keep airplanes in the hangar any longer than absolutely necessary."*

It is important that engineering staff at all levels are not afraid to voice concerns over inappropriate deadlines, and if necessary, cite the need to do a safe job to support this. As highlighted in Chapter 3, within aircraft maintenance, responsibility should be spread across all those who play a part. Thus, the aircraft maintenance technician should not feel that the "buck stops here."



## Workload - Overload and Underload

The preceding sections on stress and time pressure have both indicated that a certain amount of stimulation is beneficial to an aircraft maintenance technician, but that too much stimulation can lead to stress or overcommitment in terms of time. It is noteworthy that too little stimulation can also be a problem.

Before going on to discuss workload, it is important to consider this optimum level of stimulation or arousal.

### Arousal

Arousal in its most general sense, refers to readiness of a person for performing work. To achieve an optimum level of task performance, it is necessary to have a certain level of stimulation or arousal. This level of stimulation or arousal varies from person to person. There are people who are overloaded by having to do more than one task at a time; on the other hand there are people who appear to thrive on stress, being happy to take on more and more work or challenges. Figure 16 shows the general relationship between arousal and task performance.

At low levels of arousal, our attention mechanisms will not be particularly active and our performance capability will be low (complacency and boredom can result). At the other end of the curve, performance deteriorates when arousal becomes too high. To a certain extent, this is because we are forced to shed tasks and focus on key information only (called narrowing of attention). Best task performance occurs somewhere in the middle.

In the work place, arousal is mainly influenced by stimulation due to work tasks. However, surrounding environmental factors such as noise may also influence the level of arousal.

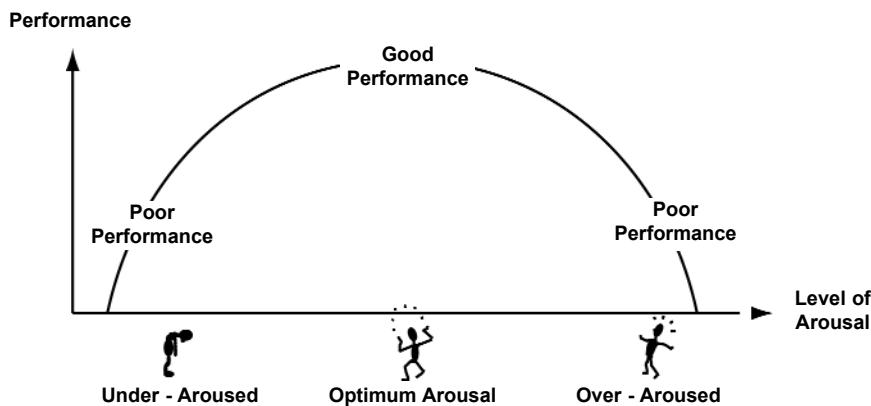


Figure 16 Optimum arousal leads to best task performance (adapted from Thom 1999)<sup>1</sup>



### **Factors Determining Workload**

An individual aircraft maintenance technician can usually identify what work he has to do quite easily. It is more difficult to assess how that work translates into workload.

As noted in the section on information processing in Chapter 2, humans have limited mental capacity to deal with information. We are also limited physically, in terms of visual acuity, strength, dexterity, and so on. Thus, workload reflects the degree to which the demands of the work we have to do eats into our mental and physical capacities. Workload is subjective (i.e., experienced differently by different people) and is affected by the nature of the task, such as:

- Physical demands it requires (e.g., strength required, etc.)
- Mental demands it requires (e.g., complexity of decisions to be made, etc.)

The circumstances under which the task is performed:

- Standard of performance required (i.e., degree of accuracy)
- Time available to accomplish the task (and thus the speed at which the task must be carried out)
- Requirement to carry out the task at the same time as doing something else
- Perceived control of the task (i.e., is it imposed by others or under your control, etc.)
- Environmental factors existing at time (e.g., extremes of temperature, etc.).

The person and his state:

- Skills (both physical and mental)
- His experience (particularly familiarity with the task in question);
- His current health and fitness levels
- His emotional state (e.g., stress level, mood, etc.)

As the workload of the technician may vary, he may experience periods of overload and underload. This is a particular feature of some areas of the industry such as line maintenance.

### **Overload**

Overload occurs at very high levels of workload (when the technician becomes over aroused). As highlighted previously, performance deteriorates when arousal becomes too high and we are forced to shed tasks and focus on key information. Error rates may also increase. Overload can occur for a wide range of reasons based on the factors highlighted above. It may happen suddenly (e.g., if asked to remember one further piece of information whilst already trying to remember a large amount of data), or gradually. As noted earlier in this section, it can be difficult to determine how work translates into workload, both for the individual concerned, and for those allocating tasks.



### ***Underload***

Underload occurs at low levels of workload (when the technician becomes under aroused). It can be just as problematic to a technician as overload, as it too causes a deterioration in performance and an increase in errors such as missed information. Underload can result from a task a technician finds boring, very easy, or too few tasks. The nature of the aircraft maintenance industry means that available work fluctuates, depending on time of day, maintenance schedules, and so forth. Hence, unless stimulating "housekeeping" tasks can be found, underload can be difficult to avoid at times.

### ***Workload Management***

Unfortunately, in a commercial environment, it is seldom possible to make large amendments to maintenance schedules, nor eliminate time pressures. The essence of workload management in aircraft maintenance should include:

- Ensuring that staff have the skills needed to do the tasks they have been asked to do and the proficiency and experience to do the tasks within the timescales they have been asked to work within
- Making sure that staff have the tools and spares they need to do the tasks
- Allocating tasks to teams or individual technicians that can be accomplished without cutting corners, in the time available
- Providing human factors training to those responsible for planning so that the performance and limitations of their staff are taken into account
- Encouraging individual technicians, supervisors and managers to recognize when an overload situation is building up

If an overload situation is developing, methods to help relieve this include:

- Seeking a simpler method of carrying out the work that is just as effective and still legitimate
- Delegating certain activities to others to avoid an individual technician becoming overloaded
- Securing further time in order to carry out the work safely
- Postponing, delaying tasks or deadlines and refusing additional work

Thus, although workload varies in aircraft maintenance engineering, the workload of technicians can be moderated. Much of this can be done by careful forward planning of tasks, manpower, spares, tools, and training of staff.



## Sleep, Fatigue, and Shift Work

### What Is Sleep?

Humans, like all living creatures have to have sleep. Despite a great deal of research, the purpose of sleep is not fully understood.

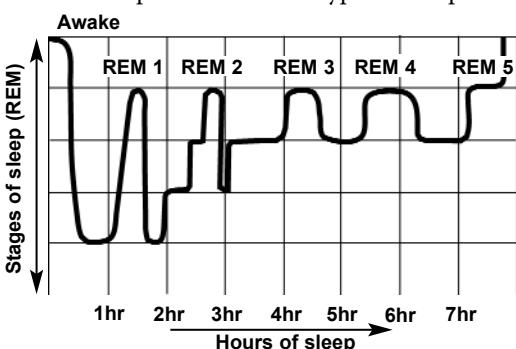
Sleep can be resisted for a short time, but various parts of the brain ensure that sooner or later, sleep occurs. When it does, it is characterized by five **stages of sleep**:

- 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.
- Stage 5:** REM Sleep: The dreaming state of sleep.

Rapid Eye Movement or **REM Sleep**: Even though this stage is characterized 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.

Stages 1 to 4 are collectively known as non-REM (NREM) sleep. Stages 2-4 are categorized as **slow-wave sleep** and appear to relate to body restoration, whereas REM sleep seems to aid the strengthening and organization 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.

As can be seen from Figure 17, sleep occurs in cycles. 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. Most deep sleep occurs earlier in the night and REM sleep becomes greater as the night goes on. Sleep is a natural state of



**Figure 17** Typical cycle of stage 1-4 (NREM) sleep and REM sleep in the course of a night. Source: Gross, 1996<sup>1</sup>



## Human Factors in Aviation Maintenance

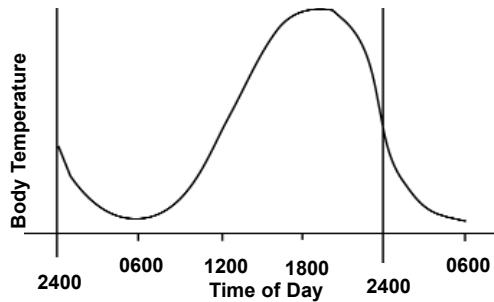
reduced consciousness involving changes in body and brain physiology which is necessary to man to restore and replenish the body and brain.

### **Circadian Rhythms**

Apart from the alternation between wakefulness and sleep, humans have other internal cycles, such as body temperature and hunger/eating. These are known as circadian rhythms as they are related to the length of the day.

Although, circadian rhythms are controlled by the brain, they are influenced and synchronized by external (environmental) factors such as light.

Figure 18 shows the circadian rhythm for body temperature. This pattern is very robust, meaning that even if the normal pattern of wakefulness and sleep is disrupted (by shift work for example), the temperature cycle remains unchanged. Hence, it can be seen that if you are awake at 4-6 o'clock in the morning, your body temperature is in a trough and it is at this time that is hardest to stay awake. Research



**Figure 18** The Circadian Rhythm for Internal Body Temperature

has shown that this drop in body temperature appears to be linked to a drop in alertness and performance in humans. Circadian rhythms are physiological and behavioral functions and processes in the body that have a regular cycle of approximately a day (actually about 25 hours in humans). An example of disrupting circadian rhythms would be taking a flight that crosses time zones. This will interfere with the normal synchronization 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.

The technician's performance at this "low point" will be improved if he is well rested, feeling well, highly motivated, and well practiced in the skills being used at that point.

### **Fatigue**

Fatigue can be either physiological or subjective. **Physiological fatigue** reflects the body's need for replenishment and restoration. It is tied in with factors such as recent physical activity, current health, consumption of alcohol, and with circadian rhythms. It can only be satisfied by rest and eventually, a period of sleep. **Subjective fatigue** is an individual's perception of how sleepy they feel. This is not only affected by when they last slept and how good the sleep was but other factors, such as degree of motivation.

Fatigue is typically caused by delayed sleep, sleep loss, de-synchronization of normal



circadian rhythms, and concentrated periods of physical or mental stress or exertion. In the workplace, working long hours, working during normal sleep hours and working on rotating shift schedules all produce fatigue to some extent.

Although there are many contributory factors, it is noteworthy that a number of major incidents and accidents involving human error have either occurred or were initiated in the pre-dawn hours, when body temperature and performance capability are both at their lowest. These include Three Mile Island, Chernobyl, and Bhopal, as well as the BAC1-11, A320, and B737 incidents summarized in Chapter 1.

Symptoms of fatigue (in no particular order) may include:

- Diminished perception (vision, hearing, etc.) and a general lack of awareness
- Diminished motor skills and slow reactions
- Problems with short-term memory
- Channeled concentration - fixation on a single possibly unimportant issue, to the neglect of others and failing to maintain an overview
- Being easily distracted by unimportant matter
- Poor judgement and decision making leading to increased mistakes
- Abnormal moods - erratic changes in mood, depressed, periodically elated and energetic
- Diminished standards of own work

The CAA highlights the potential for fatigue in aircraft maintenance engineering:

*"Tiredness and fatigue can adversely affect performance. Excessive hours of duty and shift working, particularly with multiple shift periods or additional overtime, can lead to problems. Individuals should be fully aware of the dangers of impaired performance due to these factors and of their personal responsibilities."*

### **Shift Work**

Most aircraft movements occur between 6 A.M. and 10 P.M. to fit in with the requirements of passengers. Aircraft maintenance technicians are required whenever aircraft are on the ground, such as during turn arounds. However, this scheduling means that aircraft are often available for more significant maintenance during the night. Thus, aircraft maintenance engineering is clearly a 24 hour business and it is inevitable that, to fulfill commercial obligations, aircraft maintenance technicians usually work shifts. Some technicians permanently work the same shift, but the majority cycle through different shifts. These typically comprise either an early shift, a late shift and a night shift, or a day shift and a night shift depending on the maintenance organization.



### ***Advantages and Disadvantages of Shift Work***

There are pros and cons to working shifts. Some people welcome the variety of working different times associated with regular shift work patterns. Advantages may include more days off and avoiding peak traffic times when traveling to work.

The disadvantages of shift working are mainly associated with:

- Working "unsociable hours," meaning that time available with friends, family, etc. will be disrupted
- Working when human performance is known to be poorer (i.e. between 4 A.M. and 6 A.M.)
- Problems associated with general desynchronisation and disturbance of the body's various rhythms (principally sleeping patterns)

### ***Working At Night***

Shift work means that technicians will usually have to work at night, either permanently or as part of a rolling shift pattern. As discussed earlier in this chapter, this introduces the inherent possibility of increased human errors. Working nights can also lead to problems sleeping during the day, due to the interference of daylight and environmental noise. Blackout curtains and use of ear plugs can help, as well as avoidance of caffeine before sleep.

### ***Rolling Shift Patterns***

When a technician 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 on its old wake-sleep cycle for several days, even though it is no longer possible for the person to sleep when the body thinks it is appropriate, and is only gradually resynchronised. However, by this time, the technician 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 (night shift-late shift-early shift).

### ***Continuity of Tasks and Shift Hand Overs***

Many maintenance tasks often span more than one shift, requiring tasks to be passed from one shift to the next. The outgoing personnel are at the end of anything up to a twelve hour shift and are consequently tired and eager to go home. Therefore, shift hand over is potentially an area where human errors can occur. While longer shifts may result in greater fatigue, the disadvantages may be offset by the fact that fewer shift changeovers are required (i.e., only 2 hand overs with 2 twelve hour shifts, as opposed to 3 hand overs with 3 eight hour shifts). Shift hand over is discussed further in Chapter 7 when looking at "work logging and recording."



### **Sleep, Fatigue, Shift Work and the Aircraft Maintenance Technician**

Most individuals need approximately 8 hours sleep in a 24 hour period, although this varies between individuals, some needing more and some happy with less than this to be fully refreshed. They can usually perform adequately with less than this for a few days, building up a temporary **sleep "deficit."** However, any sleep deficit will need to be made up, otherwise performance will start to suffer.

As previously noted, fatigue is best tackled by ensuring adequate rest and good quality sleep are obtained. The use of blackout curtains if having to sleep during daylight has already been mentioned. It is also best not to eat a large meal shortly before trying to sleep, but on the other hand, the technician should avoid going to bed hungry. As fatigue is also influenced by illness, alcohol, etc., it is very important to get more sleep if feeling a little unwell and drink only in moderation between duties (discussed further in the next section). Taking over-the-counter drugs to help sleep should only be used as a last resort.

When rotating shifts are worked, it is important that the technician is disciplined with his eating and sleeping times. Moreover, out of work activities have to be carefully planned. For example, it is obvious that an individual who has been out night-clubbing until the early hours of the morning will not be adequately rested if rostered on an early shift. In the B737 double engine oil loss incident, the error occurred during the night shift. The accident investigation report commented that:

*"It is under these circumstances that the fragility of the self monitoring system is most exposed because the safety system can be jeopardized by poor judgement on the part of one person and it is also the time at which people are most likely to suffer impaired judgement." A good rule of thumb is that one hour of high-quality sleep is good for two hours of activity.*

Shift working patterns encountered by aircraft maintenance technicians may include three or four days off after the last night shift. It can be tempting to work additional hours, taking voluntary overtime, or another job, in one or more of these days off. This is especially the case when first starting a career in aircraft maintenance engineering when financial pressures may be higher. Technicians should be aware that their vulnerability to error is likely to be increased if they are tired or fatigued, and they should try to ensure that any extra hours worked are kept within reason.

Finally, it is worth noting that, although most technicians adapt to shift working, it becomes harder to work rotating shifts as one gets older.

### **Alcohol, Medication, and Drug Abuse**

It should come as no surprise to the aircraft maintenance technician that his performance will be affected by alcohol, medication or illicit drugs. Under FAA, CAA and JAA legislation it is an offense for safety critical personnel to carry out their duties whilst under the influence of alcohol or drugs. Article 13 (paragraph 8) of the UK ANO states:



## Human Factors in Aviation Maintenance

---

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

At the time of this writing, 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 alcohol or drugs where there is reasonable cause, and the introduction of a blood/alcohol limit of 20 milligrams of alcohol per 100 milliliters of blood for anyone performing a safety critical role in civil aviation (which includes aircraft maintenance technicians).

It is always sensible to monitor ones performance, especially when working additional hours. Performance decrements can be gradual, and first signs of chronic fatigue may be moodiness, headaches or finding that familiar tasks (such as programming the video recorder) seem more complicated than usual.

### **Alcohol**

Alcohol acts as a depressant on the central nervous system, dulling the senses and increasing mental and physical reaction times. It is known that even a small amount of alcohol leads to a decline in an individual's performance and may cause his judgement (i.e., ability to gauge his performance) to be hindered.

Alcohol is removed from the blood at a fixed rate and this cannot be speeded up in any way (e.g., by drinking strong coffee). In fact, sleeping after drinking alcohol can slow down the removal process, as the body's metabolic systems are slower.

AWN47 provides the following advice concerning alcohol:

*"Alcohol has similar effects to tranquilizers 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 antihistamines, can form a highly dangerous and even lethal combination."*

The affects of alcohol can be made considerably worse if the individual is fatigued, ill, or using medication.

### **Medication**

Any medication, no matter how common, can possibly have direct effects or side effects that may impair a technician's performance in the workplace.

There is a risk that these effects can be amplified if an individual has a particular sensitivity to the medication or one of its ingredients. Hence, an aircraft maintenance technician should be particularly careful when taking a medicine for the first time,



## Factors Affecting Performance

---

and should ask his doctor whether any prescribed drug will affect his work performance. It is also wise with any medication to take the first dose at least 24 hours before any duty to ensure that it does not have any adverse effects.

Various publications, and especially AWN47 give advice relevant to the aircraft maintenance technician on some of the more common medications. This information is summarized below, however the technician must use this with caution and should seek further clarification from a pharmacist, doctor, or their company occupational health advisor if at all unsure of the impact on work performance.

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.

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

Medication can be regarded as any over-the-counter or prescribed drug used for therapeutic purposes.

Medication is usually taken to relieve symptoms of an illness. Even if the drugs taken do not affect the technician's performance, he should still ask himself whether the illness has made him temporarily unfit for work.

- **Analgesics** are used for pain relief and to counter the symptoms of colds and flu.
- **Antibiotics** (such as Penicillin and the various mycins and cyclines) may have short term or delayed effects which 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 an individual unfit for work.
- **Antihistamines** are used widely in "cold cures" and in the treatment of allergies (e.g., hayfever). Most of this group of medicines tend to make the user feel drowsy, meaning that the use of medicines containing anti-histamines is likely to be unacceptable when working as an aircraft maintenance technician.
- **Cough suppressants** are generally safe in normal use, but if an over-the-counter product contains anti-histamine, decongestant, etc., the technician should exercise caution about its use when working.
- **Decongestants** (i.e., treatments for nasal congestion) may contain



chemicals such as pseudo-ephedrine hydrochloride (e.g., Sudafed™) and phenylphrine. Side-effects reported, are anxiety, tremor, rapid pulse and headache. AWN47 forbids the use of medications containing this ingredient to aircraft maintenance technicians when working, as the effects compromise skilled performance.

- **"Pep" pills** are used to maintain wakefulness. They often contain caffeine, dexedrine, or benzedrine. Their use is often habit forming. Over-dosage may cause headaches, dizziness, and mental disturbances. AWN47 states that "the use of 'pep' pills while working can not be permitted. If coffee is insufficient, you are not fit for work."
- **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 in the UK, 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.

### **Drugs**

Illicit drugs such as ecstasy, cocaine, and heroin all affect the central nervous system and impair mental function. They are known to have significant effects upon performance and have no place within the aviation maintenance environment. Of course, their possession and use are also illegal in the US.

Smoking cannabis (marijuana) can subtly impair performance for up to 24 hours. In particular, it affects the ability to concentrate, retain information, and make reasoned judgements, especially on difficult tasks.

If the aircraft maintenance technician has **any** doubts about the suitability of working while taking medication, he must seek appropriate professional advice.

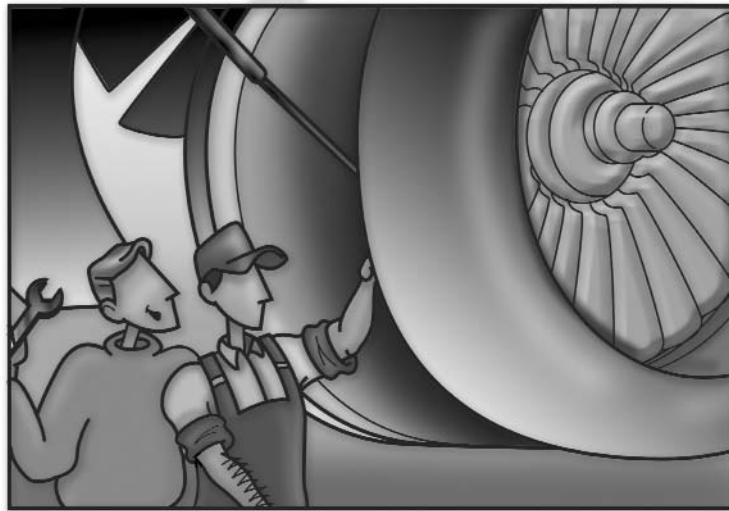
### **Summary**

Human physiology is complex and wonderful. The human body is capable of amazing levels of effort and can recover quickly from over stress. However the body is a limited machine and constant abuse will cause degraded performance and even irreparable damage.

By understanding the bodies limitations and the effect of the physical world on human physiology we can work hard and limit any adverse effects.



## Chapter 5



# Physical Environment

---

The aircraft maintenance technician 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. This depends largely on the company they work for, and the function they fulfill in the company. Both physical environments have their own specific features or factors that may impact human performance. This chapter considers the impact of noise, fumes, illumination, climate and temperature, motion and vibration, as well as the requirement to work in confined spaces and other issues associated with the general working environment.



## Noise

The impact of noise on human performance has already been discussed in Chapter 2, when examining "hearing." To recap, 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 it can damage workers' hearing (either temporarily or permanently). It was noted that the ear is sensitive to sounds between certain frequencies (20 Hz to 20 KHz) and that 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 a few hundred meters of a moving jet aircraft.

General background noise can be "filtered out" by the brain through focused attention (as noted in Chapter 2). Otherwise, for more problematic noise, some form of hearing protection (e.g., ear plugs and ear muffs) is commonly used by aircraft maintenance technicians both on the line and in the hangar to help the technician to concentrate.

The noise environment in which the aircraft maintenance technician works 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. Short periods of intense noise are not uncommon here and can cause temporary hearing loss. Technicians may move to and from these noisy areas into the relative quiet of rest rooms, aircraft cabins, supply rooms, and offices.

Noise can be thought of as any unwanted sound (especially if it is loud) that is unpleasant and annoying. It is very important that aircraft maintenance technicians remain aware of the extent of the noise around them. It is likely that some form of hearing protection should be carried with them at all times and, as a rule of thumb, used when remaining in an area where normal speech cannot be heard clearly at 2 meters (6.5 ft.).

In their day-to-day work, aircraft maintenance technicians will often need to discuss matters relating to a task with colleagues and also, at the end of a shift, hand over to an incoming technician. Clearly, in both cases it is important that noise does not impair their ability to communicate, as this could obviously have a bearing on the successful completion of the task (i.e., safety). Common sense dictates that important matters are discussed away from noisy areas.

## Fumes

By its nature, the maintenance of aircraft involves working with a variety of fluids and chemical substances. For instance, technicians may come across various lubricants (oils and greases), hydraulic fluids, paints, cleaning compounds and, solder. They will also be exposed to aircraft fuel and exhaust. In fact, there is every possibility that a



technician could be exposed to a number of these at any one time in the workplace. Each substance gives off some form of vapor or fumes which can be inhaled by the aircraft maintenance technician. Some fumes will be obvious as a result of their odor, whereas others have no smell to indicate their presence. Some substances will be benign most of the time, but may, in certain circumstances, produce fumes (e.g., overheated grease or oils, smoldering insulation).

Fumes can cause problems for technicians mainly as a result of inhalation, but they can also cause other problems, such as eye irritation. The problem may be exaggerated in aircraft maintenance engineering by the confined spaces in which work must sometimes be carried out (e.g., fuel tanks). Here the fumes cannot dissipate easily and it may be appropriate to use breathing apparatus.

It may not always be practical to eliminate fumes from the aircraft maintenance technician's work place, but where possible, steps should be taken to minimize them. It is also common sense that if noxious fumes are detected, a technician should immediately inform his colleagues and supervisor so that the area can be evacuated and suitable steps taken to investigate the source and remove them. Apart from toxic fumes that have serious health implications and must be avoided, working in the presence of fumes can affect a technician's performance, as they may rush a job in order to escape them. If the fumes are likely to have this effect, the technician should increase the ventilation locally or use breathing apparatus to dissipate the fumes.

## IIIllumination

In order for aircraft maintenance technicians to carry out their work safely and efficiently, it is imperative that their work be conducted under proper lighting conditions. It was noted in Chapter 2 that the cones in the retina of the eye require good light to resolve fine detail. Furthermore, color vision requires adequate light to stimulate the cones. Inappropriate or insufficient lighting can lead to mistakes in work tasks or can increase the time required to do the work.



**Photograph C** - Use of artificial lighting to supplement the ambient illumination in a hangar

When working outside during daylight, the technician may have sufficient **natural light** to see well by. It is possible however that they may be in a 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, airfields may appear to be awash with floodlights and other airfield lighting, but these are unlikely to provide sufficient illumination for a technician to be able to see what they are 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 flashlight (i.e., one which does not have a dark area in the center of the beam). However, the drawback of a flashlight, is that it leaves the technician with only one hand available with which to work. A light mounted on a headband gets around this problem.

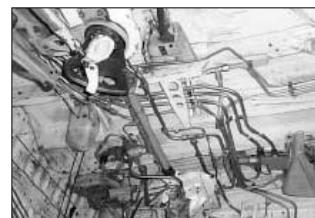


## Human Factors in Aviation Maintenance

---

Within the hangar, general area lighting tends to be some distance from the aircraft on which a technician might work, as it is usually attached to the very high ceiling of these buildings. This makes these lights hard to reach, meaning that they tend to get dusty, making them less effective and, in addition, failed bulbs tend not to be replaced as soon as they go out. In general, area lighting in hangars is unlikely to be as bright as natural daylight and as a consequence local task lighting is often needed, especially for work of a precise nature (particularly visual inspection tasks). Illumination refers to the lighting both within the general working environment and also in the locality of the technician and the task they are carrying out. It can be defined as the amount of light striking a surface. A flashlight can be very useful to the technician, but Murphy's Law dictates that the flashlight batteries will run down when the technician is across the airfield and away from the supplies. It is much wiser to carry a spare set of batteries than "take a chance" by attempting a job without enough light.

It is also important that illumination is available where the technician needs it (i.e., both in the hangar and on the line). Any supplemental task lighting must be adequate in terms of its brightness for the task at hand, which is best judged by the technician. When using task lighting, it should be placed close to the work being done, but should not be in the technician's line of sight as this will result in **direct glare**. It must also be arranged so that it does not reflect off surfaces near where the technician is working causing **indirect** or **reflected glare**. Glare of either kind will be a distraction from the task and may cause mistakes. Please refer to Photograph D.



**Photograph D** - Task lighting to facilitate internal inspection and work

Poor ambient illumination of work areas has been identified as a significant deficiency during the investigation of certain engineering incidents. It is equally important that lighting in ancillary areas such as offices and supply areas is good.

Relying on touch when lighting is poor is no substitute for actually being able to see what you are doing. If necessary, tools such as mirrors and borescopes may be needed to help the technician see into remote areas. An extract from the NTSB report on the Northwest Airlines accident at Tokyo, 1994, illustrates these points:

*"The Safety Board believes that the 'OK to Close' inspector was hindered considerably by the environment of the pylon area. He indicated, for example, that the combination of location of the scaffolding (at a level just below the underside of the wing that forced him into unusual and uncomfortable physical positions) and inadequate lighting from the base of the scaffolding up toward the pylon, hampered his inspection efforts. Moreover, the underside of the pylon was illuminated by portable fluorescent lights that had been placed along the floor of the scaffolding. These lights had previously been used in areas where airplanes were painted, and, as a result, had been covered with the residue of numerous paint applications that diminished their brightness. These factors combined to cause the inspector to view the fuse pin retainers by holding onto the airplane structure with one*



*"hand, leaning under the bat wing doors at an angle of at least 30°, holding a flashlight with the other hand pointing to the area, and moving his head awkwardly to face up into the pylon area."*

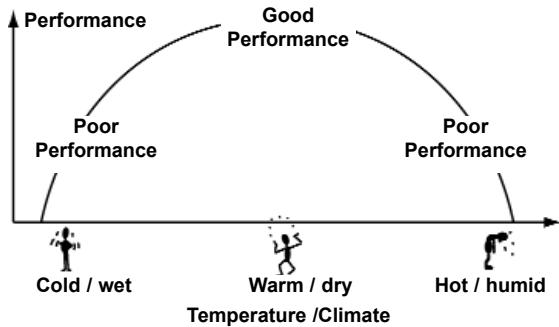
The AAIB report for the BAC 1-11 accident says of the unmanned supply area:

*"The ambient illumination in this area was poor and the Shift Maintenance Manager had to interpose himself between the carousel and the light source to gain access to the relevant carousel drawers. He did not use the drawer labels, even though he now knew the part number of the removed bolt, but identified what he thought were identical bolts by placing the bolts together and comparing them."*

He also failed to make use of his corrective lenses.

## Climate and Temperature

Humans can work within quite a wide range of temperatures and climatic conditions, but performance is adversely affected at extremes of these. Thus, as can be seen in Figure 19, when it is either too cold and/or wet or too hot and/or humid, performance diminishes.



**Figure 19** The relationship between climate, temperature, and performance

As has been noted throughout this book, aircraft maintenance technicians routinely work both within the hangar and outside. Clearly, exposure to the widest range of temperature and climate is likely to be encountered outdoors. Here, a technician may have to work in direct summer sun, strong winds, heavy rain, high humidity, or in the depths of winter. Although hangars may exclude inclement weather, they can still be cold and windy, especially if the hangar doors have to remain open. Various national safety regulations like the \_\_\_\_\_ state:

*"Hangars used to house aircraft together with office accommodation should be such as to ensure the working environment permits personnel to carry out work tasks in an effective manner. Temperatures should be maintained such that personnel can carry out required tasks without undue discomfort."*

## Climate

Technicians cannot be expected to maintain the rigorous standards expected in their profession in all environmental conditions. Environmental conditions must be adequate for work to be carried out. \_\_\_\_\_ says that:



## Human Factors in Aviation Maintenance

---

*"The working environment for line maintenance should be such that the particular maintenance or inspection task can be carried out without undue distraction. It therefore follows that where the working environment deteriorates to an unacceptable level in respect of temperature, moisture, hail, ice, snow, wind, light, dust, or other airborne contamination, the particular maintenance or inspection tasks should be suspended until satisfactory conditions are reestablished."*

Unfortunately, in reality, pressure to turn aircraft around rapidly means that some maintenance tasks are not put off until the conditions are more conducive to work.

Environmental conditions can affect physical performance. For example, cold conditions make numb fingers, reducing the technician's ability to carry out repairs that require fine motor skills. Working in strong winds can be distracting, especially if having to work at height (e.g., on staging). Extreme environmental conditions may also be fatiguing, both physically and mentally.

There are no simple solutions to the effects of temperature and climate on the technician. For example, an aircraft being turned around on the apron cannot usually be moved into the hangar so that the technician avoids the worst of the weather. In the cold, gloves can be worn, but obviously the gloves themselves may interfere with fine motor skills. In the direct heat of the sun or driving rain, it is usually impossible to set up a temporary shelter when working outside.

### Motion and Vibration

Aircraft maintenance technicians 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 a technician, for they may concentrate more on keeping their balance than the task. Furthermore, it is vitally important that technicians use mobile access platforms properly in order to avoid serious injury. Please refer to Photograph E



**Photograph E** Mobile access platforms, such as a "Cherry Picker," must be stable in use

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)**.



## Physical Environment

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 a technician's concentration.

### Confined Spaces

Chapter 2 highlighted the possibility of claustrophobia being a problem in aircraft maintenance engineering. Working in any confined space, especially with limited means of entry or exit (e.g., fuel tanks) needs to be managed carefully. As noted previously, technicians should ideally work with a colleague who would assist their entrance into and exit out of the confined space. Good illumination and ventilation within the confined space will reduce any feelings of discomfort. In addition, appropriate safety equipment, such as breathing apparatus or lines must be used when required.

### Working Environment

Various factors that affect the technician'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, etc.)
- 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 labeling or storage in different locations, etc.)



**Photograph F** It is important that tools are close at hand and the work is neat and tidy.

To some extent, some or all of the factors associated with the technician's workplace may affect their ability to work safely and efficiently. \_\_\_\_\_ 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."*

The **working environment** comprises the physical environment encapsulated in this chapter, the social environment described in Chapter 3, and the tasks that need to be

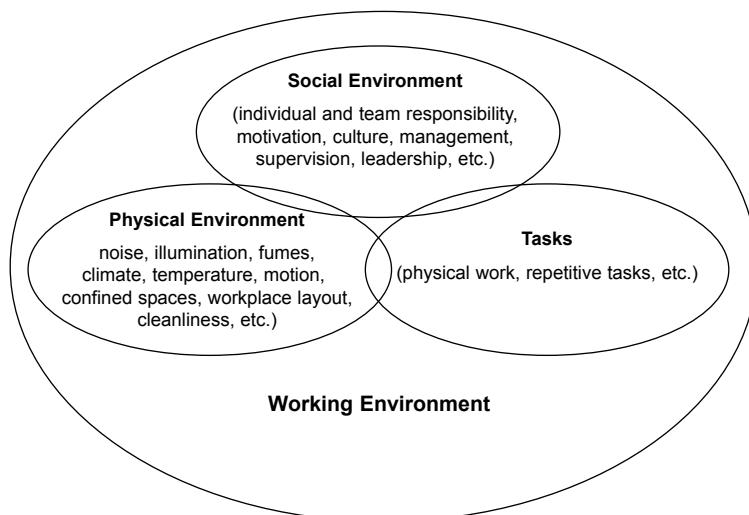


## Human Factors in Aviation Maintenance

carried out (examined in the next chapter). This is shown in Figure 20. Each of these three components of the working environment interact, for example:

- Technicians are trained to perform various tasks
- Successful task execution requires a suitable physical environment
- An unsuitable or unpleasant physical environment is likely to be de-motivating

Aircraft maintenance engineering requires all three components of the working environment to be managed carefully in order to achieve a safe and efficient system.



**Figure 20** Components of the "working environment"

It is important to recognize that technicians are typically highly professional and pragmatic in their outlook, and generally attempt to do the best work possible regardless of their working environment. Good maintenance organizations do their best to support this dedication by providing the necessary conditions for safe and efficient work.

## Summary

Understanding the physical environment and its effects allows us to control our exposure to severe conditions and limit or eliminate any detrimental effects on the body.



## Chapter 6



## Tasks

---

The everyday tasks carried out by aviation technicians and other staff can range from the highly complex to the routine. Planning, organizing, and good communication helps tasks to be completed on time, to standards, and on price. But also reduces workload and physiological stress on individuals. The daily routine for an aircraft maintenance technician could include the following processes and conditions.



## Physical Work

### **Planning**

Blindly starting a task without **planning** how best to do it is almost certainly the best way to invite problems. Before commencing a task, an individual technician, engineering team, or planner should ask themselves a number of questions.

Do I or we know exactly what the task is that has to be done?

Are the resources available to do it effectively (safely, accurately and within the time permitted)? Where resources include:

- Personnel
- Equipment/spares
- Documentation, information and guidance
- Facilities such as hangar space, lighting, etc.

Do I/we have the skills and proficiency necessary to complete the task?

Information about specific tasks should be detailed on job cards or task sheets. These will indicate the task (e.g., checks or inspection, repair, replacement, overhaul) and often further details to aid the technician (such as maintenance manual references, part numbers, etc.).

It is generally the Shift Supervisor's job to ensure that the resources are available for their staff to carry out their tasks. As noted in Chapter 3, it is likely that within a shift or a team, various sub-tasks are allocated to individuals by the Supervisor. Alternatively, they may encourage a team to take ownership of the tasks that need to be completed, giving them the discretion to manage a package of work (as noted in Chapter 3, *Teamwork*). Exactly "who does what" is likely to be based on factors such as individuals' specialization (i.e., A&P or avionics) and their experience with the task.

Although management has a responsibility to ensure that their technicians have suitable training, it is up to the individual technician to decide whether they have the necessary skills, proficiency, and experience to do what they have been asked to do. They should not be afraid to voice any misgivings, although it is recognized that peer and management pressure may make this difficult. If the technician is in any doubt what needs to be done, written guidance material is the best resource. Colleagues may unintentionally give incorrect or imprecise direction (the exception to this is discussing problems that arise that are not covered in the guidance material).



**Photograph G**  
Referring to pertinent  
maintenance documentation  
is a key element of planning



### **Physical Tasks**

Aircraft maintenance engineering is a relatively active occupation. Regardless of the job being done, most tasks tend to have elements of fine motor control, requiring precision, as well as activities requiring strength and gross manipulation.

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.

It is important that maintenance tasks on aircraft are within the physical limitations of aircraft maintenance technicians. Boeing use a computerized tool based on human performance data (body sizes, strengths, leverages, pivots, etc.) to ensure that modern aircraft are designed such that the majority of maintenance technicians will be able to access aircraft equipment, apply the necessary strength to loosen or tighten objects, etc. (i.e., designed for **ease of maintainability**).

Clearly we are all different in terms of physical stature and strength and as a consequence, our physical limitations vary. Attempting to lift a heavy object which is beyond our physical capabilities is likely to lead to injury. The use of tools generally make tasks easier, and in some situations, may make a task achievable that could not be accomplished outside our physical powers (e.g., lifting an aircraft panel with the aid of a hoist).

As noted in Chapter 4, *Fatigue*, physical work over a period of time will result in fatigue. This 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. Hence, technicians should try to take their allocated breaks.

As discussed at some length in Chapter 4, *Day-to-Day Fitness and Health*, it is very important that technicians should try to ensure that their physical fitness is good enough for the type of tasks which they normally do. As a technician gets older, the musculoskeletal system stiffens and muscles become weaker. Injuries become more likely and take longer to heal. Staying in shape will minimize the effects of aging, but they still occur. Missing a break in an effort to get a job done within a certain time frame can be counterproductive, as fatigue diminishes motor skills, perception, awareness, and standards. As a consequence, work may slow and mistakes may occur that need to be rectified.

### **Repetitive Tasks**

Repetitive tasks can be tedious and reduce arousal (become boring). Most of the human factors research associated with repetitive tasks has been carried out in manufacturing environments where workers carry out the same action many times a minute. This does not generally apply to maintenance engineering.



## Human Factors in Aviation Maintenance

---

Some technicians may specialize in a certain aspect of maintenance, such as engine module overhaul. As a result, they may possibly carry out the same or similar tasks several times a day.

The main danger with repetitive tasks is that technicians may become so **practiced** at such tasks that they may cease to consult the maintenance manual or to use job cards. Thus, if something about a task is changed, the technician may not be aware of the change. **Complacency** is also a danger, whereby a technician may skip steps or fail to give due attention to steps in a 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, which is covered in greater detail in the next section.

Making **assumptions** along the lines of "Oh, I've done that job dozens of times!" can occur even if a task has not been undertaken for some time. It is always advisable to be wary of changes to procedures or parts, remembering that "familiarity breeds contempt." 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.

In the Aloha accident report, the NTSB raised the problem of repetitive tasks:

*"The concern was expressed about what kinds of characteristics are appropriate to consider when selecting persons to perform an obviously tedious, repetitive task such as a protracted Non-Destructive Inspection (NDI). Inspectors normally come up through the seniority ranks. If they have the desire, knowledge and skills, they bid on the position and are selected for the inspector job on that basis. However, to ask a technically knowledgeable person to perform an obviously tedious and exceedingly boring task, rather than to have him supervise the quality of the task, may not be an appropriate use of personnel..."*

## Visual Inspection

Visual inspection is one of the primary methods employed during maintenance to ensure the aircraft remains in an airworthy condition.

Aircraft maintenance technicians may use magnifiers and borescopes to enhance their visual capabilities. The technician may accompany their visual inspection by examining the element using his other senses (touch, hearing, smell, etc.). They may also manipulate the element being inspected to make further judgements about its condition. For instance, they might feel a surface for unevenness, or push against it to look for any unanticipated movement.

As highlighted in Chapter 2, *Vision and the Aircraft Maintenance Technician*, good **eyesight** is of prime importance in visual inspection. Amongst other things, this calls for glasses or contact lenses to be used where prescribed and regular eyesight checks to be made.



Visual inspection is often the principal method used to identify degradation or defect in systems or components of aircraft. Although the technician's vision is important, they also have to make judgements about what they see. To do this, they bring to bear training, experience, and common sense. Thus, reliable visual inspection requires that the technician first sees the defect and then actually recognizes that it is a defect. Of course, experience comes with practice, but telltale signs to look for can be passed on by more experienced colleagues.



**Photograph H** An engineer making a visual inspection of engine fan blades

There are various steps that a technician can take to help them carry out a reliable visual inspection. The technician should:

- Ensure that they understand the area, component or system they have been asked to inspect (e.g., as specified on the work card)
- Locate the corresponding area, component, or system on the aircraft itself
- Make sure the environment is conducive to the visual inspection task (considering factors described in Chapter 5 - "Physical Environment," such as lighting, access, etc.)
- Conduct a systematic visual search, moving their eyes carefully in a set pattern so that all parts are inspected
- Examine thoroughly any potential degradation or defect that is seen and decide whether it constitutes a problem

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. Information such as technical bulletins are important as they prime the inspector of known and potential defects and they should keep abreast of these. For example, blue staining on an aircraft fuselage may be considered insignificant at first sight, but information from a Technical Bulletin of "blue ice" and external toilet leaks may make the technician suspicious of a more serious problem.

**Note:** Record any problem that is found and continue the search a few steps prior to where you left off.

Visual inspection requires a considerable amount of **concentration**. Long spells of continuous inspection can be tedious and result in low arousal. A technician's low arousal or lack of motivation can contribute to a failure to spot a potential problem or a failure in recognizing 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).

Technicians may find it beneficial to take short breaks between discrete visual inspection tasks, such as at a particular system component, frame, lap joint, etc. This is much better than pausing midway through an inspection.



## Human Factors in Aviation Maintenance

---

Finally, NDI includes an element of visual inspection, but usually permits detection of defects below visual thresholds. Various specialized tools are used for this purpose, such as the use of **eddy currents** and **fluorescent penetrant inspection**.

The Aloha accident highlights what can happen when visual inspection is poor. The accident report included two findings that suggest visual inspection was one of the main contributors to the accident:

- "There are human factors issues associated with visual and non-destructive inspection which can degrade inspector performance to the extent that theoretically detectable damage is overlooked."
- "Aloha Airlines management failed to recognize the human performance factors of inspection and to fully motivate and focus their inspector force toward the critical nature of lap joint inspection, corrosion control and crack detection..."

## Complex Systems

All large modern aircraft can be described as complex systems. Within these aircraft, there are a myriad of separate systems, many of which themselves may be considered complex, (e.g., flying controls, landing gear, air conditioning, flight management computers). Table 4 gives an example of the breadth of complexity in aircraft systems.

The purpose, composition and function of a simple system is usually easily understood by an aircraft maintenance technician. In other words, the system is **transparent** to them. Fault finding and diagnosis should be relatively simple with such systems (although appropriate manuals, etc. should be referred to where necessary).

With a complex system, it should still be clear to an aircraft maintenance technician what the system's purpose is. However, its composition and function may be harder to conceptualize - it is **opaque** to the technician.

To maintain such complex systems, it is likely that the technician will need to have carried out some form of **system-specific training** which would have furnished them with an understanding of how it works (and how it can fail) and what it is made up of (and how components can fail). It is important that the technician understands enough about the overall functioning of a large, complex aircraft, but not so much that they are overwhelmed by its complexity. Thus, system-specific training must achieve the correct balance between detailed system knowledge and analytical troubleshooting skills.

Any complex system can be thought of as having a wide variety of inputs. The system typically performs complex modifications on these inputs or the inputs trigger complex responses. There may be a single output, or many distributed outputs from the system.

**Table 4** Example of increasing complexity - the aileron system

TYPE OF AILERON	NATURE OF SYSTEM
Simple aileron	Direct connection from control column to servo tab; aerodynamic movement of surface.
Servo tab aileron	Direct connection from control column to servo tab; aerodynamic movement of surface
Powered aileron	Connection from control column to servo valve via input; hydraulic movement of surface; feedback mechanism; position indication.
Powered aileron / roll spoiler	As above but with interface to spoiler input system to provide additional roll capability.
Fly-by-wire aileron system	No connection from control column to surface. Electrical common, signal to electro-hydraulic servo valve on actuator; signal modified and limited by intermediate influence of flight control computer

With complex systems within aircraft, written procedures and reference material become an even more important source of guidance than with simple systems. They may describe comprehensively the method of performing maintenance tasks, such as inspections, adjustments, and tests. They may describe the relationship of one system to other systems and often, most importantly, provide cautions or bring attention to specific areas or components. It is important to follow the procedures to the letter, since deviations from procedures may have implication on other parts of the system of which the technician may be unaware.

In modern aircraft, it is likely that the expertise to maintain a complex system may be distributed among individual technicians. Thus, avionics technicians and A&P technicians may need to work in concert to completely examine a system that has an interface to the pilot in the cockpit (such as the undercarriage controls and indications).

A single modern aircraft is complex enough, but many technicians are qualified on several types and variants of aircraft. This will usually mean that they have less opportunity to become familiar with one type, making it even more important that they stick to the prescribed procedures and refer to the reference manual wherever necessary. There is a particular vulnerability where tasks are very similar between a number of different aircraft (e.g., spoiler systems on the A320, B757, and B767<sup>1</sup>), and may be more easily confused if no reference is made to the manual. When working with complex systems, it is important that the aircraft maintenance technician makes reference to appropriate guidance material. This typically breaks down the system conceptually or physically, making it easier to understand and work on.

## Summary

Planning, organizing and good communication helps tasks to be completed on time, to standards and on price. But also reduces workload and physiological stress on individuals.

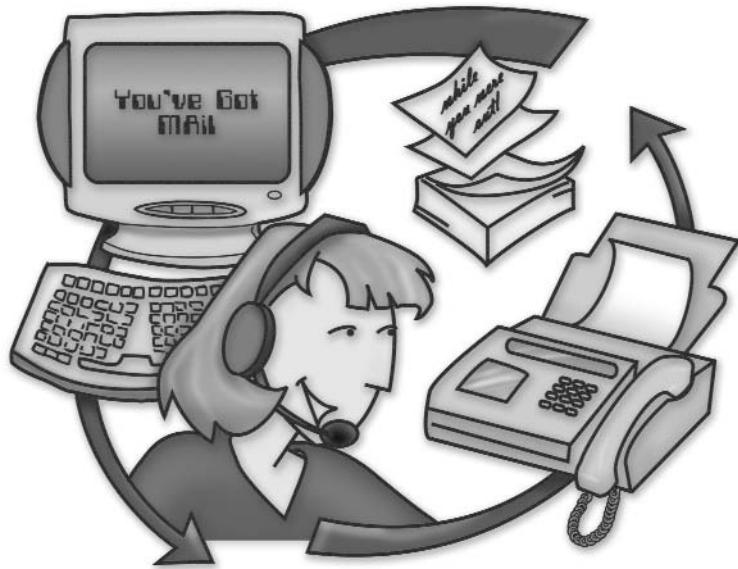


## Human Factors in Aviation Maintenance

---



## Chapter 7



# Communication

Good communication is important in every industry. In aircraft maintenance engineering it is vital. Communication, or more often a breakdown in communication, is often cited as a contributor to aviation incidents and accidents. It is for this very reason that it has its own section in the FAA Safety Handbook and JAR66 Module 9 for Human Factors. This chapter examines the various aspects of communication that affect the aircraft maintenance technician.



## Within and Between Teams

As noted in previous chapters, aircraft maintenance technicians 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 hand over. A technician needs a good understanding of the various processes of communication, as without this, it is impossible to appreciate how communication can go wrong.

### Modes of Communication

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

- Information
- Ideas
- Feelings
- Attitudes and beliefs

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

### The Definition of Communication

*"The transmission of something from one location to another. The "thing" that is transmitted may be a message, a signal, a meaning, etc. In order to have communication both the transmitter and the receiver must share a common code, so that the meaning or information contained in the message may be interpreted without error".*

As can be seen in the above definition, communication can be:

- Verbal/spoken - a single word, a phrase or sentence, a grunt
- Written/textual - printed words and/or numbers on paper or on a screen, hand written notes
- Non-verbal - written note, body language, graphic indicators
- Graphic - pictures, diagrams, hand drawn sketches, indications on a cockpit instrument
- Symbolic - "thumbs up," wave of the hand, nod of the head
- Body language - facial expressions, touch such as a pat on the back, and posture

### Verbal and Written Communication

Generally speaking, verbal and written communication are purposeful. For a spoken or written message to be understood, the sender has to make sure that the receiver:

- Is using the same **channel** of communication
- Recognizes and understands their **language**
- Is able to make sense of the message's **meaning**



The channel of communication is the medium used to convey the message. For spoken communication, this might be face-to-face, or via the telephone. Written messages might be notes, memos, documents, or e-mails.

In the USA and UK it is expected that aircraft maintenance technicians will communicate in English. However, it is also vital that the message **coding** used by the sender is appreciated by the recipient so that they can decode the message accurately. This means that technicians must have a similar knowledge of technical language, jargon, and acronyms.

Assuming the channel and language used are compatible, to extract meaning, the technician has to understand the content of the message. This means that it has to be clear and unambiguous. The message must also be appropriate to the context of the workplace and preferably be compatible with the receiver's expectations. Where any ambiguity exists, the technician must seek clarification.

### ***Non-verbal Communication***

Non-verbal communication can accompany verbal communication, such as a smile during a face-to-face chat. It can also occur independently, for instance a colleague may pass on their ideas by using a sketch rather than the use of words. It can also be used when verbal communication is impossible, such as a nod of the head in a noisy environment.

Non-verbal communication is also the predominant manner by which systems communicate their status. For instance, most displays in the aircraft flight deck present their information graphically.

Body language can be very subtle, but often quite powerful. For example, the message "No" accompanied by a smile will be interpreted quite differently from the same word said while the sender scowls.

### ***Communication Within Teams***

Individual aircraft maintenance technicians need to communicate:

- **Before starting a task** - to find out what to do
- **During a task** - to discuss work in progress, ask colleagues questions, confirm actions or intentions, or to ensure that others are informed of the maintenance state at any particular time
- **At the end of a task** - to report its completion and highlight any problems

Spoken communication makes up a large proportion of day-to-day communication within teams in aircraft maintenance. It relies both on clear transmission of the message (i.e., not mumbled or obscured by background noise) and the ability of the recipient of the message to hear it (i.e., active listening followed by accurate interpretation of the message). Good communication within a team helps to maintain **group cohesion**.



## Human Factors in Aviation Maintenance

---

It is much less common for individuals within teams to use written communication. They would however be expected to obtain pertinent written information communicated by service bulletins and work cards and to complete documentation associated with a task.

### **Communication Between Teams**

Communication between teams is critical in aircraft maintenance engineering. It is the means by which one team passes on tasks to another team. This usually occurs at **shift hand over**. The information conveyed will include:

- Tasks that have been completed
- Tasks in progress, their status, any problems encountered, etc.
- Tasks to be carried out
- General company and technical information

Communication between teams will involve passing on **written reports** of tasks from one shift supervisor to another. Ideally, this should be backed up by **spoken details** passed between supervisors and, where appropriate, individual technicians. This means that, wherever necessary, outgoing technicians personally brief their incoming colleagues. The written reports (maintenance cards, procedures, work orders, logs, etc.) and warning flags / placards provide a record of work completed and work yet to be completed - in other words, they provide **traceability**.

Furthermore, information communicated at shift hand over ensures good **continuity**. It is important that hand overs are not rushed, so as to minimize omissions.

### **Communication Problems**

There are two main ways in which communication can cause problems. These are **lack of communication** and **poor communication**. The former is characterized by the technician who forgets to pass on pertinent information to a colleague, or when a written message is not forwarded properly. The latter is typified by the technician who does not make it clear what they need to know and consequently receives inappropriate information, or a written report in barely legible handwriting. Both problems can lead to subsequent human error.

Spoken messages provide considerable flexibility and informality to express work-related matters when necessary. The key to such communication is to use words effectively and obtain feedback to make sure your message has been heard and understood.

Communication also goes wrong when one of the parties involved makes some kind of **assumption**. The sender of a message may assume that the receiver understands the terms they have used. The receiver of a message may assume that the message means one thing when in fact they have misinterpreted it. Assumptions may be based on context and expectations, which have already been mentioned in this chapter. Problems with assumptions can be minimized if messages are unambiguous and proper feedback is given.



## Work Logging and Recording

Work Logging and Recording 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 technicians think that 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. This may not necessarily be as a result of a shift change, but might be due to a rest break, illness, the need to move to another (possibly more urgent) task, etc. Basic rules of thumb to help aircraft maintenance technicians 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

In the B737 double engine oil loss incident in February 1995, for instance, one of the AAIB conclusions was:

*"...the Line Technician...had not made a written statement or annotation on a work stage sheet to show where he had got to in the inspections."*

The reason for this was because he had intended completing the job himself and, therefore, did not consider that detailed work logging was necessary. However, this contributed towards the incident in that:

*"the Night Base Maintenance Controller accepted the tasks on a verbal hand over [and] he did not fully appreciate what had been done and what remained to be done."*

The exact manner in which work should be logged tends to be prescribed by company procedures. It is usually recorded in written form. However, there is no logical reason why symbols and pictures should not also be used to record work or problems, especially when used for hand overs. There are many cases where it may be clearer to draw a diagram rather than to try to explain something in words (i.e., "a picture is worth a thousand words"). Key aspects of work logging and recording are outlined in the \_\_\_\_\_:

*"In relation to work carried out on an aircraft, it is the duty of all authorized persons to ensure that an adequate record of the work carried out is maintained. This is particularly important where such work carries on beyond a working period or shift, or is handed over from one person to another."*

*The work accomplished, particularly if only disassembly or disturbance of components or aircraft systems, should be recorded as the work progresses or prior to undertaking a disassociated task.*

*In any event, records should be completed no later than the end of the work period or shift of the individual undertaking the work. Such records should include*



## Human Factors in Aviation Maintenance

---

*"open" entries to reflect the remaining actions necessary to restore the aircraft to a serviceable condition prior to release.*

*In the case of complex tasks which are undertaken frequently, consideration should be given to the use of pre-planned stage sheets to assist in the control, management and recording of these tasks. Where such sheets are used, care must be taken to ensure that they accurately reflect the current requirements and recommendations of the manufacturer and that all key stages, inspections, or replacements are recorded."*

New technology is likely to help technicians to record work more easily and effectively in the future. ICAO Digest No.12: *"Human Factors in Aircraft Maintenance and Inspection,"* refers to hand-held computers and an **Integrated Maintenance Information System (IMIS)**. It points out that these devices are likely to encourage the prompt and accurate recording of maintenance tasks.

Modern technology is also being implemented to improve the transfer of information in maintenance manuals to worksheets and **workcards**. These help to communicate pertinent information to technicians in an accessible and useable format. A contributory factor in the B737 double engine oil loss incident was that the information which should have prompted the technician to carry out a post-inspection idle engine run to check for leaks was in the maintenance manual but not carried over to the task cards.

### **Keeping Up-to-Date, Currency**

As discussed in Chapter 6, aircraft maintenance technicians 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 (as discussed in Chapter 6, "Complex Systems"). However, the aviation industry is dynamic: operators change their aircraft, new aircraft types and variants are introduced, and new aircraft maintenance practices are introduced. As a consequence, the technician needs to keep their knowledge and skills up-to-date.

To maintain his **currency**, they 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 they work on
- Revised maintenance procedures and practices

Technicians 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 technician and the maintenance organization for which they work. The technician should make it their business to keep up-to-date with changes in his profession (remembering that making **assumptions** can be dangerous). The organization should provide the appropriate training and allow their staff time to undertake the training before working on a new aircraft type or variant. It should also make written information easily accessible to technicians and encourage them to read it. It is, of course, vital that those producing the information make it easy for technicians to understand (avoid **ambiguity**).

From a human factors point of view, small changes to the technology or procedures concerning existing aircraft carry potentially the greatest risk. These do not usually warrant formal training and may merely be minor changes to the maintenance manual. Although there should be mechanisms in place to record all such changes, this presumes that the technician will consult the updates. It is part of the technician's individual **responsibility** to maintain their currency.

### Dissemination of Information

As highlighted in the previous section, both the individual technician and the Organization in which they work have a shared responsibility to keep abreast of new information. Good dissemination of information within an organization forms part of its **safety culture** (Chapter 3). Normally, the maintenance organization will be the sender and the individual technician will be the recipient.

It was noted in Chapter 6, *Planning*, that an aircraft maintenance technician or team of technicians need to plan the way work will be performed. 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)

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

Communication is an **active** process whereby both the Organization and technician have to play their part. It is imperative that technicians 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. Poor dissemination of information was judged to have been a contributory factor to the Eastern Airlines accident in 1983. The NTSB accident report stated:

*"On May 17, 1983, Eastern Air Lines issued a revised work card 7204 [master chip detector installation procedures, including the fitment of O-ring seals]. ... the material was posted and all mechanics were expected to comply with the guidance. However, there was no supervisory follow-up to insure that mechanics and*



## Human Factors in Aviation Maintenance

---

*foremen were incorporating the training material into the work requirements... Use of binders and bulletin boards is not an effective means of controlling the dissemination of important work procedures, especially when there is no accountability system in place to enable supervisors to ensure that all mechanics had seen the applicable training and procedural information."*

### **Summary**

Nothing is possible in the human working world without good communication. Understanding the factors that interfere with communication will reduce misunderstandings and smooth the flow of work and personal relationships.



## Chapter 8



# Human Error

---

No one is perfect, human errors will occur. By understanding the root causes of human error we can reduce them and limit their effects when they inevitably happen.



## Understanding 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 error." It is an unequivocal fact that whenever men and women are involved in an activity, human error will occur at some point.

It is clear that aircraft maintenance engineering depends on the competence of technicians. Many of the examples presented in Chapter 1, *Incidents Attributable to Human Factors / Human Error*, and throughout the rest of this book highlight errors that aircraft maintenance technicians have made which have contributed to aircraft incidents or accidents.

In the past, aircraft components and systems were relatively unreliable. Modern aircraft, by comparison, are designed and manufactured to be highly reliable. As a consequence, it is more common nowadays to hear that an aviation incident or accident has been caused by "human error."

The following quotation illustrates how aircraft maintenance technicians play a key role in keeping modern aircraft reliable:

*"Because civil aircraft are designed to fly safely for unlimited time provided defects are detected and repaired, safety becomes a matter of detection and repair rather than one of aircraft structure failure. In an ideal system, all defects which could affect flight safety will have been predicted in advance, located positively before they become dangerous, and eliminated by effective repair. In one sense, then, we have changed the safety system from one of physical defects in aircraft to one of errors in complex human-centered systems."*

The rest of this chapter examines some of the various ways in which human error has been conceptualized. It then considers the likely types of error that occur during aircraft maintenance and the implications if these errors are not spotted and corrected. Finally, means of managing human error in aircraft maintenance are discussed.

In his book *Human Error*, Professor James Reason defines error as follows:

*"Error will be taken as a generic term to encompass all those occasions in which a planned sequence of mental or physical activities fails to achieve its intended outcome, and when these failures cannot be attributed to the intervention of some chance agency."*

## Error Models and Theories

To appreciate the types of error that it is possible to make, researchers have looked at human error in a number of ways and proposed various models and theories. These attempt to capture the nature of the error and its characteristics. To illustrate this, the following models and theories will be briefly highlighted:

- Design errors versus operator-induced errors



- Variable versus constant errors
- Reversible versus irreversible errors
- Slips, lapses, and mistakes
- Skill, rule, and knowledge-based behaviors and associated errors
- The "Swiss Cheese Model"

### ***Design-Versus Operator-Induced Errors***

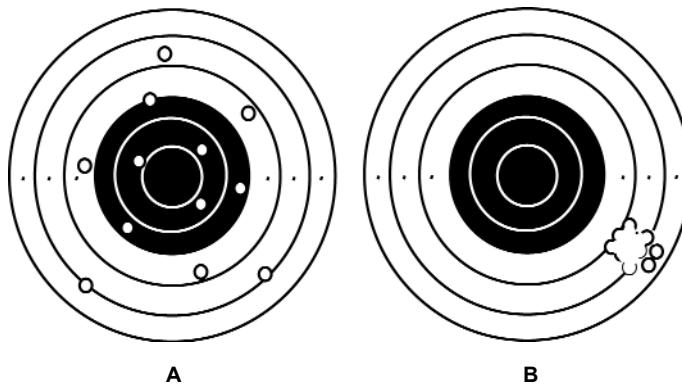
In aviation, emphasis is often placed upon the error(s) of the front line operators, who may include flight crew, air traffic controllers and aircraft maintenance technicians.

However, errors may have been made before an aircraft ever leaves the ground by aircraft designers. This may mean that, even if an aircraft is maintained and flown as it is designed to be, a flaw in its original design may lead to operational safety being compromised. Alternatively, flawed procedures put in place by airline, maintenance organization, or air traffic control management may also lead to operational problems.

It is common to find when investigating an incident or accident that more than one error has been made and often by more than one person. It may be that, only when a certain combination of errors arises and error "defenses" breached (see the "Swiss Cheese Model") will safety be compromised.

### ***Variable Versus Constant Errors***

There are two types of human error: **variable** and **constant**. It can be seen in Figure 22 that variable errors in (A) are random in nature, whereas the constant errors in (B) follow some kind of consistent, systematic (yet erroneous) pattern. The implication is that constant errors may be predicted and therefore controlled, whereas variable errors cannot be predicted and are much harder to deal with. If we know enough about the nature of the task, the environment it is performed in, the mechanisms governing performance, and the nature of the individual, we have a greater chance of predicting an error.



**Figure 22** Variable versus Constant Errors.



However, it is rare to have enough information to permit accurate predictions; we can generally only predict along the lines of "re-assembly tasks are more likely to incur errors than dismantling tasks," or "a technician is more likely to make an error at 3 A.M., after having worked 12 hours, than at 10 A.M. after having worked only 2 hours." It is possible to refine these predictions with more information, but there will always be random errors or elements which cannot be predicted.

### ***Reversible Versus Irreversible Errors***

Another way of categorizing errors is to determine whether they are reversible or irreversible. The former can be recovered from, whereas the latter typically cannot be. For example, if a pilot miscalculates the fuel he should carry, he may have to divert to a closer airfield, but if he accidentally dumps his fuel, he may not have many options open to him.

A well designed system or procedure should mean that errors made by aircraft maintenance technicians are reversible. Thus, if a technician installs a part incorrectly, it should be spotted and corrected before the aircraft is released back to service by the supervisory procedures in place.

### ***Slips, Lapses, and Mistakes***

Errors can be classified in many ways for example, in Figure 22, an example of classifying errors by measurement from a standard is shown. This method is most useful when working with physical components and systems. Common uses would be production and testing facilities. Solutions would include better metrology (measurement) systems.

Professor Reason highlights the notion of "intention" when considering the nature of error, asking the questions:

- Were the actions directed by some prior intention?
- Did the actions proceed as planned?
- Did they achieve their desired end?

Figure 23 is an example of classifying errors by the effects of human interaction with the physical world. Solutions would include Human Factors training and ergonomic designs.

The most well-known of these are **slips, lapses, and mistakes**. Slips typically occur at the task execution stage, lapses at the storage (memory) stage, and mistakes at the planning stage.

Slips can be thought of as actions not carried out as intended or planned, for example transposing digits when copying out numbers, or mis-ordering steps in a procedure.

Lapses are missed actions and omissions, (i.e., when somebody has failed to do something due to lapses of memory and/or attention or because they have forgotten something; for example, forgetting to replace an engine cowling).



Mistakes are a specific type of error brought about by a faulty plan/intention, that is, somebody did something believing it to be correct when it was, in fact, wrong, for example an error of judgement such as mis-selection of bolts when fitting an aircraft windscreen.

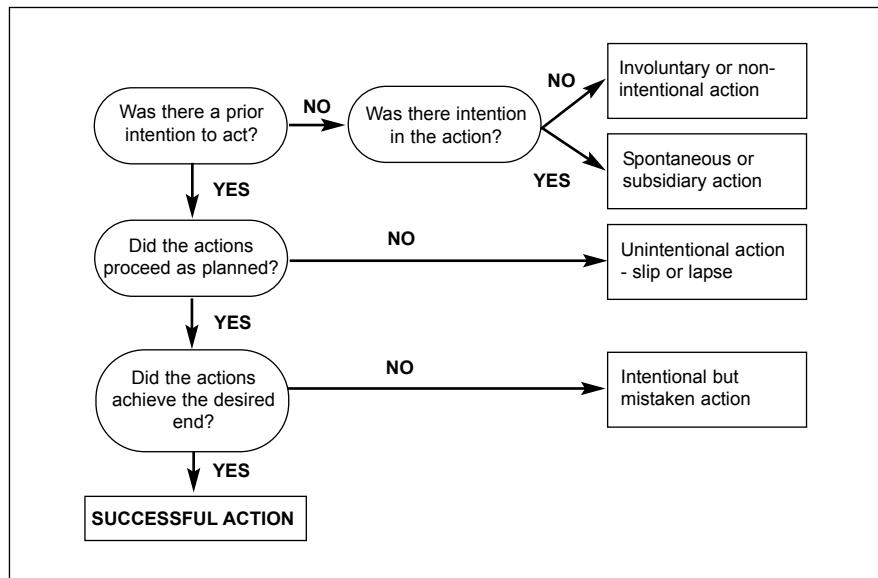


Figure 23 Error types based on intention. Source: Reason, 1990<sup>1</sup>

**Violations** sometimes appear to be human errors, but they differ from slips, lapses and mistakes because they are deliberate "illegal" actions (i.e., somebody did something knowing it to be against the rules). An example is deliberately failing to follow proper procedures. Aircraft maintenance technicians may consider that a violation is well intentioned, (e.g., "cutting corners") to get a job done on time. However, procedures must be followed appropriately to help safeguard safety.

### **Skill, Rule, and Knowledge-Based behaviors and Associated Errors**

The behavior of aircraft maintenance technicians can be broken down into three distinct categories: skill-based, rule-based, and knowledge-based behavior.

Each of these behavior types have specific errors associated with them. Examples of skill-based errors are **action slips**, **environmental capture**, and **reversion**.

Action slips as the name implies are the same as slips, (i.e., an action not carried out as intended). The example given in Figure 24 may consist of a technician realizing he needs a certain wrench to complete a job but, because he is distracted by a colleague, picks up another set to the wrong torque and fails to notice that he has tightened the bolts incorrectly.



## Human Factors in Aviation Maintenance

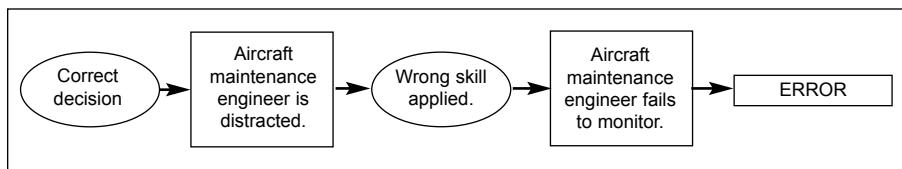
Environmental capture may occur when a technician carries out a certain task very frequently in a certain location. Thus, a technician used to carrying out a certain maintenance adjustment on an Airbus A300, may inadvertently carry out this adjustment on the next A300 he works on, even if it is not required (and he has not made a conscious decision to operate the skill).

Reversion can occur once a certain pattern of behavior has been established, primarily because it can be very difficult to abandon or unlearn it when it is no longer appropriate. Thus, a technician may accidentally carry out a procedure that he has used for years, even though it has been recently revised. This is more likely to happen when people are not concentrating or when they are in a stressful situation.

Human performance and behavior depends on the training, education, and personality of each individual. The personality of an individual is preformed long before entry into the workplace but abilities, performance and behavior can be modified. There are three types behavior that are affected by the quality of training and education of a person.

- Skill-based behavior
- Rule-based behavior
- Knowledge-based behavior

Skill-based behaviors are those that rely on stored routines or motor programs that have been learned with practice and may be executed without conscious thought. Rule-based behaviors are those for which a routine or procedure has been learned. The components of a rule-based behavior may comprise a set of discrete skills. Knowledge-based behaviors are those for which no procedure has been established. These require the aircraft maintenance technician to evaluate information and then use his knowledge and experience to formulate a plan for dealing with the situation.



**Figure 24** Example of an Action Slip

Rule-based behavior is generally fairly robust, and this is why the use of procedures and rules is emphasized in aircraft maintenance. However, errors here are related to the use of the wrong rule or procedure. For example, a technician may misdiagnose a fault and thus apply the wrong procedure, thus not clearing the fault. Errors here are also sometimes due to faulty recall of procedures. For instance, not remembering the correct sequence when performing a procedure.

Errors at the knowledge-based performance level are related to incomplete or incorrect knowledge or interpreting the situation incorrectly. An example of this



might be when a technician attempts an unfamiliar repair task and assumes they can "work it out." Once he has set out in this way, they are likely to take more notice of things that suggest they are succeeding in their repair, while ignoring evidence to the contrary (known as **confirmation bias**).

### The "Swiss Cheese Model"

In his research, Professor Reason has highlighted the concept of "defenses" against human error within an organization, and has coined the notion of "defenses in depth." Examples of defenses are duplicate inspections and pilot pre-flight functional checks that help prevent to "trap" human errors, reducing the likelihood of negative consequences. It is when these defenses are weakened and breached that human errors can result in incidents or accidents. These defenses have been portrayed diagrammatically, as several slices of Swiss cheese (and hence the model has become known as Professor Reason's "Swiss cheese" model) (see Figure 25).

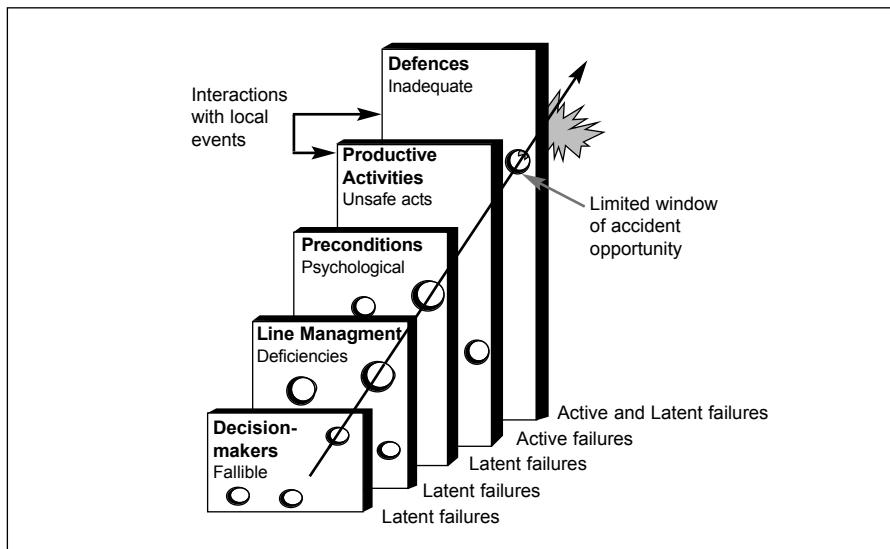


Figure 25 Reason's Swiss Cheese Model. Source: Reason, 1990<sup>1</sup>

Some failures are **latent**, meaning that they have been made at some point in the past and lay dormant. They may be introduced at the time an aircraft was designed or may be associated with a management decision. Errors made by front line personnel, such as aircraft maintenance technicians, are "**active**" failures. The more holes in a system's defenses, the more likely it is that errors result in incidents or accidents, but it is only in certain circumstances, when all holes "line up," that these occur. Usually, if an error has breached the engineering defenses, it reaches the flight operations defenses (e.g., in flight warning) and is detected and handled at this stage. However, occasionally in aviation, an error can breach all the defenses (e.g., a pilot ignores an in flight warning, believing it to be a false alarm) and a catastrophic situation ensues. Defenses in aircraft maintenance engineering will be considered further in the next section.



## Types of Error in Maintenance Tasks

As aircraft maintenance technicians are human, errors in the industry are inevitable. Examples of errors highlighted in (i) in Figure 26 are incorrect installation of line replaceable units, failure to remove a protective cap from a hydraulic line before re-assembly or damaging an air duct used as a foothold while gaining access to a task. Examples of errors in (ii) are a structural crack unnoticed during a visual inspection task or a faulty avionics box that remains on the aircraft because incorrect diagnosis of the problem led to removal of the wrong box. The actual error type responsible can be any of those highlighted in the previous section of this book.

Any maintenance task performed on an aircraft is an opportunity for human error to be introduced. Errors in aircraft maintenance engineering tend to take two specific forms:

- i) an error that results in a specific aircraft problem that was not there before the maintenance task was initiated;
- ii) an error that results in an unwanted or unsafe condition remaining undetected while performing a maintenance task designed to detect aircraft problems, (i.e., something is missed).

**Table 26** Forms of Air

### Errors During Regular and Less Frequent Maintenance Tasks

A large proportion of maintenance tasks are fairly routine, such as regular, periodical checks on aircraft. Thus, technicians will use a certain set of procedures relatively frequently and, as noted in the previous section, slips and lapses can occur when carrying out procedures in the busy hangar or line environment. Chapter 6, *Repetitive Tasks*, noted that technicians will often become so accustomed to doing a regular, often repeated task, that they will dispense with written guidance altogether. It would be unrealistic and unnecessarily time consuming to expect them to constantly refer to familiar guidance material. However, errors may occur if they do not keep up-to-date with any changes that occur to these frequently used procedures. These routine tasks are also prone to complacency, environmental capture, and rule-based errors.

When undertaking less frequently performed tasks, there is the possibility of errors of judgement. If the technician does not familiarize or re-familiarize themselves properly with what needs to be done, they may mistakenly select the wrong procedure or parts.

### Violation in Aircraft Maintenance

It is an unfortunate fact of life that violations occur in aviation maintenance. Most stem from a genuine desire to do a good job. Seldom are they acts of vandalism, however, they represent a significant threat to safety as systems are designed assuming people will follow the procedures. There are four types of violations:

- Routine violations
- Situational violations
- Optimizing violations
- Exceptional violations



**Routine violations** are things which have become "the normal way of doing something" within the person's work group (e.g., a maintenance team). They can become routine for a number of reasons, technicians may believe that procedures may be over prescriptive and violate them to simplify a task (cutting corners), to save time and effort.

**Situational violations** occur due to the particular factors that exist at the time, such as time pressure, high workload, unworkable procedures, inadequate tooling, and poor working conditions. These occur often when, in order to get the job done, technicians consider that a procedure cannot be followed.

**Optimizing violations** involve breaking the rules for "kicks." These are often quite unrelated to the actual task. The person just uses the opportunity to satisfy a personal need.

**Exceptional violations** are typified by particular tasks or operating circumstances that make violations inevitable, no matter how well intentioned the technician might be.

Time pressure and high workload increase the likelihood of all types of violations occurring when people weigh up the **perceived risks** against the **perceived benefits**, unfortunately the **actual risks** can be much higher. Examples of routine violations are not performing an engine run after a borescope inspection ("It never leaks"), or not changing the "O" seals on the engine gearbox drive pad after a borescope inspection ("They are never damaged").

An example of a situational violation is an incident which occurred where the door of a B747 came open in-flight. A technician with a tight deadline discovered that he needed a special jig to drill off a new door torque tube. The jig was not available, so the technician decided to drill the holes by hand on a pillar drill. If he had complied with the maintenance manual he could not have done the job and the aircraft would have missed the service. An example of an Optimizing violation would be a technician who has to go across the airfield and drives there faster than permitted.

### ***Errors Due to Individual Practices and Habits***

Where procedures allow some leeway, aircraft maintenance technicians often develop their own **strategies** or preferred way of carrying out a task. Often, a "good" rule or principle is one that has been used successfully in the past. These good rules become "**rules of thumb**" that a technician might adopt for day-to-day use. Problems occur when the rule or principle is wrongly applied. For example, aircraft pipe couplings are normally right hand threads but applying this "normally good rule" to an oxygen pipe (having a different thread) could result in damage to the pipe. Also, there can be dangers in applying rules based on previous experience if, for example, design philosophy differs, as in the case of Airbus and Boeing. This may have been a factor in an A320 locked spoiler incident, where subtle differences between the operation of the spoilers on the A320 and those of the B767 (with which the technicians were more familiar) meant that actions which would have been appropriate on the B767 were inappropriate in the case of the A320.



## Human Factors in Aviation Maintenance

---

In addition, technicians may pick up some "bad rules," leading to **bad habits** during their working life, as a driver does after passing his driving test. An example of applying a bad rule is the British Rail technician in the Clapham train accident who had acquired the practice of bending back old wires rather than cutting them off and insulating them.

### ***Errors Associated With Visual Inspection***

There are also two particular types of error which are referred to particularly in the context of visual inspection, namely **Type 1** errors and **Type 2** errors. A Type 1 error occurs when a good item is incorrectly identified as faulty; a Type 2 error occurs when a faulty item is missed. Type 1 errors are not necessarily a safety concern, except that it means that resources are not being used most effectively, time being wasted on further investigation of items which are not genuine faults. Type 2 errors are of most concern since, if the fault (such as a crack) remains undetected, it can have serious consequences (as was the case in the Aloha accident, where cracks remained undetected).

### ***Professor Reason's Study of Aviation Maintenance Engineering***

Professor Reason analyzed<sup>1</sup> the reports of 122 maintenance incidents occurring within a major airline over a 3 year period. He identified the main causes as being:

- Omissions (56%)
- Incorrect installation (30%)
- Wrong parts (8%)
- Other (6%)

It is likely that Professor Reason's findings are representative for the aircraft maintenance industry as a whole. Omissions can occur for a variety of reasons, such as forgetting, deviation from a procedure (accidental or deliberate), or due to distraction. The B737<sup>2</sup> double engine oil loss incident, in which the HP rotor drive covers were not refitted is an example of omission. Incorrect installation is not surprising, as there is usually only one way in which something can be taken apart but many possible ways in which it can be reassembled. Professor Reason illustrates this with a simple example of a bolt and several nuts (see Figure 27), asking the questions:

- How many ways can this be disassembled? (the answer being 1)
- How many ways can it be reassembled? (the answer being about 40,000, excluding errors of omission!)

In the BAC 1-11 accident in June 1990, the error was fitting the wrong bolts to the windscreens. This illustrates well the category of "wrong parts."

### Bolt to be placed



## Implications of Errors (i.e., Accidents)

In the worst cases, human errors in aviation maintenance can and do cause aircraft accidents. However, as portrayed in Figure 27, accidents are the observable manifestations of error. Like an iceberg which has most of its mass beneath the water line, the majority of errors do not result in actual accidents.

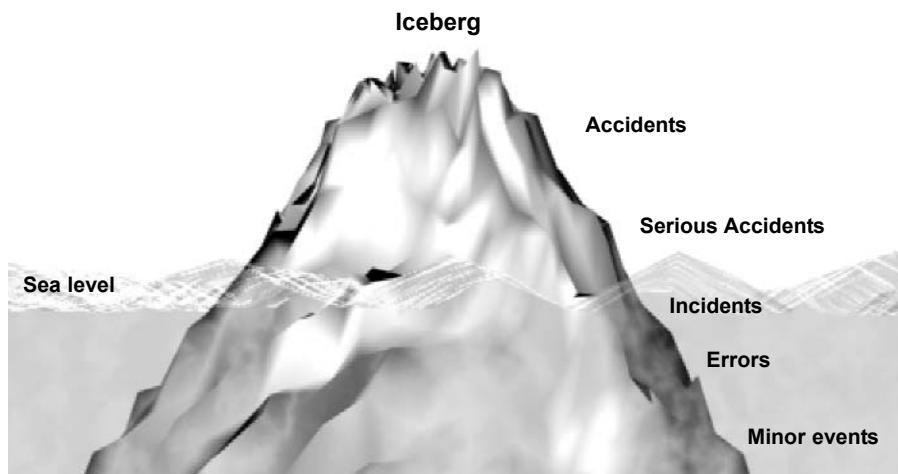


Table 27 The "Iceberg Model" of Accidents

### Iceberg

Errors that do not cause accidents but still cause a problem are known as **incidents**. This subject was introduced at the beginning of this document in Chapter 1, *Incidents Attributable To Human Factors / Human Error*, which gave examples of aviation incidents relating to aircraft maintenance errors. Some incidents are more high profile than others, such as errors causing significant in-flight events that, luckily, or because of the skills of the pilot, did not become accidents. Other incidents are more mundane and do not become serious because of defenses built into the maintenance system. However, all incidents are significant to the aircraft maintenance industry, as they may warn of a potential future accident should the error occur in different circumstances. As a consequence, all maintenance incidents have to be reported to the Civil Aviation Authority **Mandatory Occurrence Reporting Scheme** (MORS). This data is used to disclose trends and, where necessary, implement action to reduce the likelihood or criticality of further errors. In the UK, the **Confidential Human Factors Incident Reporting Program** (CHIRP) scheme provides an alternative reporting mechanism for individuals who want to report safety concerns and incidents confidentially.

It is likely that the greatest proportion of errors made by aircraft maintenance technicians are spotted almost immediately when they are made and corrected. The technician may detect their own error, or it may be picked up by colleagues, supervisors or quality control. In these cases, the technician involved should (it is hoped) learn from their error and therefore (it is hoped) be less likely to make the same error again.



## Human Factors in Aviation Maintenance

---

When an error occurs in the maintenance system of an airline, the technician who last worked on the aircraft is usually considered to be "at fault." The technician may be reprimanded, given remedial training or simply told not to make the same error again. However, **blame** does not necessarily act as a positive force in aircraft maintenance. It can discourage technicians from "coming clean" about their errors. They may cover up a mistake or not report an incident. It may also be unfair to blame the technician if the error results from a failure or weakness inherent in the system which the technician has accidentally discovered (e.g., a latent failure such as a poor procedure drawn up by an aircraft manufacturer - possibly an exceptional violation).

All National Aviation Authorities should have stressed that they seek to provide an environment in which errors may be openly investigated in order that the contributing factors and root causes of maintenance errors can be addressed.

To facilitate this, it is considered that a lapse which is inadvertant and not premeditated should not incur any punitive action, but a breach of professionalism may do so (e.g., where a technician causes deliberate harm or damage, has been involved previously in similar lapses, attempted to hide their lapse or part in a mishap, etc.). It is vital that aircraft maintenance technicians learn from their own errors and from the errors made by others in the industry. These powerful and persuasive lessons are the positive aspects of human error.

### Avoiding and Managing Errors

While the aircraft maintenance engineering industry should always strive towards ensuring that errors do not occur in the first place, it will never be possible to remove or eliminate them completely. Therefore all maintenance organizations should aim to **"manage" errors.**

Professor Reason refers to the two components of error management:

- Error containment
- Error reduction

To prevent errors from occurring, it is necessary to predict where they are most likely to occur and then to put in place preventative measures. Incident reporting schemes (such as MORS) do this for the industry as a whole. Within a maintenance organization, data on errors, incidents, and accidents should be captured with a **Safety Management System** (SMS), which should provide mechanisms for identifying potential weak spots and error-prone activities or situations. Output from this should guide local training, company procedures, the introduction of new defenses, or the modification of existing defenses.

Error management includes measures to:

- Minimize the error liability of the individual or the team
- Reduce the error vulnerability of particular tasks or task elements
- Discover, assess, and then 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 the workplace or system
- Make latent conditions more visible to those who operate and manage the system
- Improve the organization's intrinsic resistance to human fallibility

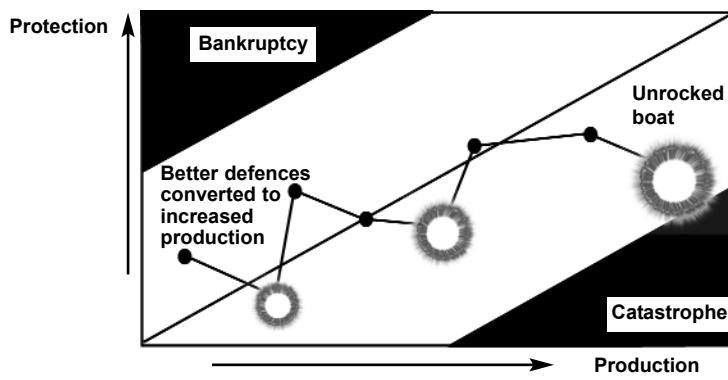
It would be very difficult to list all means by which errors might be prevented or minimized in aircraft maintenance. In effect, the whole of this book discusses mechanisms for this, from ensuring that individuals are fit and alert, to making sure that the hangar lighting is adequate.

Ultimately, maintenance organizations have to compromise between implementing measures to prevent, reduce or detect errors, and making a profit. Some measures cost little (such as replacing light bulbs in the hangar); others cost a lot (such as employing extra staff to spread workload).

Error management seeks to:

- Prevent errors from occurring
- Eliminate or lessen the bad effects of errors

One of the things likely to be most effective in preventing error is to make sure that technicians follow procedures. This can be effected by ensuring that the procedures are correct and usable, that the means of presentation of the information is user friendly and appropriate to the task and context, that technicians are encouraged to follow procedures and not to cut corners. Incidents tend to result in short term error mitigation measures, but if an Organization has no incidents for a long time (or has them but does not know about them or appreciate their significance), there is a danger of complacency setting in and cost reduction strategies eroding the defenses against error (Figure 28).



**Figure 28** The lifespan of a hypothetical organisation through the production - protection space. Reason, 1997



## Human Factors in Aviation Maintenance

---

It is important that organizations balance profit and costs, and try to ensure that the defenses which are put in place are the most cost-effective in terms of trapping errors and preventing catastrophic outcomes.

Ultimately, it is the responsibility of each and every aircraft maintenance technician to take every possible care in his work and be vigilant for error (see Chapter 3). On the whole, aircraft maintenance technicians are very conscious of the importance of their work and typically expend considerable effort to prevent injuries, prevent damage, and to keep the aircraft they work on safe.

### **Summary**

No one is perfect, errors will occur. By understanding the root causes of human error we can reduce them and limit their effects when they inevitably happen.



## Chapter 9



# Hazards In The Workplace

Hazards in the workplace tend to be a health and safety issue, relating to the protection of individuals at work. All workplaces have hazards and aircraft maintenance engineering is no exception. Health and safety is somewhat separate from human factors and this chapter therefore gives only a very brief overview of the issues relating to the aircraft maintenance engineering.



## Recognizing and Avoiding Hazards

### **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)
- Moving equipment, moving vehicles and vibration

Many of these have been addressed earlier in this book (e.g. Chapter 5, *Physical Environment*).

### **Relevant Legislation and the Maintenance Organization Responsibilities**

In the USA the FAA and OSHA have responsibility for overseeing safety in the workplace. In the UK Health and Safety Executive (HSE) has this responsibility. The various national Health and Safety At-Work Laws places a responsibility on employers to produce a written statement of general policy with respect to the Health and Safety at Work of its employees. The employer is also obliged to bring to the notice of all its employees this policy together with the Organization and arrangements in force for carrying out that policy. Thus, in an aircraft maintenance organization, the **health and safety policy** might include statements applicable to the organization such as the need to:

- Carry out assessments of work including inspections to determine Health and Safety risks
- Provide safe working practices and procedures for plant, machinery, work equipment, materials, and substances
- Inform employees and other persons including temporary workers of any risk
- Provide suitable training and/or instruction to meet any Health and Safety risks
- Develop and introduce practices and procedures to reduce risks to Health and Safety including the provision of special protective devices and personal protective equipment
- Provide for the welfare of employees
- Discuss with and consult employee representatives on Health and Safety matters



## Hazards In The Workplace

---

Maintenance organizations should appoint someone with health and safety responsibilities. If hazards cannot be removed from the workplace, employees should be made aware that they exist and how to avoid them. This can be effected through training and warning signs. To be effective, warnings signs must:

- Clearly identify the hazard
- Describe the danger (e.g., electric shock, radiation, etc)
- Inform employees what to do or not to do

The sign must attract a technician's attention, it must be visible and it must be understandable to the people it is aimed at. Additionally, in the maintenance industry, it must be durable enough to remain effective, often for years, in areas where they are exposed to dust and the elements.

Positive recommendations are more effective than negative ones. For example, the statement "Stay behind yellow line on floor" is better than "Do not come near this equipment." Warning signs should contain a single word indicating the degree of risk associated with the hazard: DANGER denotes that the hazard is immediate and could cause grave, irreversible damage or injury. CAUTION indicates a hazard of lesser magnitude. The sign should also detail how to avoid or manage the risk. CAUTION signs are generally yellow and black. DANGER signs use red, black, and white.

### ***Technician's Individual Responsibilities***

The legislation notes that every individual in a workplace also has health and safety responsibilities.

Thus, in an aircraft maintenance organization, the **health and safety policy** might include statements applicable to technicians such as the need to:

- Take reasonable care of the health and safety of themselves and others who may be affected by their acts or omissions at work
- Cooperate with the maintenance organization to ensure that statutory requirements concerning health and safety at work are met
- Work in accordance with any safety instruction and/or training received
- Inform their supervisor or management of work situations that represent an immediate or potential danger to health and safety at work and any shortcomings in protection arrangements

In brief, a maintenance organization has a duty under health and safety legislation to:

- Identify hazards in the workplace
- Remove them where possible
- Communicate the risks to employees

Every aircraft maintenance technician should be aware that they can influence the



## Human Factors in Aviation Maintenance

---

safety of those with whom they work and not interfere intentionally or recklessly with, nor misuse, anything provided in the interests of health and safety.

The attitude of an individual technician, team, or maintenance organization (i.e., **organizational culture**) can have a significant impact on health and safety. Individuals who display an anti-authority attitude, are impulsive, or reckless are a danger in aircraft maintenance.

### ***Safety In the Working Environment***

Technicians should ensure that they keep the working environment safe. Clutter, rubbish, etc. is not only a nuisance to others, but can constitute a danger (e.g., a trip hazard, fire hazard, etc.). In addition, technicians should be careful when working on the line not to leave objects when a job has been completed. **Foreign Object Damage** (FOD) is a risk to aircraft operating at an airfield.

### ***Safety When Working On Aircraft***

Before operating or working on aircraft system, a technician should carry out clearance checks around moveable surfaces (e.g., flying controls, landing gear, flaps, etc.). Deactivation procedures should be followed (e.g., pull circuit breakers, isolate valves, disconnect power, etc.). Notification of deactivation through the provision of adequate placard in key locations is essential to inform others of system status.

### ***Dealing With Emergencies***

Careful handling of health and safety in the maintenance environment should serve to minimize 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 a 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 organization. The organization 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 aid personnel.

Emergency drills are of great value in potentially dangerous environments. Aircraft maintenance technicians should take part in these wherever possible. Knowledge of what to do in an emergency can save lives.

The basic actions in an emergency are to:

- Stay calm and assess the situation
- Observe what has happened



- Look for dangers to oneself and others
- Call for help
- Never put oneself at risk
- Make the area safe
- Protect any casualties from further danger
- Remove the danger if it is safe to do so (i.e., switching off an electrical current if an electrocution has occurred)
- Be aware of ones own limitations (e.g., do not fight a fire unless it is practical to do so)
- Assess all casualties to the best of ones abilities (especially if one is a qualified in first aid)
- Summon help from those nearby if it is safe for them to become involved
- Call for local emergency equipment (e.g., fire extinguisher)
- Call for emergency services (ambulance or fire department, etc.)
- Provide assistance as far as one feels competent to do so

## Summary

There are special physical hazards surrounding us all in the aviation world. Most of these hazards are outside the experience of most people. Bringing them to attention and outlining their risks and protective measures greatly reduces the probability of accidents.





## Conclusion

Recent investigations of incidents and accidents have drawn the unanimous conclusion that there is a significant need for modern aviation maintenance technicians to understand human factors and how it relates to aviation maintenance engineering. Knowing the physical limitations of human performance through a proper understanding of our senses and cognitive processes assist in regards to this.

Several factors can affect a maintenance technician's performance both positively and negatively. Understanding the role of the working environment both physically, psychologically, and socially can help a maintenance technician in taking the right steps down the pathway to success.

Learning how to approach tasks properly and applying best practices for doing work as an individual or part of a team are critical skills for reducing error and increasing safety. Working with job cards and other memory aids develops practices that eliminates memory errors and reinforces that the proper steps of a task are to be adhered to.

Communication with colleagues and supervisors plays a critical role for success in the workplace, especially in the area of task hand over. Good communication stresses the importance of taking physical notes and transferring information in an environment that is clear from noise and distractions. This is an important factor in making sure that the job is completed successfully by others.

Although understanding human factors can greatly reduce the potential for mistakes made by aviation maintenance technicians, it is equally important to recognize that humans are inherently flawed and susceptible to error. Keeping this in mind, maintenance technicians should not to be discouraged, but rather encouraged in taking the proper steps through an understanding of human factors. Everyone should be encouraged to learn from their mistakes so that they may help prevent any future incidents and accidents.



# ADVANCED AIRCRAFT TRAINING LTD

EASA PART 147 AIRCRAFT TYPE TRAINING COMPANY



HUMAN FACTORS  
IN  
AVIATION  
Stress Management Today



# ADVANCED AIRCRAFT TRAINING LTD

EASA PART 147 AIRCRAFT TYPE TRAINING COMPANY

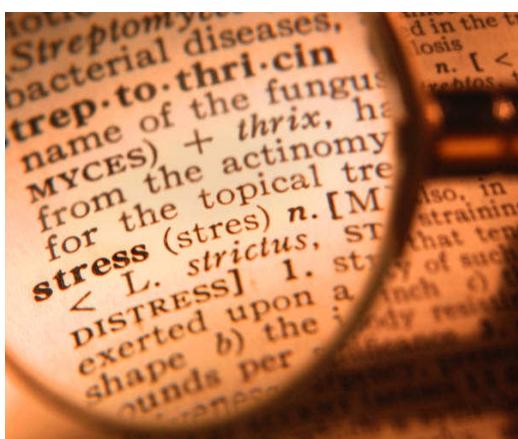


This booklet is the copyright material of AAT Ltd. and may not be copied or re-sold without the permission of AAT Ltd.



# Stress Management Today

By David J. Taylor



<b>Contents</b>	<b>Page</b>
<b>Introduction</b>	<b>2</b>
<b>1. Causes and Symptoms Of Stress</b>	<b>3</b>
<b>2. Stress Rating</b>	<b>6</b>
<b>3. Personality And Stress</b>	<b>7</b>
<b>4. Stress management</b>	<b>9</b>
<b>5. Time Pressure and Deadlines</b>	<b>10</b>
<b>6. Workload</b>	<b>11</b>
<b>7. Stress In The Working Environment</b>	<b>16</b>
<b>8. Women In The Workplace</b>	<b>17</b>
<b>9. Managing Your Stress</b>	<b>18</b>
<b>10. Managing your manager</b>	<b>20</b>
<b>11. Managing your career</b>	<b>20</b>
<b>12. Stress Management Simple Techniques For Today</b>	<b>21</b>
<b>13. Problems Or A Challenge</b>	<b>24</b>
<b>14. Time Management</b>	<b>25</b>
<b>15. Problems, Problems, Problems</b>	<b>27</b>
<b>16. Planning Time</b>	<b>28</b>
<b>17. Learning To Plan</b>	<b>29</b>
<b>18. Contingency Plans</b>	<b>32</b>
<b>19. Simple Relaxation Techniques</b>	<b>34</b>
<b>20. Advanced Relaxation Techniques</b>	<b>39</b>



## Stress Management Today: Introduction

The overall theme of this book is stress. Stress can have many causes, and negative stress can prevent us from performing at our very best. I believe that one of the main reasons for stress at work is lack of preparation. Any task should follow the golden rule;

**90% PREPARATION 10% PERSPIRATION**

*'The human brain starts the moment we are born and never stops until we stand up to speak in public.'*

Most people could substitute ‘speaking in public’ for many other situations. For example, you may feel stressed when asked to conduct an interview or even to take part in a business meeting. With a few simple ‘management techniques’ anyone can reduce their stress level, no matter what the situation.

Stress is an inescapable part of life for all of us. From a human viewpoint, stress results from the imposition of any demand or set of demands which require us to react, adapt or behave in a particular manner in order to cope with or satisfy them.

Up to a point, such demands are stimulating and useful, but if the demands are beyond our personal capacity to deal with them, the resulting stress is a problem.



*'Stress can be defined as any force, that when applied to a system, causes some significant modification of its form, these forces can be physical, psychological or due to social pressures.'*



## 1.0 Causes and Symptoms Of Stress

Stress is usually something experienced due to the presence of some form of **stressor**, which might be a one-off stimulus (such as a challenging problem or a punch on the nose), or an on-going factor (such as an extremely hot hangar or an acrimonious divorce). 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, vibration, presence of something damaging to health (e.g. carbon monoxide);
- Psychological - such as emotional upset (e.g. due to bereavements, domestic problems, etc.), worries about real or imagined problems (e.g. due to financial problems, ill health, etc.);
- Reactive - such as events occurring in everyday life (e.g. working under time pressure, encountering unexpected situations, etc.).

### 1.1 Typical Causes

Research into work-related stress in Europe and the United States shows that many of the following issues have been found to be particularly stressful in large organizations.

Relationships; Inability to get on with people, conflict with superiors, colleagues.

Role insecurity : No definite role specification, lack organization of clear objectives, difficulty in delegation, poor time management.

Organizational: No positive feedback on performance factors, no acceptance of new ideas, poor communications, threat of redundancy. Imposed Rapid change Unrealistic targets, high work load, presentations, interviews.

Head count restrictions: reduced training budgets, un-chosen teams Need to ‘perform’ at meetings,





## 1.2 Typical Symptoms

*"A stress problem can manifest itself by signs of irritability, forgetfulness, sickness absence, mistakes, or alcohol or drug abuse. Management have a duty to identify individuals who may be suffering from stress and to minimize workplace stresses. Individual cases can be helped by sympathetic and skillful counseling which allows a return to effective work and licensed duties."*

The first step towards stress reduction is to admit to yourself that you are already suffering stress, or are a potential candidate. The following is a list of symptoms which may indicate stress. The higher the number of symptoms you recognize, the more urgent the need to look at your lifestyle and work practices. The list is limited to the most commonly reported:

### Physical

- Stomach cramps
- Headaches
- Unexplained aches and pains
- Constipation or diarrhea
- Dry mouth
- Shaking limbs
- Nausea
- Excessive sweating
- Alteration of menstrual pattern in women.



### Emotional

- Loss of concentration
- Worry
- Irritability
- Lack of self-esteem
- Loss of confidence
- Feeling apprehensive
- Loss of enthusiasm
- Cynicism
- Unhappiness, loss of sense of humor
- Feelings of dissatisfaction.





## Behavioral

- Over indulgence in food/smoking/alcohol
- Dependence on drugs
- Changes in sleep patterns: difficulty dropping off, waking early, waking tired
- Being too busy to take time off for hobbies/holidays/exercise
- Taking work home
- Difficulty in making decisions
- Consistently working late
- Poor time management
- Loss of appetite or major weight loss/gain
- A shut down of emotions and loss of interest in everyday events. Tears near to surface for no apparent reason.



## Summary

In brief, the possible signs of stress can include:

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



## 2.0 Stress Rating

Psychologists have compiled a list of some of life's stressful events and given each a score.

If your total in any 12-month period exceeds 75 points, you have a 50/50 chance of a stress-related illness. For a total of 150 points, the chance of developing a stress-related illness soars to 80/20.

Use the figures below to give your own score to events not listed but which you find stressful

Stress Rating	%
• Death/bereavement	50
• Separation/divorce	35
• Moving House	31
• Marriage	25
• Redundancy/retirement	23
• Pregnancy/care for elderly	20
• Changes at work	18
• Family squabbles	17
• Promotion	16
• Change in lifestyle	13
• Changed working conditions	10
• New hobby/social life	9
• Changing sleep patterns	8
• Change in diet or eating habit	7
• Holidays/Christmas	6
• A brush with the law	5





### 3. Personality and stress

No two people necessarily respond to the same stressor in the same way.

Individual personality factors are significant. Personality is defined as; ‘the dynamic organization within the individual of the psychophysical systems that determine his characteristic behavior and thought’. Various types and traits of personality have been established over the last 30 years; these are classified as follows:

<b>1. Type ‘A’ - Ambitious</b>	Active and energetic; impatient if he has to wait in a queue; conscientious; maintains high standards; time is a problem - there is never enough; frequently intolerant of those who may be slower in thought or action.
<b>2. Type ‘B’ - Placid</b>	Quiet; very little worries them; put their worries into things they can alter or control and leave others to worry about the rest.
<b>3. Type ‘C’ - Worrying</b>	Nervous; highly strung; not very confident of self-ability; anxious about the future and of being able to cope.
<b>4. Type ‘D’ - Carefree</b>	Loves variety; often athletic and daring; very little worries them; not concerned about the future.
<b>5. Type ‘E’ - Suspicious</b>	Dedicated and serious; very concerned with other people’s opinions of them; do not take criticism kindly and tend to dwell on such criticism for a long time; distrust most people.
<b>6. Type ‘F’ - Dependent</b>	Bored with their own company; sensitive to surroundings; rely on others a great deal; people who interest them are oddly unreliable; they find that the people they really need are boring; do not respond easily to change.
<b>7. Type ‘G’ - Fussy</b>	Punctilious; conscientious and like a set routine; do not like change; any new problem throws them because there are no rules to follow; conventional and predictable; great believers in authority.

Research indicates that most people combine traits of more than one of these ‘types’, and so the above definitions can only be used as a guide. The type most at risk to stress is Type A.



## Summary:

### Domestic Stress

When aviation managers, aircraft maintenance technicians and other staff 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 technician'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.

It should be noted that individuals respond to stressful situations in very different ways.

Generally speaking though, people tend to regard situations with negative consequences as being more stressful than when the outcome of the stress will be positive (e.g. the difference between being made redundant from work and being present at the birth of a son or daughter).

### Work Related Stress

Aviation managers, aircraft maintenance technicians and other staff can experience stress for two reasons at work:

1. because of the task or job they are undertaking at that moment
2. because of the general organizational 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). This type of stress can be reduced by careful management, good training, etc.

Within the organization, the social and managerial aspects of work can be stressful.

It is important to know the impact on the individual of peer pressure, organizational culture and management, all of which can be stressors. In the commercial world that aircraft maintenance technicians work in, shift patterns, lack of control over own workload, company reorganization and job uncertainty can also be sources of stress.





## 4. Stress Management

Once we become aware of stress, we generally respond to it by using one of two strategies: **defense or coping**.

Coping strategies involve dealing with the source of the stress rather than just the symptoms (e.g. delegating workload, prioritizing tasks, sorting out the problem, etc.).

Unfortunately, it is not always possible to deal with the problem if this is outside the control of the individual (such as during an emergency), but there are well-published techniques for helping individuals to cope with stress. Good stress management techniques include:

- Relaxation techniques;
- Careful regulation of sleep and diet;
- A regime of regular physical exercise;
- Counseling - ranging from talking to a supportive friend or colleague to seeking professional advice.

There is no magic formula to cure stress and anxiety, merely common sense and practical advice.

Defense strategies involve alleviation of the symptoms (taking medication, alcohol, etc.) or reducing the anxiety (e.g. denying to yourself that there is a problem (denial), or blaming someone else).

Coping is the process whereby the individual either adjusts to the perceived demands of the situation or changes the situation itself.





## 5. 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 technicians, or **perceived pressure** where technicians 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 technicians set themselves deadlines to complete work (e.g. completing a task before a break or before the end of a shift).

Management have 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 technicians 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.



### 5.1 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 (either 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.



## 5.2 Managing Time Pressure and Deadlines

One potential method of managing time pressures exerted on technicians is through regulation. For example, FAA research has highlighted the need to insulate aircraft maintenance technicians from commercial pressures. They consider this would help to ensure that airworthiness issues will always take precedence over commercial and time pressures. Time pressures can make ‘corner-cutting’ a cultural norm in an organization. Sometimes, only an incident or accident reveals such norms.

Those responsible for setting deadlines and allocating tasks should consider:

- Prioritizing various pieces of work that need to be done;
- The actual time available to carry out work (considering breaks, shift handovers, etc.);
- The personnel available throughout the whole job (allowing a contingency for illness);
- The most appropriate utilization of staff (considering a technician’s specialization, and strengths and limitations);
- Availability of parts and spares.

It is important that engineering staff at all levels are not afraid to voice concerns over inappropriate deadlines, and if necessary, cite the need to do a safe job to support this. As stated before within aircraft maintenance, responsibility should be spread across all those who play a part. Thus, the aircraft maintenance technician should not feel that the ‘buck stops here’.

## 6. Workload - Overload and Under load

The preceding sections on stress and time pressure have both indicated that a certain amount of stimulation is beneficial to an aircraft maintenance technician, but that too much stimulation can lead to stress or over-commitment in terms of time. It is noteworthy that too little stimulation can also be a problem.

Before going on to discuss workload, it is important to consider this optimum level of stimulation or **arousal**.

### 6.1 Arousal

Arousal in its most general sense, refers to readiness of a person for performing work.

To achieve an optimum level of task performance, it is necessary to have a certain level of stimulation or arousal. This level of stimulation or arousal varies from person to person.

There are people who are overloaded by having to do more than one task at a time; on the other hand there are people who appear to thrive on stress, being happy to take on more and more work or challenges.





**The relationship between arousal and task performance.** At low levels of arousal, our attention mechanisms will not be particularly active and our performance capability will be low (**complacency** and **boredom** can result). On the other hand, performance deteriorates when arousal becomes too high.

To a certain extent, this is because we are forced to shed tasks and focus on key information only (called **narrowing of attention**).

In the work place, arousal is mainly influenced by stimulation due to work tasks. However, surrounding environmental factors such as noise may also influence the level of arousal.





## 6.2 Factors Determining Workload

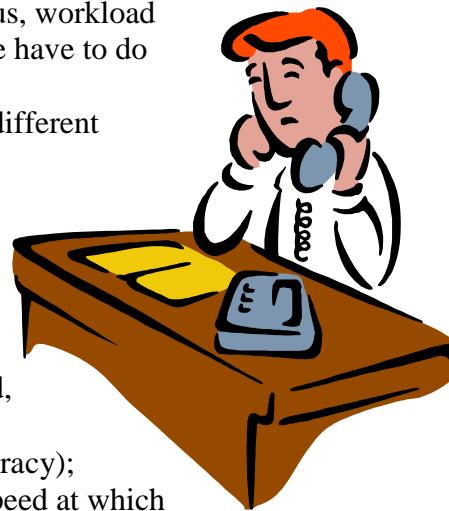
An individual aircraft maintenance technician can usually identify what work he has to do quite easily. It is more difficult to assess how that work translates into workload.

Humans have limited mental capacity to deal with information. We are also limited physically, in terms of visual acuity, strength, dexterity and so on. Thus, workload reflects the degree to which the demands of the work we have to do eats into our mental and physical capacities.

Workload is subjective (i.e. experienced differently by different people) and is affected by:

The nature of the task, such as the:

- physical demands it requires (e.g. strength required, etc.);
- mental demands it requires (e.g. complexity of decisions to be made, etc.).
- The circumstances under which the task is performed, such as the:
  - standard of performance required (i.e. degree of accuracy); time available to accomplish the task (and thus the speed at which the task must be carried out);
  - requirement to carry out the task at the same time as doing something else;
  - perceived control of the task (i.e. is it imposed by others or under your control, etc.);
  - environmental factors existing at time (e.g. extremes of temperature, etc.).
- The person and his state, such as his:
  - skills (both physical and mental);
  - his experience (particularly familiarity with the task in question);
  - his current health and fitness levels;
  - his emotional state (e.g. stress level, mood, etc.).



As the workload of the technician may vary, he may experience periods of overload and under load. This is a particular feature of some areas of the industry such as line maintenance.



### 6.3 Overload

Overload occurs at very high levels of workload (when the technician becomes over aroused). As highlighted previously, performance deteriorates when arousal becomes too high and we are forced to shed tasks and focus on key information. Error rates may also increase.

Overload can occur for a wide range of reasons based on the factors highlighted above. It may happen suddenly (e.g. if asked to remember one further piece of information whilst already trying to remember a large amount of data), or gradually. As noted earlier in this section, it can be difficult to determine how work translates into workload, both for the individual concerned, and for those allocating tasks.

### 6.4 Under load

Under load occurs at low levels of workload (when the technician becomes under aroused). It can be just as problematic to an technician as overload, as it too causes a deterioration in performance and an increase in errors, such as missed information.

Under load can result from a task an technician finds boring, very easy, or indeed a lack of tasks. The nature of the aircraft maintenance industry means that available work fluctuates, depending on time of day, maintenance schedules, and so forth. Hence, unless stimulating ‘housekeeping’ tasks can be found, under load can be difficult to avoid at times.



## 6.5 Workload Management

Unfortunately, in a commercial environment, it is seldom possible to make large amendments to maintenance schedules, nor eliminate time pressures. The essence of workload management in aircraft maintenance should include:

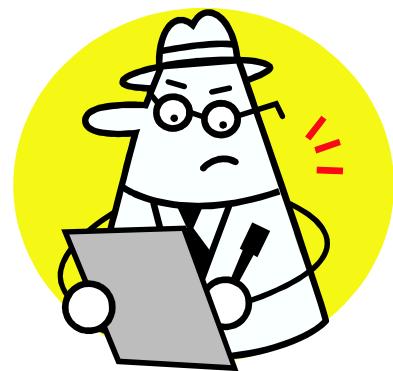
Ensuring that staff have the skills needed to do the tasks they have been asked to do and the proficiency and experience to do the tasks within the time scales they have been asked to work within;

- making sure that staff have the tools and spares they need to do the tasks;
- allocating tasks to teams or individual technicians that are accomplishable (without cutting corners) in the time available;
- providing human factors training to those responsible for planning so that the performance and limitations of their staff are taken into account;
- encouraging individual technicians, supervisors and managers to recognize when an overload situation is building up.

If an overload situation is developing, methods to help relieve this include:

- seeking a simpler method of carrying out the work (that is just as effective and still legitimate);
- delegating certain activities to others to avoid an individual technician becoming overloaded;
- securing further time in order to carry out the work safely;
- postponing, delaying tasks/deadlines and refusing additional work.

Thus, although workload varies in aircraft maintenance engineering, the workload of technicians can be moderated. Much of this can be done by careful forward planning of tasks, manpower, spares, tools and training of staff.





## 7. Stress in the Working Environment

Not all stress is bad for us and not all stressful events have the same effect on people. It is the intangible nature of the condition that makes it so difficult to recognize and conquer.

The following are some questions to ask about your working environment.

### The Working Environment

- Do you consistently meet deadlines?
- Do you have an opportunity to take short breaks during the day?
- Is your work sufficiently interesting and varied?
- Do you have enough work to do?



### Feelings about your work

- Do you feel that your job is worthwhile?
- Do you feel that what you do is appreciated by others?
- Do you have a choice of daily work pattern?



### Colleagues

- Do you enjoy working with your colleague?
- Can you discuss work-related problems with them?

### Your manager

- Do you get feedback on your work?
- Does he give you constructive criticism/praise when warranted?
- Does your manager operate an open-door policy?
- Do you discuss your career planning with him?



### Your role within the organization

- Do you have a job description?
- Do you have clear objectives?
- Are you kept informed of changes in the company which affect your job?
- Do you have sufficient resources to do your job successfully?
- Are you fairly paid for the job?

### The Physical Environment

- Is your workplace conducive to the work you do there?
- Is your workplace well laid out, well lit, adequately ventilated, comfortably heated?
- Do you have your own desk/work station?
- Do you have sufficient privacy?

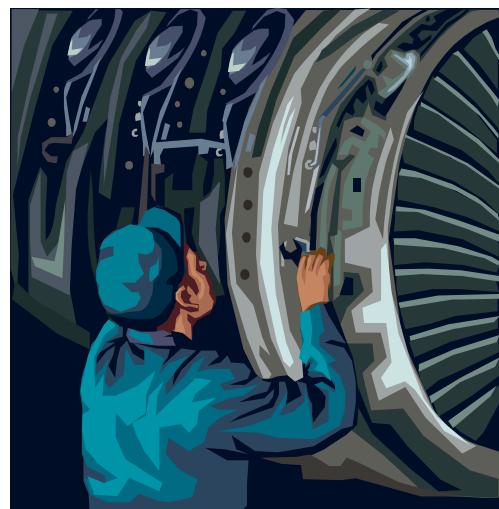


## 8. Women In the Work Place

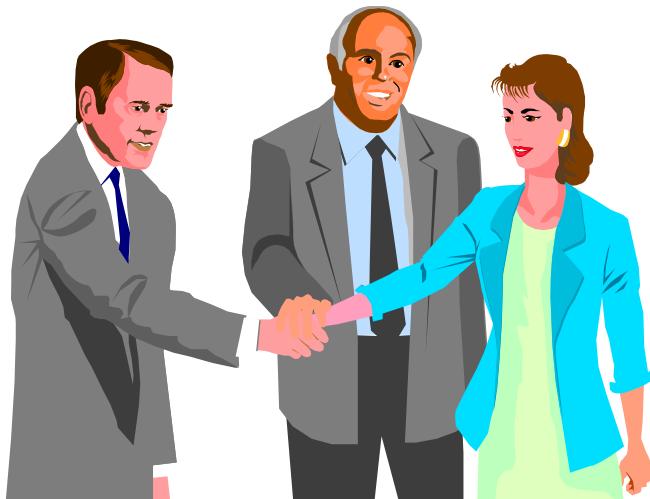
Stress levels being experienced by working women are on the increase. In the 1990s women are encouraged to be the 'perfect mother', the 'perfect manager'. They often place unrealistic expectations on themselves at home and at work, and if there is little support from their employer, the outcome may result in stress. Fortunately most responsible organizations operate an Equal Opportunity Policy, and are sensitive to issues of sexism and racism. They also encourage training.

Women can be subject to many stressors at work which are not suffered by their male counterparts. While sexual harassment is a common cause of stress among women, other causes of stress include:

- (a) performance-related pressures;
- (b) lower rates of pay;
- © the problem of maintaining dependants at home;
- (d) lack of encouragement from superiors, including not being taken seriously;
- (e) discrimination in terms of advancement;
- (f) sex discrimination and prejudice;
- (g) pressure from dependants at home;
- (h) career-related dilemmas, including whether to start a family or whether to marry or live with someone;
- (i) lack of social support from colleagues;
- (j) being single and labeled as an oddity; and
- (k) lack of domestic support at home.



Management should be aware of the various forms of stress women are exposed to while at work. Wherever necessary measures should be taken.





## 9. Managing Your Stress

At the end of this exercise, you may have highlighted several causes of stress in your working environment.

### 9.1 Causes of negative stress:

- Not getting enough success - leading to low self esteem
- Different attitudes/values from boss
- Impossible deadlines imposed without consultation
- Colleagues being made redundant
- Inadequate resources to do a good job
- Facing up to situations which have been avoided and therefore never having learned to cope with them
- Power struggles - winning is fun, losing is not
- Personal; divorce, ill health, moving house etc.

It is as well to recognize that there are some things we can't change, short of looking for another job. However, work could certainly be improved.

For example, many of the questions about work, meeting deadlines and work patterns, could be improved with better time management.





## 9.2 Improving your Working Environment and reducing stress.

Some of the factors in your Working Environment could be improved with a little planning. Try:

- Moving your desk and other office equipment to another position
- Clearing your desk of all paperwork. Have only the work in progress on the desk. Allocate a file drawer for the rest of the paperwork, to be tackled later
- Surrounding yourself with things to lift your spirits. For example, plants, flowers, posters, photographs
- If you need to work undisturbed, without the normal office hubbub of interruptions and telephones, remove yourself to a quiet room. Most offices have a board room, training or interview room which is not in constant use. Trying to work with constant interruptions is a major cause of stress.

## 9.4 Your Workspace:

Take an objective look at your work space

1. Does your desk grow paper?
2. Is your desk a clean working surface that helps you focus your energy on the task at hand?
3. Do you get a positive feeling when you approach your desk?
4. Is your desk such a mess that you invent ways to avoid it all together?
5. Is your filing cabinet a black hole that sucks in paper, notes, articles, documents and endless items you have duplicated?
6. Is your filing system a streamlined, orderly one that supports you in getting your job done?
7. Is the physical appearance of your work space uncluttered, cheerful and light?
8. Is your work space conducive to clear, creative thinking?





## 10. Managing your manager

**'If you don't know where you are going you'll end up somewhere else.'**

One of the commonest complaints from employees is that they are not quite sure what they should be doing. In other words, they have no job description or objectives. This lack of direction and feedback feeds feelings of anxiety. Check that:

- You have a current job description. If you don't, then liaise with your Manager or Personnel Department to write one
- You have up-to-date objectives for your job
- Your objectives are in writing
- You understand and have agreed these with your manager
- You know the performance factors relating to your objectives.



## 11. Managing your career

- Set goals for yourself. Ask, what do I want to be doing one year from now? In five years?
- Discuss career prospects with your manager. Performance appraisal time is a good opportunity to start
- Assess what training (if any) you need to develop the skills/knowledge which are holding you back
- Draw up an outline plan to put you back in the driving seat
- Put realistic time frames on it.



## 12. Stress Management Simple Techniques For Today

Scientific research shows clearly that certain emotions and states of mind can exert enormous influence on our long-term mental and physical health.

For example if you're feeling stressed, this can cause an increased heart rate and rise in blood pressure. Clinical evidence has shown that the stress of anger produces a unique hormonal response that is particularly dangerous to your health.

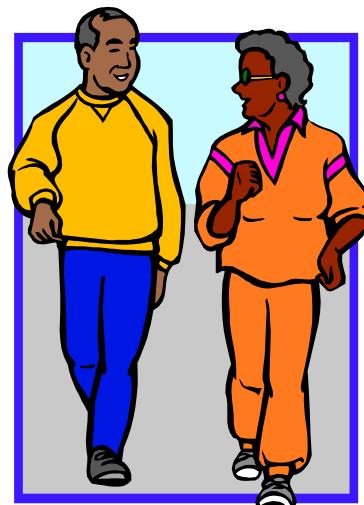
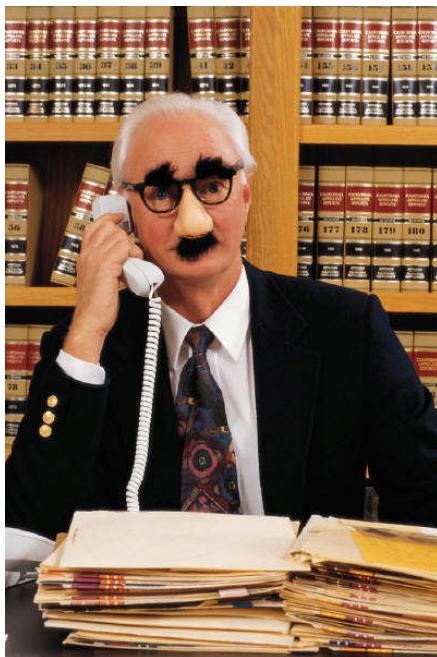
This doesn't mean the occasional angry out burst which helps clear the air, but anger of the chronic, sustained variety. This state can lead to symptoms such as hypertension, digestive disorders, skin complaints, rashes, headaches and heart disease.

One American study carried out over a 25-year period found that the 20 per cent of respondents who scored highest on a hostility ratings scale all died earlier than those whose hostility readings were much lower.

Anger works by blocking unpleasant sensations caused by stressful events. The positive side of anger is that it can often mobilize you to make changes in your life which, if you didn't feel quite so riled, you would never consider. If your anger does get out of control, try one of the following:

### 12.1 Stress Management Actions

- Verbalize what you feel. Calmly talk it through with the person responsible which you feel angry – this should highlight problem areas
- Exercise is often the solution to expending angry energy
- Use relaxation techniques
- Humor can help put things in perspective.





## 12.2 Strengthening your working relationship

How to establish a good working relationship with your colleagues:

- Smile
- Establish eye contact
- Use their names
- Give your undivided attention
- Mirror and pace their body language, etc.
- Try to ‘speak the same language’
- Show that, without any shadow of doubt, you respect and accept the person, regardless of race, sex, culture etc.
- Demonstrate respect for your colleagues and your organization
- Be calm and confident
- Be well-groomed and look the part.

## 12.3 Low Stress Communication

### ***STRESS IS A CHAIN REACTION***

You will find it beneficial if you can help colleagues keep their own stress levels down. This will help everyone to work more productively.

A good rule of thumb is to try to make as many of your transactions rewarding and positive for the other people involved.

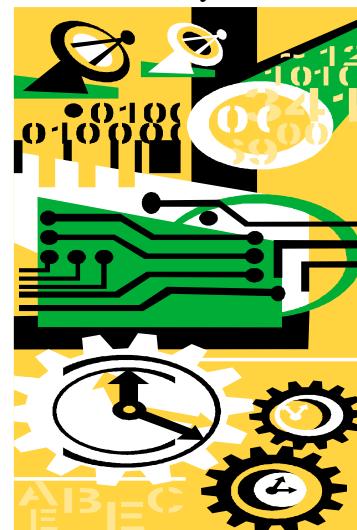
Experience tells us that this is not always possible, as there are times when you need to take a strong position in opposition to others.

Think about your own personal communication style with others. Is it, in behavioral science terminology, a punishing experience, i.e. one that an individual is not likely to repeat? Or is it a rewarding experience, i.e. one that he is likely to want to have again.

If the people with whom you communicate usually experience their transactions with you as positive, affirming to their own self-esteem, and productive for them personally, they will usually repeat the experience. If they don't like the result, they will interact with you as little as possible.

This principle provides a very simple way to assess your communication skills and to identify specific managerial behaviors that cause stress to others. Review your day-to-day communication patterns of communicating with others in work and non-work situations.

Ask yourself the question, “to what extent do people seek me out - to communicate with me, share ideas, include me in their personal and social activities?”





## 12.4 Reward and Punishment

The following are some of the most common **punishing behaviors**:

- Monopolizing the conversation
- Displaying negative body language
- Insulting or using non-verbal put-downs
- Speaking dogmatically; not respecting others' opinions
- Criticizing excessively; fault finding
- Refusing to negotiate or compromise
- Playing 'games' with people; manipulating or competing in subtle ways
- Overusing 'should' language
- Asking loaded or accusing questions
- Breaking confidences
- Failing to keep promises.

**Rewarding behaviors** include:

- Giving others a chance to express views, share opinions and information.
- Listening attentively
- Displaying positive body language
- Giving constructive feedback
- Negotiating
- Treating others as equals
- Stating one's needs and desires honestly
- Confronting others constructively on difficult issues
- Questioning others openly and honestly
- Keeping the confidences of others
- Giving one's word sparingly and keeping it
- Expressing genuine interest in the other person
- Keeping a sense of humor.



Review these lists and add any other behaviors that come to mind. Think about your own personal style and see which specific behaviors you can identify in your day-to-day patterns of working with others.

Decide whether your management style is that of a punisher or a rewarder. These behaviors also apply in private life.

In the long term, it is the rewarding style of dealing with others that helps keep down your own stress levels; it helps others do the same, and makes life more pleasant for everyone. Building constructive, congenial relationships with others helps to minimize your over-all stress, but also can play a direct part in your career success and in your advancement in the organization.



## 12.5 Stress Free Communication Summary:

Often poor communication is a cause of stress at work.

Many employees complain that they never get 'positive strokes' from their managers. Here are ten suggestions for getting along better with people:

1. Think before you speak. Say less than you think.
2. Make promises sparingly, and always keep them.
3. Never let an opportunity pass to give praise or say a kind word. Give credit where it is due.
4. Show interest in others, their work, hobbies, families.
5. Be cheerful and adopt a positive attitude. Don't dwell on the negative.
6. Discourage gossip, and don't take part in it. It is destructive.
7. Be careful of other people's feelings.
8. Disregard any ill-natured remarks about you. Live so that nobody will believe them.
9. Don't be anxious about getting credit. Just do your best and be patient.
10. Keep an open mind. Discuss but don't argue. Try to put yourself in other people's shoes.



## 12.6 SOLUTIONS TO BAD COMMUNICATION

What is Communication? Passing On To Others Your Meaning And Intent.

Lack Of Communication Is Caused By: Poor Management, Bad Leadership, Poor Training

Lack Of Communication will cause: Misunderstandings, wasted hours of work, safety problems, stress.

<p>THE SECRET TO GOOD COMMUNICATION IS:</p> <ul style="list-style-type: none"><li>• You have</li><li>• 2 Ears</li><li>• 2 Eyes</li><li>• 1 Mouth</li></ul> <p>Use them in that order</p> 	<p>Solutions: To Improve Communication <i>"Learn to Listen"</i></p> <ul style="list-style-type: none"><li>• Don't :<ol style="list-style-type: none"><li>1) Debate</li><li>2) Detour</li><li>3) Pre-plan</li><li>4) Tune-out</li></ol></li><li>• Do :<ol style="list-style-type: none"><li>1) Ask Questions</li><li>2) Paraphrase</li><li>3) Make eye contact</li><li>4) Use positive body language</li><li>5) Communication Training</li></ol></li></ul>
--	---



## 13. A PROBLEM OR A CHALLENGE?

How we view stressful events has an effect on how we cope with them. Often it helps to deal with the situation step by step. Try this five point plan:

1. Define the problem.
2. Brainstorm a wide range of alternative actions for dealing with the problem. (Consider how your colleagues might tackle it.)
3. Look at your list and evaluate the pros and cons of each idea. Rank them in order of most practical.
4. Try the most acceptable and feasible solution.
5. Reconsider the original problem in the light of your attempts to tackle it. How does it look now?



To tackle the problem in this way you will need time to sit quietly and work out your strategy; you will need to speak to other people about it, get their advice, and enlist their support.

Exposing yourself to small amounts of stress at a time helps you to focus in on the problem, a little at a time.

Very often we get into ‘stress overload’ when we look at the ‘whole picture’, which looks too much to handle, and we may be tempted to give up. This only serves to increase stress levels.

### 13.1 THEMES FOR REDUCING STRESS

#### BE ASSERTIVE

- Don’t apologise profusely
- Be direct
- Keep it short
- Don’t justify yourself for making the request
- Give a reason for the request (Don’t try to ‘sell’ it.)
- Don’t play on people’s friendship or good nature
- Don’t take a refusal personally
- Respect the other person’s right to say no.



#### Refusing requests

- Keep it short
- Keep it simple
- Give a reason - but don’t invent an excuse
- Avoid ‘I can’t’ phrases
- Don’t apologise profusely
- Pay acknowledgement to the requester: ‘Thank you, but...’
- Honestly state limitations: It will be impossible to but I could ...’
- Ask for clarification, more information, or time to decide
- Speak steadily and calmly.



## 14. TIME MANAGEMENT AND ANXIETY

Among the skills needed by today's executives/managers is the capacity to work comfortably under pressure.

The following five categories have been identified as contributing to the relationship between poor time management and anxiety:



- Thoughts and feelings of inadequacy, including self-criticism or self-condemnation, such as calling yourself names like 'stupid'
- Worrying about one's performance, as compared with personal standards or how well others are doing
- Contemplating alternatives - too long and fruitlessly
- Thinking about imagined consequences of doing poorly in the test - disapproval, punishment, loss of status or self-esteem, damage to academic record or career prospects
- Being preoccupied with bodily reactions associated with anxiety, leading to intensified anxiety symptoms.

Here are a few steps towards capturing a positive state of mind to cope:

1. Realize that pressure can be handled without discomfort.
2. Analyze the pressure you feel and prepare for similar situations in the future.
3. Anticipate deadlines - start early.
4. Find a hobby that relaxes you.
5. Say 'no'.
6. Work no more than ten hours daily.
7. Examine your eating patterns and balance your diet.
8. Plan some time for yourself every day.

Stress results from the anticipation of future unpleasantness, especially unpleasantness that we feel we may not be able to cope with. And our time management suffers. The person who moves from one current demand to another without systematically assessing and planning for future outcomes will be less certain about how to handle future demands. The following are some helpful hints for improving your self-organization.



### 14.1 Key ideas for better time management

1. List goals and set priorities. (Remember to set clear objectives.)
2. Make a daily To do' list.
3. Start with your top priority on the list. (Work down your list, from most important to least important.)
4. Ask 'What is the best use of my time right now?'
5. Handle each piece of paper only once.
6. Don't procrastinate - do it now!



## 15. Problems, Problems, Problems

Here are a few of the most common problems facing managers and some suggested solutions.

### Problem

Task is unpleasant/difficult/risky, for example preparing a report or presentation giving bad news.

### Possible solution

Give yourself a pep talk: ‘Next time I pick this up, I’ll do something about it.’ This is a start. If guilt is getting in the way, put aside time to address the deeper issues so that you get yourself into a positive frame of mind.

$$\begin{aligned} \int \frac{x+5}{x^2-2x-3} dx &= \int \frac{2}{x-3} dx - \int \frac{1}{x+1} dx \\ &= 2 \ln(x-3) - \ln(x+1) \\ &= \ln \frac{(x-3)^2}{x+1} + C \end{aligned}$$

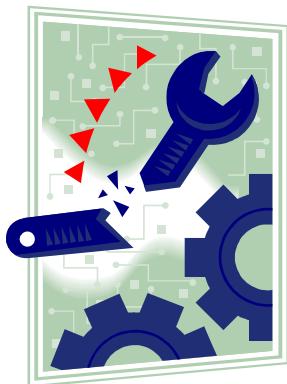
### Problem

You started the job, got bogged down and couldn’t re-start.

### Possible solution

Try one of these:

- Before you stop, have the next step planned
- Take a break
- Try new surroundings
- Stand up if you have been sitting
- If the task is repetitious, set yourself ‘mini’ deadlines to meet
- Award yourself a ‘treat’ when you have met your deadlines, e.g. buy yourself a book, flowers, a new tie
- arrange the task differently.



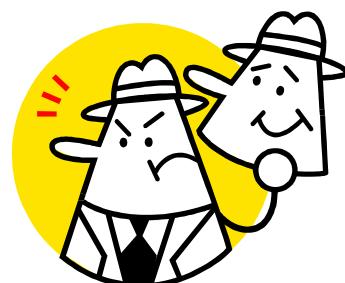
### Problem

You have an unpleasant priority task to start and are about to start on a non-priority task.

### Possible solution

Ask yourself what you are afraid of:

- getting angry?
- feeling guilty?
- hurting yourself or a colleague?
- being rejected?
- taking on too much responsibility?



Now, write down what you are afraid of. Single out your most likely concern and deal with that head on,

e.g. if you write the procedure manual, will you do yourself out of a job?

### Problem

You haven’t got the resources to do the kind of job you would like to feel proud of.

### Possible solution

Don’t aim for perfection, just do the best you can – but discuss it with your boss and get his acknowledgement, at least about acceptable quality standards.



## 16. Planning Time

Identifying time stealers

The following are six of the most often quoted time-stealers for managers.

1. Answering the telephone
2. Dealing with mail and e-mail
3. Attending meetings
4. Paperwork
5. Commuting
6. Computers and e-mail
7. Business lunches.

You need to examine how your time is spent. Memory itself is very misleading. A time sheet, diary, log, etc. will provide reliable information. Keep a log for a month. This will enable you to identify and eliminate things that need not be done at all. Ask the question, 'What would happen if this were not done at all?' If the answer is 'nothing', there's not much point in wasting time doing it. We waste a lot of time in routine tasks, for example, paper work.

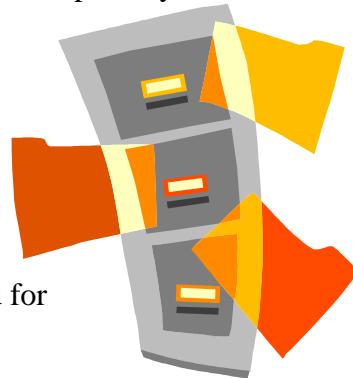
**Next to the dog the wastebasket is man's best friend.**

There may appear to be unlimited ways in which a piece of paper can be dealt with, and that can lead to painful and unnecessary dithering over fairly unimportant correspondence. In fact there is a mercifully limited choice of actions when confronted with any document.

Start today to separate your mail and deal with it in these simple ways:

- Throw it away. Delete it!
- Pass it on
- File it
- Clip it into the workbook.
- Limit all e-mail to only essential urgent communications, in every other case use the phone or a memo.

If you decide to file, then decide who will file what and for how long.



Five tips for easy filing

1. Put the more recent information in the front of folders. On the computer number each file and name e.g. 1report, 2report etc. to show the most recent.
2. Staple papers together, don't clip. Clips fall off the paper.
3. Lightly pencil in 'throwaway dates' on filed material.
4. Fold oversized papers with the printing on the outside for easy reading.
5. Don't leave papers lying around randomly - Don't pile, file.



Why not clip a copy of this simple list of options to your in-tray as a reminder?



## 17. Learning To Plan

Without planning it is impossible to predict, prepare for and cope with the future. It is just as important for individuals to plan as it is for large organizations. The future arrives whether we are ready for it or not. Being able to anticipate and meet the demands of the future means one is less vulnerable to stress. There are three major planning steps:

- Selection of goals
- Formulating objectives from goals
- Selection of the activities for the achievement of objectives.

To begin, ask yourself the question ‘What do I want out of life?’ Start answering this question in terms of broad, general categories. Think of all the things you would like to achieve, obtain, or experience and list them. List everything, even those areas that are not realistic without prioritizing. For example:

### 17.1 Career goals

1. Gain promotion
2. Increase quota
3. Study for an MBA
4. Build skills by attending management training courses
5. Start own business.

### 17.2 Personal goals

1. Wealth
2. A good relationship
3. Sail around the world
4. Write a book
5. Own a Porsche  
and so on . . .

Once you have generated your list, go back and examine it.

Look for goals that are not likely to be within your power.

Some may be modified to more achievable ones.

Try to be clear about what you mean by each goal statement. The clearer and more specific the goal, the easier it is to decide whether it is achievable. If you feel it is possible, think about how you would go about it.

Look for inconsistencies among your goals. Working toward incompatible goals can tear you apart psychologically. Examples of some common pairs of goals that are inconsistent in most cases are the following:

- Attain career advancement and never work evenings and weekends
- Have strong opinions, speak your mind, and still have everyone like you.



### 17.3 Rank-order the goals

Spotting conflicting goals will alert you to potential problems.

Earlier in this book we looked at setting clear objectives. The same rules apply here. Decide which goals are most important to you, then derive a set of objectives for each one.



## 17.4 Record progress

An appointment book, which breaks the day into half-hour blocks, is useful for recording progress.

- Record the objective and activities related to the goal you wish to achieve
- Allocate times for those activities and write them in your weekly schedule
- Check these daily/weekly to assess progress and adjust as necessary.

The following acronym should help you to remember to include all the elements of good objectives in future:

Good objectives should be SMART: This means:



<b>Specific</b>	- <b>Clear and unambiguous</b>
<b>Measurable</b>	- <b>How will you know you have achieved them?</b>
<b>Agreed</b>	- <b>With you. (You must 'buy into' the idea and want to succeed.)</b>
<b>Realistic</b>	- <b>Achievable</b>
<b>Timely</b>	- <b>Can be done in the time available</b>

## 17.5 Procrastination

Procrastination, or putting off things that you want or need to do, goes hand in hand with stress and poor time management. Ultimately, avoidance breeds avoidance. Avoiders fall farther and farther behind and the work mounts up.

To help avoid procrastination, you may have to look at your working methods. For example, some of the following factors actually help us procrastinate.

## 17.6 Perfectionism



Being a perfectionist makes one more likely also to be a procrastinator. As a perfectionist, you are dissatisfied unless you do things perfectly. You always feel something of a failure if any performance has a flaw. Therefore any task becomes aversive, because no task is ever completed 100 per cent right. Like the manager who puts off writing his report until the night before it is due by which time it is too late for him to produce the high-caliber work he is capable of.



## 17.7 Inappropriate commitments

In order to do those things in life that are really important to you, you must learn to make appropriate commitments. Most of us are more likely to honor a commitment made to another person than we are to honor a commitment made to ourselves. This is a fact we can turn either to our advantage or disadvantage.

If you are the kind of person who says 'Yes' to most requests made on your time by other people, you are likely to be someone who often does not get around to doing the things that are important to you.

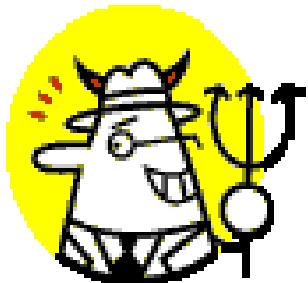
To achieve your own goals, you must learn to avoid commitments that waste your time.

Conversely, making a commitment to others (especially a public commitment) to do something that is important to you is an excellent way to mobilize yourself.



## 17.8 Deception

Another way to procrastinate is by self-deception.



Straightforward procrastination is, for example, going to the theatre when you need to be planning for presentation to the Board. Devious procrastination involves performing some activity other than the target activity because (1) it is redeeming in some way, or (2) it is ‘preparation’ for the target activity. Reading a book entitled ‘Conducting Meetings’ when you need to write a report is avoidance.

Watching television or reading a book to ‘relax\* so that you can work later is a feeble excuse for avoiding work and no real help in getting started. You may feel better indulging in this activity, but it will not help you get the work done.

Learn to correctly label avoidance activities to over- come procrastination.

## 17.9 Jobs that are too big

We often avoid getting to work on a project because it seems to be too big to tackle. Break your task into manageable parts that can be tackled one at a time. Even if you spend a few minutes on each on a regular basis, the task will soon be completed.

For example, planning a presentation can seem a daunting task when you consider the work involved. If your presentation is not imminent, you could ease yourself into it by perhaps starting to work on the objectives or the audience profile, then the Introduction, and so on.



## 17.10 Learn to play



For most of us, learning to play is the most difficult of all objectives. The manager who never has time to take a holiday, or the person so wrapped up in the responsibilities of parenthood that he can never have time to himself, are people who need to learn to take time out for themselves. The pressures of a career and family are dealt with more effectively by people who can get away from them. The person who is not able to play is often irritable and anxious, and very often is not an efficient worker. By using the methods described here you may be able to find time to play. Many people use play time to ‘reward’ themselves after some

accomplishment. This kind of self-reinforcement can often help you get more work done. Changing your behavior, as well as your thinking, can reduce stress and improve your use of time. The four cornerstones of such an approach are:

- Planning
- Record keeping
- Overcoming procrastination
- Play.

Being more organized in all of these areas can greatly improve your chance of minimizing the stress in your life.



## 17.11 Visualize Success

*'Nothing will ever be attempted if all possible objections must first be overcome.'*  
*Dr. Samuel Johnson*

Visualization is being used successfully in areas such as sports training, where coaches are trying to build up the confidence and performance of the athlete.

Firstly think of the event. It could be giving a speech, attending an interview or sitting an exam. Think of the worst thing that could happen. Paint the worst picture you possibly can. What would it be like, for example, if you were to 'dry up'; or if your mind were to go completely blank. By imagining the worst possible scenario, you have acknowledged the fear. Now develop this into a positive outcome. Build up a picture of you giving a wonderful performance and appreciate the warm glow which this produces. In any potentially stressful situation, follow the formula:



**Preparation      Visualization      Relaxation**

## 18.0 Contingency Plans

Things can and do go wrong occasionally, but with some forethought you can help reduce the possibility.



For all business occasions compile a 'What If\*' list. Make this part of your preparation. For example, if you are preparing a presentation, at each stage ask yourself what could go wrong. One of your fears might be that the overhead projector may break down. The contingency plan would then be to arrange to have a back-up machine, or carry a spare bulb with you. With good preparation you will reduce the risk of things going wrong. If they do (and sometimes this will be out of your control), you will at least be prepared with a contingency plan.



## Conclusion

This book has endeavored to give a broad overview of the problem of stress at work, a subject which is rarely considered. The most difficult task is getting people to recognize the existence of the stress response within individuals and within the organization and that their decisions could be stressful for other people. Many managers still adopt the Victorian maxim 'If you can't stand the heat, get out of the kitchen!' Such a response is totally unhelpful to people going through stressful events in their lives, be they associated with the work situation or private life.



## Summary

1. Stress is a common feature of most people's lives and the causes of stress are many and varied. It is most commonly associated with changes in people's lives, some of which may be brought about by the organization.
2. There is a need within organizations for a greater understanding of the stress response and the causes of stress.
3. Stress reduction strategies should be considered at boardroom level and implemented wherever necessary.
4. The costs of stress-related ill health can be substantial in terms of time lost for conditions diagnosed as 'anxiety state', 'depression' and 'nervous breakdown'.
5. Where employees may be exposed to the risk of violence, employers must take appropriate measures to prevent or control these risks.





## 19.0 Simple Stress Reduction Relaxation Techniques

### How do we know if we are tense?

Strange to say, but it is the case that we can be so habitually tense, almost without realizing it, that we gradually become accustomed to the sensations of living in a tense state and just think of it as “normal”.

So here are some clues that may help you to spot undue levels of tension:

- tense muscles
- heart racing or pounding
- hyperventilating; feeling light-headed or faint
- persistent tiredness or exhaustion
- aches and pains
- difficulty with sleeping
- loss of appetite or not eating well, perhaps with our stomach “in knots”
- developing minor ailments such as headaches, migraines or stomach upsets
- mind in a whirl; can’t think straight, concentrate or work effectively
- sense of rush and pressure, lack of time.



These symptoms can also be caused by other medical problems, so if you are unsure, it is worth checking this out with your GP.

Whilst some tension can help in the short-term by making us alert, or by motivating us to get on with something, in the longer-term it can begin to cause problems with our health, and in time our work and relationships are also likely to suffer.

### Which approach to relaxation?

There are many approaches to learning to relax; none is “right” for everyone - it is more a matter of finding an approach that makes sense and works for you. Learning to physically relax muscle groups, learning mental relaxation, meditation, yoga, prayer, biofeedback - all are possible approaches. As our body is not disconnected from our mind and our emotions, it is possible to use any of these starting points to benefit our entire being.

Like exercising in order to get fit, doing relaxation exercises once won’t make you “fit”: learning to relax takes time and practice in order for you to become proficient.





## 19.1 A simple physical relaxation technique

Here is one simple physical method which is designed to be useful in everyday situations: it doesn't aim at deep relaxation or require you to lie down for half an hour! Rather, it aims to reduce *unnecessary* levels of tension, so that you can continue with your current activity more effectively; it can be used just about anywhere - sitting in a lecture or examination, walking down the street, or going to sleep in bed.



### How it works

In the early part of this century it was recognized that when people tense up and then relax muscle groups, they end up more relaxed than when they began! In fact this is a natural process that we all use, for example when we stretch, or yawn.

But the key to this particular method lies in two factors:

1. that we learn the difference in the sensations of being tense and being relaxed, and
2. that it gives signals to the subconscious and "automatic" parts of our system (the autonomic nervous system) that "all is well", "there is no need to be tense any longer", and it is your autonomic nervous system which will do the real work by slowing down your heart rate, stopping the release of adrenaline into your blood stream, etc. - things which we do not normally have under our conscious control.

Hence the exercises themselves are deceptively simple. Don't be fooled - they *do* work; but like all relaxation methods, it takes time and practice for this to be useful in real-life stressful situations!



### The method

For each of the areas of the body described, it is suggested that you tense up and then relax muscle groups. Do each exercise three times. As you get better with time at relaxing these areas, try using less tension before relaxing.



## How to handle stress (1): Basic Relaxation method

The basic relaxation method is an effective tool to reduce stress, and it is often used with breath control. This method relaxes the mind and body and can be mastered in three or four weeks by training for 15 minutes a day.

### Basic relaxation method

1. **Lie down** on your back, or sit in a comfortable up-right chair in a room where you can not be disturbed.
2. **Prepare** by loosening clothing and taking off your glasses. Then you should put both hands, palms up, besides your body and close your eyes.
3. **Tension and relax** your muscles using the following method and keep the tense state for a few seconds. Follow the sequence; each leg, belly, chest, back, each arm, face.

legs	Stretch out your toes and tension your calf and thigh.
belly	Tighten your belly and tension your belly muscles.
Chest and back	Pull back both shoulders and tension the muscles of back.
arms	Close your fist and tension your whole arm.
face	Close eyelids powerfully, and let a muscle of a face feel tense.

4. **Feel** the difference each time you tension and relax your muscles.

When you slack off, you should feel the sense that your body is heavier and that you are sinking into the surface or chair. If you become sleepy during practice, it is the sign that the training is successful.



5. **Visualize** a quiet scene, take a deep breath slowly with a pleasant feeling and repeat the tension and relaxation of your whole body.

6. **Breath** in as you tension your muscle and breath out as you relax your muscles





## 19.2 Relaxation and sleep

Relaxing is not the same as sleeping! Many people sleep without being very relaxed, and although relaxing can lead one to yawn or feel sleepy, it need not lead to sleep.

However, learning to relax can certainly help you to get to sleep more easily, and then to sleep more restfully. Use the physical relaxation exercises described earlier when you are ready for sleep. Some other suggestions that may help with sleeping are:

- don't use your bed as a place to work during the day
- stop working some while before you want to sleep
- put your work books etc. out of sight of your bed
- develop a routine prior to going to bed
- once in bed, get as comfortable as possible
- yawn! "Artificial" yawns are just as good as the real thing in helping you to slow down your breathing, and at releasing the fluid between your eyelids which will enable them to stay closed all night. Having yawned, keep your eyes gently closed.



## 19.3 Stopping thinking altogether

To quieten all thoughts and leave an empty mind is very difficult, but if thoughts are going round and round in your mind as you attempt to sleep, try these ideas:

- first, use the physical relaxation techniques described above
- with your eyes gently closed, look straight ahead and "stare into space" as if looking at a distant, unmoving spot. Just keep looking at this distant black spot
- if your thoughts still won't stop, try focusing on your breathing and gently slowing it down
- or imagine your thoughts as images on a black screen, which you can "wipe out" with a board rubber.





## 19.4 Building relaxation into everyday life



For these techniques to be of real use, you will need to build them into your everyday life, so that when something very stressful comes along, you are already thoroughly practiced in the skills of relaxation and can put them to good use in the midst of difficulty. The day of an examination, interview or presentation is not the day to begin practicing!

As time goes by, you will probably find that you are more readily aware of any signs of tension in your body. As you become more alert to the early warning signs in your body, you can begin to relax before tension becomes a major problem.

You may become so proficient that you do not need to tense up muscle groups prior to relaxing them - the tensing stage is not actually necessary, but was introduced as an easier method for beginners. You may find in time that you can simply relax at will.

You cannot overdose on these exercises; nor are they in any way harmful or addictive! They simply make good use of a natural process.

Practice when life is going well, and then gradually build it into more stressful events. Incorporate it into all aspects of your life and then you will be well able to keep disabling tension at bay when stressful events arise!





## 20.0 Advanced Relaxation Techniques

### How to handle stress (2): Advanced Relaxation method

We all need to develop a means for relaxing and coping with stress. In fact there are many things that we do in order to relax without thinking about stress:

- listening to music or reading a book
- going for a walk
- engaging in sport - golf, tennis, for example
- engaging in a hobby activity - like gardening
- watching television

All of these activities can be highly effective PREVENTION measures. However, we are sometimes more stressed than we realize and there may be a need to engage in specific stress-reducing procedures such as:

- Breathing exercises
- Relaxation
- Meditation
- Massage
- Yoga
- Visualization

As the heading suggests we are concentrating here on techniques to help you relax specifically breathing and muscle relaxation exercises. There are many methods available and there is no 'best method'. Relaxation training involves you in acquiring skills, for example, abdomen and chest breathing and techniques to enable you to 'switch off'. These can be used to cope with emotional and bodily reactions to stress situations. It is necessary to practice these exercises daily until they become an effective habit.

### 20.1 Breathing Exercises

Breathing is essential to life. Life begins with a person's first breath and ends with the last. Breathing is automatic and usually involuntary, being controlled (like all other internal functions) by the autonomic, or involuntary, nervous system. However, breathing is unique in that it can also be controlled by an act of will. Since we breathe between 16,000 to 20,000 times a day it can be a very powerful tool in gaining some degree of control over autonomic functions.

Breathing patterns often reflect our state of mind or emotions. For example, an anxious person tends to breathe rapidly and often, only using the upper part of the chest; a depressed person tends to sigh; a **child**, during a temper tantrum, holds his or her breath until blue in the face; the anxious person talks at the end of an inhalation in a high-tone voice; and the depressed person talks at the end of an exhalation in a low-tone voice.

#### How should we breathe?

There are two main types of breathing: costal (meaning 'of the ribs') and diaphragmatic (or abdominal) breathing. Costal breathing is characterized by an outward, upward movement of the chest. It is useful during vigorous exercise but is quite inappropriate for ordinary, everyday activity.



## Abdominal or diaphragmatic breathing

The principal muscle involved in abdominal breathing is the diaphragm, a strong dome shaped sheet of muscle that separates the chest cavity from the abdomen. When we breathe in, the diaphragm contracts and pushes downwards, causing the abdomen to relax and rise. In this position, the lungs expand, creating a partial vacuum which allows air to be drawn in. When we breathe out, the diaphragm relaxes, the abdomen contracts and expels air containing carbon dioxide.

Diaphragmatic breathing is the most important tool available for stress management. It promotes a natural, even movement of breath which both strengthens the nervous system and relaxes the body. It is the most efficient method of breathing, using minimum effort for maximum oxygen. The main benefits of diaphragmatic breathing are that it provides the body with sufficient oxygen, expels carbon dioxide adequately, relaxes the body and the mind and improves circulation to the abdominal organs by its massaging action.

### How to do it

1. Lie on your back with your feet a comfortable distance apart or sit upright comfortably, but not rigidly.
2. Close your eyes.
3. Place one hand on your chest and the other hand on your abdomen. Become aware of the rate and rhythm of your breath. Note which hand is moving with your breathing movements.
4. Inhale and exhale slowly, smoothly and deeply through the nostrils without noisy jerks or pauses.
5. Consciously pull in your abdominal muscles when you exhale and, if necessary, push the abdominal muscles gently with your hand. When you breathe out be aware of the abdominal wall pushing out.
6. Now place your hands by your side, continue inhaling and exhaling and concentrate exclusively on the breathing movements, being aware only of your abdomen rising and falling.
7. Practice 3-5 minutes a day until you clearly understand the movement and diaphragmatic breathing becomes your natural pattern of breathing, whether you are sitting, standing or lying down.



## Revitalising breath

The oxygen you take in each time you breathe revitalizes every single cell in the body. Try imaging this process actually taking place; through this imagination you can send energy-giving breath to any area which feels dull or sluggish.

### How to do it

1. You can do this exercise sitting down or standing up. Close your eyes if you like.
2. Take a deep breath in and feel the abdomen expand as you bring your arms out from your sides and slowly up over your head.
3. Stretch as you breathe out and slowly bring down your arms.
4. As you breathe in again, imaging your breath revitalize your entire body, filling it with energy and dissolving away the tension. Feel it becoming alive, with oxygen spreading through every part of your body as you bring your arms up again as in 2.
5. Slowly exhale and bring your arms down by your side.
6. Repeat the above sequence 3 times. Notice any sensations you may feel, for example warmth, relaxation, tingling.
7. Now focus on an area where you feel tension, for example, between the shoulder blades. Take another revitalizing, deep breath and feel it moving into the tense area. Imaging your warm breath massaging the area and easing away the tension. Exhale.
8. Choose another tense area to focus on and repeat the exercise.
9. Take a few extra inspirations and expirations and imagine your body full of vigor and vitality.
10. Stretch slowly as your palms reach up to the ceiling and rock your body from side to side by switching your weight from your left foot to your right foot. Slowly bring your arms down to your sides.
11. Stand still for a few seconds and enjoy the sights and colours around you. Continue with your routine feeling refreshed and happy.
12. Practice twice a day for about 3 minutes each time.

### One-breath relaxation

Several times during the day become aware of your breathing. Take one deep breath. Feel the energy coming in and revitalizing your body. Breathe out and relax. Use frequent occurrences in daily life like waiting for someone to answer your telephone call, getting in or out of the car, or stopping at red traffic lights whilst driving. You should be able to fit in approximately 20 such one-breath relaxation exercises during your entire day.



## 20.2 Relaxation Exercises

These are just a sample of the methods which are available to achieve relaxation. Yoga exercises and meditation are others and you might wish to explore the wider range of possibilities.

### Deep muscle relaxation

Each time one of your muscles contracts, thousands of electrical impulses travel along the nerves to the brain. There is scientific evidence which suggests that a part of the brain called the hypothalamus, which controls stress-response with its mental, emotional, behavioral and physical components, becomes highly charged when it is bombarded with a variety of sensory stimulations. When the hypothalamus is sensitized in this way, everyday stressors can easily lead to stress-response.

It is possible to cut down drastically on the sensory impulses traveling to the brain by lying down, closing your eyes, learning not to be distracted by external noises and then deeply relaxing the entire body. The result is amazing: both body and mind return to a state of balance or recuperative rest.

Such relaxation should occur spontaneously after any activity but, unfortunately, the endless demands of modern life often prevent this. The result is an accumulated state of stress which can eventually culminate in a stress disorder. You need to learn the art of letting go and allowing your body's restorative ability to take over.



## How to do it

1. Practice relaxation on an empty stomach or at least one and a half hours after a light meal.
2. Make sure you are comfortable in loose-fitting garments. Loosen your tie, belt and other constricting clothes.
3. Lie flat on your back on a firm bed or on folded blankets on the floor.
4. Make sure your head, body and legs are in a straight line. Keep your legs a little apart and allow your feet to flop loosely so that your heels are pointing inwards and toes are pointing outwards. Keep your hands by your side with palms upwards and fingers slightly flexed.
5. Close your eyes.
6. Exhale and inhale through your nostrils and breathe slowly and rhythmically using your diaphragm.
7. Take your mind to different parts of the body sequentially, become totally aware of every aspect of the feelings in each part of your body. Imagine each part relaxing as deeply as possible and savor the feeling of relaxation for a few seconds. The sequence in which you relax is suggested as follows
8. right toes, instep, heel, ankle, leg, knee, thigh and hip
9. left toes, instep, heel, ankle, leg, knee, thigh and hip
10. right fingers, thumb, palm, wrist, forearm, elbow, upper arm and shoulder left fingers, thumb, palm, wrist, forearm, elbow, upper arm and shoulder spine, lower back, middle back and upper back
11. chest, sides, abdomen
12. neck, jaw, lips, tongue, face, muscles around the eyes, forehead and scalp
13. The body should be completely and totally relaxed. Stay in that state of relaxation for 5-10 minutes.
14. To come out of relaxation, take one deep breath, feeling the energy coming down into your arms and legs. Move arms and legs slowly. Open your eyes slowly, sit up and stretch your body, feeling refreshed and re-energized.
15. Practice at least once and, if possible, twice a day.
16. Once you have mastered the technique you should be able to relax appropriately - sitting, standing or lying down - and within a matter of seconds.



## Progressive muscle relaxation

The overall principle of progressive relaxation is that each of the main muscle groups in the body is first tensed, then held taut, and then relaxed in turn, until the whole body is relaxed. The idea is that before you can relax your body, you must learn how your muscles feel when they are tight and tense. Letting go after tensing gives a physically pleasant feeling in the relaxed muscles. It is essential to develop this awareness of the difference between muscle tension and muscle relaxation. Try clenching the hand into a fist, holding it tight for a while and then letting go, appreciating the feeling of release. Or hunch up your shoulders, stay that way, and then let all the muscles go.

Relaxation methods involving tensing the muscles are not recommended by some doctors for people with hypertension (high blood pressure).

The best way to learn relaxation is probably by attending a class with a teacher. It is also possible to buy tapes or records giving instructions for you to follow, or you may be able to get hold of some written instructions which a friend or relative could read out to you. Alternatively, you could yourself record the instructions on to a tape and play it back when you want it.





## How to do it

If you want to practice relaxation, you should allow at least a quarter of an hour a day and try to follow the same sequence every time.

Relaxing surroundings are helpful but not essential. It is best (at least at first) to choose a quiet, dimly-lit room where you can be warm and comfortable and not subject to distractions.

Relaxation should not be practiced for an hour after a light meal, and one and a half hours after a big meal. A full stomach not only hinders relaxation of the body, but may also lead to indigestion if the stomach becomes relaxed. Above all, relaxation should be enjoyable, otherwise it will not work. Begin by taking off your shoes and loosening any tight clothing, especially around the neck and waist. Adopt a relaxing posture: the easiest is probably lying down.

Lie down on a carpeted floor, or a bed - provided it is not too soft. Each part of your body should be supported comfortably. Lie with your arms and legs a little apart. It is better to do without a pillow.

You should tense and relax each part of your body in turn, starting either with hands and arms, then head and down through the trunk to the legs, or starting with the feet and legs and working up through the body.

If you begin with the hands and arms, you should first clench the fists, which also entails clenching the forearm muscles. Hold this for a little while, perhaps 10 seconds, and feel the tension; then let go and feel the difference - a sensation of welcome release. Then hold the hands (fists clenched) against the shoulders so as to tense the upper arms, feel the tension, and then let it go.

Next the neck can be held taut with the chin pressed in,, then relaxed. followed by the different facial muscles - forehead (frown and relax), eyebrows (raise up then release), eyes, mouth (purse up and release), jaw (thrust forward and release),then the shoulders (hunch up then let go), stomach, buttocks, thighs, legs and feet. Each time you should consciously feel the tension before you let go.

After tensing and relaxing each muscle group in turn, you should feel relaxed all over.

Instead of thinking of yourself in **parts** be aware of the whole body and if you feel any remaining tension anywhere, try to release it - if necessary by first deliberately tensing the affected muscles and then letting go.

Allow 5 to 10 minutes at the end in which to enjoy your relaxed state. You should be breathing quietly, with slow and gentle breaths. You may want to imagine a peaceful scene, for instance lying peacefully by the side of a blue lake, with green grass and trees, the song of the birds, the warmth of the sun, your body warm, heavy and relaxed. Choose your own imagined scene - whatever you like best.

When you are ready to get up, first have a good stretch, then either sit up very slowly or turn over (on to your side first into what is called 'the recovery position') then get up.

Your aim should be to carry over your relaxed state into whatever activity follows your period of relaxation.

Although it is easier to practice relaxation while lying down, sitting is also fine. You can practice in an armchair - and in time you should be able to relax even in an office chair or on a bus or in the driver's seat of a parked car, or wherever you happen to be at the time.



## Staying relaxed

Once the technique of relaxation has been learned, it should be possible to relax without first tensing all the muscles and it should be easy to detect any area of tension and quickly release it.

Throughout the day, get into the habit of checking whether you are tensing any muscles unnecessarily. If you are, you are not only wasting energy and effort but could well bring on headache, neck ache, and backache.

If your face is tensed and mouth turned downward, relax it and consciously force the corners of your lips upwards into a smile. It may be mechanical, but helps you to feel less dejected or stressed.

