9.1 General

The aviation industry is growing, and if we continue the same way we are working currently we will have soon one fatal accident per week!

In order to stop this, we must also consider the human being as a factor, as about 70% of the maintenance related accidents come from improper installation etc...

The need to take human factors into account

"Human factors" refers to the study of human capabilities and limitations in the workplace. Human factors researchers study system performance. That is, they study the interaction of maintenance personnel, the equipment they use, the written and verbal procedures and rules they follow, and the environmental conditions of any system.

The aim of human factors is to optimise the relationship between maintenance personnel and systems with a view to improving safety, efficiency and well-being

Human factors include such attributes as:

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)

To understand human factors, the **SHEL model** can help.

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 centre of the model, including maintenance engineers, supervisors, planners, managers, etc.).

`Incidents attributable to human factorshuman error`

Most problems that were leading to accidents are:

There were staff shortages

Time pressures existed

All the errors occurred at night

Shift or task handovers were involved

They all involved supervisors doing long hands-on tasks

There was an element of a -can-do- attitude

Interruptions occurred

There was some failure to use approved data or company procedures

Manuals were confusing

There was inadequate pre-planning, equipment or spares.

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Murphy's Law

There is a tendency among human beings towards complacency that an accident will never happen to me or to my Company.

("**If anything can go wrong, it will**") It was named after Capt. Edward A. Murphy, an engineer working on Air Force

`You must foresee things when you are doing your planning`

9.2 Human Performance and Limitations

Just like aircraft components have limitations, engineers also do have certain capabilities and limitations.

Vision: Please study the Basic Function of the Eye! (CAP 715)

You should understand Pupil, iris, lens, cornea, retina, cones & rods, optic nerve to the visual cortex in the brain, and Myopia, presbyopia, hypoxia, Colour Vision - see CAAIP!

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 colour sensitive. This means the human eye can distinguish about 1000 different shades of colour.

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

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

Various factors can affect the eye:

Physical factors such as: physical imperfections in one or both eyes (short sightedness, long sightedness),age

The influence of ingested foreign substances such as: drugs, medication, alcohol, cigarettes.

Environmental factors such as: amount of light available, clarity of the air (e.g. dust, mist, rain, etc.).

Factors associated with object being viewed such as: size and contours of the object, contrast of the object with its surroundings, relative motion of the object, distance of the object from the viewer, the angle of the object from the viewer.

Colour-defective vision (normally referred to incorrectly as colour blindness) 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. - see CAAIP!

Individual light requirements doubles with age

[1] **CAP 715 & CAP 716** UK-CAA, 2007.

Glare of light affects older people more
For crack inspection hold light at an angle of 5 to 45 degrees to the surface to be checked
Perception is what you are expecting to see
For more see exam questions!

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Hearing: see CAP 715!
The Basic Function of the outer ear, middle ear and inner ear.
You should know auditory canal, eardrum, ossicles, acoustic or aural reflex, eustachian tube, cochlea, basilar membrane, auditory nerve.
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), with greatest sensitivity at about 3000 Hz.
Normal hearing is from 20 Hz to 20,000 Hz
Hangar noise is about 70 to 75 decibel
Earplugs reduce noise by 20 decibel
Earmuffs reduce noise by 40 decibel

Impact of Noise on Performance

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).
It is normally accepted that a TWA (Time Weighted Average sound level) noise level exceeding 85 dB for 8 hours is hazardous and potentially damaging to the inner ear. Exposure to noise in excess of 115 decibels without ear protection, even for a short duration, is not recommended.
Presbycusis is hearing deteriorates naturally as one grows older.
Hearing test: The ability to hear an average conversational voice in a quiet room at a distance of 2 metres (6 feet) from the examiner is recommended as a routine test.

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Information Processing

Information processing is the process of receiving information through the senses, analysing it and making it meaningful.
`Sensory Receptors and Sensory Stores`
Physical stimuli are received via the sensory receptors (eyes, ears, etc.) and stored for a very brief period of time in sensory stores (sensory memory). Visual information is stored for up to half a second in iconic memory and sounds are stored for slightly longer (up to 2 seconds) in echoic memory. This enables us to remember a sentence as a sentence, rather than merely as an unconnected string of isolated words, or a film as a film, rather than as a series of disjointed images.
Attention can be thought of as the concentration of mental effort on sensory or mental events.
You should know Selective attention-cocktail party effect- , Divided attention , Focused attention , Sustained attention and that attention is influenced by arousal level and stress.
`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.
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 can be considered to be the storage and retention of information, experiences and knowledge, as well as the ability to retrieve this information.
You should know Ultra short-term memory , the role of sensory stores, Short term memory, long-term memory, Semantic memory, Episodic memory, Iconic memory
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, thought hectic, changes slowly relative to flight operations. In terms of situation awareness, engineers must have the ability to extrapolate the consequences of their errors over hours, days or even weeks. To do this, the situation awareness cues that are taught must be tailored to fit the maintenance environment using MRM-specific simulations.
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.
An example of situation awareness is an engineer seeing (or perceiving) blue streaks on the fuselage. His comprehension may be that the lavatory fill cap could be missing or the 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.
You should know about Decision Making, Memory, and Motor Programmes
Motor programme may revert to associative phase
Skill behaviour is associated with motor programme
Repetitive tasks, too low & too high temperature, not enough light and noise can reduce alertness
Poor access to components to be worked on can provoke increased discomfort and high probability of omissions
Experienced personnel is more prone to errors by not using FIM
Light sensitive cells are cones only on fovea
Fitness/health

Counseling is symptom directed coping
Hyperventilation: breath slowly and deeply
Episodic memory can be influenced by expectations as to what should have happened
Echoic memory is auditory 2-8 sec
Iconic memory is visual 0.5-1 sec
Most sleep is spent in stage 2 sleep Phase
3/4 sleep is most beneficial for body recovery =Slow wave sleep
Ill health can lead to sickness
Claustrophobia = Claustrophobia can be defined as abnormal fear of being in an enclosed space.
Fear of Physical Access and Fear of Heights can cause mental problems to the engineer!

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Chapter 9.3 Social Psychology !
Engineers do not work alone, they work in a system with an organisational culture.
In this organisation are certain structures and rules. The engineer or a group of engineers influence the orgranisation or are influenced by the organisation. The engineer or group has responsibilities and also conflicts. Many tasks can be done better by a team, but a team can also lead an individual to do things which the individual would not normally do (group polarisation, risky shift, group thinking).
Best technicians are involved in more accidents as they work most when really needed
An example of assertive behaviour is when a technician refuses to sign off for unsafe work despite pressure
-Culture- issues
Team working
The disadvantage of teamwork is that responsibility can be delegated
Team performance exceeds individual performance
Social loafing reflects the tendency for someone to work less hard
Social loafing is a tendency for some individuals to work less hard on a task when they believe others are working on it
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 characterised 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.

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The Dirty Dozen, which are 12 areas of potential problems in human factors.
`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 didnt 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 torqueseal. 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.
`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 isnt self-induced. Communicate your concerns. Ask for extra help. Just say -No-.
`9. Lack of assertiveness`
If it is 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 instruction changed. Be aware the-norms- do not make it right.

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

Maslow considered that humans are driven by two different

sets of motivational forces:
those that ensure survival by satisfying basic physical and psychological needs;
those that help us to realise our full potential in life known as self-actualisation needs (fulfilling ambitions, etc.)
First you must satisfy basic needs like food, housing etc. , this goes over safety needs, esteem etc. needs up to self actualisation.
`Peer pressure` is the actual or perceived pressure which an individual may feel, to conform to what he believes that his peers or colleagues expect.

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The `culture of an organisation` can be described as the way we do things here. It is a group or company norm.
`Safety culture` is a set of beliefs, norms, attitudes, roles and social and technical practices concerned with minimising exposure of employees, managers, customers and members of the general public to conditions considered dangerous or hazardous
Whilst safety culture has been discussed from the organisational perspective, the responsibility of the individual should not be overlooked. Ultimately, safety culture is an amalgamation of the attitude, beliefs and actions of all the individuals working for the organisation and 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.
Managers and supervisors have a key role to play in ensuring that work is carried out safely. It is no good instilling the engineers and technicians with good safety practice concepts, if these are not supported by their supervisors and managers.
A leader in a given situation is a person whose ideas and actions influence the thought and the behaviour of others.
A good leader in maintenance engineering is:
Motivating his team
Reinforcing good attitudes and behaviour
Demonstrating by example
Maintaining the group
Fulfilling a management role
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 is not about addressing the individual human factors of the engineer or his manager; rather, it looks at the larger system of human factors concerns involving engineers, managers and others, working together to promote safety.
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 programme.

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9.4 Factors Affecting Performance
JAR 66.50 imposes a requirement that certifying staff must not exercise the privileges of their certification authorisation if they know or suspect that their physical or mental condition renders them unfit. **See CAAIP CAP455**
Many conditions can impact on the health and fitness of an engineer and there is not space here to offer a complete list. However, such a list would include:
Minor physical illness (such as colds, flu, etc.);
More major physical illness (such as HIV, malaria, etc.)
Mental illness (such as depression, etc.)
Minor injury (such as a sprained wrist, etc.)
Major injury (such as a broken arm, etc.)
Ongoing deterioration in physical condition, possibly associated with the ageing process (such as hearing loss, visual defects, obesity, heart problems, etc.)
Affects of toxins and other foreign substances (such as carbon monoxide poisoning, alcohol, illicit drugs, etc.).

`Positive Measures`
Aircraft maintenance engineers 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)
Stopping smoking
Sensible alcohol intake (for men, this is no more than 3 - 4 units a day or 28 per week, where a unit is equivalent to half a pint of beer or a glass of wine or spirit

Stress: Domestic and Work Related:
Stress can be defined as any force, that when applied to a system, causes some significant modification of its form, where forces can be physical, psychological or due to social pressures.
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.)
AWN47 points out that: 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 minimise workplace stresses. Individual cases can be helped by sympathetic and skilful counselling which allows a return to effective work and licensed duties.
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, diarrhoea, ulcers, etc.
Behavioural 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.
Pre-occupation with a source of `domestic stress` can play on ones mind during the working day, distracting from the working task.
Work related Strss: Stress can be felt when carrying out certain tasks that are particularly challenging or difficult. This stress can be increased by lack of guidance in this situation, or time pressures to complete the task or job (covered later in this chapter). This type of stress can be reduced by careful management, good training, etc.
`Stress Management - defence or coping`
Defence 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.
Good stress management techniques include:
Relaxation techniques
Careful regulation of sleep and diet
A regime of regular physical exercise
Counselling - 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.
The Effects of Time Pressure and Deadlines
The potential stressors in maintenance is time pressure. This might be actual pressure where clearly specified deadlines are imposed by an external source (e.g. management or supervisors) and passed on to engineers, or perceived where engineers feel that there are time pressures when carrying out tasks, even when no definitive deadlines have been set in stone. In addition, time pressure may be self-imposed, in which case engineers set themselves deadlines to complete work (e.g. completing a task before a break or before the end of a shift).
Managing Time Pressure and Deadlines
Those responsible for setting deadlines and allocating tasks should consider:
Prioritising 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 utilisation of staff (considering an engineers specialisation, and strengths and limitations)
Availability of parts and spares.

Workload - Overload and Underload: it is important to consider this optimum level of stimulation or arousal.
Too much boredom is as bad as heavy work overload and both will lead to failures!
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 engineers 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 engineers, supervisors and managers to recognise 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 engineer becoming overloaded
securing further time in order to carry out the work safely postponing, delaying tasksdeadlines and refusing additional work.

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Sleep, Fatigue and Shift Work
Sleep is a natural state of reduced consciousness involving changes in body and brain physiology which is necessary to man to restore and replenish the body and brain.
Sleep is characterised by five stages of sleep:
`Stage 1:` This is a transitional phase between waking and sleeping. The heart rate slows and muscles relax. It is easy to wake someone up.
`Stage 2:` This is a deeper level of sleep, but it is still fairly easy to wake someone.

`Stage 3:` Sleep is even deeper and the sleeper is now quite unresponsive to external stimuli and so is difficult to wake. Heart rate, blood pressure and body temperature continue to drop.
`Stage 4:` This is the deepest stage of sleep and it is very difficult to wake someone up.
`Rapid Eye Movement or REM Sleep:`
Even though this stage is characterised by brain activity similar to a person who is awake, the person is even more difficult to awaken than stage 4. It is therefore also known as paradoxical sleep. Muscles become totally relaxed and the eyes rapidly dart back and forth under the eyelids. It is thought that dreaming occurs during REM sleep.
Stages 1 to 4 are collectively known as non-REM (NREM) sleep. Stages 2-4 are categorised as slow-wave sleep and appear to relate to body restoration, whereas REM sleep seems to aid the strengthening and organisation of memories. Sleep deprivation experiments suggest that if a person is deprived of stage 1-4 sleep or REM sleep he will show rebound effects. This means that in subsequent sleep, he will make up the deficit in that particular type of sleep. This shows the importance of both types of sleep.

`Circadian rhythms` are physiological and behavioural functions and processes in the body that have a regular cycle of approximately a day (actually about 25 hours in man). An example of disrupting circadian rhythms would be taking a flight that crosses time zones. This will interfere with the normal synchronisation with the light and dark (day night). This throws out the natural link between daylight and the bodys internal clock, causing jet lag, resulting in sleepiness during the day, etc. Eventually however, the circadian rhythm readjusts to the revised environmental cues.

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`Fatigue` can be either physiological or subjective. Physiological fatigue reflects the bodys need for replenishment and restoration. Subjective fatigue is an individuals perception of how sleepy they feel
A good rule of thumb is that one hour of high-quality sleep is good for two hours of activity.
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 seem more complicated than usual.
Symptoms of fatigue 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 matters
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.

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Alcohol, Medication and Drug Abuse

Performance will be affected by alcohol, medication or illicit drugs. Under both UK and JAA legislation it is an offence 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: The holder of an aircraft maintenance engineers licence shall not, when exercising the privileges of such a licence, be under the influence of drink or a drug to such an extent as to impair his capacity to exercise such privileges.
6.2 The current law which does not prescribe a blood/alcohol limit, is soon to change. There will be new legislation permitting police to test for drink or drugs where there is reasonable cause, and the introduction of a blood/alcohol limit of `80 milligrams of alcohol per 100 millilitres` of blood for anyone performing Maintenance in UK civil aviation (same as for driving - 20 milligrams of alcohol per 100 millilitres for pilots).
As a general rule, aircraft maintenance engineers should not work for at least eight hours after drinking even small quantities of alcohol and increase this time if more has been drunk.
`Medication` is usually taken to relieve symptoms of an illness. Even if the drugs taken do not affect the engineers performance, he should still ask himself whether the illness has made him temporarily unfit for work.
Analgesics used for pain relief, Antibiotics, Anti-histamines widely used in -cold cures-, Cough suppressants, Decongestants, -Pep- pills or Sleeping tablets may reduce the fitness to work in aircraft maintenance.
If the aircraft maintenance engineer has any doubts about the suitability of working whilst taking medication, he must seek appropriate professional advice.
Illicit drugs such as ecstasy, cocaine and heroin all affect the central nervous system and impair mental function. Smoking cannabis can subtly impair performance and lead to make wrong judgments for up to 24 hours.

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`CAAIP 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:`
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 bodys various rhythms (principally sleeping patterns).
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, noise etc...

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Continuity of Tasks and Shift Handovers
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 handover is potentially an area where human errors can occur. Whilst 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 handovers with 2 twelve hour shifts, as opposed to 3 handovers with 3 eight hour shifts).
The primary objective of handovers is to ensure that all necessary information is communicated between the outgoing and in-coming personnel. Effective task and shift handover depends on three basic elements:
The outgoing persons ability to understand and communicate the important elements of the job or task being passed over to the incoming person.
The incoming persons ability to understand and assimilate the information being provided by the outgoing person.
A formalised process for exchanging information between outgoing and incoming persons and a place and time for such exchanges to take place.
Organisations should have a recognised procedure for task and shift handovers which all staff understand and adhere to. This procedure should be listed in the MOE. Ideally the procedure should provide for sufficient time to be made available by way of a shift overlap, depending on the complexity of task(s) to be handed over. As a guideline, 20 to 30 minutes could be considered good human factors practise. It would also be good practice for the outgoing shift supervisor to leave a contact telephone number with the incoming shift, in case they have any queries after a handover has taken place. Whilst all essential information (especially the detailed status of tasks) should be recorded in written form, it is also important to pass this information verbally in order to reinforce it. This is known as redundancy, or the belt and braces approach.

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9.5 Physical Environment !
It is very important that aircraft maintenance engineers 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 metres.
`white noise` are like the hums produced by air
Apart from noxious fumes that have serious health implications and must be avoided, working in the presence of fumes can affect an engineers performance, as he may rush a job in order to escape them. If the fumes are likely to have this effect, the engineer should increase the ventilation locally or use breathing apparatus to dissipate the fumes.
`Lights:` It is also important that illumination is available where the engineer needs it (i.e. both in the hangar and one 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 engineer. When using task lighting, it should be placed close to the work being done, but should not be in the engineers 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 engineer is working causing indirect or reflected glare. Glare of either kind will be a distraction from the task and may cause mistakes.
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 engineer see into remote areas.
Climate and Temperature
JAR 145.25(c) (AMC) requires that environmental conditions be adequate for work to be carried out, stating:

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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/other airborne contamination, the particular maintenance or inspection tasks should be suspended until satisfactory conditions are re-established
Environmental conditions can affect physical performance.
Motion and Vibration 5.1 Aircraft maintenance engineers often make use of staging and mobile access platforms to reach various parts of an aircraft. As these get higher, they tend to become less stable.
Vibration in aircraft maintenance engineering is usually associated with the use of rotating or percussive tools and ancillary equipment, such as generators. Low frequency noise,

such as that associated with aircraft engines, can also cause vibration. Vibration between 0.5 Hz to 20 Hz is most problematic, as the human body absorbs most of the vibratory energy in this range. The range between 50-150 Hz is most troublesome for the hand and is associated with Vibratory-induced White Finger Syndrome (VWF). Pneumatic tools can produce troublesome vibrations in this range and frequent use can lead to reduced local blood flow and pain associated with VWF. Vibration can be annoying, possibly disrupting an engineers concentration.
Confined Spaces: claustrophobia may be 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. When working in a fuel tank, as guard must be outside of the fuel tank!
Working Environment
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.).
The engineers workplace may affect his ability to work safely and efficiently. JAR 145.25(c) - Facility Requirements states: The working environment must be appropriate for the task carried out and in particular special requirements observed. Unless otherwise dictated by the particular task environment, the working environment must be such that the effectiveness of personnel is not impaired.
The working environment comprises the physical environment, the social environment and the tasks that need to be carried out.
Working environment interact, for example: engineers 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.

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9.6 Tasks

Before commencing a task, an individual engineer, engineering team or planner should ask themselves a number of questions. These may include:
Do Iwe 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; equipmentspares; documentation, information and guidance; facilities such as hangar space, lighting, etc. Do Iwe have the skills and proficiency necessary to complete the task?
Information about specific tasks should be detailed on job cards or task sheets.
It is generally the shift supervisors job to ensure that the resources are available for his staff to carry out their tasks. Although management have a responsibility to ensure that their engineers have suitable training, at the end of the day, it is up to the individual engineer to decide whether he has the necessary skills and has the proficiency and experience to do what he has been asked to do.
Physical work
As an engineer gets older, the musculoskeletal system stiffens and muscles become weaker. Injuries become more likely and take longer to heal. Staying in shape will minimise the effects of ageing, 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 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.
Complacency is also a danger, whereby an engineer 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.
Making assumptions along the lines of -Oh I have done that job dozens of times!- — remember that -familiarity breeds contempt-.

Visual inspection
Visual inspection can be described as the process of using the eye, alone or in conjunction with various aids to examine and evaluate the condition of systems or components of an aircraft.
Good eyesight is of prime importance in visual inspection! The engineer should: ensure that he understands the area, component or system he has 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 , such as lighting, access, etc.); conduct a systematic visual search, moving his 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; record any problem that is found and continue the search a few steps prior to where he left off.
Visual inspection requires a considerable amount of concentration.
Finally, non-destructive inspection (NDI) includes an element of visual inspection, but usually permits detection of

defects below visual thresholds. Various specialist tools are used for this purpose, such as the use of eddy currents and fluorescent penetrant inspection (FPI).

Complex systems
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.
With a complex system, it should still be clear to an aircraft maintenance engineer what the systems purpose is. However, its composition and function may be harder to conceptualise - it is opaque to the engineer. To maintain such complex systems, it is likely that the engineer will need to have carried out some form of system-specific training! System-specific training must achieve the correct balance between detailed system knowledge and analytical troubleshooting skills.
When working with complex systems, it is important that the aircraft maintenance engineer makes reference to appropriate guidance material. This typically breaks down the system conceptually or physically, making it easier to understand and work on.

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9.7 Communication

An aircraft maintenance engineer might regularly communicate: information; ideas; feelings; attitudes and beliefs
As the sender of a message, he will typically expect some kind of response from the person he is communicating with (the recipient), which could range from a simple acknowledgement that his message has been received (and hopefully understood), to a considered and detailed reply. The response constitutes feedback.
Communication can be: verbalspoken - e.g. a single word, a phrase or sentence, a grunt; writtentextual - e.g. printed words andor numbers on paper or on a screen, hand written notes; non-verbal - graphic - e.g. pictures, diagrams, hand drawn sketches, indications on a cockpit instrument; symbolic - e.g. -thumbs up-, wave of the hand, nod of the head; body language - e.g. facial expressions, touch such as a pat on the back, posture.
Much of flight operations are characterised by synchronous, -face-to-face- communications, or immediate voice communications (e.g. with ATC) over the radio. The three components of spoken communication are: speaking, listening and feedback
To ensure communication ask for feedback in return
Communication Within Teams
Individual aircraft maintenance engineers 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.
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.

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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 handover. 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 engineers. This means that, wherever necessary, outgoing engineers 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 (see Section 2 below). Furthermore, information communicated at shift handover ensures good continuity. It is important that handovers are not rushed, so as to minimise omissions.
The two main problems are lack of communication and poor communication.
The difficulty of written communication is limited feedback and you cannot easily ask questions
The 3 C's in written communication are: Correct writing, Complete writing, Clear writing
Parts of communication are 55% body language, 38% tone of voice and only 7% verbal
Basic rules of thumb to help aircraft maintenance engineers minimise 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.
Work Logging and Recording: This is one of the most critical aspects of communication within aviation maintenance, since inadequate logging or recording of work has been cited as a contributor to several incidents.

9.8 Human Error

Errors tend to be -active- in that their consequences follow on immediately after the error Active failures are direct
The consequences of an engineers error are often not immediately apparent, and this has implications for training

for error avoidance.

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. Examples: design- versus operator-induced errors; variable versus constant errors; reversible versus irreversible errors; slips, lapses and mistakes; skill-, rule- and knowledge-based behaviours and associated errors; the -Swiss Cheese Model-.

Slips can be thought of as actions not carried out as intended or planned, e.g. transposing digits when copying out numbers, or misordering 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, e.g. forgetting to replace an engine cowling. Mistakes are a specific type of error brought about by a faulty plan/intention, i.e. somebody did something believing it to be correct when it was, in fact, wrong, e.g. an error of judgement such as mis-selection of bolts when fitting an aircraft windscreen.

Latent failures are dormant and may lead to problems A mistake is not intended An error is not intended e.g. pulling the wrong circuit breaker

Violations sometimes appear to be human errors, but they differ from slips, lapses and mistakes because they are deliberate illegal actions, such as cutting corners,

There are four types of violations: Routine violations; Situational violations; Optimising violations; Exceptional violations.

Time pressure and high workload increase the likelihood of all types of violations occurring. People weigh up the perceived risks against the perceived benefits, unfortunately the actual risks can be much higher.

Skill-based behaviours are those that rely on stored routines or motor programmes that have been learned with practice and may be executed without conscious thought.

Rule-based behaviours are those for which a routine or procedure has been learned.

The components of a rule-based behaviour may comprise a set of discrete skills.

Knowledge-based behaviours are those for which no procedure has been established. These require the [aircraft maintenance engineer] to evaluate information, and then use his knowledge and experience to formulate a plan for dealing with the situation.

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.

Where procedures allow some leeway, aircraft maintenance engineers often develop their own strategies or preferred way of carrying out a task - Rule of thumb

In addition, engineers may pick up some -bad rules-, leading to bad habits during their working life

Errors Associated With Visual Inspection : 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.

Reasons Study of Aviation Maintenance Engineering main causes are: Omissions (56%) Incorrect installation (30%) Wrong parts (8%) Other (6%)

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UK Civil Aviation Authority Mandatory Occurrence Reporting Scheme (MORS). These data are 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 Programme (CHIRP) scheme provides an alternative reporting mechanism for individuals who want to report safety concerns and incidents confidentially.

It is vital that aircraft maintenance engineers 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.

Error management seeks to: prevent errors from occurring; eliminate or mitigate the bad effects of errors

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 organisation, 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 defences, or the modification of existing defences. Boeing brought out a similar system called MEDA, it is sometimes asked in Essay questions!

One of the things likely to be most effective in preventing error is to make sure that engineers 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 engineers are encouraged to follow procedures and not to cut corners.

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9.9 Hazards in the Workplace

Hazards in the workplace tend to be a health and safety issue, relating to the protection of individuals at work.

Recognising and avoiding hazards

There are many potential hazards in aircraft maintenance

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.
The health and safety policy might include statements applicable to the organisation 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 andor 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.
In brief, a maintenance organisation has a duty under health and safety legislation to: identify hazards in the workplace; remove them where possible; mitigate the risks to employees.
Warning sign must attract an engineers attention!
The health and safety policy might include statements applicable to engineers 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; Co-operate with the maintenance organisation to ensure that statutory requirements concerning health and safety at work are met; Work in accordance with any safety instruction andor 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; Not interfere intentionally or recklessly with, nor misuse, anything provided in the interests of health and safety.
It is necessary to establish and organisational safety culture!
Poor housekeeping is causing most accidents!

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

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Dealing with emergencies
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 and drills should be provided by the maintenance organisation.
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;
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 first aider)
Call for help
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 brigade, etc.).
Provide assistance as far as one feels competent to.

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