CAT-A/B1/B2

AVIATION MAINTENANCE TECHNICIAN CERTIFICATION SERIES

HUMAN FACTORS

9

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9.2 HUMAN PERFORMANCE AND LIMITATIONS

INTRODUCTION

This Submodule provides an overview of physical and mental human performance factors which affect an aircraft maintenance technician's (AMTs) working environment, such as vision, hearing, information processing, attention and perception, memory, and decision making.

Just as certain mechanical components used in aircraft maintenance have limitations, technicians themselves have certain capabilities and limitations that must be considered when looking at the maintenance 'system'. For instance, rivets used to attach aluminum skin to a fuselage can withstand forces that act to pull them apart. It is clear that these rivets will eventually fail if enough force is applied to them. While the precise range of human capabilities and limitations might not be as well defined as that of mechanical or electrical components, 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. People can also fail to function properly in certain situations. Physically, humans become fatigued, are affected by cold, can break bones in workplace accidents, etc. Mentally, humans can make errors, have limited perceptual powers, can exhibit poor judgment 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 of AMTs can also be to the detriment of aviation safety.

VISION

Vision is vital for AMTs. Think of how much is subject to visual inspection. Vision is best when ensuring appropriate lighting to illuminate the work area, and best protected by ensuring that protective eyewear is clear and suitable for use. An individual's lack of color discrimination, or defective color vision, may make it difficult to distinguish between red and green, even with appropriate illumination. This can lead to errors in tasks such as dealing with electrical wiring.

In order to understand vision, it is useful first to know a little about the anatomy of the eye. [**Figure 2-1**] 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 finally falls on the retina. Here the light stimulates the sensitive cells on the retina (rods and cones) which then 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.

BASIC COMPONENTS OF THE EYE

THE CORNEA

The cornea is the clear 'window' at the very front of the eye. The cornea acts as a fixed focusing device. Focusing is achieved by the shape of the cornea bending the incoming light rays. The cornea

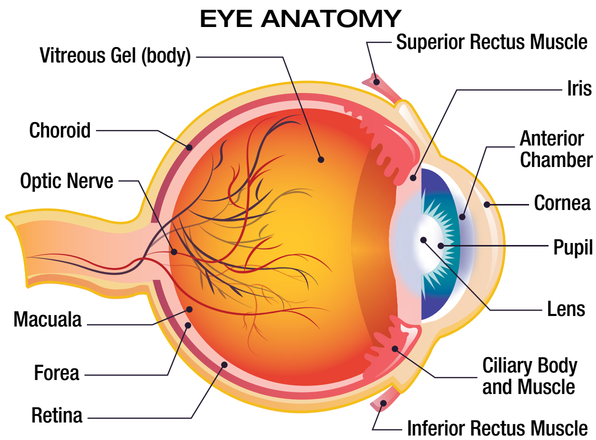

Figure 2-1. Anatomy of the human eye.

employee. Some of the causes of fatigue originate with company policies; for example, hours of work, the extent to which work is performed during the night, and the predictability of work schedules. Other causes stem from the employee's personal situation, including commuting time, family responsibilities, and the demands of second jobs.

Figure 4-10 shows some of the main sources of fatigue. Employer and employee each share responsibility for managing fatigue.

RESPONSIBILITIES OF THE EMPLOYER
- Schedule work hours and time off to give the employee sufficient opportunity for restorative sleep.
- Manage workload and breaks.

RESPONSIBILITIES OF THE EMPLOYEE
- Manage personal time to make sure you are rested and fit for duty.
- When reporting incidents, note if fatigue was a factor.

STRATEGIES TO DEAL WITH FATIGUE
Some of these might be considered common sense, but others may not be as obvious.
- Get More Sleep: The first and most obvious way to prevent fatigue is to get more good quality sleep. This is easier said than done, particularly if you work irregular hours, have a second job, or have young children.
- Controlled Naps: Numerous research studies have shown that even a brief nap can result in performance improvements. Napping used to be widely discouraged by employers, but now pilots, air traffic controllers and others are being allowed to take brief controlled naps when workload permits.

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

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

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

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

PROGRESSIVE RESTRICTIONS
One way to deal with fatigue in maintenance is to keep those who are most fatigued away from the most critical tasks, an approach sometimes called 'progressive restrictions'. [**Figure 4-11**]

Some companies have internal policies progressively limiting the tasks an AMT can perform the longer they have been at work. For example, an AMT who has been on duty for longer than 12 hours might not be permitted to certify the work of others, or may not be permitted to perform engine runs or other critical tasks.

KEY POINTS
- Fatigue seriously impairs work performance and increases the chances of human error.

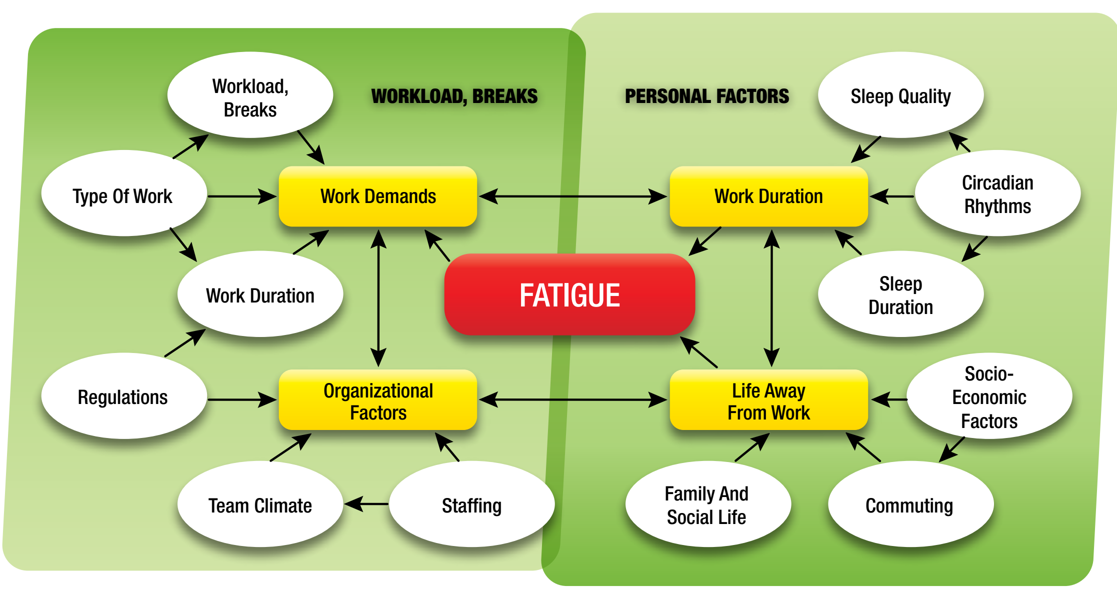

Figure 4-10. Employer and employee responsibilities for managing stress.

Figure 5-1. Two varieties of hearing protection from simple foam plugs to full earmuff; each offering protection (noise reduction) from 25–30 dB.

FUMES, CHEMICALS, TOXIC METALS AND SOLVENTS

The maintenance of aircraft involves working with a variety of hydraulic fluids, paints, cleaning compounds, and solvents. AMTs will also be exposed to aircraft fuel and exhaust. In fact, there is every possibility that an AMT could be exposed to a number of solvents and chemicals during their daily work. The following is a list of some chemicals AMTs are exposed to, and some recommended safety actions.

CHEMICALS

GASOLINE ENGINE EXHAUST (CARBON MONOXIDE)

Carbon Monoxide (CO) is both odorless and colorless. Symptoms of CO exposure are not immediately apparent, but no matter how small, any amount of exposure severely affects the function of sensitive tissues like the brain. Moderate CO poisoning results in headache, rapid breathing, nausea, weakness, confusion, and discoloration of the lips and nail beds. High exposures result in the loss of consciousness without other symptoms. Headache, nausea and vomiting start with lower exposures, while confusion and collapse, followed by death may occur with high exposure. [**Figure 5-2**]

Survivors of CO poisoning often show delayed effects that appear two to forty days after an apparent complete recovery. The most frequently reported symptoms are mental deterioration including apathy, disorientation, amnesia, and irritability. Other symptoms include mood disorders, unusual behaviors, irrational speech content, and gait movement disorders.

AMTs are likely to encounter CO in ground equipment, such as fueling trucks and tugs. Unlike most automobiles, exhaust from ground support trucks is usually routed to the front instead of the rear of the vehicle. Refueling trucks spend a lot of time with their engines idling, allowing more CO to enter the cab. Small engines can produce CO that is just as deadly as that produced by these larger engines. Here are some safety strategies to minimize the risks to AMTs:

- Do not allow the use or operation of gasoline powered engines or tools inside hangars, even if the doors are open, unless the engine can be located outside and away from air intakes;
- Keep engines tuned, minimizing the production of CO;
- Recognize the symptoms of CO overexposure: headache, nausea, weakness, dizziness, visual disturbance, personality changes and loss of consciousness;
- When possible, use compressed air tools or tools powered by electricity rather than those powered by a gasoline engine;
- Place a CO monitor in the work area, truck cab, cockpit, or on yourself.

A coworker exhibiting any of the mentioned signs of over exposure demands the same treatment as if the individual were found unconscious. The following actions are recommended prior to emergency room admission:

- Remove victim from the work area into fresh air;
- Note any abrasions or other evidence of trauma that may have occurred if the victim fell while unconscious;
- Administer 100% breathing oxygen if available;
- Keep victim warm and protected and prepare for transport to an emergency room.

KEROSENE BASED FUELS

Kerosene based fuels include both jet and diesel fuels. Respiratory exposures to jet fuel are low for most AMTs, but symptoms include:

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

Figure 5-2. Many types of CO detectors will quickly warn of an emerging situation.

DEFECT	ACTION TAKEN	MECHANIC	INSPECTOR
Reference card 27-00-56. Card completed fully up to state D). Hydraulic system depressurized by the transmitter operating link is not reconnected. Operating link to be reconnected prior to performing stage F).			

Figure 7-4. Additional task card example.

SHIFT HANDOVER

At the point of shift change, the need for effective communication between the outgoing and incoming personnel in maintenance is extremely important. The absence of such effective communication has been evident in many accident reports from various industries, not just aircraft maintenance. While history is littered with past experiences of poor shift handover contributing to accidents and incidents there is little regulatory or guidance material regarding what constitutes a good handover process relevant to aircraft maintenance. This section attempts to provide guidelines on such a process and is drawn from work performed by the UK Health and Safety Executive (HSE) and the US Federal Aviation Administration (FAA).

CONCEPTS

Effective shift handover depends on three basic elements:

- The outgoing person's ability to understand and communicate the important elements of the job or task being passed over to the incoming person.
- The incoming person's ability to understand and assimilate the information being provided by the outgoing person.
- A formalized process for exchanging information between outgoing and incoming people and a place for such exchanges to take place.

The US Department of Energy shift handover standards stress two characteristics that must be present for effective shift handover to take place: ownership and formality. Individuals must assume personal ownership and responsibility for the tasks they perform. They must want to ensure that their tasks are completed correctly, even when those tasks extend across shifts and are completed by somebody else. The opposite of this mental attitude is "It didn't happen on my shift", which essentially absolves the outgoing person from all responsibility for what happens on the next shift.

Formality relates to the level of recognition given to the shift handover procedures. Formalism exists when the shift handover process is defined in the Maintenance Organization Exposition (MOE) and managers and supervisors are committed to ensuring that cross shift information is effectively delivered. Demonstrable commitment is important as workers quickly perceive a lack of management commitment when they fail to provide ample shift overlap time, adequate job aids and dedicated facilities for the handovers to take place.

In such cases the procedures are just seen as the company covering themselves as they don't consider the matter important enough to spend effort and money.

AIDS TO EFFECTIVE COMMUNICATION AT SHIFT HANDOVER

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

People have to physically transmit information in written, spoken or gestured (nonverbal or body language) form. If only one medium is used there is a risk of erroneous transmission. The introduction of redundancy, by using more than one way of communicating i.e. written, verbal or nonverbal, greatly reduces this risk. For this reason information should be repeated via more than one medium. For example verbal and one other method such as written or diagrams etc. The availability of feedback, to allow testing of comprehension etc., during communication increases the accuracy. The ability for two way communication to take place is therefore important at shift handover. [**Figure 7-5**]

A part of the shift handover process is to facilitate the formulation of a shared mental model of the maintenance system, aircraft configuration, tasks in work etc. Misunderstandings are most likely to occur when people do not have this same 'mental picture' of the state of things. This is particularly true when deviations from normal working has occurred such as having the aircraft in the flight mode at a point in a maintenance check when this is not normally done. Other considerations are when people have returned following a lengthy absence (the state of things could have changed considerably during this time) and when handovers are carried out between experienced and inexperienced personnel (experienced people may make assumptions about their knowledge that may not be true of inexperienced people). In all these cases handovers can be expected to take longer and time should be allowed for.

Figure 7-5. A successful shift handover employs multiple forms of verbal and written communication and best takes place at the work site.

INCIDENT

On March 20, 2001 a Lufthansa Airbus A320 almost crashed shortly after takeoff because of reversed wiring in the captain's sidestick flight control. Quick action by the copilot, whose sidestick was not faulty, prevented a crash.

CAUSE

The investigation has focused on maintenance on the captain's control carried out by Lufthansa Technik just before the flight. During the previous flight, a problem with one of the two elevator/aileron computers had occurred. An electrical pin in the connector was found to be damaged and was replaced. It has been confirmed that two pairs of pins inside the connector has accidentally been crossed during the repair. This changed the polarity in the sidestick and the respective control channels "bypassing" the control unit, which might have sensed the error and would have triggered a warning. Clues might have been seen on the electronic centralized aircraft monitor screen during the flight control checks, but often pilots only check for a deflection indication, not the direction. Before the aircraft left the hangar, a flight control check was performed by the mechanic, but only using the first officer's sidestick.

Figure 8-11. Electrical wiring discrepancies to include cross connections. A description of a Lufthansa Airbus A320 that almost crashed due to reversed wiring of the flight controls.

INCIDENT

Alaska Airlines Flight 261, a McDonnell Douglas MD-83 aircraft, experienced a fatal accident on January 31, 2000, in the Pacific Ocean The two pilots, three cabin crew members, and 83 passengers were killed and the aircraft was destroyed.

CAUSE

The subsequent investigation by the National Transportation Safety Board (NTSB) determined that inadequate maintenance led to excessive wear and catastrophic failure of a critical flight control system during flight. The probable cause was stated to be "a loss of airplane pitch control resulting from the inflight failure of the horizontal stabilizer trim system jackscrew assembly's acme nut threads. The thread failure was caused by excessive wear resulting from Alaska Airlines insufficient lubrication of the jackscrew assembly."

Figure 8-12. Failure to Lubricate. A description of Alaska Airlines Flight 261 that crashed due to insufficient lubrication of the jackscrew assembly.

improperly labeled parts"; and "management can fix the factors that contribute to the events".

Since the introduction of MEDA , a growing number of related maintenance organizations have also adopted MEDA; a tool for investigating the factors that lead to an event, and making suggested improvements to reduce the likelihood of future events. MEDA was designed to process and help maintenance organizations identify why these events occur and how to prevent them in the future. Successful implementation of MEDA requires an understanding of the following:

- The MEDA Philosophy
- The MEDA Process
- Management Resolve
- Implementing MEDA
- The benefits of MEDA

THE MEDA PHILOSOPHY

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

To break this cycle, MEDA was developed in order to assist investigators to look for factors that contribute to the event, rather than concentrate upon the employee who made the error. The MEDA philosophy is based on these principles:

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

POSITIVE EMPLOYEE INTENT

This principle is key to a successful investigation. Traditional "blame and train" investigations assume that errors result from individual carelessness or incompetence. Starting instead from the assumption that even careful employees can make errors, MEDA interviewers can gain the active participation of the technicians closest to the event. When technicians feel that their competence is not in question and that their contributions will not be used in disciplinary actions against them or their fellow employees, they willingly team with investigators to identify the factors that contribute to events and suggest solutions. By following this principle, operators can replace a negative "blame and train" pattern with a positive "blame the process, not the person" practice.

CONTRIBUTIONS OF MULTIPLE FACTORS

Technicians who perform maintenance tasks on a daily basis are often aware of factors that contribute to the event. These include information that is difficult to understand such as work cards or maintenance manuals, inadequate lighting, poor communication between work shifts, and aircraft design. Technicians may even have their own strategies for addressing these factors. One of the objectives of MEDA investigation is to discover these successful strategies and share them with the entire maintenance operation.

MANAGEABILITY OF EVENTS

Active involvement of the technicians closest to the event reflects the MEDA principle that most of the factors that contribute to an event can be managed. Processes can be changed, procedures improved or corrected, facilities enhanced, and best practices shared. Because events most often result from a series of contributing factors, correcting or removing just one or two of these factors can prevent the event from recurring.