Module - 9.1

GENERAL / INTRODUCTION TO HUMAN FACTORS
What does "Human Factors" mean to you?
Human Factors
in Aviation Maintenance

Oman Air
Engineering and Maintenance Division
THE AIM OF HUMAN FACTORS IN AVIATION MAINTENANCE

The aim of human factors in aviation maintenance is to optimize the relationship between maintenance personnel and systems with a view to improving safety, efficiency and well-being.
Human Factors Means principles which apply to aeronautical design, certification, training, operation and maintenance and which seek safe interface between the human and other system components by proper consideration of human performance
Principles which apply to aeronautical design, certification, training, operations, and maintenance and which seek safe interface between the human and other system components by proper consideration to human performance.
A SIMPLE DEFINITION OF HUMAN FACTORS

Human factors is the inter-relationship of a person to their environment; man, machine and the system.
AVIATION 110 YEARS AGO
WRIGHT BROTHERS
In the days of early technology, human error was the cause of many safety related incidents.
Human errors continued to repeat even with advanced technology
“2000 gallons unleaded please..”
HUMAN FACTORS are also keeping the balance between Safety and efficiency
MURPHY’S LAW

Anything that can go wrong will go wrong.
HISTORY OF HUMAN FACTORS

• Began in Second World War in response to ‘people problems’
• After World War Two it expanded beyond aviation to cover a wide range of hazardous technologies that needed to be managed safely
• Until recently almost all of the aviation human factors research has been directed towards flight crew performance, flight deck design and air traffic control
WHY DO WE NEED TO ADDRESS HUMAN FACTORS ON AIRCRAFT MAINTENANCE?

IS THERE A PROBLEM?
Human Factors in Aviation Accidents

1903 0% 100%

Machine Causes

Human Factors

Today 1903
Causes of Aircraft Accidents

- Human Factors: 73%
- Mechanical: 11%
- ATC: 11%
- Weather: 5%

Prime accidents causes 1959 - 1989
Cockpit Fire Damage ASA Bombardier CRJ-200

- simply caused by a cockpit fire, probably due to an overheated electrical power relay. Preliminary NTSB report:

- ASA Airlines flight 5533, a Bombardier CRJ-200 registration: N830AS, experienced a cockpit fire on the ground shortly after external power was applied to the airplane in preparation for flight.

- The captain and one flight attendant evacuated the airplane via an air stair without injuries. They were the only individuals on the airplane at the time.

- The fire department extinguished the fire after it had burned an approximate 18 inch hole through the left upper cockpit crown skin.

- The flight was to be flown from Tallahassee Regional Airport (TLH), Tallahassee, Florida, to Hartsfield Jackson Atlanta International Airport (ATL), Atlanta, Georgia.
American Airlines made mistakes before, after fire, safety board says

- Safety investigators traced a 2007 American Airlines engine fire to unapproved maintenance practices.
- Fire happened shortly after American Airlines Flight 1400 departed Lambert-St. Louis International Airport. The pilots returned to the airport without injuries or fatalities to any of the plane's crew or 138 passengers.
- Pilots prolonged the fire by failing to follow a checklist during such an emergency.
- Crew became distracted, failed to quickly shut off fuel to the damaged engine, causing a loss of hydraulic pressure. That led to problems deploying the front landing gear.
- It was a series of people taking shortcuts that accumulated on this particular day into what could have been a much more catastrophic incident.
American Airlines made mistakes before, after fire, safety board says....Contd

- During the week before the accident, the jet’s left engine failed to start on multiple occasions,

- Mechanics repeatedly used an unapproved tool, such as a screwdriver, to open a valve that manually starts the engine,

- Boeing warned carriers in 1997 that using the wrong tool could deform a pin on the start valve.

- The damaged pin triggered a malfunction that sent sparks into the metal cover that contains the engine, where there was probably some kind of fuel leak,

- The safety board determined that American mechanics replaced the start valve six times but missed the cause of the failed engine starts: a worn-out, stainless steel air filter.
Loose Fastener Causes Control Disconnect

- Aerospatiale AS 350B. Substantial damage. Four fatalities, three serious injuries.
- The helicopter was returning from a sightseeing flight on March 8, 2007.
- The pilot reported hydraulic system problems and that he would perform a run on landing at the Princeville (Hawaii, U.S.) Airport.
- As the helicopter neared the runway, the pilot radioed, “Okay, we’re done.”
- The sound of the rotors changed, and the helicopter descended into a grassy area next to the runway.
- The pilot and three passengers were killed, the three other passengers sustained serious injuries.
Loose Fastener Causes Control Disconnect

• “Post accident examination of the helicopter revealed that the left lateral flight control servo became disconnected in flight at the transmission.”

• The disconnection was traced to maintenance personnel who, while replacing the servo about a month before the accident, had installed a “severely worn” lock washer and had tightened the jam nut on the lower clevis – a U-shaped attachment fitting – to the lower torque value specified for the upper clevis.

• “Examination of the company’s maintenance program revealed that none of the mechanics at the helicopter’s base had received factory training.

• The maintenance manuals they used were three revisions out of date” the report said.
Wrong Fuel Causes Forced Landing - But Why?

• On January 30, 2009, the pilot of a CESSNA 421C landed the aircraft in a field in the 13000 Blk. 69th St. N. in Sedgwick County.

• After an examination of the airplane, the NTSB found that the fuel tanks contained a mixture of 100 low-lead and Jet-A fuel.

• After questioning, an employee of Jabara Airport admitted to fueling the plane with 80 gallons of jet fuel.
Garuda Pilot Jailed In 2007 Accident

- Komar was the captain of a Boeing 737-400 that overshot the runway on landing at Yogyakarta airport in central Java, and slid into a rice field.

- The aircraft burst into flames, killing 21 people, while 119 others were able to escape through the exits of the burning jet in the March 7, 2007 accident.

- Komar ignored repeated warnings -- both from cockpit alarms, and the flight's co-pilot -- that the jet was coming in for landing much too fast.

- Cockpit recordings indicated the co-pilot had repeatedly called for the captain to abort the landing, and go-around.

- In its final report on the crash, released in October 2007, Indonesia's National Transportation Safety Committee (NTSC) found the pilot was "singing" during the approach.
• It came to light during the investigation that Garuda pilots were paid bonuses for saving fuel,
  – A possible factor in the decision by Komar not to go around.

• The airport also came under heavy criticism for taking an hour to reach the burning plane with firefighting equipment.

• The Pilot still blames defective flaps for the crash. Investigators say they were working fine.
Module - 9.2

SAFETY CULTURE/ORGANISATIONAL FACTORS
## Safety Issues Vs Onboard Fatalities 1982-91

<table>
<thead>
<tr>
<th>Issue</th>
<th>Accidents</th>
<th>Fatalities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Controlled Flight into Terrain</td>
<td>26</td>
<td>2169</td>
</tr>
<tr>
<td>Maintenance and Inspection</td>
<td>47</td>
<td>1481</td>
</tr>
<tr>
<td>Loss of Control</td>
<td>9</td>
<td>1387</td>
</tr>
<tr>
<td>Air System and Communication</td>
<td>39</td>
<td>1000</td>
</tr>
<tr>
<td>Approach &amp; Landing without CFIT</td>
<td>133</td>
<td>910</td>
</tr>
<tr>
<td>Post Crash Survivability</td>
<td>41</td>
<td>739</td>
</tr>
<tr>
<td>In-Flight Smoke/Fire</td>
<td>6</td>
<td>618</td>
</tr>
<tr>
<td>Ground De-Icing/Anti-icing</td>
<td>9</td>
<td>384</td>
</tr>
<tr>
<td>Wind shear</td>
<td>10</td>
<td>381</td>
</tr>
<tr>
<td>Uncontained Engine Failure</td>
<td>11</td>
<td>199</td>
</tr>
<tr>
<td>Out of Configuration Take Off</td>
<td>11</td>
<td>188</td>
</tr>
<tr>
<td>Airport Ground Operations Control</td>
<td>23</td>
<td>136</td>
</tr>
<tr>
<td>Rejected Take Off</td>
<td>19</td>
<td>53</td>
</tr>
</tbody>
</table>
Is the Public Interested in Safety?
New York Times Front Page Stories
October 1988 to October 1989

<table>
<thead>
<tr>
<th>Category</th>
<th>Stories/1000 Fatalities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suicide</td>
<td>0.03</td>
</tr>
<tr>
<td>Cancer</td>
<td>0.04</td>
</tr>
<tr>
<td>Automobiles</td>
<td>0.08</td>
</tr>
<tr>
<td>Homicide</td>
<td>1.7</td>
</tr>
<tr>
<td>AIDS</td>
<td>2.3</td>
</tr>
<tr>
<td>Commercial Jet</td>
<td>138.2</td>
</tr>
</tbody>
</table>
“Irrespective of the concept invoked to define what safety is at a particular point in time, as a society progresses, it demands a higher degree of safety. Thus safety is a target moving continuously towards zero risk; except for interruptions during economic distress and high unemployment.”

Michael Baram
Safety At Any Price?

• Society determines what is an acceptable level of safety

• People want to pay the least amount for their tickets but expect 100% reliability and 100% safety

• Regulators balance the competing desires of society through rule making

• ICAO set minimum standards for international transport

• National Regulators set the safety standards acceptable to their country’s expectations and ensure they are achieved
Organizational Factors

- **Internal**
  - Management decisions
  - Poor planning
  - Inadequate allocation of resources

- **External**
  - Market competition
  - Legislative framework
  - Contingency events
Effects would be......

• Excessive workload

• Flawed decisions

• Spread of “cutting corners” attitude

• Loss of staff motivation

• Mistrust between operational personnel and management
Module - 9.3
HUMAN ERROR
Some Experiences of Human Factors in Aircraft Maintenance

- BAC 1-11, June 1990
- Embraer 120, September 1991
- A320, August 1993
- B747, March 1994
- B737, February 1995
- B757, October 1996
Maintenance Errors
Reported to the UK CAA

• 1982-91 = 230
• 1992-94 = 230
• 1995 = 240
• 1996 = 294
# Maintenance Error as a Primary Cause

## Hull Loss Accidents Worldwide Commercial Jet Fleet

<table>
<thead>
<tr>
<th>Cause</th>
<th>1959-1989</th>
<th>1990-1999</th>
<th>known causes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cockpit crew</td>
<td>281</td>
<td>91</td>
<td>74</td>
</tr>
<tr>
<td>Airplane</td>
<td>40</td>
<td>15</td>
<td>10.5</td>
</tr>
<tr>
<td>Maintenance &amp; Inspection</td>
<td>10</td>
<td>8</td>
<td>2.6</td>
</tr>
<tr>
<td>Weather</td>
<td>18</td>
<td>10</td>
<td>4.7</td>
</tr>
<tr>
<td>Airport/ATC</td>
<td>17</td>
<td>5</td>
<td>4.5</td>
</tr>
<tr>
<td>Miscellaneous/other</td>
<td>14</td>
<td>6</td>
<td>3.7</td>
</tr>
</tbody>
</table>

| Total with known causes      | 380       | 135       |              |
| Unknown or awaiting reports  | 58        | 65        |              |
| Total                        | 438       | 200       |              |

**Note:** The chart shows the number of accidents and the percentage of accidents due to maintenance error as a primary cause, categorized by cause type, with separate data for 1959-1989 and 1990-1999.
Significant Accident Caused in 93 Major Accidents:
(Graeber & Marx, 1994)

- 33% Pilot deviated from basic operational procedures
- 26% Inadequate cross-check by second crew member
- 13% Design faults
- 12% Maintenance and inspection deficiencies
- 10% Absence of approach guidance
- 10% Captain ignored crew inputs
- 9% Air Traffic Control failures or errors
- 9% Improper crew response during abnormal conditions
- 8% Insufficient or incorrect weather information
- 8% Runways hazards
- 7% Air Traffic Control/Crew communication deficiencies
- 6% Improper decision to land
Recent NTSB Investigated Accidents

Of 16 Accidents Investigated by NTSB since 1995

- 2 are due to loading errors
- 7 are due to Flight Crew human failures
- 7 are due to maintenance error
### Mean Number of Problems Contributing to Fatal Accidents

<table>
<thead>
<tr>
<th>Aircrafts Type</th>
<th>No. of Accidents</th>
<th>No. of Problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Helicopters</td>
<td>22</td>
<td>1.95</td>
</tr>
<tr>
<td>Light Aircraft</td>
<td>29</td>
<td>3.38</td>
</tr>
<tr>
<td>Large Jets</td>
<td>39</td>
<td>4.46</td>
</tr>
</tbody>
</table>
ERROR Models

- SHELL Model
- PEAR Model
SHEL MODEL

Liveware (people)
- Physical
- Knowledge
- Attitudes
- Cultures
- Stress

Liveware (teams)
- Teamwork
- Communication
- Leadership
- Norms

Hardware
- Tools
- Aircraft
- Equipment

Software
- Tools
- Aircraft
- Equipment
- Manuals
- Placards

Environment
- Communication
- Physical
- Organizational
- Economic

Software
- Tools
- Aircraft
- Equipment
- Manuals
- Placards
SHEL EXAMPLES

S  Ambiguous procedures, badly written manuals, difficult to use software

H  Gauges difficult to read, tooling that does not fit correctly, aircraft access difficult

E  Too hot or cold, noisy, excessive fumes, poor lighting, organizational culture

L  Miscommunication, poor supervision, fatigue, lack of knowledge
PEAR Model

- **People** who do the job
- **Environment** in which they work
- **Actions** they perform
- **Resources** necessary to complete the job
Herrare Humananum est”
(To err is human – Cicero)

• People make mistakes, it is part of being human
• Making mistakes is all part of the learning process for humans
• Some errors have good outcomes, most have very little consequences but some have catastrophic consequences
• In aviation, what we cannot tolerate are the bad effects of errors
Error Facilitator

- Poor lighting, noise etc
- Time pressure, stress, fatigue, etc
- Distraction, ambiguous procedures etc

Sensing & Perception
Processing, Judgment & Decision Making
Taking Action
Error Types

• Error of Commission (Type 1 Error)
  - performing the wrong action
  - E.g. anti-wire locking a component
• Error of Omission (Type 2 Error)
  - not performing a required action
  - E.g. forgetting to wire lock the component
    forgetting (Oil Cap)
Error Types

Slips and Lapses
- the actions do not go according to plan

Mistakes
- The plan itself is inadequate to achieve its objective
‘Normal’ Errors

→ ‘Normal’ errors are that naturally occur within the ‘as designed’ system

→ ‘Normal’ errors are to be expected although the rate by which errors occur will be different within each system
‘Normal’ Errors
Common Mistakes

- Misapply a good rule or principle
- Apply a bad rule or principle
- Fail to apply a good rule or principle (violation)
Misapplying Good Rules

A ‘good rule or principle’ is one that has been useful in the past. These good rules are the ‘rule of thumb’ principles that we use in our everyday life. The problems occur when the rule or principle is wrongly applied.
Examples of a Misapplied Rule

- Aircraft pipe couplings are right hand threads. We do not check with the Maintenance Manual because we all know this.
- Applying this ‘normally good rule’ to an oxygen pipe could result in damage to the pipe because they are an exception to the ‘rule’.
Applying Bad Rules

• We all pick up some ‘bad rules’ (bad habits) as we go through life
• Although bad, they frequently serve our immediate purpose and ‘we get away with it’, i.e. no negative or bad effects
• These are dangerous because the more we ‘get away with it’ the more we convince ourselves and other it is a ‘good rule’.
Examples

‘Applying a Bad Rule’

1. The British Rail Technician in the Clapham rail accident had acquired the practice of bending back old, redundant, wires rather cutting them off and insulating them

2. Changing the DC-10 engine using a fork lift truck instead of the proper lifting gear
Errors and Violations

• Violations are deliberate acts whereas errors are unintentional
Violations

1. Violations are shaped mainly by attitudes, beliefs, group norms and safety/company culture
2. Most stem from a genuine desire to do a good job. Very seldom are they acts of vandalism or sabotage
3. They represent a significant threat to safety as the maintenance system is designed assuming that people will follow the procedures.
Types of Violations

1. Routine violations
2. Situational violations
3. Optimizing violations
4. Exceptional violations
Routine Violations

1. These are violations which have become the normal way of doing something within the persons work group

2. They can become routine for a number of reasons, e.g.:
   a) Short cuts saves time and energy
   b) The procedures may be overly prescriptive and skilled people tend to think they know best.
Situational Violations

- These violations occur due to the particular factors that exist at the time e.g.
  - unrealistic deadlines (time pressure)
  - high workload
  - unworkable procedures
  - inadequate tooling
  - poor working conditions
- These occur often when in order to get the job done a procedure cannot be followed
Examples of a Situational Violation

a) An engineer working out-of-hours with a tight deadline discovers he needs a special jig to drill off a new door tongue tube

b) The engineer discovers that the jig is not available and Tech Services is not available for guidance so he decides to drill the holes by hand

c) If he had complied with the maintenance manual he could not have done the job and the aircraft would have missed the service.
Optimizing Violations

1. These are breaking the rules for ‘kicks’
2. These are often quite unrelated to the actual task. The person just uses the opportunity to satisfy a personal need.
3. An example would be when asked to drive a company van to stores to collect a part and you get a thrill from drive fast, spinning the wheels and doing handbrake turns
Exceptional Violations

• These are described by Jim Reason as ‘double binds’
• A violation is inevitable regardless of how well intentioned the person is
• These normally occur in emergency situations when the normal rules no longer apply due to the local conditions, e.g. Three Mile Island accident
People who Break the Rules

• Males (research shows that women tend to be far more compliant and take less risks)
• Young people
• Experts’ (this includes experienced aviation maintenance technicians!)
Considerations
When Deciding to Violate Rules

- If it was 3 ‘o’ clock in the morning, the roads are deserted and you are very late getting home. What things would you consider when deciding if you will break the speed limit?
The mental ‘economics of rule-breaking

Perceived benefits of violation

perceived cost of violation

Violation likely

Violation unlikely
## The Violation Balance Sheet

<table>
<thead>
<tr>
<th>Perceived Benefits</th>
<th>Perceived Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easier way of working</td>
<td>Accident to aircraft</td>
</tr>
<tr>
<td>save time</td>
<td>injury to self</td>
</tr>
<tr>
<td>more exiting</td>
<td>others damage to assets</td>
</tr>
<tr>
<td>gets the job done</td>
<td>costly to repair</td>
</tr>
<tr>
<td>shows skill</td>
<td>Punishment</td>
</tr>
<tr>
<td>meets a deadline</td>
<td>loss of job/promotion</td>
</tr>
<tr>
<td>job/promotion</td>
<td>disapproval of peers</td>
</tr>
<tr>
<td>looks ‘Macho’.</td>
<td></td>
</tr>
</tbody>
</table>
General Factors in Violations

• Violations have a tendency to become routine because they involve less time and effort.
• Time pressure and high workload increases 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.
Organizational culture is an important factor. Most companies have safety as their stated overriding goal. In reality, production is often their first concern.

If workers believe that the company want them to ‘bend the rules’ to get the aircraft away, then ‘messages’ from management saying safety is first and follow the procedures is seen as just covering themselves.

General Factors in Violations
General Factors in Violations

• The more rules or procedures we are expected to abide by, the greater the probability that violations will occur.
• If we write a new procedure each time we have a bad event, there comes a point where it is almost impossible to get the job done without breaking a rule.
• If managers and supervisors turn a ‘blind eye’ to violations, people will feel that their actions are condoned.
• Violation + error = an accident.
Can We Predict Errors?
Figure 3-1 Variable versus Constant Errors.
Target patterns of 10 shots fired by two riflemen. Rifleman A’s pattern exhibits no constant error, but large variable errors; rifleman B’s pattern exhibit’s a large constant error but small variable errors. The latter would, potentially, be easier to predict and to correct (e.g. by correctly aligning the rifle sight).

Chapanis, 1951
The Financial Cost of Error

• Ramp incidents alone cost industry $3 billion a year, which equates to $300,000 per jet aircraft (1998 figures)

• Indirect costs, non-insurable costs, loss of revenue etc can exceed the direct costs by up to 20 times

• $16,000,000 repair costs (parts and labour only) by one US operator over a three year period.
Do We Need Procedures for Everything?

- Not always!
- Detailed working instructions are not needed if the person is trained and competent.
- Organizations and managers prefer to issue work instructions as it is cheaper than training and a programme of competence assessment.
The Importance of Procedures

• There is an assumption that people will follow the procedures laid down in the safety management system.

• When this assumption is broken the whole basis of the safety system is put at risk.

• Maintenance requirements, ergo safety, is based almost solely on an assumption that people will follow the procedures.
Top Maintenance Problems – CAA Study 1992

1. Incorrect installation of components
2. The fitting of wrong parts
3. Electrical wiring discrepancies (including cross-connections)
4. Loose objects (tools, etc..) left in aircraft
5. Inadequate lubrication
6. Cowlings, access panels and fairings not secured
7. Fuel/oil caps and refuel panels not secured
8. Landing gear ground lock pins not removed before departures
Top Seven Causes of In-Flight Shutdowns

- Incomplete installation (33%)
- Damage on installation (14.5%)
- Improper installation (11%)
- Equipment not installed (11%)
- Foreign Object Damage (6.5%)
- Improper fault isolation, inspection, test (6%)
- Equipment not activated or deactivated (4%)
Can we make a Reliable System from Unreliable Parts?

Two competing theories
1. High reliability theory
2. Normal accidents theory
Sagan’s High Reliability Theory

• Accidents can be prevented by good organizational design and management
• Safety is the priority organizational objective
• Redundancy enhances safety through duplication and overlap
• Decentralized decision making is required to ensure prompt and appropriate actions to surprises
• Continuous training can maintain reliable operations
• Learning from accidents and incidents can be effective
Perrow’s Normal Accident Theory

- Accidents are inevitable in complex and tightly coupled systems
- Safety is one of a number of competing objectives
- Redundancy often causes accidents by increasing interactive complexity, opaqueness and risk-taking
- Decentralization is needed for complexity, but centralization is need for tightly coupled system
- A military model of intense discipline, slavishly following orders etc is incompatible with democratic and social values
- Organizations cannot train for all situations, some of which unknown
- Denial of responsibility, faulty reporting etc prevent learning efforts
Defences in Depth

Effective QA

Adequate Resources

Trained, Competent Staff

Tasks Performed iaw the MM

Duplicate Quality Inspections performed
The ‘Swiss cheese’ model
(Prof J. Reason)

Some holes due to active failures

Some holes due to latent conditions

Defenses-in-Depth
Error: Once in a Million Flights

- Flaps omitted
- Checklist failure
- Unheeded warning

Error Deviation Amplification Degradation/ breakdown
Errors: Almost on Every Flight

Flaps omitted

Checklist Effective works

warning

Error Deviation Amplification Normal operation
Common Features of Organizational Accidents

a) All involved ‘well-defended’ or ‘defence in-depth’ systems
b) Combination of many failures
c) All involved unsafe acts at the ‘sharp end’
d) Root causes could be traced to latent conditions that had been present for a considerable time
Organizational Processes and Responsibilities

Safety strategies
Shift rostering
Discipline
Pay & Reward
Production incentives
Goal setting
Policy making
Organizing
Facilities
Manning levels
Recruitment & selection
Job design
Leadership style
Organizational structure

Forecasting
Planning
Financing
Budgeting
Communicating
Purchasing
Monitoring
Logistics
Career development
Training
Motivation
Profit sharing
Health and safety
Apprenticeships
Safety is our No.1 Priority!

• Most companies will state that safety is their number one priority
• In reality this is rarely demonstrated. When there are problems, production is the first concern.
• Organizational processes tend to weighed in favor of releasing the aircraft or component
• Safety is considered as another business risk
• At best safety is probably the number 3 priority
  - Profit (no profit, no business)
  - Regulatory approval (no approval, no business)
  - An accident (in JAA countries the accident rate is 1 per 5 million departures)
Safety Vs Profit

1. In all safety dependent industries decisions are made that balance profit against the risk of having an accident.

2. Using accidents as a measure of safety is too crude. If a company has never had an accident does this mean it is safe?
What sort of company is the most safety conscious?

The one that just had an accident (or nearly did)
Rule Making and the Role of the Regulator

- The regulators write rules to control and reduce risks.
- Elimination of risk are not possible.
- ‘Cooke cutter’ approach that is not appropriate for all organizations.
- Convention would say that safety is defined as being in compliance safety airworthiness regulations.
Changes to the Requirements to Address Human Factors
ICAO Annex 6, Part 1 Changes

“The training programme established by the maintenance organization shall include training in knowledge and skills related to human performance, including co-ordination with other maintenance personnel and flight crew.”
ICAO Annex 6, Part I Changes

• “The design and application of the operator’s maintenance programme shall observe human factors principles.”
ACM 145.30 [(e)] states:

In respect of the application of human factors and human performance issues, maintenance, management, and quality audit personnel should be assessed for the need to receive Initial Human Factors training, but in any case all maintenance, management, and quality audit personnel should receive Human Factors continuation training. This should concern to a minimum:
Who Should Attend?

- Post-holders, managers, supervisors
- Certifying staff, technicians, and mechanics.
- Technical support personnel such as, planners, engineers, technical record staff
- Quality control/assurance staff
- Specialized services staff
- Human Factors staff/ Human Factors trainers
- Store department staff, purchasing dept. staff
- Ground equipment operators
- Contract staff in the above categories
MODULE - 9.4

Human Performance and Limitations
Human Capabilities & Limitations

• The aviation maintenance system is heavily dependent upon people performing in a way the system designer intended
• Machines are very reliable, people are very unreliable
• If we operate a machine outside of its specification it will cease to operate (hard failure)
• Human degrade in more subtle ways than machines
Humans do Some Things Better than Machines

- Deal with unexpected and novel situations
- Exercise judgment
- Mentally and physically adaptable
- They are often cheaper to obtain and train to do new tasks than buying a machine
- They have feelings and emotions
Human Performance and the Maintenance System

• Maintenance personnel are central components of the maintenance system

• Understanding human capabilities and limitations are important if we are ever to achieve a reliable system made up of such unreliable components
Physical Characteristics of the Human

- Size and shape (anthropometry)
- Strength, leverage, torque (biomechanics)
- Health and fitness (physical and mental)
Vision

• The most important of our senses
• At least 80% of our information about the world comes through the visual system
• 99% of aircraft inspections are visual
• Many tasks require a combination of distance and near vision
The Six Senses

• Vision
  - 80% of our knowledge of the world comes through vision
• Hearing (aural)
• Smell (olfaction)
• Taste
• Touch
• Proprioception
  - Provides information about position, location, orientation and movement of the body
Lighting Conditions

- Vision improves with increased lighting levels (up to a point)
- Too much light results in glare
- Younger people need less light to see well
- Older people need twice as much light to see things properly
Colour Discrimination

- Cone cells are responsible for colour vision
- Approximately 8% of males and 0.5% of females have defective colour vision
- Failing to distinguish between red and green is the most common deficiency
- Yellowing of the lens occurs with age resulting in poor blue-green discrimination
- People do not always realize they have colour defective vision unless tested (learn by experience to associate certain colours with varying sensations of brightness)
Hearing

• The human ear is sensitive to sound between 20 and 20,000 Hz
• Greatest sensitivity is at about 3000 Hz
• We are more sensitive to higher frequencies than lower ones (low tones have to have more intensity to be of equal loudness)
• With age we lose sensitivity in the higher frequencies
Typical Noise Levels

- Rustling of leaves: 30 dbA
- Office Noise: 40 dbA
- Car at 15m: 70 dbA
- Petrol mower at 2m: 90 dbA
- Night Club: 110 dbA
- Jet Engine: 140 dbA
- Threshold of pain: 140 dbA

Note: Noise is exponential, e.g. 10 jet engines = 150 dbA.
     100 jet engines = 160 dbA.
**Recommended Maximum Noise Exposure Exposure Times**

<table>
<thead>
<tr>
<th>Exposure per day</th>
<th>Sound Level in dBa</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 hrs</td>
<td>90</td>
</tr>
<tr>
<td>6 hrs</td>
<td>92</td>
</tr>
<tr>
<td>4 hrs</td>
<td>95</td>
</tr>
<tr>
<td>3 hrs</td>
<td>97</td>
</tr>
<tr>
<td>2 hrs</td>
<td>100</td>
</tr>
<tr>
<td>1 hrs</td>
<td>105</td>
</tr>
<tr>
<td>0.5 hrs</td>
<td>110</td>
</tr>
<tr>
<td>&gt;0.25 hrs</td>
<td>115</td>
</tr>
</tbody>
</table>
Hearing Protection

• Protection against excessive noise is needed to combat the effects of:
  - Fatigue
  - Distraction
  - Temporary hearing damage
  - Permanent hearing damage
  - Health and Safety legislation
Hearing Protection

• Ear defenders reduce noise levels by 40dbA
• Ear plugs reduce noise levels by 20dbA
• Like most human factors intervention strategies there can be a down-side:
  - Oral-aural communication will be affected by wearing ear protection
  - Removing or reducing the source of the noise is the preferred strategy
Fear and Phobias

- Enclosed spaces
- Heights
- People may not have a clinically defined ‘phobia’ but if they do not like the situation they are in they will want to exit from it as soon as possible
  - Short-cutting and incomplete maintenance
  - Supervisors should allocate tasks accordingly
Information and Processing

• Information processing is the process of turning data acquired from the senses and making sense of it
• Perception, attention, mind-set, expectancy and memory are all part of information processing
Perception

• “Perception is not determined simply by stimulus patterns; rather it is dynamic searching for the best interpretation of the available data….perception involves going beyond the immediately available evidence of the senses”.

• “What we perceive is not the data, but the interpretation of it”.
Horizontal Vertical Illusion
Keep staring at the black dot. After a while the gray haze around it will appear to shrink
Count the black dots.
Describe this Picture
Attention

• The vast majority of what arrives at our senses is never perceived
• The brain has only a limited capacity to process and interpret sensory information
• Imagine how chaotic things would be if we were always aware of all the things reaching our senses
Attention

- Focused attention requires some sources of information to be attended to and others ignored
- Selective attention is the process by which of the many stimuli we choose to attend to
- Distraction is the diversion of attention from one stimulus to another (normally because it is more interesting or important)
- Attention is selective, but we continue to monitor other inputs (Cocktail Party Phenomenon)
Doing Two Things at Once

- Divided attention is possible when one of the tasks is performed with little mental processing e.g.
  - Learning to drive a car requires focused attention and any distraction reduces performance
  - When the skills are learnt we perform the task ‘automatically’ with little mental processing. This allows us to happily chat, sing to the radio etc
Biased Perception

• Expectations – seeing what you expect to see
  - Expectations can strongly influence perception that they affect outcomes and actions (self-fulfilling prophecy)

• Attitudes – Our perception of events can be biased by prejudgments, e.g. two opposing football fans would perceive an off-the-ball event differently. One would see a deliberate foul and the other an accident.

• Information – If we are given information prior to an event our perception of the event is frequently different

• Belief Perseverance – Perceiving only in ways that support our original belief in spite of contradictory information
Memory

- Ultra short-term memory
- Short-term memory; chunking
- Working memory
- Long-term memory
- Limitations of memory
Human Factors Can be Affected by

- Drugs, medicines, alcohol
- Physical fitness
- Tiredness, fatigue and circadian rhythms
- Environmental factors
- Stress and Stressors
- Motivation
- Emotional state
- Social factors
Social Psychology
Situational Awareness

• Knowing what is going on around you:
  - The perception of important elements
    - Seeing: loose bolts, missing parts
    - Hearing: verbal communications
  - The comprehension of their meaning
    - Why is it like this
    - Is this how it should be
  - The projection of their status in the future
  - Future effects on safety, schedule, air worthiness
Situational Awareness

• Perception
  - Seeing blue streaks on fuselage

• Comprehension
  - Lavatory fill cap could be missing or drain-line leaking

• Projection
  - Leak can allow water to freeze, leading to engine or airframe damage
Norms

• A norm is a pattern or type of behavior that is typical within a group of people.
  - e.g. nobody in the hangar performs a leak check after changing an engine filter
• Norms are very powerful as we have a strong desire to be accepted by the group
• Non-conformance with established norms tends to lead to rejection by the group (peer pressure to conform)
• Norms can be good or bad (positive or negative)
HABITS

• A habit is a type or pattern of behavior that is peculiar to that person.
  - e.g. An Engineer routinely removes an igniter plug to perform a boroscope instead of removing the boroscope plug as per the task card.

• Bad habits are difficult to detect during audits but should be detected by Supervisors.
Active and Latent Failures

• **Active failures**: Errors and violations having an immediate impact.

• **Latent failures**: Delayed action failures. May lay dormant for a long time, only becoming apparent when they combine with active failures and a bad effect is felt.
Latent Conditions

• Arise from decisions made by managers, manufacturers, regulators, etc.
• These are the ‘time bombs’ sitting in the system. In isolation they do not normally cause accidents.
• Latent conditions + active failures = an accident
Performance Shaping Factors (PSF)

- **Internal PSFs**
  - Fitness, training, tiredness, skills, emotional state etc

- **External PSFs**
  - Quality of procedures and manuals, lighting, access staging, company culture etc.
Factors Affecting Human Performance
SLEEP
Why do we sleep?

• Almost every living creature needs sleep to survive
• There are many theories regarding why we need sleep (researched since the 1800s)
  - Restoration theory
  - Evolutionary theory
  - Hibernation theory
  - Core sleep and optional sleep (5 hrs core, the rest optional)
• General agreement that it serves a restorative function:
  - Mentally
  - Physically
Sleep Deprivation and Effects on Performance

- Tiredness
- Disorientation
- Irritability and Short-Temperedness
- Lethargy
- Visual and Tactile Misperceptions
- Negative Mood States
- Microsleep
- *Eventual Death*
Sleep Deprivation and Effects on Performance

- Vigilance and concentration difficult
- Information processing difficult
- Short term memory is degraded
- Long term memory recall very difficult
- Performance is worse during circadian lows
Lack of Sleep

• Less than 5 hours sleep per night will degrade performance
• A sleep debt accrues if insufficient sleep is taken over time
• Very little sleep credits can be made
• 5 hours of sleep may not be enough for shift workers due to effect of circadian rhythms and poor sleep quality during the day resulting in a day to day build up of sleep deprivation
Performance Degrades with Lack of Sleep

- Long, dull, boring tasks
- Concentration and Vigilance
- Tasks requiring Mental effort
- Problem solving tasks
Can Napping Help?

• Day-time naps can help in reclaiming lost night time sleep
• A series of naps over 24 hours can replace an unbroken night-time sleep (quality and quantity is not as good though)
• After a nap performance is usually worse for the first two hours due to sleep inertia
MOTIVATION
Characteristics of Motivation

• Motivated
  - High performance and results consistently achieved
  - Energy, enthusiasm and determination to succeed
  - Unstinting co-operation in overcoming problems
  - Accepts responsibilities and accommodates change

• De-motivated
  - Apathy and indifference to the job
  - A poor record of time-keeping and high absenteeism
  - Exaggerates the effects and difficulties encountered
  - A lack of co-operation in dealing with problems or difficulties
  - An unjustified resistance to change
De-Motivation and the Aviation Technician

• Research performed show that safety was not normally affected by the effects of low moral, dissatisfaction or de-motivation.
• Technicians tended to: work to ‘the book’ and snagged many more defects.
• It could be said that safety was improved, but the aircraft would depart late and cost the company more money.
Stress

- The word stress comes from the Latin word stringere, ‘to stretch’
- Stress is the response to any demand, or set of demands, requiring us to adapt in order to match them
- The cause of the stress is called a ‘stressor’
What is Stress?

• We generally consider stress as our perceived inability to cope with the demands placed upon us
• Stress is a normal part of life and inevitable
• Some stress is good and keeps us alert
• Too much stress is positively harmful
Fight-or Flight Response

‘The fight-or-flight response was originally effective for primitive humans facing starvation, exposure and attack etc

• Stressors prompt the nervous system to initiate a stress response, e.g. increase heart rate, blood pressure, perspiration, blood sugar levels, showing of digestion system etc

• Modern humans are rarely subject to the same threats as our primitive ancestors, although our bodies react exactly the same
Managing of Organization and Personal Workload

- Task Analysis
- Scheduling of planned and unplanned work
- Control and monitor of over time
- Integrating a fatigue and risk management system into the shift allocation/rostering
- Facilitating a feedback system
- Providing adequate time and facilities for rest during the working day/night
Organizational Factors Affecting Workload

- Staff shortages
  - in numbers but also in specialist roles
- Low levels of experience, knowledge and skills
- Lack of facilities
- Equipment malfunction or failure
- Non-existent, or inadequate task analyses
  - Matching manpower
- Extreme ebbs and flows in peak/off-peak workload
  - An inability to plan and spread workload effectively
Fatigue

• Fatigue is the weariness that accrues from applying oneself to a task over a period of time
• Sleep and fatigue are intimately related. Fatigue normally dissipates during normal rest and sleep
• Fatigue can be mental or physical
• Fatigue results in both an inability to continue a task (mental or physical) and a disinclination to perform a task (motivation)
• Each person has a different ability to withstand fatigue which diminishes with age
• Not to be confused with sleepiness
Fatigue

• Fatigue can be acute, or chronic
• Acute
  - intense physical or mental activity of short duration that is cured by normal rest or sleep
• Chronic
  - intense physical or mental activity over a long period of time that can result in serious illness
• People suffering from fatigue are often the last people to realize it!!
Alcohol, Medication and Drugs
ALCOHOL

• Consuming alcohol will impair performance
  - tasks
  - memory
  - judgment and decision making
• Impairment lasts for at least 14 hours and longer in the case of large doses
ALCOHOL

• Small doses of alcohol affect performance roughly the same as boredom, eating, fatigue, many prescribed drugs and various everyday risk factors

• Alcohol in combination with drugs can be highly dangerous, even lethal
MEDICATION

• Sleeping tablets – dulls the senses, causes mental confusion and slower reaction times
• Tranquilizers – lack of alertness
• Antibiotics – can have an effect on performance but the effects of the infection may be more important
• Anti-histamine – drowsiness
MEDICATION

• Pep pills (e.g. caffeine, dexedrine, and benzedrine) – potentially habit forming and can lead to over-confidence, headaches, dizziness

• ‘Sudafed’ – can cause anxiety, tremors, rapid pulse and headaches

• ‘Melatonin’ – No clinical tests performed but widely available ‘over-the-counter’ in the USA to combat effects of jet lag. Causes sleepiness and impairs performance immediately after ingestion and for up to 12 hours after
DRUGS

• Drugs may be for medical or recreational purposes (e.g. cannabis)
• Any drug will probably have some sort of effect on performance
CAFFEINE

• Caffeine occurs naturally in many food products and in many cases it is added, e.g. soft drinks
• Caffeine in moderate doses has been shown to increase the ability to sustain vigilance, increase alertness and gives a positive mood state
CAFFEINE

• Excessive consumption of caffeine can result in anxiety and disturbed sleep
• Heavy takers can suffer headaches and negative mood states if caffeine is suddenly stopped (cold turkey)
Task-related Factors

• The level of fatigue can also depend on the intensity of the work being undertaken (workload)
• The effect of time-on-task is most acute during tasks requiring sustained attention
• This effect can be overcome by short breaks in activity (approx. 15 minutes)
Circadian Rhythms and Internal Body Clock

• The word circadian comes from the Latin Circa meaning ‘about’ or ‘around’ and Dies meaning ‘day’
• Virtually all species have developed biological clocks with frequencies close to 24 hours
• The human works on a predominantly 25 hour cycle without any external cues
• Various cues keep us maintained to a 24 hour cycle, light/dark being the most dominant
Circadian Rhythms

- Many functions are affected by the circadian timing system
  - hormonal output
  - body core temperature
  - hunger
  - rest
  - activity
  - sleep and wakefulness (sleep/wake cycle)
  - thinking and reasoning (psychological and mental processes)
Repetitive Tasks/Complacency

• **Leads to:**
  – Over Confidence
  – Self-satisfaction with one's own performance
    • coupled with an unawareness of danger, trouble, or controversy
  – State of Confidence Plus Contentment
  – Low index of suspicion
  – Unjustified assumption of satisfactory system state
  – Loss of situation awareness, and unpreparedness to react in a timely manner when system fails
Module – 9.5

ENVIRONMENT
Peer pressure

• Professional
  – Certain employees perform better.

• Personal
  – Formation of groups and gangs at work
Professional Peer Pressure

- Certain employees perform better
  - If understood positively, would act as a Motivator

- Negative side:
  - Management too starts developing an inclination and bias towards them
  - Other employees may feel neglected
  - Can often de-motivate employees
Personal Peer Pressure

• Formation of groups and gangs at work
  – Work as a closed group
  – Will not accept others
  – Others drift apart
  – Would disrupt the flow of the organization as others get a feeling of inhibition when working in these groups
Peer pressure

• Would always be a challenge for employees

• It is up to the individual to either take it up as a struggle or as an inspiration.
Modern Stressors

- Frustration
- Conflict
- Disruption of circadian rhythm (e.g. shift working)
- Major life changes (divorce, getting a mortgage, retirement etc)
- Every day hassles and annoyances
- Pressure
Responding to Stress

• We generally respond to stress using one of two strategies
• Defence
  - alleviate the pain (medicine, alcohol etc)
  - reduce the anxiety (blame someone else or deny to yourself there is a problem etc)
• Coping
  - addressing the source of the stress, not merely alleviating the symptoms
Time Pressure and Deadlines

• *Hurry-up Syndrome*
• Meeting a deadline interferes with our ability to complete tasks correctly
• Quantity versus Quality
• Lack of resources, Knowledge
• The worst of them all - self-induced pressure
Workload

- **Planned Workload**
  - Approved Maintenance programs

- **Unplanned Workload**
  - Other day-to-day tasks which arise on demand in response to commercial activities and unforeseen situations

- **Subjective Workload**
  - Refer to the subjective viewpoints of each and every worker, team, department (shop) and shift, involved in fulfilling the required tasks

- **Fleet Composition**
  - Size and diversity of an airline’s fleet, or the range of aircraft a maintenance organization is contracted to work on
Factors Affecting Subjective Workload

- Level of experience, knowledge and skill
- Familiarity and level of confidence
- Workspace design
- Levels of fatigue and stress
- Health issues
- Sleep debt
- Off duty activities

- Some of these factors are personal and cannot be measured.
- Feedback should be gained to reduce risk
WORK - Overload & Under-load

• Overload
  - stressor
  - trade off accuracy for speed, therefore, more likely to make errors

• Under-load
  - low level of arousal (alertness)
  - prone to complacency
  - errors due to inattentiveness
Shift Work

• The normal working day of 07.00 hrs to 15.00 hrs means we are working during our most alert and efficient times

• Shift workers are continuously trying to cope with circadian de-synchronisation
  - Trying to work when the body wants to naturally sleep
  - Trying to sleep when the body wants to naturally be awake
Problems with Shift Work

• Sleep is the primary function disrupted by shift work
• Quality and quantity of sleep is less
• Temperature, blood pressure and heart rate are at their lowest ebb at night
• Performance degraded
• Increase in errors made
Problems with Shift Work

• Severe sleep disturbance leads to chronic fatigue, anxiety, nervousness and depression
• Psychological and emotional distress
• Stomach disorders more likely than day working
• Cardiovascular and heart disease 40% more likely than day workers
• Over the age of 50 people find coping with shift work more difficult (they become ‘morning people’)
• Young people find coping with shift work difficult due to the social disruption
Shift Systems

• There is no ‘best’ shift system, it is just that some are worse than others
• The worse shift schedules are those that result in:
  - shortened sleep
  - Fragmented or disrupted sleep
  - And working hours not synchronised with your circadian rhythms
Shift Systems

- The best shift systems attempt to:
  - Minimise the build up of fatigue over periods of work
  - Maximise the dissipation of fatigue over periods of rest
  - Minimise sleep problems and circadian disruption
Physical
Environmental
Factors
The Aviation Maintenance Environment

- The physical environment under which maintenance is performed presents many human factor challenges:
  - Illuminating all areas difficult
  - Noisy
  - Maintaining temperatures difficult
  - Access to the aircraft difficult
  - More maintenance is being performed outside of a hangar where it is not possible to control the environment
ILLUMINATION

• Frequently found problems include
  - Lighting conditions can vary dramatically
  - Variety of lighting systems in use
  - No consideration to colour rendition (choice of light source important, e.g. sodium lamps unsuitable when colour judgment required)
  - Average levels on upper and lateral external surface is frequently sufficient
    but
  - Average levels elsewhere frequently inadequate
Recommended Lighting Levels

Area lighting in a hangar should be a minimum of 750 lux (1000-1500 lux preferred)

- Task lighting for inspections require at least 1000 lux
- Fine detail inspections require 2000-5000 lux
- Supplemental lighting must be readily available and suitable for the job
- Always check lighting levels during the day and at night
- If the workforce have a substantial number over 45 years of age, the lighting level should be increased
## Temperature

**Effects of ambient temperature on human performance**

<table>
<thead>
<tr>
<th>Temp (°C)</th>
<th>Temp (°F)</th>
<th>Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>32°</td>
<td>90°</td>
<td>Approaching the upper limit for performance</td>
</tr>
<tr>
<td>25°</td>
<td>75°</td>
<td>Optimum with minimal clothing</td>
</tr>
<tr>
<td>21°</td>
<td>70°</td>
<td>Optimum with typical clothing and tasks</td>
</tr>
<tr>
<td>18°</td>
<td>65°</td>
<td>Optimum with winter clothing</td>
</tr>
<tr>
<td>15°</td>
<td>60°</td>
<td>Hand and finger dexterity begins to deteriorate</td>
</tr>
<tr>
<td>12°</td>
<td>55°</td>
<td>Hand dexterity reduced by approx 50%</td>
</tr>
</tbody>
</table>
Noise

- The effects of noise on performance is complex with no clear guidelines
- Motivation can be affected by people react differently
- Noise is a fatiguing stimulus even at levels of <65 dBA
- Generally accepted levels of 7-75 dBA
- Concern when occasional levels of 110 dBA
- Removing the source of noise is the preferred method of controlling noise
The Effects of Heat and Performance

• The human body tries to maintain a core temperature of approximately 37°C
• We can only tolerate a small deviation from this without experiencing performance degradation
• Deviations of 3-4°C can result in death
• If we start to get too hot we perspire, increase our blood flow and more blood flows nearer the skin surface
• If we get too cold we shiver, exercise our muscles to generate heat and blood flow to the skin surface is reduced
Hazards in the workplace

• What are they?
  – Anything with the potential to cause harm
  – Any condition, event, or circumstance which could induce an accident
  – any existing or potential condition that can lead to injury, illness, or death to people; damage to or loss of a system, equipment, or property; or damage to the environment
  – a condition that is a prerequisite to an accident or incident
Hazard and Threat Identification

• Reactive
  – Investigation of safety occurrences, accidents and incidents
  – Determine the hazard that played the role in that event

• Proactive
  – An open reporting process for those near to the hazards
  – Safety Surveys
  – Safety Audits
  – Safety Monitoring
  – Safety assessments
  – Line Operations safety Audits

These have been designed to capture real life strategies
Lack of Manpower

• Staff shortage will lead to cutting corners and causing errors.
• Increase work load
• Causing fatigue
Module – 9.6

Visual Inspection

Reliability
Task Access

• Appropriate access must be given dependent on the task that is being performed
• People need to feel ‘comfortable’ when performing tasks
• A person will exit the task quickly if they feel unsafe or uncomfortable
• Note: Revision to MSG3 now requires the ability to touch what is being inspected during a General Visual Inspection (GVI)
Factors Affecting Inspection Reliability

Training and experience
- training must be supported by adequate experience

Experience is required to become proficient in:
- searching an area or system for defects
- recognising and interpreting defect indications
- making judgments on serviceability
Factors Affecting Inspection Reliability

• The efficiency of an inspector is heavily dependent on his experience
• The quality of his judgment depends not only on the number of times he has experienced the defect, but on the reinforcement he gets from feedback, e.g.
  - an external toilet leak may be considered insignificant but feedback from Tech Services telling him why it is significant will affect his judgment in the future
Factors Affecting Inspection Reliability

Feed-Forward – improves reliability as it primes the inspector of known and potential defects in the inspection area
Factors Affecting Inspection Reliability

• Workplace factors –
  - Access to the aircraft
  - Access to the task (e.g. fuel tanks)
  - Cleanliness of the inspection area
  - Noise, heating
  - Feeling of safety and comfort
  - Equipment
  - torch, mirror, penknife, hand lens, coin
Factors Affecting Inspection Reliability

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

• The effects are made worse when the inspector has a very low expectation of finding a discrepancy, i.e. on a new aircraft

• Motivation and arousal is low without the reward of a defect
Work Logging and Recording

• Detailed information must be passed before, during and after any task, and especially across the handover of shifts.
• When messages are complex they should be written down.
• Use of logbooks, worksheets, and checklists etc. should be encouraged.
• Verbal messages can be kept short, with the most critical elements emphasized at the beginning and repeated at the end.
• Assumptions should be avoided and opportunities for asking questions both given and taken.
TECHNICAL DOCUMENTATION

• Access, Quality and Revision status of:
  – Job Cards, TN, QN
  – Aircraft Manuals
  – Check lists
Procedures

• Mismatch between the written procedure and what's practiced
• Complex or ambiguous procedures
• Ignoring the procedure due to norms
• Check lists not being signed on site but being done at the end of the day
Module - 9.7

COMMUNICATION
During Shift/Task Handovers

- Detailed information must be passed before, during and after any task, and especially across the handover of shifts.
- Complex messages should be written down.
- Use of logbooks, worksheets, and checklists etc. should be encouraged.
- Verbal messages can be kept short, with the most critical elements emphasized at the beginning and repeated at the end.
- Assumptions should be avoided and opportunities for asking questions both given and taken.
Methods of Communication

• Communication is defined as the dynamic and irreversible process by which we exchange and interpret messages within a given situation or context

• Verbal
  • Tone of voice
• Body Language (Non-verbal Communication)
• Written (includes text, symbols and pictures)
Communication Efficiency

• Which form of communication do you think is the most important during communication?
  - Verbal
  - Tone of voice
  - Body language
Communication Efficiency

- Verbal = 7%
- Tone of voice = 38%
- Body language = 55%

Total = 100%
Communication

• Of the three types of communication, spoken words are the least important
• People attach more important to tone of voice and most importance of all to facial expressions, gestures, etc
• When two messages conflict with each other, more importance is placed on the non verbal communication (NVC) cues
• NVC may give information about people’s attitudes (Posture, pupil size, and eye contact etc)
• NVC may give information about emotional states-fear, anger, anxiety etc as signals ‘leak’
Communication Model

A + B + C = What is said
A + C = What is said that is subject to interpretation
B = What is understood. This is only about 30%
Redundancy in Communication

• Communication is extremely important in the context of aviation maintenance

• Because communication is very difficult to be 100%, more than one method of communication should be used whenever possible.

• The more redundancy we have, the greater the likelihood that effective communication will occur.
Communication with Flight Crew

• As a Regulatory Requirement, the flight crew will report defects on a Technical Log book (Paper/Electronic).
  – In addition, verbally explain to the maintenance personal.

• If a defect cannot be cleared/rectified and needs to be differed, the maintenance crew would raise an MDD.
  – Also brief the flight crew on the defect, the limitations and special flight procedures if any to ensure the crew fully understands the status of the aircraft.

• If maintenance requires the flight crew to perform special procedures due to a maintenance requirement,
  • They would brief the flight crew on what needs to be done and raise a paper document (Notice to Crew) which would describe what has to be done.
Communication with Flight Crew

The final fuel figure for a particular flight would be given by the flight crew to the maintenance crew in paper form.

Once received, maintenance personnel would verbally confirm the figures before starting the refueling process.
Communication with Cabin Crew

• The cabin crew would report all cabin defects on the cabin log book.
  – Brief maintenance personnel on their entries for better understanding.
  – The maintenance crew would then take the necessary actions to clear the log book and also brief the cabin crew on their actions.
Social and Cultural Differences

• **Social factors**: relate to personal interactions between people who find themselves in the same place, at the same time, and who need to coordinate with each other to achieve a common task.

• **Cultural factors**: refer to the collective values, beliefs and behaviors held by a group of people who share a common identity; especially as differentiated from other (different) groups of people.
  - Interactions between people from the same culture can be affected where the degree (or depth) to which values and beliefs are held vary.
Social and Cultural Differences

• Situations may arise where socio-cultural issues add to the complexity of interactions among people.

• Therefore, at the start of every task, we need to socialize with people who could be strangers to us.
“...two or three engineers working together commit fewer testing and troubleshooting errors than a single person working alone”
Teamwork

The successful team:
• Functions smoothly
• Has good relationships
• Can accomplish goals

The unsuccessful team:
• Wastes time
• Feud
• Cannot accomplish goals

THE UNDERSTANDING OF INTERPERSONAL RELATIONSHIPS equals: EFFECTIVE TEAMS
Team Growth:

- Team Growth occurs in 4 stages
- Each stage is characterised by behaviour

- Forming
- Storming
- Norming
- Performing
Forming:
- The time when the team comes together

Storming:
- Arguments among team members
- Choosing of sides
- Negative attitudes
- Discouragement of team members
Norming:
- Conflicts smooth out
- The team begin to understand the strengths & weaknesses of other team members
- Development of an harmonious working atmosphere

Performing:
- The team is a cohesive unit
- Fewer costly mistakes
- Morale is high
Barriers to Growth: the “Storming” stage ...

- Teams tend to be “ME” centred Vs. “TEAM” centred
- Company support required
- Individual attitudes need to change and blend
Characteristics of a successful team:

- Good team leaders
- Clear goals
- Well defined decision making procedures
- Good communication skills
- Well established ground rules
Team Leading :

Definition of a team leader:

“Has a natural authority, Generates commitment and builds team cohesiveness by setting a clear vision for the team, reflected in core values”.
Team Leading: Effective behavioral indicators

- Communicates frequently a realistic picture of future plans, so people know what has to be done and why.
- Arrives at decisions by consensus, where appropriate, to gain team commitment.
- Is supportive of the team / individuals and helps in overcoming problems to achieve targets.
- Leads by example; displays behaviors which reflect the desired work norms and values.
**Team Lead**: Effective behavioral indicators

- Spends time finding out the way individuals want to be managed and work together; adapts leadership style to match.

- Maximises the available resources by constructing well-balanced teams; acknowledges and helps others value the unique contributions of each team member.

- Identifies own leadership style and strengths; adapts these to specific situations.

- Follows up with dissenters or blockers to contain negativity.
Ground Rules:

- Meeting attendance & time-keeping
- Written agenda and objectives
- Conventional courtesies
- Language and humour
- Behaviour
TEAM PROBLEMS

Teams are people and have ‘people problems’

Dealing with personality based problems in the team:

- Dominating participants
- Reluctant participants
- Impatient participants
- Negative participants
- Indifferent participants
- Feuding participants

There will always be people problems as well as technical problems, for the team to deal with.
TEAM PROBLEMS

Dominating Participants:

• Monopolise the conversation

• Loves to hear his / her own voice
TEAM PROBLEMS

Dominating Participants:

• Keep discussions focused on goals & objectives

• Try to have a balanced participation
TEAM PROBLEMS

Reluctant Participants:

- Shy
- Non-vocal
- Keeps to himself / herself
TEAM PROBLEMS

Reluctant Participants:

• Try asking for input, use open ended questions
• Actively listen to the person when they talk
• Help them to feel a part of the team
Teamwork

TEAM PROBLEMS

Impatient Participants:

- Rush to solutions
- They lose their opportunity to be creative
TEAM PROBLEMS

Impatient Participants:

- Allow open discussion and balance participants
- Use well defined decision making tools
- Use well defined idea generating procedures
- Provide constructive feedback
TEAM PROBLEMS

Negative Participants:

- Negative attitudes can be contagious
- Negative participants can destroy the team!
TEAM PROBLEMS

Negative Participants:

• Team leader is used in one-on-one confrontation

• As a last resort - remove from the team
Indifferent Participants:

- Little participation offered
- Agrees with the majority each time
- May have personal problems?
Teamwork

TEAM PROBLEMS

Indifferent Participants:

• Use team leader in a one-on-one discussion / counselling
Teamwork

TEAM PROBLEMS

Feuding Participants:

• Arguing without reason

• The feud usually pre-dates the team formation
Teamwork

TEAM PROBLEMS

Feuding Participants:

- Prevention
- Use team leader in one-on-one confrontation
- Last resort, remove the most disruptive party from the team
Management, Supervision and Leadership

To be a good manager, supervisor or leader, requires the same attributes. Since all managers and all supervisors must also be leaders, we will use the term ‘leader’ to represent all three types.

The following is a list of what is required to be a good leader:

- Communication skills
- Listening skills
- Decision making skills
- Decisiveness
- Sense of responsibility
- Enthusiasm
- Ethics
- Recognition
- Sensitivity
- Flexibility
- Humour
- Stamina
- Perseverance
- Emotional Stability
- Image
Management, Supervision and Leadership

When it comes to ‘HUMAN FACTORS’ it doesn’t matter who’s the manager, supervisor, leader or cleaner / laborer.

Within the realms of human factors we are all the same, we are simply ‘people’.
Decision Making

• The cognitive process of selecting a course of action from among multiple alternatives

• Has four components:
  – Defining the problem
  – Considering the options
  – Selecting and implementing the options
  – Reviewing the outcome
Decision making is influenced by:

- **Situational Awareness**
  - a combination of availability of information and the ability of the decision maker to interpret the information
  - Skills and Professional Knowledge

- **Experience**

- **social pressure, national and institutional culture**

- **Situational limitations**
  - Physiological & psychological pressures (stress, fatigue, etc.), time pressure
The Good Decision Maker

- Canvasses a wide range of alternative courses of action
- Surveys all the objectives to be fulfilled
- Weighs all that he knows about the costs and risks associated with each alternative
- Searches for new information to further evaluate the alternatives
- Takes into account any new information even when it does not support his preferred action
- Re-examines the positive and negative consequences of all alternatives, including those originally regarded as unacceptable, before making a final choice
- Executes the action paying particular attention to contingency plans should the known risk materialize
Module – 9.9

PROFESSIONALISM AND INTEGRITY
Keeping Up to Date - Currency

• Only the most current documents should be used for reference
• Revision status of documents should be followed at all times.
• Hard copies, CDs of manuals should be updated and records should be maintained for auditing purposes
• Continuation training should be obtained to maintain accuracy of knowledge and information
Some Things to Think About!

• A company is entitled to an approval if it meets the requirements
• Requirements for maintenance are normally prescriptive codes, they tell you what is required and how to achieve it.
• If a company meets all the requirements, can it be considered safe (i.e. free from risk)?
• Regulators only audit against the requirements
Some Things to Think About!

• The audit process is a sampling process. Neither the company or the Regulator can check everything or know everything.

• The maintenance system is dynamic and complex, with an indeterminable number of ways to go wrong.

• In the event of an accident the omissions take on a sinister significance.
Some Things to Think About!

• Accident investigators have the benefit of hindsight and evidence. You only have a copy of the Requirements and a gut feeling whether the company is intrinsically safe.
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.
• If in doubt consult Quality Assurance department.
Error Management in Aviation Maintenance
REPORTING ERRORS

• The working environment should be conducive to reporting errors using forms supplied by Quality Assurance.

  – Abnormal Occurrence Report (AOR)
  – Ground Safety Report (GSR)
  – Engineering Confidential/Anonymous Report
  – Feedback forms filled in by staff
REPORTING ERRORS

• Error reports should be used to find the root causes of the errors, not to establish blame or liability
• Personnel involved in reporting should be given feedback of the results of the error analysis
• The use of a non-punitive approach to reporting is recommended to encourage personnel to report errors
• The mechanism for reporting errors should be made straightforward and easily accessible at all organizational levels
• The electronic or hard copy reporting forms should be made unambiguous and easy to use
Error Reporting Barriers

- Fear of individual punishment or organizational repercussion
- Belief that the operational error can be used as a measure of the individual competence
- Staff who are forced to report errors are less likely to provide in depth information because their primary motivation is self protection and adherence to a requirement, not to help others avoid the same error
Who has been Traditionally Managing Errors?

- The Regulator?
- Quality Assurance?
- Aircraft Designers?
- Trainers?
- Maintenance Manual and Procedure Writers?
- Line Supervisors?
Methods of Managing Error

- Reporting Error
- Error Reduction/Error Elimination
- Error Tolerance
- Error Capturing
Error Reduction/Elimination

- The maintenance system is designed (or redesigned) so that errors are unlikely or impossible, e.g.
  - Improve the lighting levels
  - Unambiguous procedures
  - Tooling easy to use
  - Redesign the aircraft (Murphy Proof)
  - Stop doing certain tasks!
Error Tolerance

• The aircraft is functional and safe even after a maintenance error has occurred, e.g.
  - Not doing the same maintenance tasks on all the engines on an aircraft at the same time
Error Capturing

• Additional Tasks performed to ‘capture’ any errors before the aircraft is released to service, e.g.
  - Second Inspections
  - Functional Checks
  - Operational Checks
  - Leak Checks
Managing Error is Not New

- Licensing of Engineers
  - Training and competence assessment
  - Audits
  - Work Cards
  - Tags and Flags
  - Warning notes in manuals
  - Procedures
  - Discipline
  - TQM, Six Sigma
  - Second Inspections
Traditional Error Investigation Process

- Find out what happened
- Find out who did it
- Discipline the guilty person (or people)
  - Dismissal
  - Time off without pay
  - Removal of certification privileges
  - Letter on file
  - Re-training
  - Told to be more careful
A Changing Approach to Error Management

- Differentiate between the error and the consequences of the error
  - Separate out the underlying causes of the error
- Accept that errors are ‘normal’
- Errors are committed within a specific context (the work environment, the goals and the constraints)
- 70% of errors committed have their causes rooted in the inadequacies of the ‘system’ for which management are responsible, not the front-line technician.
What is Wrong with the ‘Traditional’ Approach to Managing Errors

- Collectively they have not prevented a rise in maintenance errors
- They are piecemeal attempts at fixing problems
- They are reactive
- No data is collected to determine systemic problems
- Fragmented ownership of problem
- Focuses on active failures and not the latent and system failures
The Principles of Error Management

- We all make mistakes and it is inevitable that we will make some
- Human error can be reduced but cannot be totally eliminated
- Errors are made at all levels in the organization, not just by those holding a torch and spanner
- Errors are more often the result of error provoking situations than error prone people
The Principles of Error Management

- Errors are not directly manageable
- Changing the environment and system is a more effective way to influence errors than trying to change the person (removing a distraction is more effective than telling the person to be more careful in the future)
- People cannot easily avoid actions they did not intend to make in the first place
- Errors are a product of a chain of events that include many related factors
  - task, organizational, situational, workplace, etc.
The Principles of Error Management

- Only manage what is manageable
- Some types of errors recur, and patterns can be identified
- The culture of the organization has to support the error management process
- The role of punishment and blame has to be well understood.
Is Punishment Appropriate?

- Why do we punish someone for doing something that they never intended to do in the first place?

- Will it prevent them or anyone else from committing the same error?
Is Punishment Appropriate?

- If you were distracted by a bee in your car and you drove through a red traffic light would it be appropriate for the police to fine you?

- Do you think that the police should take into account that the bee caused you to go through the red light?
Maintenance Error Investigation

- Maintenance error investigation has traditionally been restricted to errors made by maintenance personnel (active failures)
- The investigations failed to identify and correct the factors that provoked the maintenance person into making the error
- The error provoking factors remain within the system to provoke someone else into making the same mistake in the future
Latent Failures

System (barrier) Organizational weaknesses

Failures

- Procedures Management culture
- Task cards Inexperience
- Inspection Poor decisions by managers
- Duplicate inspection Support systems
- Supervision etc etc
- etc etc
Conventional Definition of an Error

- ‘When there is general agreement that the person should have done something other than what they did.’

- The person is then said to have ‘committed an error’
New Definition of a Maintenance Error

1. “A maintenance error is considered to have occurred when the maintenance system, which includes the human element, fails to perform in the manner expected in order to achieve its safety objectives.”

2. This now defines a maintenance error as a system failure, and people are just part of the system. To investigate a maintenance error you will now have to consider all the elements of the system.
The Human Reliability Curve

Human Reliability

Factors Affecting Human Performance

Human Error

Normal operation
“Prescription without diagnosis is malpractice, be it in medicine or management”

(Ken Albrecht)
The Iceberg Effect

Errors that “Hurt”
e.g. Delays, ATB’s, Cancellations etc.

ERRORS YOU KNOW
NOTHING ABOUT!

Serious Events and Audits
Errors...

...Are Like Mosquitoes....
To Get Rid of Them ...

...Drain Their Breeding Swamps
The Role of the Supervisors

Correct Errors

Error management
Understanding Operational Errors

Error consequences

Threat to safety

No significant consequences
Culpability and Punishment

- Effective event investigation cannot occur unless the issue of discipline is well understood by the workforce and management, i.e. what behaviors will result in disciplinary action
- Society does not accept the principles of a blame free system (or culture), therefore, impossible to import into an organization
- People will support a fair and just system, where the honest mistake is tolerated but recklessness or unprofessional behavior is not
The Role of Punishment

- To deter others from behaving the same way
- To deter the person from behaving the same again
- To remove the person so they cannot cause harm
- To teach every one what is good and bad behavior
- Retribution (evil acts must be punished)
- To show that action has been taken to prevent recurrence
- To deflect the blame from other causes
Why a Disciplinary Policy is Necessary

- To establish the environment of trust and fairness
- Discipline if used fairly will help reduce unacceptable behavior
- If people are disciplined for every mistake, they:
  - will not talk openly during an investigation
  - will hide their contribution to an event
  - will cover up their mistakes
  - may not perform some tasks which are known to be error prone.
Culpability Based on the Level of Intent

Purpose and knowledge
- the person knew that their actions would cause a bad outcome

Recklessness
- conscious disregard that their actions would significantly and unjustifiably increase the probability that an incident would occur

‘The line in the sand’

Negligence
- the person should have known that their actions would significantly increase the probability that an incident would occur
Disciplinary policy guidelines

- Discipline should not be decided only on a rule violation or how severe the outcome of the event was.
- Discipline should be reserved for behavior involving:
  - Purpose and knowledge
  - Recklessness
- People should not be disciplined for unintentional errors
- Other reasons may increase or decrease the level of discipline
Oman Air’s JUST CULTURE Policy

• No disciplinary action will be taken against any member of staff who reports an incident or occurrence involving human error, and who openly participates in the investigation and subsequent development of error prevention strategies.

• The policy will not apply to employees who have behaved in a reckless or illegal manner or who have committed a series of human errors that indicate a general lack of care and professionalism.
Maintenance Error Investigation Techniques

- Round table group discussions
- Paper based tools
- PC based tools
- Reactive tools
- Proactive tools
- Self reporting schemes
ATTITUDES OF ‘NORMAL ERRORS’

- Good intentions
- No risk-taking behavior
- The ‘system’ shapes the human performance
ATTRIBUTES OF AT-RISK BEHAVIOR

- The behavior or actions are intentional (not necessarily the outcome)
- The behavior or actions increase the likelihood of an error, but does not make certain it will occur
- The person does not know, recognize or underestimates the risk
Proactive Error Management

- Most error management tools are reactive
- Companies tend to support these programmes because they have experienced an expensive mistake and do not want it to happen again
- An error management system must also have a proactive element
SUMMARY

- Human Factors is a large subject as it embraces many of the traditional sciences
- The human is going to remain the principle component of the maintenance system for the foreseeable future
- We should strive to ensure that good human factors principles become our normal way of working
- Perhaps in the future, we will not be talking specifically about ‘human factors’, but about managing ‘system safety’
Something to think about

“Risk will never be eliminated from high risk systems....However, we might stop blaming the wrong people and the wrong factors, and stop trying to fix the systems in ways that only make them riskier”
Something to think about

- ‘For the commercial success of air transport, accidents must be reduced. But the hard core of system accidents, while small, will probably not get smaller. This is because with each new advance in equipment or training, the pressures are to push the system to its limits’.
FEEDBACK

• Give positive and negative feedback.

• Ensure that errors are known to all the workforce in order to ensure safety.