Part 66 Cat. B1 / B2 Module 9A

HUMAN FACTORS

Vilnius – 2017

Human Factors in Aviation Maintenance

The first attempts of the thing we can call "Human Factors" appeared in early aviation time as aircraft compatibility with the humans, and who could be better pilot. The last question was solved through medical investigations.

After a years, when mass – production started it was realized that the compatibility of aircraft with humans could be solved through control of design and instrument layout compatibility with pilots.

The massive application of HF in aviation started in the last 90-ties. The principles of HF were used in investigation and during analysis of Aloha incident with B-737 in-flight break-up (1988). This incident generated a deep understanding about maintenance human factors.

Evaluation of human personality impact on aviation safety resulted in "Aviation Safety Act" (year 1988) and special training manuals in Human Factors in Maintenance.

Statistics

According overall statistics nowadays, transport aviation is 98% safe. According to US National Transportation Safety Board (NTFS) in year 2 000, it appeared in about 3 accidents to 1 000 000 departures in aviation or in overall 92 fatalities. The last year records show less than one fatal accident occurring every 2 million flights. In turn, the same statistics for automotive transportation gives a figure of about 41 800 fatalities.

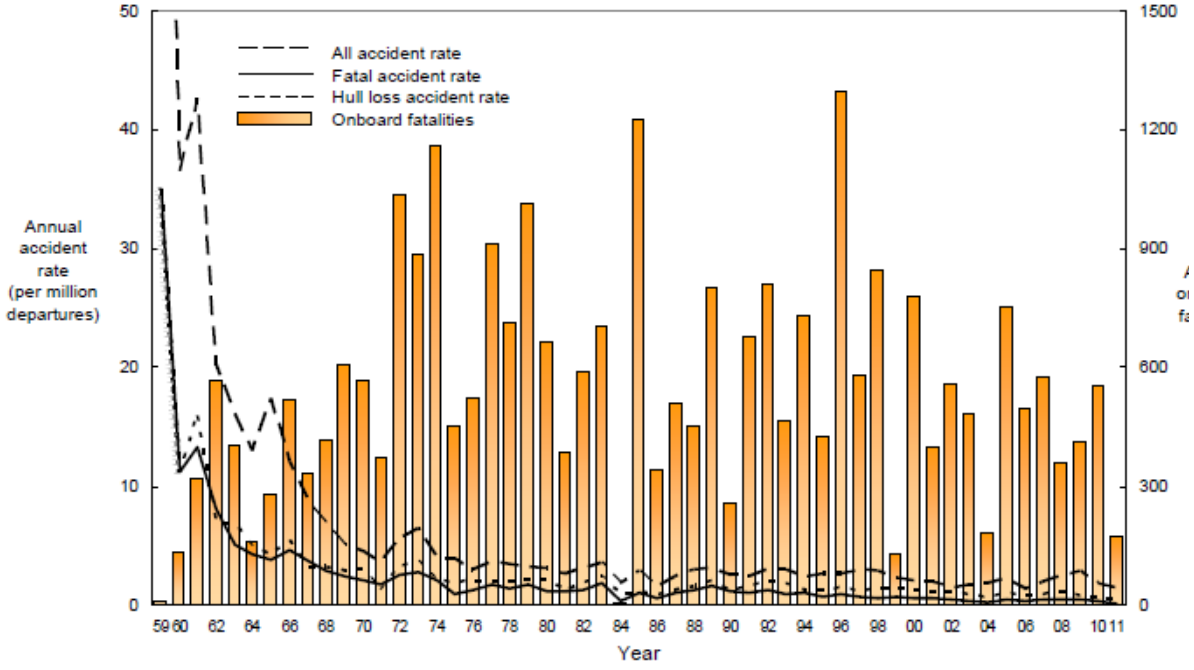


Figure 1.1. Accident statistics

The Boeing "Statistical Summary of Commercial Jet Airplane Accidents. Worldwide Operations 1959-2011" (**Fig. 1-1**) shows comparison of the number of accidents to the number of departures.

It gives rise to the next conclusions:

1. Airline travels are very safe;
2. The safety rate is high and difficult to improve;
3. The slightly increased number of worldwide accidents almost does not influence the statistics;
4. The regular aviation transportation in the USA, Canada and EASA countries is extremely safe.

Other statistics from the same source concern Hull Loss Accidents (**Fig. 1-2**).

Cause	*Number of Acc.*
Flight Crew	91
Airplane	15
Weather	10
Maintenance	8
Misc./Other	6
Airport/ATC	5
Total with known causes	135
Unknown or awaiting reports	66
Total	201

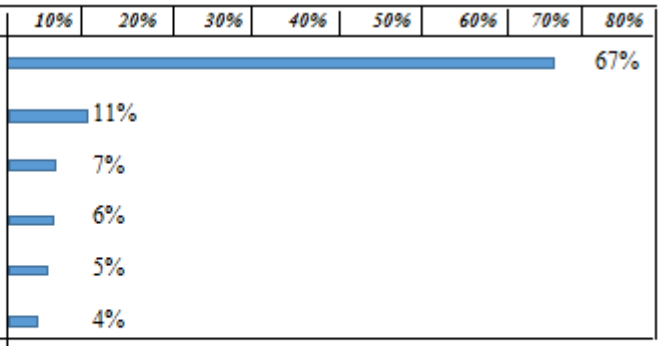


Figure 1-2. Hull Loss Accident – Worldwide Commercial Jet Fleet – 1990 through 1999

According to, the year 1990-1999 statistics show flight crews make the main income to fatalities. Maintenance with about 6% takes the 4-th place only.

What can be cause of errors leaded to those accidents? It may be:

- Fatigue;
- Incomplete / Incorrect documentation;
- Personal problems;
- Fumes;
- Cold;
- Unrealistic deadlines;
- Neglecting of circadian rhythm and many other.

Normally only one factor does not make a problem. Mostly a problem arises from several factors making a chain of events.

From the same BOEING study, it is seen before the HF was explicitly taken into account aviation maintenance errors taken about 15% of total 9 583 lives of passengers and crewmembers (**Fig. 1-3**). The comparison with **Fig. 1-2** shows the consequent work in HF give results – maintenance causes diminished twice. But in both tables about of 80% of these accidents are a result of human error!!!

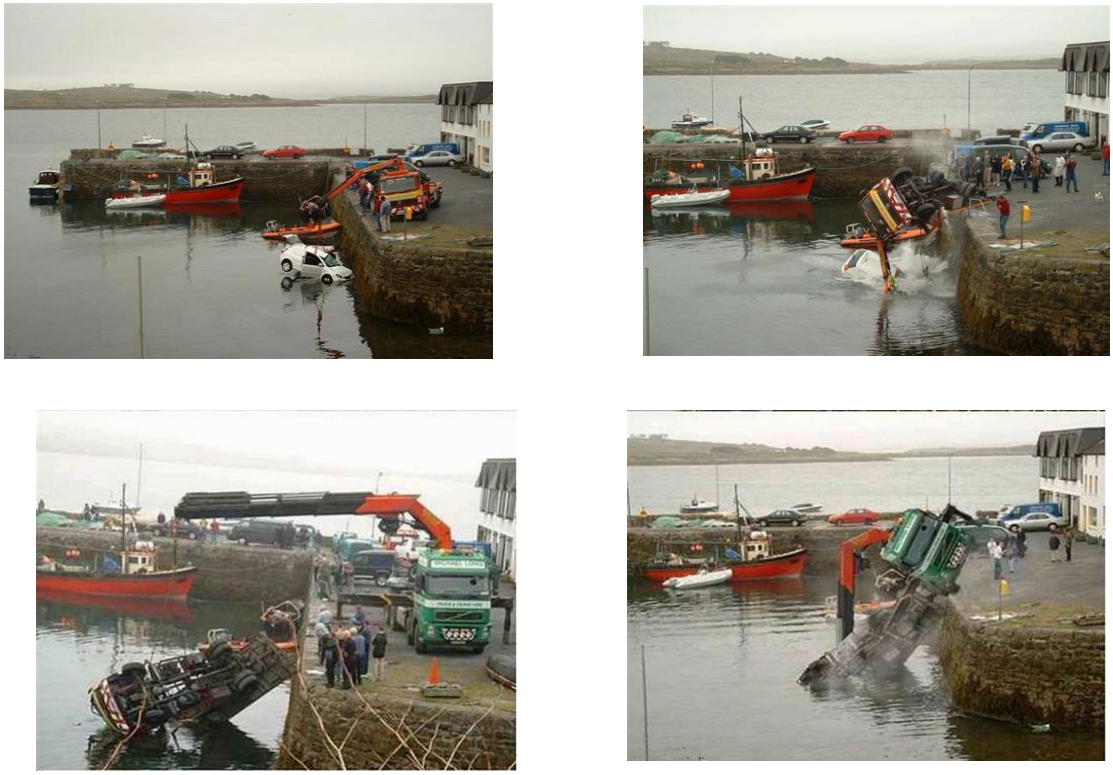


Figure 1-13. All they were too complacent

There are a lot of other variations and consequences from Murphy law:

If there is any way to do it wrong, they will found it

If anything just cannot going wrong, it will anyway

If everything seems to be going well, you have obviously overlooked something

Things go worse under pressure

Nothing is as easy as it looks

All these jokes put on one's guard against complacency and arrogance; they call for professionalism, attention to details and changing conditions.

The ear has three divisions: outer ear, middle ear and inner ear (**Fig. 2-7**). These act to receive vibrations from the air and turn these signals into nerve impulses that the brain can recognise as sounds.

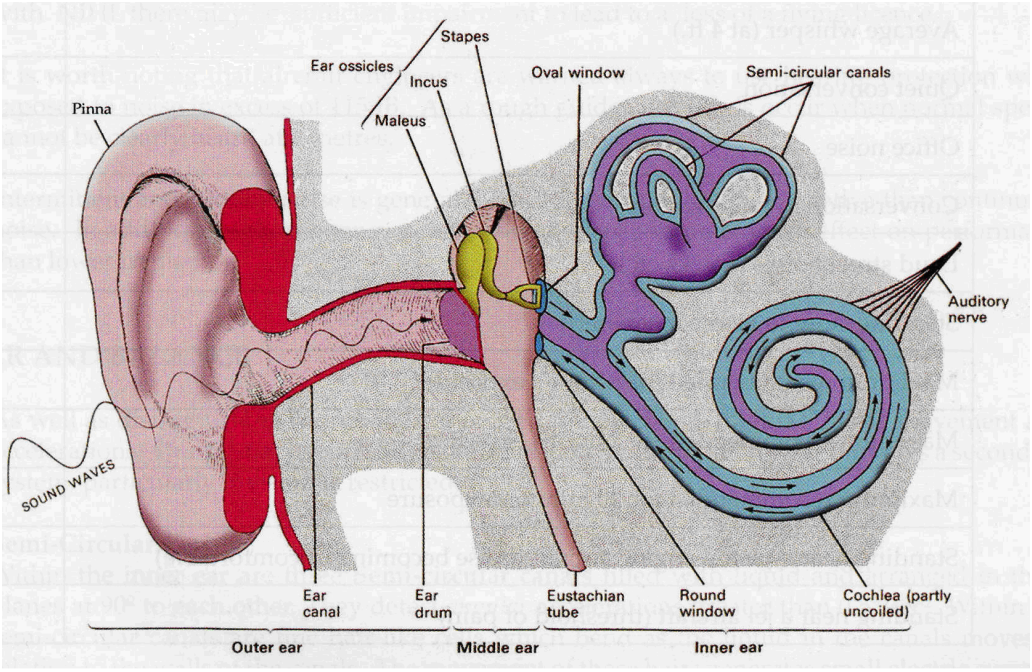


Figure 2-7. Ear structure

Outer Ear

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

Middle Ear

Beyond the eardrum is the middle ear, which transmits vibrations from the eardrum by way of three small bones known as the ossicles, to the fluid of the inner ear. The middle ear also contains two muscles, which help to protect the ear from sounds above 80 dB (this is approximately equal to the noise we can't communicate normally at the distance of 1 m) by means of the acoustic or aural reflex, reducing the noise level by up to 20 dB. However, this protection is provided for a maximum of about 15 minutes, and does not provide protection against sudden impulse noise such as gunfire. It does explain (one reason of several) why a person is temporarily "deafened" for a few seconds after a sudden loud noise.

The middle ear is usually filled with air, which is refreshed by way of the Eustachian tube, which connects this part of the ear with the back of the nose and mouth. Such connection makes ear a kind of differential Bellows, joint by the eardrum.

As the Eustachian tube is narrow enough, the airflow out and into the middle ear is slow enough and could be disrupted. Under these circumstances (e.g. when aircraft change the flight altitude or during

9.3 SOCIAL PSYCHOLOGY

Social psychology is about understanding individual behavior in a social context. Baron, Byrne & Suls (1989) define *social psychology* as:

social psychology - the scientific field that seeks
to understand the nature and causes of individual behavior in social situations

Each individual person could be characterized by his knowledge, abilities, physical and psychological characteristics. These characteristics express themselves when begin interact with such "global" factors as placed on **Fig. 3-1**.

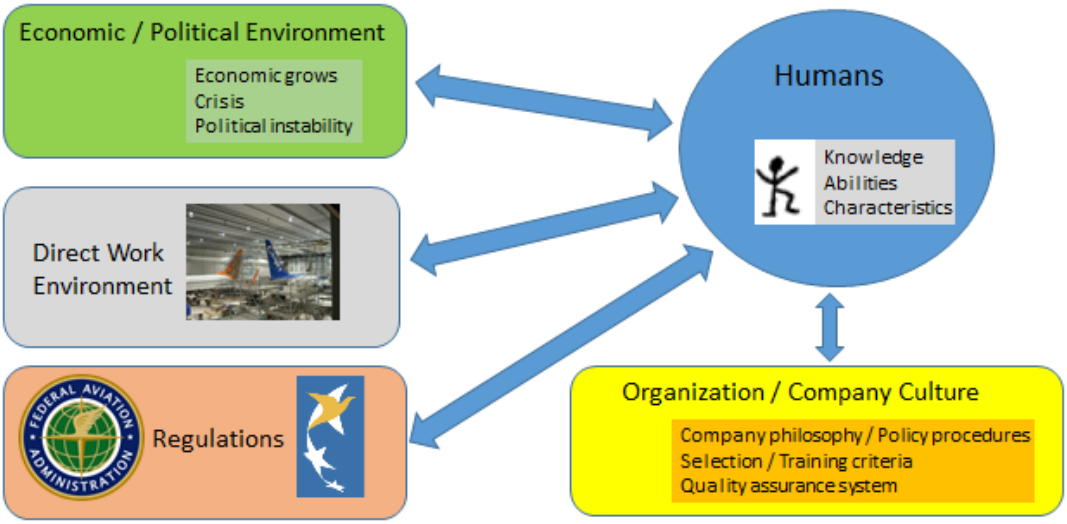


Figure 3.1. The social environment factors

Direct Work Environment

The nearest to adult individual person is Direct work environment including:

- Physical environment;
- Supervisory environment;
- Organization (Company) culture;
- Regulations;
- Economic and political environment of society.

The "physical" part of the direct environment in aviation maintenance is related not only to hangar and to other facilities, tools and equipment, but to aircraft design as well. These are designed for keeping conditions suited for better performance and to fit existing regulations. The last is ensured by regular audits.

Moreover, it includes such conditions as hangar/workshop temperature or climate conditions during line maintenance.

The "supervisory" part of the direct environment consists of day-to-day planning, prioritizing tasks and delegating duties, instructions given concerning particular task, team-building issues and on-job-training, feedback given to managing directives, etc.

Company Culture

Every organisation or company employing aircraft maintenance mechanics will have different "ways of doing things". This is called the *organisational culture*.The company culture depends on:

1. Company philosophy and policy (business organization, staff incorporation into decision-making, etc.);
2. Procedures (Management and public relation procedures, information dissemination, management and work site arrangement, etc.);
3. Selection and training criteria (how personnel is selected, who and when is trained, appointed to the post, etc.);
4. Quality assurance system (job assessment, working procedures, human error management and reporting systems).

These factors are strongly company-dependent. It is important to understand how the organisation in which the mechanic works might influence him, because the impact of the organisation may be positive or negative (**Fig. 3-2**).

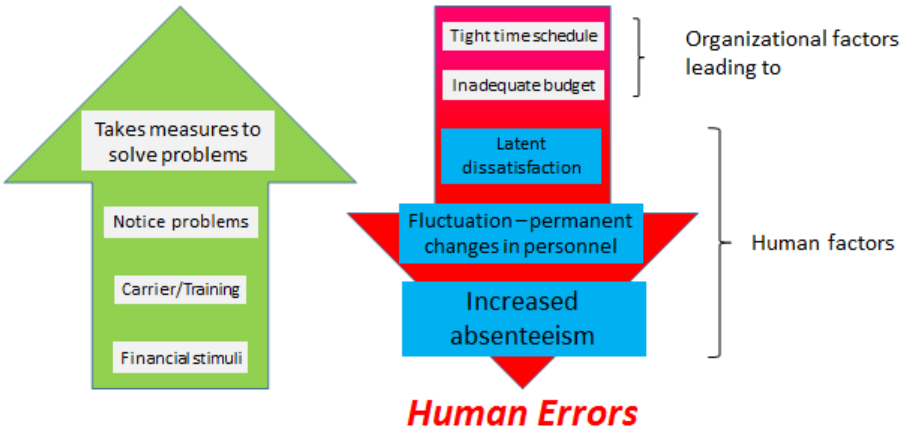


Figure 3-2. Organization influence

Organisations may encourage their employees (both financially and with career incentives), and take notice of problems that their mechanics encounter, attempting to learn from these and make changes where necessary or possible.

When motivating personnel, the lowest priority is given to the financial stimuli. Various investigation showed the financial stimuli lasts no more than 3 (three) month. After this term personnel adapts and the need in new financial stimulation appear. Carrier initiatives are more powerful stimulator up to the moment when person began to feel he/she is fully satisfied by current position.

Talking about stress, we usually give him a negative aspect. What could be the negative factors determining stress condition? – They could be external and internal (**Fig. 4-2**).

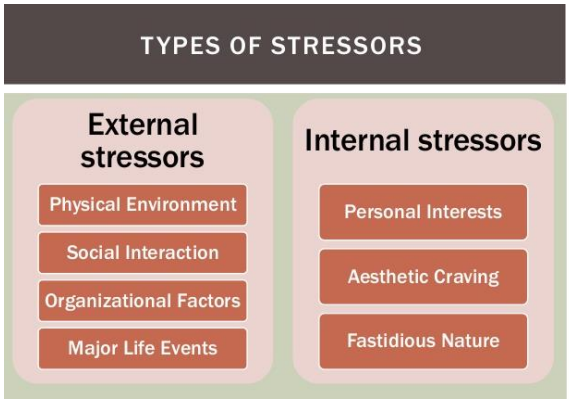


Figure 4-2. External and internal stress factors

From the other site, they are divided into physical, psychological and reactive factors or stressors (**Fig. 4-3**).

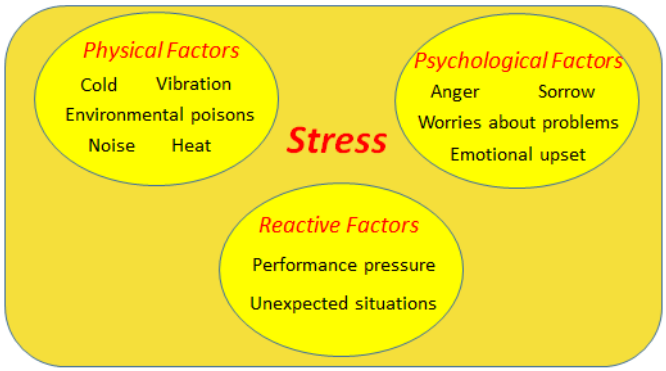


Figure 4-3. Physical, psychological and reactive stressors

What are the first effects of negative stress situation? –Rising pulse and slightly rising temperature. If the situation (stress) lasts, it shows serious physical and physiological reaction (**Fig. 4-4**).

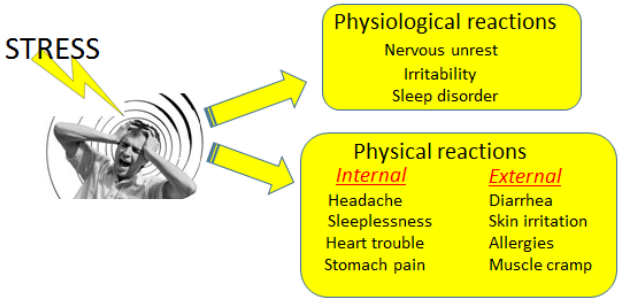


Figure 4-4. Physiological and physical reactions to stress situation

Because stress cause such negative reactions, and almost all of surroundings could be the source of stress, could we create a completely stress-free environment? In other words "Is it possible to improve the overall work performance if working in a completely stress free environment?"

What is a stress-free environment? Here is the story posted by Sam Biddle titled "The Quietest Place on Earth will drive you insane within 45 minutes":

"There is a small room in Minnesota that blocks out 99% of all external sound (**Fig. 4-5**). That is an impressive number! Also impressive: nobody can take more than 45 minutes alone in the room before they go nuts.

Figure 4-5. The anechoic room in Minnesota, USA (Photo by Steven Orfield)

The Daily Mail describes Orfield Labs' anechoic chamber - perfect for making extremely sensitive audio measurements. Also perfect for sending you into a hallucinatory hell so hellacious you will need a chair:

"When it's quiet, ears will adapt. The quieter the room, the more things you hear. You will hear your heart beating, sometimes you can hear your lungs, hear your stomach gurgling loudly. In the anechoic chamber, you become the sound."

This is a very disorientating experience. Mr. Orfield explained that it is so disconcerting that sitting down is a must. He said: "How you orient yourself is through sounds you hear when you walk. In the anechoic chamber, you do not have any cues. You take away the perceptual cues that allow you to balance and maneuver. If you're in there for half an hour, you have to be in a chair."

9. 7 COMMUNICATION

Communication is a very interesting and important process. Nevertheless, people understand communication process in different ways. In many cases these differences in understanding lead to misunderstanding and failed communication resulting by various mistakes.

To avoid misunderstanding start with communication definition first.

Definition of Communication

One of the well-known definitions of communication is that of given in Penguin Dictionary of Psychology:

Communication - the transmission of something from one location to another.

The "thing" that is transmitted may be a message, a signal, a meaning, etc.

According to this definition, communication may be assigned as a one-way process of transmitting information from one person to another, or when superiors just communicate their decisions to employees not bothering if that decisions are accepted or not.

To eliminate the problem of rejected information (in communication process) and thus, failed communication, another definition may be proposed:

Communication is a two-way process of reaching mutual understanding,
in which participants not only exchange (encode-decode) information, news, ideas and feelings
but also create and share meaning

According to this definition if *shared meaning is not created, we have an obvious case of failed communication*.

In any case working together for communication to be effective it requires common elements. Good communication is important in every industry. In aircraft maintenance, it is vital. Misunderstandings and communication failures are important in the whole life, at work as well as in personal (**Fig. 7-1**).

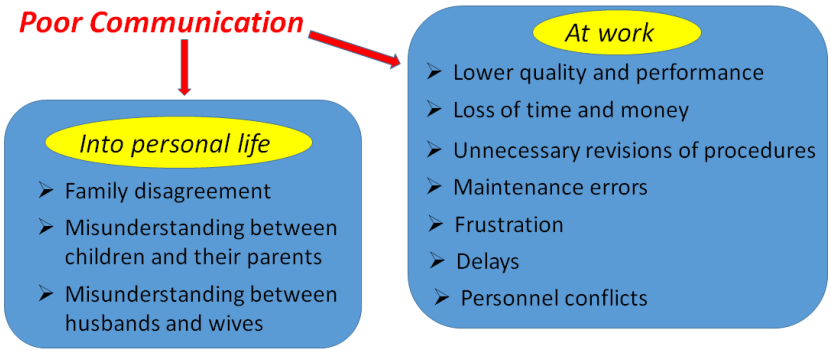


Figure 7-1. The consequences of poor communication

Communication Elements

Clear communication can be the difference between getting a job at the first time, or expensive re-work; doing the job safely or injury to personnel.

To communicate effectively we need know some basic principles of communication based on the simple understandable model of communication (**Fig. 7-2**).

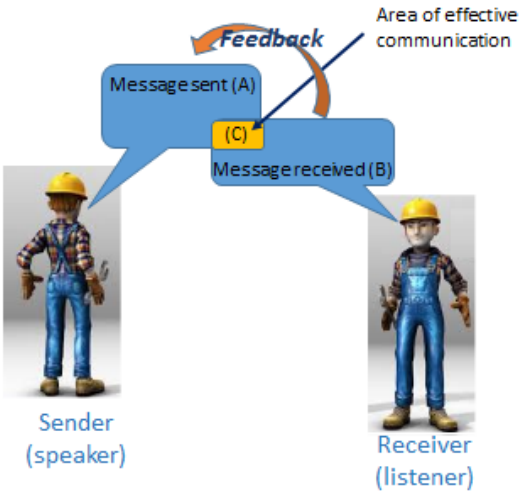


Figure 7-2. A simple model of communication

We are communicating:

- Information;
- Ideas;
- Feelings;
- Attitudes and beliefs.

As the senders of a message, we typically expect some kind of response from the person we are communicating with (the recipient – "Receiver" or listener), which could range from a simple acknowledgement that this message has been received (and we hope it was understood), to a considered and detailed reply. The response constitutes feedback.

It looks rather simple, but why communication is so difficult? Why there are so many communication errors?

Look at the possible communication channels first.

Communication Channels

When talking about communication we think about oral (spoken) communication first, but, in aircraft maintenance a lot of communication is not a spoken communication. Maintenance is heavily reliant on documentation – logbooks, various maintenance manuals and part catalogs. Information is transferred through various graphs, symbols. We accompany speech by gestures and attitudes (body language) that constitutes non-verbal cues.

9. 8 ERRORS

Many aircraft accidents are related to maintenance errors. Up to 30% of engines in-flight shut-downs relates to maintenance problems. All of us being airlines passengers sometimes were rebelled by flight delay. We learn about delay of charter flights – a lot of them due to engine problems. Up to 50% of such problems related to flight delay and cancellation are due to maintenance errors.

Humans make errors and that will never change. We have studied some possible error sources in "Human Performance and Limitations" related to humans physical aspects and brain functioning.

Relating to error we only could minimize their occurrence and aftereffects. To minimize error occurrence is a matter of safety and cost. Indeed, it is pride when you make a little errors or they are only the small one. This is difficult if we do not understand error itself. Such understanding starts from definition, which gives us correct direction to error understanding and minimization.

Errors Models and Theories

Errors may be defined differently as:

- An unsafe act unintentionally committed, or
- A wrong action attributable to bad judgment, ignorance, or inattention.

Professor Reason's Swiss cheese model also know as "The Window of Opportunity" is theoretical model that illustrates how accidents occur in organizations (**Fig. 8-1**).

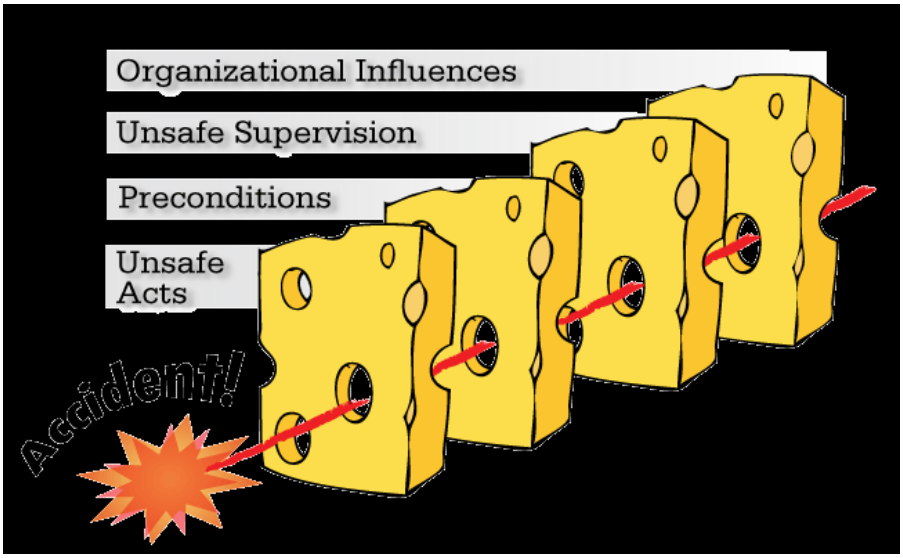


Figure 8.1 Swiss cheese model

The model focuses on both organizational hierarchy and human error. It states that the typical accident occurs because several (human) errors have occurred at various levels in the organization in a way that made the accident unavoidable.

Types of Errors in Maintenance Tasks

Maintenance presents many possibilities for errors. While disassembling tasks are rather simple and give rare possibility to err, reassembly gives a lot. A bolt with eight nuts is a classic example by prof. James Reason (**Fig. 8-2**) – there is only 1 (one) possibility to disassemble nuts but more than 40 320 opportunities to miss the previous order when assembling them back. The nowadays aircrafts like Boeing or Airbus present much more opportunities for errors.

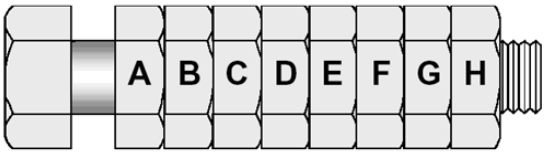


Figure 8-2. This combination of a bolt and marked nuts gives 40 320 combinations of re-assembling

The Reason model of errors differs between errors made after unintended or intended actions (**Fig. 8-3**).

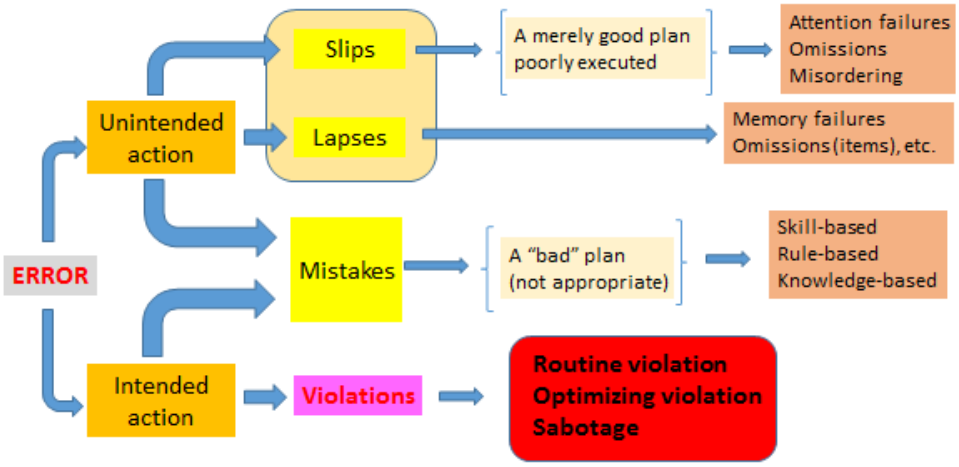


Figure 8-3. Reason model of errors

After identifying the type of error, the possible correction action may be developed. In the case of unintended error we could find ourselves doing a task in a way we never thought about (a slip) or we leave out a required step (a washer do not installed) making a lapse. These errors typically occurs when our attention is distracted.

Mistakes are related to "bad" plan executed due to bad knowledge, use of incorrect procedure or skill.

Intended action in most cases do not means that the person intended harm. Intended actions can be divided into "mistakes" and "violations". **Fig. 8-3** shows that "mistakes" may arise both from unintended and intended actions.

9.9 HAZARDS IN THE WORKPLACE

Each work has its own hazards. When you working as aviation maintenance mechanic or in a workshop, there may be various hazards depending on your job. A long use of pneumatic rivet gun can influence your hearing, welding can affect vision; you can inhale noxious fumes or fall from significant height.

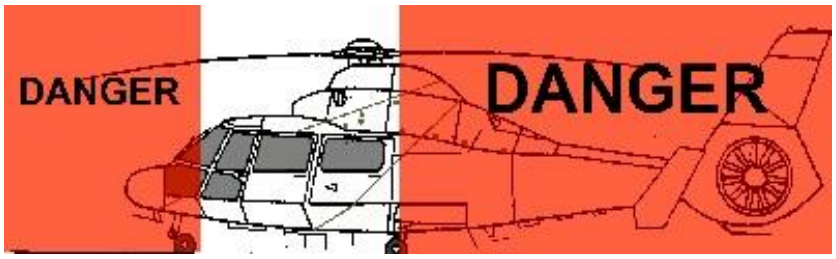
To avoid such possibilities you must know how to avoid and deal with hazards at workplace.

Recognizing and Avoiding Hazards

Thus, the sample list of hazards in maintenance environment (both line, hangar and workshop) could be as follows:

Maintenance	Hazardous object/job	Hazard
Line Maintenance	Propellers/Rotor blades	Propeller/Rotor strike
	Jet engines	Intake suction
		Jet blast at max trust
	Hydraulic systems	Hydraulic fluid squirted into the eye
	Movable surfaces	Caught in/under/between
Base Maintenance	Pneumatic riveting	Loud sound
	Wing or empennage, stairs	Fall from
	Aircraft bathing or painting	Vapor inhalation or ingress of moisture
	Hydraulic systems	Hydraulic fluid squirted into the eye
	Oxygen	Burning while contacting petroleum products
	Movable surfaces	Caught in/under/between
Workshop/Other	Welding	Very bright lights
	Parts bathing/painting	Vapor inhalation or ingress of moisture
	Mechanical processing	Caught in/under/between
	Composite processing	Dust inhalation and skin adsorption

Propeller / Rotor

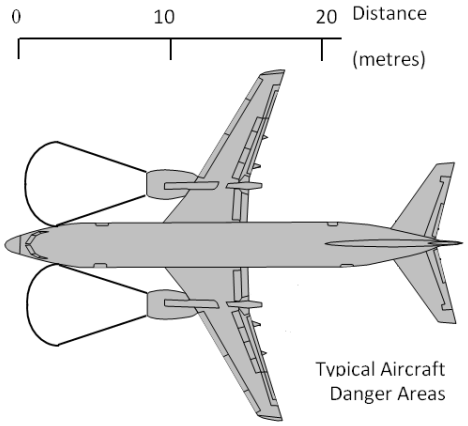


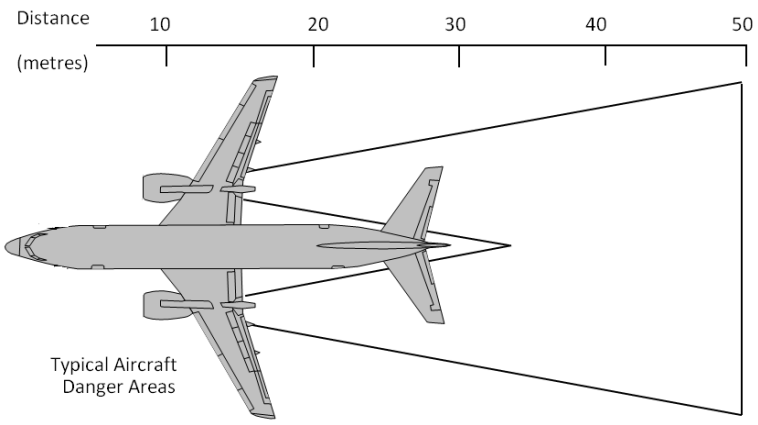
The propellers / rotors are difficult to see while turning especially when being distracted and forget about the danger. Most blades are marked in yellow on the tip but when distracted or being under stress (domestic or work related) you can forget that.

Avoiding hazard:

- Follow rules to correct approach (leave) of propeller aircraft;
- Do not approach from the front wing side;
- Approach to helicopter from the side.

Jet Engines





Working jet engine creates a strong suction in front of engine and jet blast at the rear. The first one can suck into engine and killing yourself if being too close, or suck a foreign object (plier, wrench, etc.) causing a damage and huge financial loses (an engine of a large aircraft can cost up to several million dollars).

Avoiding hazard:

- Do not approach working jet engine straight nearer that approximately 7-8 meters;
- The distance to straight approach to jet engine working at full trust shall be not less that about 50 meters.