MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE

NATIONAL AVIATION UNIVERSITY

AEROSPACE FACULTY

AIRCRAFT CONTINUING AIRWORTHINESS DEPARTMENT

APPROVED

Head of department

__________O.V. Popov

‘___’___________2021

GRADUATION WORK

(EXPLANATORY NOTES)

FOR THE DEGREE OF MASTER

SPECIALTY 272 ‘AVIATION TRANSPORT’

Theme: ‘INFLUENCE OF HUMAN FACTOR ON CONTINUED AIRWORTHINESS SYSTEM EFFICIENCY”

Done by: __________ D.O.Ovcharenko

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Controllers of separate chapters of explanatory notes:

Environment Protection __________ T.V.Sayenko

Labor Protection__________ V.V. Kovalenko

Standard controller________A.M.Hymko

Kyiv 2021

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TASK

for graduation work execution

Ovcharenko D

1. Theme: «Influence of human factor on continued airworthiness system efficiency», approved by order №2676/ст of the Rector of the National Aviation University of 02.11.2020.

2. Duration of which is from 25th of October to 13th of February.

3. Input data for the work: Current regulations on the Human Factor influence prevention; Investigation of areas of Human Error the greatest impact; Research of the role of Human Nature in aircraft maintenance.

4. Content of explanatory notes: Introduction; Chapter 2: The main issues which concern human factor and its influence on aircraft maintenance; Chapter 2: Investigation methodology of human factor influence on aircraft airworthiness;

Chapter 3: Efficiency factors and the methods of its improvement; Chapter 4: Investigation results and the ways of implementation; Chapter 5: Labor protection; Chapter 6: Environment protection; Conclusions.

5. List of mandatory graphic material: tables, figures, charts, graphs.

6. Planned schedule

№	Task	Duration	Signature of supervisor
1.	Validate the rationale of graduate work theme		
2.	Carry out a literature review		
3.	Develop the first chapter of diploma		
4.	Develop the second and third chapter of diploma		
5.	Preparing graphic materials		
6.	Prepare additional chapters: Labor and Environment protection		
7.	Tested for anti-plagiarism and obtaining a review of the diploma		

7. Controllers of separate Chapters

Chapter	Controller	Date,signature	
		Task appointed	Task Received
Labor Protection	V.V. Kovalenko		
Environment Protection	T.V.Sayenko		

7. Date of assignment: ‘____’___________ 2020

Supervisor ______________ V.O.Maksymov

The task took to perform ______________ D.O.Ovcharenko

ABSTRACT

Explanatory notes to qualification work ‘Influence of human factor on continued airworthiness system efficiency” contained:

106 pages, 14 figures, 1 table, 20 references.

HUMAN FACTOR, ERROR, MAINTENANCE, INVESTIGATION, HUMAN NATURE, TRAINING, PERSONNEL, SAFETY

The object of the research – The Influence of Human Factor on the Aircraft Maintenance and Aircraft Continued Airworthiness .

The purpose of the master work – to define the level of influence of Human Nature on the aircraft continued airworthiness efficiency system and to decrease the rate of its influence.

Research Method –in the work to study the process of accidents analysis, different trainings, which consider different errors, made due to the human nature. Research of various documents based on the problem of human factor influence.

The scientific novelty of the research: obtaining new knowledge, identifying new opportunities and creating ways and stages human factor influence decreasing on aircraft continued airworthiness.

INTRODUCTION

Aviation safety depends largely on maintenance. When will it be not done correctly, it contributes a significant share aviation accidents and incidents. Some examples of maintenance errors are incorrectly installed parts and the necessary checks are not performed. in comparison with many other threats to aviation security there may be errors in aviation maintenance technicians (AMT). harder to detect. Often these errors are present but are not visible and have the potential to remain latent, affecting safe operation of aircraft for a longer period of time. AMTs face a set of unique human factors in aviation. They often work in the evenings or early in the morning, in confined spaces, on platforms that are at a high level and in various adverse temperatures / humidity conditions. Work can be physically stressful, but also requires attention to detail.

By nature of maintenance tasks, AMT usually spend more time to prepare for the task than to actually perform it. Right documentation of all maintenance work is a key element, and AMTs usually spend the same amount of time updating maintenance logs of how they do the job.

Awareness of human factors can lead to improved quality, an an environment that ensures the continuous operation of workers and aircraft security and a more involved and responsible workforce. Sea in particular, it can reduce even minor errors measurable benefits, including reduced costs, fewer missed deadlines, reduced occupational injuries, reduced warranty claims and reduction of more significant events that can be traced to a maintenance error. In this chapter many aspects of the human factor are discussed in connection with aviation maintenance. The most common human factors are introduced along with ways to mitigate the risk of ending them from growing into a problem

What is the human factor The term human factor is becoming more and more popular as well The commercial aviation industry realizes that human error is faster than mechanical failure, underlies most aviation accidents and incidents. Science or technology of the human factor multidisciplinary areas, including contributions from psychology, engineering, industrial design, statistics, operations research and anthropometry. This is the term that covers the science of understanding human properties opportunities, application of this understanding to design, development and deployment of systems and services, and the art of ensuring the successful application of the human factor principles in the work environment.

A list of human factors that can affect aviation maintenance and productivity is wide. They cover a wide range problems that affect people very differently than people not everyone has the same opportunities, strengths and weaknesses, or restrictions. Unfortunately, aviation maintenance puts it do not take into account the huge number of human limitations lead to technical errors and injuries. There are some human factors that affect AMT. Some are more serious than others, but in most cases when you combine three or four of the factors they create are a problem that contributes accident or incident.

Elements of the human factor

The human factor consists of many disciplines. This section discusses ten of these disciplines: Clinical psychology, experimental psychology, anthropometry, Computer science, cognitive science, safety, Medical science, organizational psychology, education Psychology and industrial engineering.

The study and application of the human factor is comprehensive because there is only one simple answer to fix or change how people are affected by certain conditions or situations. Research of the human factor of aviation service has the overall goal of identifying and optimizing the factors that affect human productivity during maintenance and inspection. Focuses on technology, but extends to the whole engineering organization. Research is available optimized by including many influencing disciplines human factor and helps to understand how people can work more efficient and maintain productivity. Understanding each of the disciplines and applying them to different situations or human behavior, we can right identify potential human factors and eliminate them earlier they grow into a problem or create a chain of problems which lead to an accident or incident

With the beginning of the First World War (1914–1918) others complex equipment was developed and the inability of staff to use such systems has led to an increase interest in human capabilities. So far in the spotlight aviation psychology was on the pilot, but over time, the focus shifted to the plane. Of particular concern was the design of controls and displays, effects altitude and environmental factors per pilot. War also necessitated aeromedical research and the need for tests and measurement methods.

Another significant development was in the civil sector, where there was an impact of lighting on the productivity of workers examined. This led to the identification of Hawthorne An effect that suggested motivating factors could significantly affect a person's ability to work.

With the beginning of the Second World War (1939-1945) it was it is becoming increasingly difficult to select people for previous work. Now I had to design the equipment take into account human limitations and enjoy human preferences opportunities. This change took time, because there were many of them research to be conducted to determine human capabilities and limitations that had to be achieved. An example of this This is a 1947 study by Fitts and Jones, who studied the most efficient configuration of the control knobs in which it will be used flight decks of aircraft. Much of this research has gone to other equipment for the manufacture of controls and displays that are easier for operators to use.

In the first 20 years after World War II, most human factors research was conducted by Alphonse Chapanis, Paul Fitts and Arnold Small. The beginning of the Cold War led to the Great expanding research with the support of the Ministry of Defense laboratories and many laboratories established during the war began to expand. Most post-war research was funded by the military and provided large sums of money universities for research. The scope of the study also expanded from small equipment to entire workstations and systems. In the civil industry, the emphasis has shifted from research to participate through advice to engineers in equipment design.

Workplace practice evolves over time, thanks to experience and often influenced by a certain workplace culture. These practices can be both good and bad, safe and dangerous; they are called "the way we do things here" and become the Norms. Unfortunately, this practice follows unwritten rules or behaviors that deviate from the necessary rules, procedures, and instructions. These Standards can then be applied through peer pressure and the power of habit. It is important to understand that most Standards have not been designed to meet all circumstances and have therefore not been properly tested against potential threats. Rules and procedures had to be developed and tested, and therefore should be followed and strictly followed. If employees feel pressured to reject or circumvent the procedure, this information should be returned so that the procedure can be reviewed and changed if necessary. Developing perseverance can allow employees to express concerns about dangerous standards, despite peer pressure.

CONTENTS

LIST OF CONDITIONAL TERMS AND ABBREVIATIONS

AMI	Aircraft Maintenance Information-Task
AMO	Airworthiness Management Organizations
ANAP	Aviation Noise Abatement Policy
ASRS	Aviation Safety Reporting System
ATM	Air Traffic Management
CAS	Continuous Analysis and Surveillance
CIT	Continuous Improvement Teams
CMAQ	Cockpit Management Attitudes Questionnaire
CRM	Crew Resource Management
ERC	Error reduction conditions
FAA	Federal Aviation Agency
GOM	Ground Operations Manual
H.E.A.R.	Human Error and Accident Reduction
HF	Human Factor
IFSP	In-flight Stop Performance
MEDA	Maintenance Error Decision Aid
PSF	Productivity Factors
QF	Quality Factor
SARPs	Standards and recommended practices
SHEM	Safety, Health and Environmental Management

SOJT	Structured On-the-Job Training
TATS	Task Analytic Training System
TOQ	Technical Operations Questionnaire

CHAPTER 1

THE MAIN ISSUES WHICH CONCERN HUMAN FACTOR AND ITS INFLUENCE ON AIRCRAFT MAINTENANCE

1.1. Human factor Consideration necessity

Why Does “Human Factors” Matter?

The FAA defines the human factor as a multidisciplinary effort to create and gather information about human capabilities and to restrict and use that information to ensure safe, comfortable, and efficient human work. In air traffic management (ATM), where safety, efficiency and continuity are critical elements in virtually any field of knowledge, people are often both the greatest asset and the greatest source of risk. A study on the human factor showed that the top 5 ATM security risks are almost always “human error”. As airspace and ATM systems become more complex, analyzing and optimizing human components becomes more and more important.

The people involved in AM are the ultimate solution providers, in ATM, system development and integration, maintenance or a whole host of other important roles. Analyzing the human factors in this way can improve overall performance, reduce technical risk in system acquisitions, lower the life cycle costs of systems and devices, improve human influence on the system, contribute to economic decisions in controller training, and provide other benefits. In terms of system performance, RF analysis examines and optimizes human-computer interaction and simple hardware and software usage. By studying the users of the systems, researchers will receive a better understanding of the skills and abilities required, how to develop more effective trainings procedures, and how to address the risks connected with fatigue. HF also examines the work environment and finds ways to optimize operating conditions, organizational structures and procedures, device configurations and other environmental aspects.

Aircraft maintenance is an essential part of the aviation system that supports the global aviation industry. The air traffic grows and the correct requirements of commercial flight schedules place increased demands on aircraft usage, the pressure on on-time maintenance operations performance will continue to increase. This will open further opportunity windows for human errors and successive failures in the system's safety net. That is a fact that human error in aircraft maintenance has been not a causal factor in several airline accidents. There is also no question that if the aviation industry does not make conclusions from these events and preventing procedures to avoid next similar situations, maintenance-related safety failures will continue to occur. From a Human Factors perspective, essential truths have been uncovered during the occurrence investigation.

Throughout the digest and in accordance with the Human Factors Digests of ICAO series, both the SHEL and Reason models are presented and referenced repeatedly to introduce the relevance of human factors to flight safety and effectiveness. Information about aircraft accidents in which maintenance errors are found is included to illustrate the problems encountered. The digest demonstrates the importance of the exchange of information, the share of maintenance work experience for the operators and the resulting safety benefits receiving.

The need to follow the established maintenance procedures by all supporters is emphasized and all the negative issues of non-compliance are explained by using practical examples. New and improved training methods for aircraft maintenance personnel are completely discussed and potential benefits are considered.

1.2. Contemporary Maintenance Problems

There is no question that human error in aircraft maintenance and inspection has been a factitive factor in several recent airline accidents. Whenever humans are involved in an activity, human error is the series of actions. According to some sources, the number of maintenance-related accidents and incidents involving public transport aircraft has increased essentially. This source defines maintenance issues as a problem that is not necessarily a maintenance failure (it may be a design flaw) but one that is significant which relates to the maintenance staff as frontline managers for technical problems in day-to-day operations. This source also states that there were 17 maintenance-related accidents and incidents in the first half of the 1980s in which only aircraft operated by western operators were involved and all "routine" technical failures (engine, landing gear, systems, structure, components, Ramp accidents, etc.) were excluded.

All these accidents and incidents had serious consequences (death, serious hazard, significant previous occurrences, essential airworthiness implications, etc). In the second half of the 1980s, the same source has published about 28 accidents of maintenance attitude, an increase of 65% over the first half of the decade. In the same period, traffic activities (flight departures, scheduled and non-scheduled) increased by 22%. During the first three years of the 1990s there were 25 accidents connected with maintenance issues.

Whether maintenance-relevant phenomena are a “new” phenomenon in aviation or whether they have always existed but have only recently been statistically validated and may be a matter of dispute. Indeed, awareness of the flight safety maintenance importance may to be the logical consequence of the gradual acceptance of broader, flight safety systemic approaches. Despite the all preventing procedures, the increase in the accident and incident rate still seems to be at least statistically significant. Over the past decade, the annual average has increased by more than 100% while the number of flights has increased by less than 55%.

Traditionally, human factors efforts have focused on flight crew performance and, to a lesser extent, on air traffic control performance. Until recently, the available literature showed some notices of human factors that could affect aircraft maintenance personnel who inspect and repair aircraft. This was a great oversight, as it is understandable that human error in aircraft maintenance actually has indeed had as negative impact on the safety of flight operations as the mistakes of pilots and air traffic controllers.

Aircraft maintenance and inspection service can be very complex and diverse in an environment where opportunities for errors exceed the certain level of permissibility. Maintenance staff frequently work under considerable time pressures. Personnel at the maintenance base and at the flight line stations realize the importance of performing all the necessary procedures during certain period of time. Operators have increased aircraft use in order to counteract the economic issues that plague the industry. Aircraft maintenance technicial staff are also maintaining a fleet that is increasing in age.

1.3. Human Factors in Aircraft Maintenance and Inspection

1.3.1. Perception of information

Procedure of operator while dealing with the machine (Fig 1) starts from receiving information about the performed object. Basic psycho processes which take part in receiving the information are perception, feeling, imagination and thinking.

Receiving the information by human-operator should be analyzed as the process of forming perceptive (feeling) mode. It is represented as subjective reflection in human consciousness such parameters as properties of acting object.

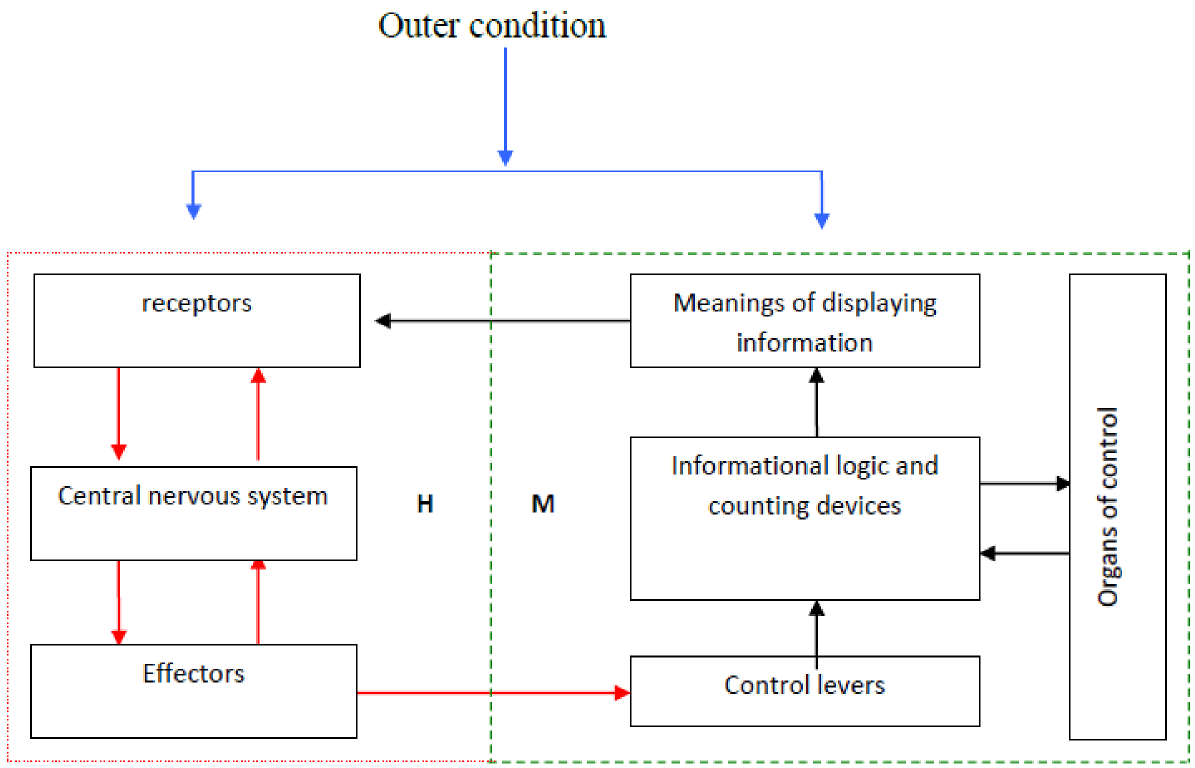

Figure 1. Structural scheme of system “human-machine”

Forming of perceptive mode is phase process. It includes several stages: detecting, differentiation and recognition.

Detecting – stage of perception at which the viewer highlight the object from the background but still can’t judge about its shape, symptoms and state.

Differentiation – stage of perception at which the viewer is able to percept 2 objects separately, located together (or 2 states of one object), highlight details of objects.

Recognition – stage of perception at which the viewer notice significant symptoms of object and classify it.

Duration of such phases depends on difficultness of perceptive signal. Knowing sequence of defining symptoms of signal and dynamic of forming its mode is very important for solution of such engineer- psychological tasks as choosing the optimal sketches of signs, defining number of lines on the monitor, rate of transferring signals and change of pictures in projector systems of displaying etc.

Great importance while plotting perceptive mode takes place imagination (secondary mode), based during forming process. Procedure of perception is simultaneously comparison of forming mode with example which is already saved in memory.

1.3.2. Human analyzers

Physiological base for forming perceptive mode is work of analyzers.

Analyzers are nervous devices using which the person operate analysis of irritations acting on him.

Any analyzer consists of 3 main parts: receptor, transfer nervous pathways and centre in the brain core.

Basic function of analyzer is transforming the energy of acting irritator into nervous process. Entrance of receptor is used for receiving signals of definite type – light, sound etc. Thus its outer part sends signals which are the same for any entrance of nervous system. These impulses, when reach brain core, are under definite analysis and then go back to receptors.

Depending upon type of signal analyzers can be classified as:

- Visual
- Hearing
- Vibrissa
- Taste
- Olfactory
- Kinesthetical
- Vestibular
- Thermal

Basic characteristic of any analyzer is limit of its perception – absolute (upper and lower), differential and operative.

Minimal quantity of irritator, which causes the minimum feeling is called lower absolute boundary perception and maximal allowable quantity – upper absolute boundary perception.

Interval between upper and lower boundaries is called spectrum of perception of analyzer.

For characterizing difference of uniform signals meaning differential limit is used, which means minimal definition between two irritators or between two stages of one irritator, which causes the minimum difference in perceptions.

Experimentally defined, that quantity of differential limit is proportional to the initial quantity of irritator:

$$\frac{dJ}{J} = k = const, \tag{1.1}$$

where J – initial quantity of signal (irritator);

dJ – quantity of differential limit;

k – constant, =0,01 for visual analyzer, 0,1 for hearing and 0,3 for vibrissa;

Due to this equation (1.1) we can receive dependence between quantity of signal and quantity of feeling caused by it:

$$S = k\,ln\,J + C, \tag{1.2}$$

where S – quantity of feeling;

k and C – constants.

Dependence (1.2) is named as basic psychophysical law or Weber-Fechner’s law. According to this law intensity of perception is linear dependence to the logarithm of irritator force.

Vision

Special role in human life and its relation with outer world vision plays – the most important physiological process. Vision allows to percept shape, color, brightness and movement of objects, distance to them. Mostly 90% of all information human-operator receives through vision.

Human eye works by photo cam principle, where eye-lens plays the role of lens. Sunlight passing through the lens brakes and create minimized reversible picture on inner wall of eye (retina). There are light preceptors on retina which are called rods and cones. Each eye contains 130 million rods and 7 million cones. Cones are located in central part of retina – in front of centre of apple eye (yellow spot). From each cone and group of rods (approximately 100 rods) leads thin nervous fiber which connects them with visual centre in back part of brain’s core.

Functions of cones and rods differ too much. Firstly, cones are able to percept irritation only during high brightness of the object and therefore are the objects of “day vision”, while rods react on weak brightness and provide “night” (twilight) vision. Secondly, cone type vision is central, very sharp, giving the opportunity to define details; vision, provided by rods is peripheral, helps to orientate in space. By the way perception of colors is performed through the cone apparatus only.

Abilities of visual perception are defined by different characteristics:

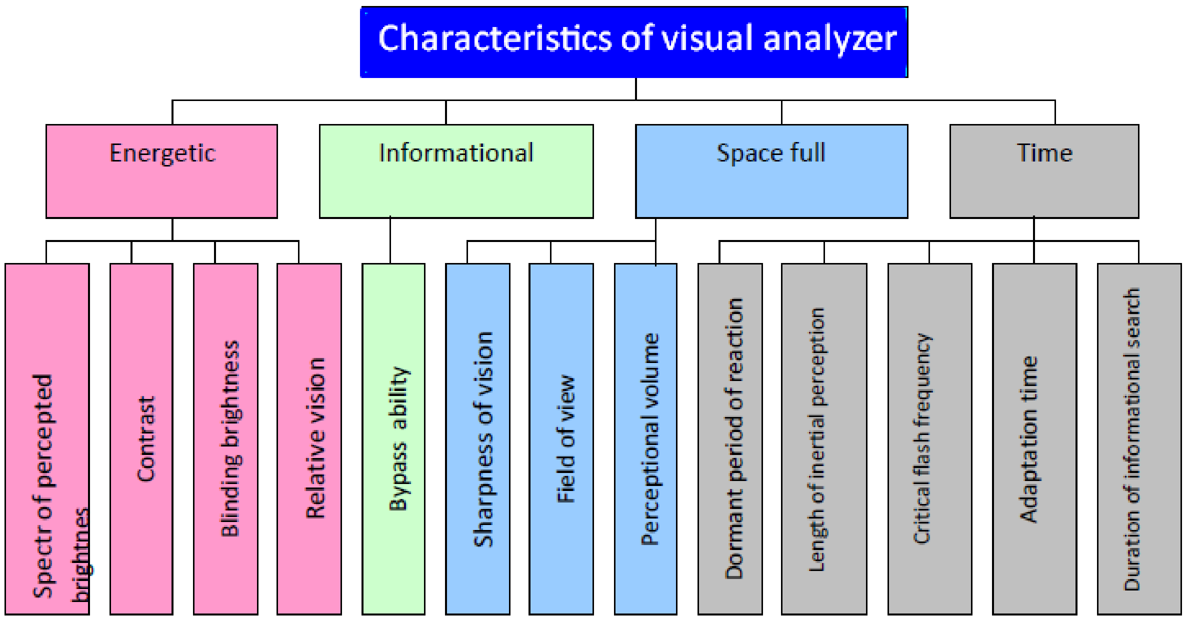

Figure 2. Characteristics of Visual Analyzer

where J – light force, light stream produced on unit of bode angle;

S – area of shining surface;

α- angle under which the surface is observed

The unit of brightness is candela measured on 1 m² (cd/m²) or nit(nt)

In general case brightness of object is defined by two components – brightness of radiation and brightness according to outer shine (brightness of reflection).

$$\boldsymbol{B} = B_{изл.} + B_{отр.} \qquad (1.3)$$

Brightness of radiation is measured by power of the source of light and its efficiency.

$B_{отр}$ – is determined by level of enlightenment of given surface and its efficiency properties.

$$B_{отр.} = \frac{E\rho}{\pi}, \qquad (1.4)$$

Where E – lightness of the surface;

ρ – coefficient of reflection of the surface.

Reflector coefficient generally is defined by color of surface, it shows what part of falling on the surface light stream is reflected by it.

Hearing

In the control systems of the information supplied to the person in the form of audio signals. As the crew of a radio with ATS, between members of the crew (SPU), receiving a sound signal on the operation of systems and units of aircraft receive emergency messages from the RI-65, etc.

The perception of the sound energy is carried out by the auditory analyzer. Human auditory analyzer captures the waveform, frequency spectrum, provides analysis and synthesis within a certain range of sound stimuli, detects and identifies sounds in a wide range of intensities and frequencies.

Auditory analyzer allows to differentiate the sound stimuli and to determine the direction of the sound source and its distance from the source.

Hearing aid of man perceives audible sound - vibrations with a frequency of 16 Hz ... 20 kHz. The ear is most sensitive to fluctuations in the medium frequency

(1 ... 4 kHz).

The main parameters of the sound waves are: intensity, frequency and form, which are reflected in the auditory sensations, such as volume, pitch, timbre. Sound intensity is measured by sound pressure, measured in (W/m2).

The range of pressures felt by the ear, is very wide from 10-12 to 100 W/m2. To characterize the variables that determine the perception of sound, the essential is not so much the absolute values of sound intensity and sound pressure, as their relationship to the threshold values (I0 = 10 -12 W/m2 and P0 = 2 10-5 Pa).

Information processing by human

Before a person can respond to received information, he must firstly understand it. Therein lies the possibility of error because the range of functioning sensory systems is extremely narrow. From the senses the information goes to the brain, where it is processed, resulting in an opinion on the nature and value of the received message. Such activity, known as the assimilation of information is a favorable environment for the occurrence of errors. Expectation, experience, attitude, motivation and impulse − all of these concepts have an influence on the uptake and, possibly, on the sources of error.

Once, after the conclusions are drawn regarding to the content of incoming message, the process of decision making starts. To the wrong decision can lead many factors, such as particular training or previous experience, emotion or character of the business considerations, fatigue, medication effects, motivation, and physical or psychological disorders.

For the decision should be an action (inaction). This is another, and error-prone step, because if the equipment is designed so that it cannot function properly, an error will occur sooner or later. Once the action has taken place, begins to operate a feedback mechanism. The disadvantages of this mechanism can also lead to errors.

In addition, many operators intend to keep some of these aircraft in service in the predictable future, perhaps beyond the turn of the century. Engine hush kits will make some older narrow-body aircraft economically and environmentally viable. However, these aircraft are maintenance-intensive. The old airframes require careful inspection for signs of fatigue, corrosion and general deterioration. This places an increased burden on the maintenance workforce. It creates stressful work situations, particularly for those engaged in inspection tasks, because additional maintenance is required and because the consequences may be serious if the signs of aging, which are frequently subtle, remain undetected.

While maintenance of these aging aircraft is ongoing, new technology aircraft are entering the fleets of many of the world's airlines, thus increasing the demands on aircraft maintenance. These new aircraft embody advanced technology such as composite material structures, “glass cockpits”, highly automated systems and builtin diagnostic and test equipment.

The need to service new and old fleets requires aircraft maintenance technicians to be more objective and experienced in their work than they could have been before. The tasks, together with the maintenance of various air transport fleets, require a highly skilled workforce with appropriate education. Nowadays, awareness of the importance of the human factor in the maintenance and specification of aircraft.

The safety and efficiency of the airline's operations is also increasingly linked to the work of the people who inspect and service the fleet. One of the purposes of this digest is to highlight the human factor issues that are important for aviation safety.

To facilitate a better understanding of the issue, two models,1 widely used by ICAO to allow an organized, systemic approach to the comprehension of the Human Factors issues involved, will be discussed before progressing to the specific Human Factors issues involved in aircraft maintenance and inspection.

1.4. The most important Models for Human Factor understanding

1.4.1. SHEL Model

The SHEL Model was first proposed by Professor Alvin Edwards in 1972, and a modified diagram to illustrate the model was later developed by Captain Frank Hawkins in 1975. Its components are: software, hardware, environment, live programs) and are depicted with a clear impression of the need to match the components. The following interpretations are offered: living means (human), hardware (machine), software (procedures, symbols, etc.) and environment (conditions in which the L-H-S system must function).

This block diagram does not cover interfaces which are outside Human Factors (e.g. between hardware-hardware; hardware-environment; software-hardware) and is intended only as an aid for understanding Human Factors.

Liveware. In the centre of the SHEL model are the humans at the front line of operations. Although humans are remarkably adaptable, they are subject to considerable variations in performance. Humans are not standardized to the same degree as hardware, so the edges of this block are not simple and straight. Humans do not interface perfectly with the various components of the world in which they work. To avoid tensions that may compromise human performance, the effects of irregularities at the interfaces between the various SHEL blocks and the central Liveware block must be understood. The other components of the system must be carefully matched to humans if stresses in the system are to be avoided.The SHELL model is useful in visualizing the following interfaces between the various components of the aviation system:

Liveware-Hardware (L-H). The L-H interface refers to the relationship between the human and the physical attributes of equipment, machines and facilities. The interface between the human and technology is commonly considered with reference to human performance in the context of aviation operations and there is a natural human tendency to adapt to L-H mismatches. Nonetheless, this tendency has the potential to mask serious deficiencies, which may only become evident after an occurrence.

Liveware-Software (L-S). The L-S interface is the relationship between the human and the supporting systems found in the workplace, e.g. regulations, manuals, checklists, publications, standard operating procedures (SOPs) and computer software. It includes such issues as recency of experience, accuracy, format and presentation, vocabulary, clarity and symbology.

Liveware-Liveware (L-L). The L-L interface is the relationship among persons in the work environment. Since flight crews, air traffic controllers, aircraft maintenance engineers and other operational personnel function in groups, it is important to recognize that communication and inter-personal skills, as well as group dynamics play a role in determining human performance. The advent of crew resource management (CRM) and its extension to air traffic services (ATS) and maintenance operations has created a focus on the management of operational errors across multiple aviation domains. Staff/management relationships as well as overall organizational culture are also within the scope of this interface.

Liveware-Environment (L-E). This interface involves the relationship between the human and both the internal and external environments. The internal workplace environment includes such physical considerations as temperature, ambient light, noise, vibration and air quality. The external environment includes operational aspects such as weather factors, aviation infrastructure and terrain. This interface also involves the relationship between the human internal environment and its external environment. Psychological and physiological forces, including illness, fatigue, financial uncertainties, and relationship and career concerns, can be either induced by the L-E interaction or originate from external secondary sources. The aviation work environment includes disturbances to normal biological rhythms and sleep patterns. Additional environmental aspects may be related to organizational attributes that may affect decision making processes and create pressures to develop ―work-arounds‖ or minor deviations from standard operating procedures.

According to the SHELL Model, a mismatch between the Liveware and other four components contributes to human error. Thus, these interactions must be assessed and considered in all sectors of the aviation system.

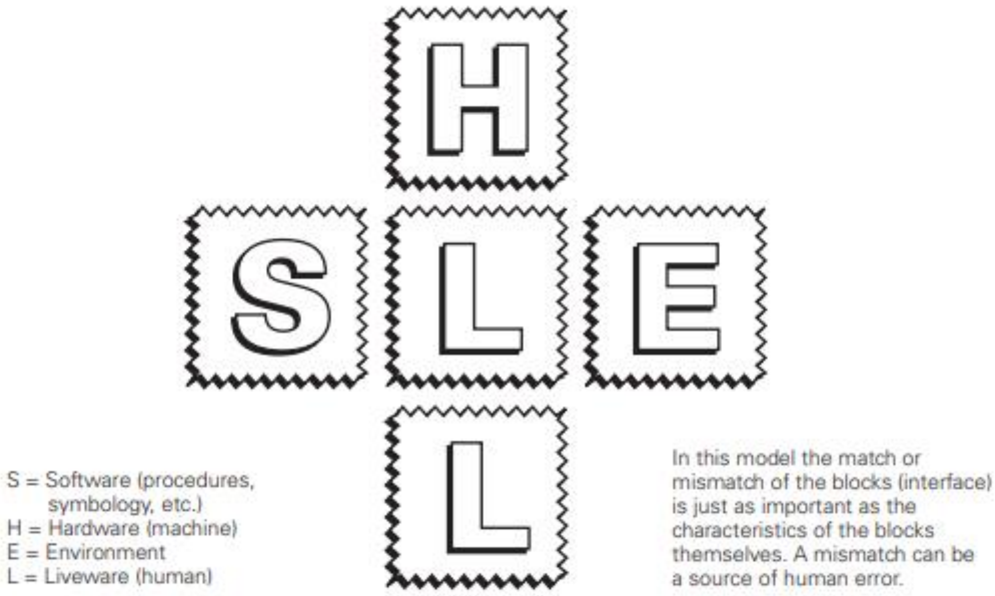

Figure 3. The SHEL Model

1.4.2. The Reason Model

Rison considers the aviation industry as a complex production system. One of the main elements of the system is the decision-makers (senior management, corporate or regulatory body) who are responsible for setting goals and managing available resources to achieve and balance two different goals: safety goals and the goal of timely and cost-effective passenger transportation; cargo. The second key element is line management - those who implement the decisions made by senior management. In order for the decisions of senior management and the actions of line management to lead to efficient and productive activities of the involved workforce, there must be certain prerequisites. For example, equipment must be accessible and reliable, the workforce must be skilled, knowledgeable and motivated, and the environment must be safe. The latter element, protection or precautions, is usually in place to prevent suspected injury, damage, or costly interruptions.

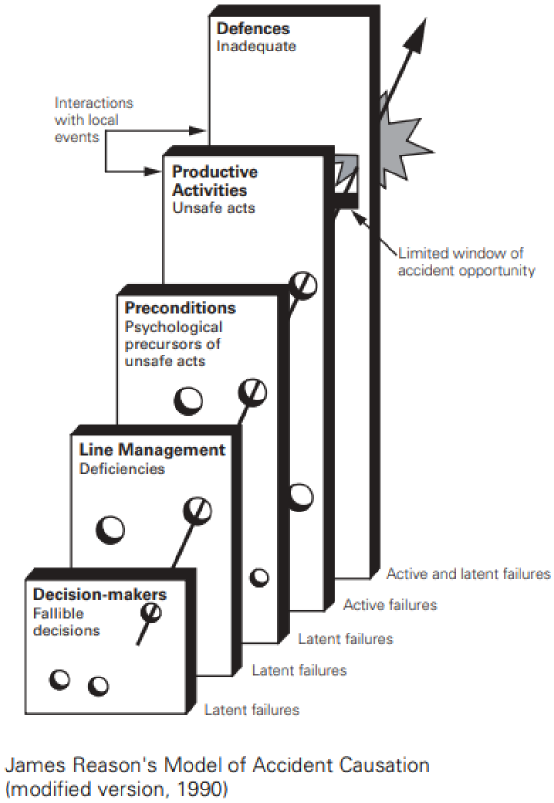

Figure 4. The Reason Model

The Reason model shows how humans contribute to the destruction of complex, interactive, and well-guarded systems, such as commercial aircraft, for an accident. In the aviation context, "well guarded" means strict rules, high standards, inspection procedures and sophisticated monitoring equipment.

Professor Reason considers the aviation industry as a complex production system. One of the main elements of this system consists of decision makers who are responsible for setting goals and managing available resources to achieve and balance for clearly defined goals: security and timely and efficient transportation of passengers and cargo. Another key element is linear leadership - individuals who implement decisions made by the highest echelon of leadership. To make the decision of the upper echelon and the action linear leaderships have been embodied in effective and productive activities appropriate labor force, certain preconditions must be met. For example, equipment must be available and reliable, employees - qualified, knowledgeable and interested, working conditions - safe. The final element - various types of labor protection or precautions - usually designed to prevent suspected injuries. Rison's model explains how people contribute to the disorder performance of complex, interoperable and well-protected systems, resulting in an aviation event occurs. In the aviation context, the definitions of "well protected" refers to the application of strict rules, high standards, procedures inspections and the presence of a complex and perfect control equipment.

Thanks to technical progress and reliable measures to protect the causes events are rarely purely erroneous actions by operating personnel or failure of basic equipment. On the contrary, they are the result of the interconnected the impact of a number of failures and defects already present in this system. Many of these failures are not always easy to detect, and their consequences may not be manifested at once.

Failures can be of two types depending on the time of manifestation of their consequences. An active failure is an error or violation that immediately leads to negative consequences. A covert refusal is the result of a decision or action that was made long before the event and the consequences of which may not manifest themselves for a long time.

Such failures usually occur at the levels of decision-makers, regulators or line managers; that is, with people far in time and space from the event. The decision to merge two companies without training to standardize aircraft maintenance and flight procedures illustrates a hidden type of failure. These failures can also be caused by a person's condition at any level of the system, for example, due to poor motivation or fatigue.

Due to technical progress and excellent protection, accidents rarely occur solely due to errors of operational personnel (operators on the front line) or as a result of serious equipment failures. Instead, they are the result of the interaction of a series of failures or shortcomings that are already present in the system. Many of these failures are not immediately apparent, and they have delayed consequences.

Schemes for classifying human errors have been described as behavioral, contextual, or conceptual in nature (Reason, 1990). Behavioral classifications describe human errors in terms of easily observable surface features. Behavioral classifications divide human errors by such dimensions as their formal characteristics (omission, commission, extraneous) (e.g., Swain and Guttman, 1983), immediate consequences (nature and degree of injury or damage), observability of consequences (active / immediate against hidden / deferred) (Reason and Maddox, 1995), the degree of recovery and the responsible party. Or classifications do not provide a reflection of surface characteristics on causal mechanisms. Contextual classifications begin to consider the cause-and-effect relationship, linking human error with the characteristics of the environment and the context of the task. These classification systems are valuable because they emphasize the complex interactions between system components, including human operators, and tend to lead to greater data collection on the circumstances of incidents and accidents. relationships. In addition, these correlation classifications alone cannot explain why such environmental circumstances do not lead to deterministic repetitive errors (Reason, 1990).

1.5 CONCLUSIONS TO CHAPTER 1

A HF analysis provides an understanding of the human error impact on the situation and ultimately contributes to the development of more comprehensive and effective mitigation/ corrective actions. A human error model is the basis of the analysis process and it defines the relationship between performance and errors and categorizes errors to permit the root hazards to be more readily identified and better understood. This understanding ensures the adequate completion of a root cause analysis. Individual actions and decisions, viewed out of context can appear to be virtually random events, escaping its due attention. Human behavior; is not necessarily random. It usually conforms to some pattern and can be analysed and properly understood. Ultimately, this important HF perspective results in a more comprehensive and in-depth mitigation process. Human factor analysis ensures that the organization‘s risk mitigation process, when identifying root, contributory or escalation factors, that human factors and their associated circumstantial, supervisory and organizational impacts are duly taken into consideration.

CHAPTER 2

INVESTIGATION METHODOLOGY OF HUMAN FACTOR INFLUENCE ON AIRCRAFT AIRWORTHINESS

2.1. The analysis of Human Factor influence areas and the main reasons of it arrising

Workings processes, depending on operating conditions, loads, and the external environment affect therate of change of the technical condition of Aviation technology, which are turn necessitates of a maintenance process to one or another intensity. Consequently, the technical condition of the aircraft maintenance changes in the performance of business functions and recovery.

The set of recovery operations and the organization of their conducts, is the one of basic directions optimization of management the state of technical devices.

The problem of optimizing the management of the technical state of objects of exploitation can be put both in a wide and in narrow plan.

A chart and design of the device, modes of exploitation, control system, level of reliability, is optimized in first case, the methods of maintenance and so on, which is characteristic for facilities designed of aviation equipment.

For serial wares the second case is characteristic, when for the set structural chart and reliability of stuff elements it is necessary to choose the most rational program, providing high quality of maintenance wares of aviation equipment.

The basic requirement, produced to the system of maintenance in general, consists of that, to provide the greatest value of the coefficient of technical use of aircraft with limited labor costs, time and money to maintain the airworthiness of aircraft maintenance.

As applied to transport aircraft in civil aviation operational and periodic types of maintenance form a complexplanning of preventive measures, through which are provided the serviceability of fleet, flight safety and regularity, and consequently the effectiveness of their use.

With the growth of design complexity significantly increases the volumes of maintenance, control of parameters has difficulty from their variety, the process of discovery and removal of nascent refuses becomes complicated, probability of appearance of refuses is increased in connection with the leadthrough of difficult labourintensive forms of maintenance.

Technical personnel is part of ergatic system, which should be taken into account when developing the general concept of aviation equipment of maintenance.The joint study of the structural properties of the objects of exploitation and the quality of maintenance supports the development and creation of optimal programs maintenance.

An auxiliary technical personnel often works at the considerable deficit of time, in connection with the increase of intensity of the use of aircraft, by the necessity of maintenance of park of senescent aircraft, which require careful control of the state in the presence of signs of fatigue, corrosion and general wear of elements of construction, that lies down an additional burden on an auxiliary technical personnel and creates stress production situations. At the same time, the park of many airline companies of the world is filled up of aircrafts of new generation, which embodies the modern technological advances, such as: power elements from composite materials,"transparent cockpit", highly automatedsystem, built-in diagnostic and testing equipment.The need to serve both new and old fleet of aircraft requires professionals to perform the maintenance, more vast knowledges and greater ability.The problem of simultaneous maintenance of such a heterogeneous fleet needs a highly skilled workforce with the proper level of of general training.

Information, which is related to the psychological aspects of organizations, confirms that organizations can prevent accidents and contribute to theiremergence. Very often,when developing the measures of prevention accidents in the aviation industry does not take into account the fact that human error occurs in a specific organizational conditions which help or prevent its occurrence.

2.1.2 Factors, which define the quality of maintenance

Safety flights are impacts on the level of organization and providing of flights, quality and completeness of instructions, manuals, regulations and technology of maintenance Aviation technology, degree of automation and mechanization of technical operation.

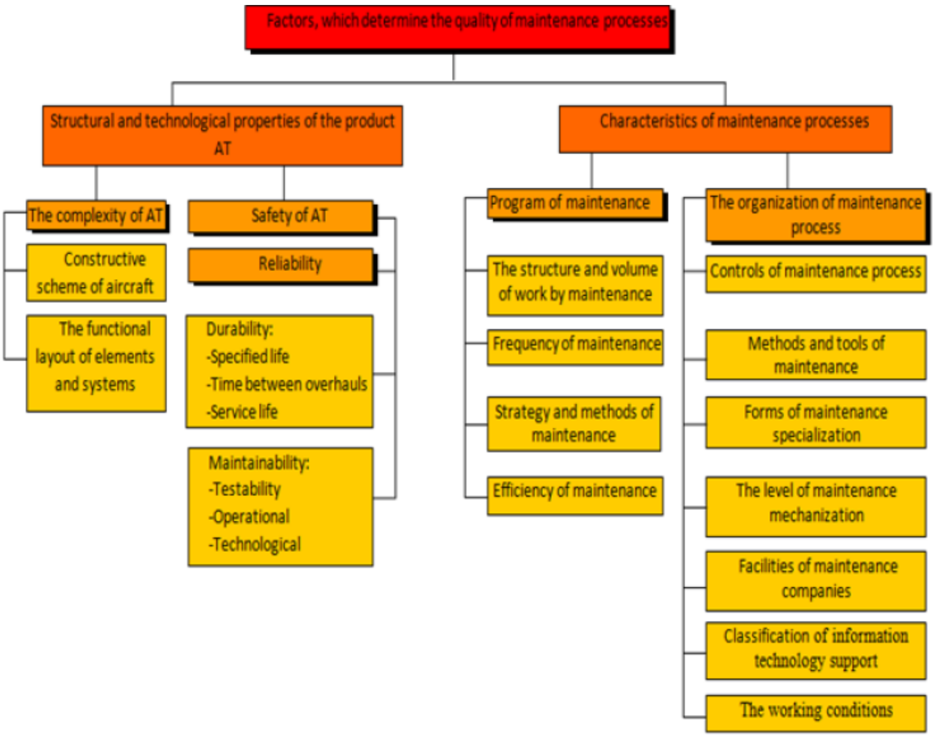

Figure 5. Different Factors, hat make an impact on Maintenance

Development and implementation methods of maintenance show that the practical implementation of progressive methods, in particular of maintenance "as" leads to a sharp increase in the volume of information. The source of such information is the statistics about the results of operation and control of the aircraft equipment.

Control functions and diagnostics of vehicle products of aircraft equipment are not limited to thepresent, only the control parameters of the products and their analysis,but should also include elements of active control of the process of operation of AT, the issuance of corrective actions, provide for the systematization of information, etc.

Thus methods of monitoring and diagnostics of aircrafts should be directed atpreventing all kinds of losses during the operation, which helps to reducemistakes in work ofInformation technology support, greater stability of technological processes of naintenance, increase productivity, work quality and reliability of the aircraft equipment. Great influence on the number of errors of technical personnel have their degree of training, working and living conditions, organization andscheduling of production processes, the degree of skill, level of management,and etc.

In cases where a person feels personally responsible, understands the danger of the situation, the number of random errors is reduced. Thus, the study of errors of performers and develop specific recommendations of staff serving the product of the aircraft equipment, help to ensure the required reliability ofcomplex aircraft ergatic systems.

By the fundamental characteristics of man as an element ergaticsystemare adapted to conditions of work, personality, sensitivity to emotionalinfluences, the ability to fatigue and rest, the possibility of errors, etc.

Safety is of the complex characteristic by which one can judge the reliability of the aircraft equipment of the, as a control efficiency of operation of aircraft,personnel qualifications and maturity, as well as on the state of discipline and order in the general aviation enterprises.

Stress is a non-specific reaction in response to what any negative impact. In accordance with the concept of Hans Selye, there is some"normal"or "optimal" state of the organism, and stressors (stimuli or situations that cause a human operator the state of stress) contribute tothis deviation from the normal state. Usually, stress is an attempt of the organism or to adapt to new conditions or to eliminate them and get back to normal as soon as possible.

The following types of stress:

1. Household stresses arise in a person's life (divorce or death of a relative).

2. Stress due to environmental influences associated with specific activitiesof people and occur most often as a result of factors such as temperature, noise, humidity, light and vibration.

Information related of stress, psychological and emotional peculiarities of the job with the decision.

Yorkesa Dodson Law (Fig.6) which defines the relationship between the level of health of people depending on the degree ofexcitation and at a time when any increase in the excitation affects thesolution of the problem.

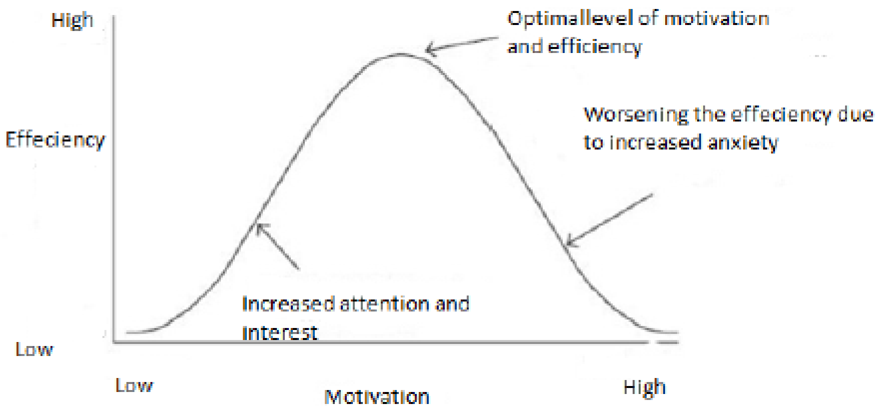

Figure 6. Dependency graph of Efficiency of Maintenance performance and Motivation

The chart of maintenance of aircraft is reflected by a delicate compromise between the desire to get the maximum number of flight hours, profitable, and the need to perform the required of maintenance. It is clear that sometimes, especially in those cases when not all goes according to the plan, and it happens quite often, short of time leads to a compromise are not in favor of maintenance.

Functions of the airworthiness maintenance department of aircraft of complex design:

- participation in the development and improvement of aviation rules, other normative documents on the issues of approval of airworthiness management organizations (AMO) and supervision of airworthiness maintenance of aircraft of complex design.

- organization and carrying out of works on approval and supervision of organizations with CAO (Continuing Airworthiness Organisations) of aircraft of complex design, according to Subpart G Part-M - approval of the management staff of organizations with CAO

- preparation and conduct of scheduled and unscheduled inspections, including outside Ukraine

- maintaining a database on the airworthiness of aircraft of complex design, inspections of organizations with CAO in the information system of the State Aviation Service of Ukraine

- consideration of the CAO Manual

- consideration of the Program of maintenance of aircraft of complex design

- inspection of airplanes of complex design for airworthiness and / or registration (exclusion)

- monitoring the maintenance of airworthiness of aircraft of complex design

- issuance of a certificate of suitability of aircraft of complex design (Flight Permit, Airworthiness Certificate, Airworthiness Review Certificate) and their equipment (Permit for airborne radio stations) for flight operations and compliance with environmental protection requirements (Certificate for noise and terrain) .

Human error in maintenance is usually manifested as an unintentional non-compliance of the aircraft (physical degradation or breakdown), due to the actions or inaction of the aircraft maintenance specialist (AMT). The word "attributed" is used because human error in maintenance can take two main forms. In the first case, the error leads to a certain mismatch of the aircraft, which did not exist before the start of the maintenance task. Any aircraft maintenance task is a possibility of human error, which can lead to unwanted non-compliance of the aircraft. Examples include incorrect installation of blocks that can be replaced on the line, or not removing the protective cap from the hydraulic line before reassembly, or damage to the air duct used as a support during access to perform the task (among other faults, these examples also illustrate the discrepancy in L-H SHEL model interface). The second type of error causes undesirable or dangerous conditions to remain undetected during scheduled or unscheduled maintenance designed to detect aircraft deterioration. Examples include a structural crack that is invisible during a visual inspection, or a faulty avionics unit that remains on the aircraft because misdiagnosis of the problem has resulted in the removal of the faulty box. These errors can be caused by latent failures such as lack of training. , poor allocation of resources and maintenance tools, lack of time, etc. They can also be caused by poor ergonomic tool design (poor L-H interface), incomplete documentation or manuals (lack of L-S interface), and so on.

The cause of several widespread accidents was human error in maintenance. The American Airlines DC-10 crash in Chicago in 19792 was the result of an engine replacement procedure when the pylon and engine were removed and installed as one unit rather than separately. This unauthorized procedure (a hidden fault, probably with a mismatch between L-H and L-S) led to a failure of the pylon design, which became apparent when one of the wing-mounted engines and its pylon separated from the aircraft during takeoff. The resulting damage to the hydraulic systems led to the rejection of the front edges of the left wing and the subsequent loss of control. In 1985, a Boeing 7473 Japan Airlines underwent rapid decompression in flight when an improperly repaired rear pressure bulkhead failed (a hidden fault, probably with a mismatch between the L-H and L-S). Further overpressure of the plumage and the expansion of the shock wave due to the explosive rupture of the spherical pressure bulkhead caused the failure of the control system and the destruction of the aircraft with great human losses.

In April 1988, Aloha Airlines Boeing 7374 had a structural failure of the upper part of the fuselage. In the end, the plane landed, killing only one person. This accident was due to improper maintenance (hidden failures), which allowed structural wear to go unnoticed.

ICAO has developed the handbook as a guide for not only aircraft maintenance and inspection engineers, but also industry professionals to understand the capabilities and limitations that affect performance and safety in aircraft maintenance and inspection. The manual repeatedly covers the SHEL and Reason models in all sections to expand the importance of the human factor for aviation safety and efficiency. This digest highlights the human factor issues that are important for aviation safety.

2.2. Human error: models and management

The problem of human error can be considered in two ways: a personal approach and a systems approach. Each has its own model of causation, and each model generates quite different philosophies of error management. Understanding these differences has important practical implications for overcoming the persistent risk of failure in clinical practice.

Summary points

- Two approaches to the problem of human fallibility exist: the person and the system approaches
- The person approach focuses on the errors of individuals, blaming them for forgetfulness, inattention, or moral weakness
- The system approach concentrates on the conditions under which individuals work and tries to build defences to avert errors or mitigate their effects
- High reliability organisations—which have less than their fair share of accidents—recognise that human variability is a force to harness in averting errors, but they work hard to focus that variability and are constantly preoccupied with the possibility of failure

Person approach

The ancient and widespread tradition of personal approach focuses on dangerous actions - mistakes and procedural violations - of people who are at the acute end: nurses, doctors, surgeons, anesthesiologists, pharmacists and more. He believes that these dangerous actions occur primarily due to abnormal mental processes, such as forgetfulness, inattention, poor motivation, negligence, carelessness and carelessness.

Naturally, the associated countermeasures are aimed primarily at reducing the undesirable variability of human behavior. These methods include advertising campaigns that appeal to fear, writing another procedure (or supplementing an existing one), disciplinary action, the threat of litigation, retraining, naming, accusations, and shame. Proponents of this approach tend to view mistakes as moral problems, assuming that bad things happen to bad people - what psychologists have called the just world hypothesis.

System approach

The basic premise of a systems approach is that people make mistakes and expect mistakes, even in the best organizations. Errors are seen as consequences, not as causes that have their origins not so much in the perversion of human nature as in the systemic factors that "up". These include the pitfalls of recurring mistakes in the workplace and the organizational processes that generate them. Countermeasures are based on the assumption that although we cannot change a person's condition, we can change the conditions under which people work. The central idea is to protect the system. All hazardous technologies have barriers and precautions. When an adverse event occurs, the important question is not who made the mistake, but how and why the defense failed.

2.2.1. Evaluating the person approach

Personal approach remains the dominant tradition in medicine, as everywhere. From some points of view, this has something to praise. Blaming people emotionally is more fun than focusing on institutions. People are seen as free agents, able to choose between safe and dangerous behaviors. If something goes wrong, it seems obvious that a certain person (or group of people) should have been responsible. The desire, as far as possible, to separate the dangerous actions of a person from any institutional responsibility is undoubtedly in the interests of managers. It is also legally more convenient, at least in Britain.

However, the personal approach has serious shortcomings and is ill-suited to the medical field. Indeed, further adherence to this approach is likely to hinder the development of safer health facilities.

While some dangerous actions in any area are glaring, the vast majority are not. In aviation maintenance - a practical activity in many ways similar to medical practice - about 90% of quality violations were considered impeccable.

1. Effective risk management depends crucially on establishing a reporting culture.

2. Without a detailed analysis of mishaps, incidents, near misses, and “free lessons,” we have no way of uncovering recurrent error traps or of knowing where the “edge” is until we fall over it. The complete absence of such a reporting culture within the Soviet Union contributed crucially to the Chernobyl disaster.

3. Trust is a key element of a reporting culture and this, in turn, requires the existence of a just culture—one possessing a collective understanding of where the line should be drawn between blameless and blameworthy actions.

4. Engineering a just culture is an essential early step in creating a safe culture.

Another serious weakness of the person approach is that, by focusing on individual sources of error, it isolates dangerous actions from their systemic context. As a result, two important signs of human error tend to go unnoticed. First, often the best people make the worst mistakes - a mistake is not a monopoly of the few unfortunates. Second, failures are not accidental, but often recurring. The same set of circumstances can provoke such mistakes, regardless of who is involved. The desire for greater security seriously hinders an approach that does not seek or eliminate error-causing properties in the system as a whole.

2.2.2. The Swiss cheese model of system accidents

Means of protection, barriers and precautionary measures play a key role in the systemic approach. High-tech systems have many protective layers: some are designed (alarm, physical barriers, automatic shutdown, etc.), others rely on humans (surgeons, anesthesiologists, pilots, control room operators, etc.), and still others depend on procedures and administrative controls. . Their function is to protect potential victims and assets from local dangers. Mostly they do it very effectively, but there are always weaknesses.

Ideally, each protective layer would be intact. In fact, they are more like pieces of Swiss cheese with many holes - although unlike cheese, these holes are constantly opening, closing and changing their location. The presence of holes in any "slice" usually does not lead to a bad result. Usually this can only happen when the holes in many layers coincide instantly to create the possibility of an accident trajectory, bringing danger into harmful contact with the victims.

The holes in the defences arise for two reasons: active failures and latent conditions. Nearly all adverse events involve a combination of these two sets of factors.

Active failures are dangerous actions committed by people who are in direct contact with a patient or system. They take many forms: misses, errors, mistakes and procedural irregularities. Active failures have a direct and usually short-term impact on the integrity of the defense. In Chernobyl, for example, operators mistakenly violated the station's procedures and shut down sequential security systems, thus creating an immediate trigger for a catastrophic explosion in the core. Followers of the personal approach often do not look for the causes of adverse events once they have identified these proximal dangerous actions. But, as discussed below, virtually all such actions have a causal history that extends past and up through system levels.

Latent conditions are inevitable "resident pathogens" in the system. They arise from decisions made by designers, builders, authors of procedures and top management. Such decisions may be erroneous, but not necessary. All such strategic decisions have the potential to introduce pathogens into the system. Concealed conditions have two types of adverse effects: they can lead to conditions that provoke mistakes in the local workplace (for example, limited time, lack of staff, inadequate equipment, fatigue and inexperience), and can create long holes or weaknesses in protection (unreliable). alarms and indicators, inoperable procedures, design and construction defects, etc.).

Latent conditions - as the term implies - can be inactive in the system for many years before they are combined with active failures and local triggers to create the possibility of an accident. Unlike active failures, the specific forms of which are often difficult to predict, latent states can be identified and remedied before an adverse event occurs. Understanding this leads to proactive rather than reactive risk management.

We cannot change a person's condition, but we can change the conditions in which people work.

To use another analogy: active failures are like mosquitoes. They can be swatted one by one, but they still keep coming. The best remedies are to create more effective defences and to drain the swamps in which they breed. The swamps, in this case, are the ever present latent conditions.

2.2.3. Some paradoxes of high reliability

Just as medicine knows more about diseases than health, so do the safety sciences know more about what causes adverse effects than how best to avoid them. For the past 15 years or so, a group of sociologists based primarily at Berkeley and the University of Michigan have sought to address this imbalance by studying security advances in organizations rather than their infrequent but more notable failures. These Stories success associated with nuclear aircraft carriers, air traffic control systems, nuclear power plants (box). Although such highly reliable organizations may seem far from clinical practice, some of their defining cultural characteristics can be imported into the medical field.

Most managers of traditional systems explain human unreliability by undesirable variability and seek to eliminate it as much as possible. Highly reliable organizations, on the other hand, recognize that human variability in the form of compensation and adaptation to changing events is one of the most important means of protecting the system.

Reliability is a "dynamic event". It is dynamic because security is maintained through timely human change; it is not an event because successful results rarely attract attention. Highly reliable organizations can readjust themselves to local conditions. In normal mode, they are controlled in the usual hierarchical manner. But at a high pace or in emergencies, control shifts to on-site experts - as is often the case in the medical field. Once the crisis is over, the organization gradually returns to routine control.

Paradoxically, this flexibility stems in part from the military tradition - even highly reliable civilian organizations have large ex-military personnel. The forces of the organization, as a rule, clearly have their own goals, and for this, these bursts of semi-autonomous activity were successful, it is important that all participants clearly understand and share these aspirations. While highly reliable organizations expect and encourage the variability of human action, they also work very hard to maintain a consistent mood of reasonable caution. Blaming people emotionally is more fun than focusing on setting.

Apparently, the team is a highly reliable feature of organizational organizations is their concern about the possibility of failure. They expect to make mistakes and teach their employees to recognize and recover them. They constantly repeat familiar scenarios of failure and persistently try to imagine new ones. Instead of isolating failures, they generalize them. Instead of doing local repairs, they are looking for systemic reforms.

High reliability organisations

So far, three types of high reliability organisations have been investigated: US Navy nuclear aircraft carriers, nuclear power plants, and air traffic control centres. The challenges facing these organisations are twofold:

- Managing complex, demanding technologies so as to avoid major failures that could cripple or even destroy the organisation concerned;
- Maintaining the capacity for meeting periods of very high peak demand, whenever these occur.

The organisations had these defining characteristics:

- They were complex, internally dynamic, and, intermittently, intensely interactive
- They performed exacting tasks under considerable time pressure
- They had carried out these demanding activities with low incident rates and an almost complete absence of catastrophic failures over several years.

Although, at first glance, these organizations are far from the medical field, they share important characteristics with health care facilities. The lessons to be learned from these organizations are certainly relevant to those who run and run health facilities.

ICAO Requirements on Operators' continuing airworthiness responsibilites

(Annex 6 Part I Chapter 8, 8.1 and Annex 6 Part III Section II Chapter 6, 6.1), require the following:

1 Operators in accordance with procedures acceptable to the State of Registry, ensure that each aircraft they operate is maintained in an airworthy condition;

2 Operators shall employ a person or group of persons to ensure that all maintenance is carried out in accordance with the maintenance control manual.

To meet the intent of the abovementioned Standard, some States issue acceptances or approvals to a person or group of persons within the operator or a maintenance control organization with a specific approval (e.g. EASA Part M, Subpart G) to manage the continuing airworthiness responsibilities of the operator, both with requirements to maintain the continued validity of the acceptance/approval.

Where a State has issued an acceptance/approval to an operator or to a maintenance control organization with continuing airworthiness responsibilities it means it has determined that:

a) the operator or the maintenance control organization has a satisfactory regulatory compliance history and the on-site inspection activities required to be completed could not be performed by the States issuing the acceptance/approval for the:

continuation of acceptance of a person or group of persons within an operator with continuing airworthiness responsibilities; or

b) continuation of the specific approval for a maintenance control organization with continuing airworthiness responsibilities (e.g. EASA Part M, Subpart G, Part-CAMO) for an operator;

and

c) the person or group of persons within an operator or a maintenance control organization with continuing airworthiness responsibilities holding a valid acceptance/approval have met the requirements for the continuation of the acceptance/approval, except for the State's on-site inspection.

2.2.4. Educational impact on Human nature

Due to the growing complexity of new aircraft, maintenance is becoming an increasingly important function. At the beginning of the development of aviation, aircraft maintenance was considered a higher level of car maintenance, not too far from car maintenance, and such skills could be successfully applied in any direction.

Such a consideration could not last long, as aviation technology quickly became a much more complex technology.

Today, aircraft maintenance professionals must have a good knowledge of systems theory, be able to perform complex tests and interpret results, maintain structural elements that are significantly different from typical riveted aluminum structures, and evaluate sensitive electronic and automated systems where the simplest problem can be misapplied. cause significant damage. Trends in the development of aircraft and systems clearly indicate that future aircraft technicians must be highly educated and trained to the level of an engineer or its equivalent in order to work successfully.

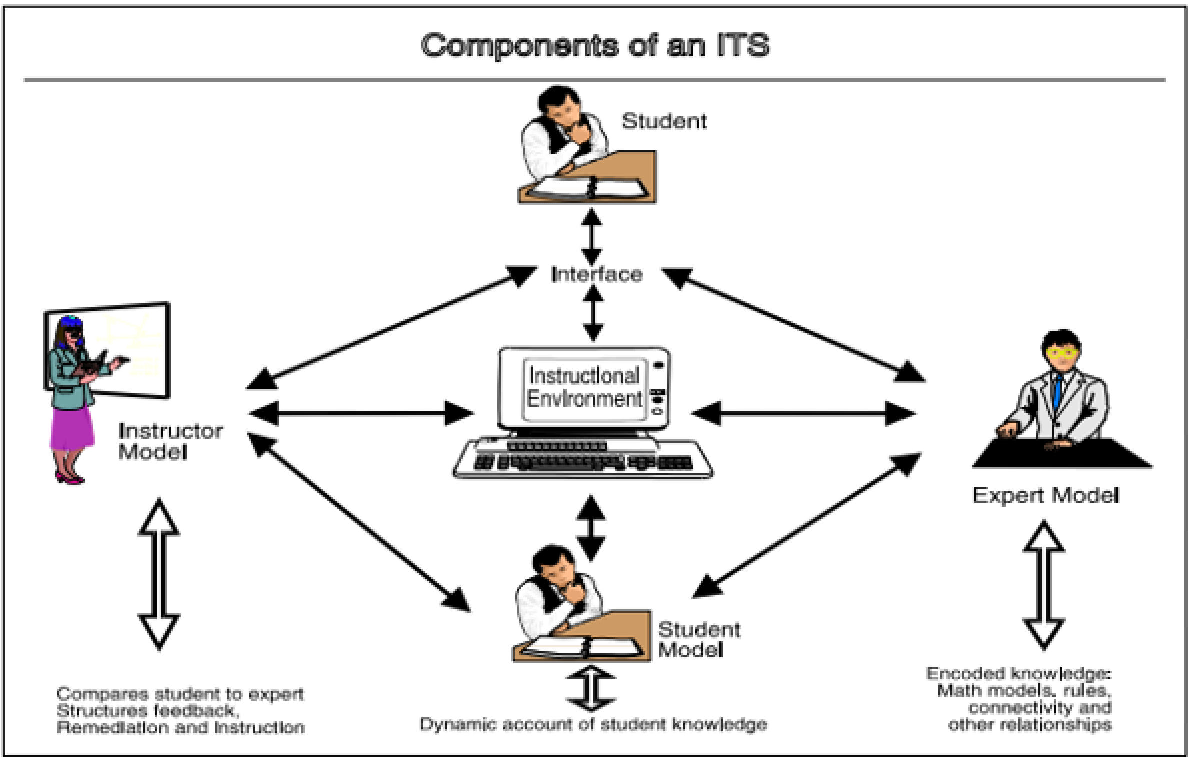

Figure 7. The components of an Intelligent Tutoring System

Although many, if not all, airlines are experiencing few problems today with hiring qualified maintenance personnel, this may not be the case in the future. Competition from other industries - perhaps with better working conditions and more interesting jobs - and the growing demand for more highly skilled aircraft maintenance people are some of the reasons why it may be more difficult for airlines to staff their maintenance companies in the future. For those facing this prospect, possible actions should be considered to increase future stocks of properly trained service personnel.

Supporting quality secondary education in public schools and raising awareness of aircraft maintenance careers among school-age groups are two relatively inexpensive tools. Other methods include borrowing equipment or instructors for A&P schools, providing credits or grants to prospective students in exchange for work agreements, developing more formal training or apprenticeship programs, and recruiting service talent from non-traditional groups such as women. The parentheses suggest supporting the industry and promoting expanded computer education in secondary schools, as the trend shows that future service activities can be largely supported by computerized and automated systems, even in countries that do not currently use significant e-support systems.

Aircraft maintenance is often performed at night. Physiologically and mentally we are most alert during the day and prefer to rest or sleep at night. When job requirements violate this model, there may be a shortage of productivity. This can undoubtedly create problems in aircraft maintenance, where safety is vital to the faultless operation of technical personnel. In most accidents, due to maintenance errors similar to those discussed in this report, the faulty maintenance work that caused the accident was performed at night (causing an L-E interface defect). Operators must carefully study work tasks for their impact on technicians and their work. Physically difficult tasks should not be accompanied by strenuous work that requires intense concentration. Management should be aware of the dangers of activities such as re-checking for identical items such as rivets or turbine blades.

A long history of research shows that operator vigilance decreases rapidly when performing these tasks, and error can easily occur. Similarly, the use of certain types of equipment is associated with a malfunction. Old-fashioned testers rely heavily on technicians' ability to manipulate equipment, as well as to detect and interpret subtle instrument readings. Combine these difficulties with a tired technician, and the probability of error increases sharply. Shift managers should pay special attention to the fatigue of technicians, as well as monitor and perform subsequent checks of tasks to detect any resulting errors. Checking the daytime maintenance work on the previous night can also significantly reduce the likelihood of an error occurring on the crashed aircraft.

The health and physical condition of the equipment can also affect performance. Aircraft maintenance and inspection activities can sometimes be physically difficult. Climbing over wings and horizontal stabilizers, as well as working in awkward positions and in tight or confined spaces are common. This can be demanding, especially for a maintenance technician who is overweight, ill, or in poor condition and can lead to omissions, incompleteness, or improper performance of work. The need for good, and sometimes normal color vision is also important. Elderly people often need vision correction in the form of glasses or contact lenses. There are currently no medical requirements for aircraft maintenance technicians. As with many people, technicians may not cure vision defects in a timely manner, especially given the fact that without periodic examinations, progressive visual impairment is difficult to detect until vision deteriorates significantly. Moreover, the technician may feel insecure at work and therefore avoid reports of visual impairment.

At present, it is rare to find an operator or administration that requires regular medical examinations of technicians to identify violations that may impair their work. However, due to the growing correlation between aviation safety and the work of maintenance technicians, it may be timely to consider introducing regular medical examinations for aircraft maintenance technicians.

2.3 CONCLUSIONS TO CHAPTER 2

There is no single way to reduce human service errors. At Northwest Airlines, we believe that the key is a systematic approach to the human factor. Only by looking at the problems we face from several angles will we be able to see a truly more realistic picture. Only then can our efforts to minimize the risk of human error be truly focused.

The projects and initiatives discussed in this paper serve to improve communication between and within working groups, reduce the likelihood of injury and error, and create a more positive culture in which the goal of reducing human error in maintenance operations can best be achieved. achieved through the integrated application of the principles of the human factor, which goes beyond the training of awareness of resource management skills. This approach should take into account the selection and training of staff, the tools provided for the safe and efficient performance of work, and motivational factors. Delta is working to fully integrate the human factor to increase security in all of our operations units.

Corporate Human Factors: brief history the formal integration of human factors into Delta Air Lines began in the late 1980s, when crew training was introduced in our flight division. The purpose of this training was, and remains, to provide our pilots with awareness and training in six "non-technical" skills areas: communication, crew coordination, planning, decision making, workload management and situational awareness management. The introduction of CRM training, combined with concerted efforts to standardize cockpit procedures, has been recognized as improving the safety and efficiency of the entire flight system. In 1995, a corporate human factor group was established within the Corporate Security and Compliance Department.

The main mission of this group is to provide services that support the integration of human factors throughout the corporation. In addition to working with flights, the corporate human factor provides assistance and support in the development of human factor programs in the departments of technical operations (maintenance) and customer service at the airport (operations on the ramp).

Integration of human factors from an applied point of view of air carriers, the main purpose of integrating the human factor into maintenance (or other operations) is to increase safety through more effective management of human errors that lead to injuries and damage. Improving the efficiency and morale of employees are important and desirable by-products of the integration of human factors; however, improving security remains a top priority.

As a rule, the main means by which the principles of the human factor are officially implemented in the operational sphere is the development and implementation of training programs on resource management. As we noted earlier, this is how the human factor was introduced into our flights; and, as we will describe, resource management training is an important part of our approach to integrating human factors into maintenance on the ramp.

Delta Air Lines believes that resource management awareness training is a necessary but insufficient part of a comprehensive approach to human factor integration. We recognize that in order for the human factor principles to be fully integrated into our operational environment, it is necessary to go beyond resource management training and consider other areas of application, such as staffing, task resources and motivation systems. A high-quality training program, provided by low-skilled staff, will bring minor benefits at best. Similarly, effective training in incorrect or poorly designed procedures will not improve productivity. And if the desired behavior is not recognized and reinforced by daily operations, it is likely to disappear over time.

As we continue to work to achieve our goal of enhancing security through the integration of the principles of the reliable human factor, we take advantage of each operational area of capability to influence each of the areas listed above. As our experience shows, although the principles are applied in different areas, the approach to integration may differ from one domain to another. Dr. Lofaro describes many differences between training CRM pilots and training mechanics with MRM. We have also found that flexibility in the "packaging and delivery" of human factor principles is needed. The following sections present the initiatives we have taken to date during our maintenance operations and ramps to achieve full integration of the human factor principles.

CHAPTER 3

EFFICIENCY FACTORS AND THE METHODS OF ITS IMPROVEMENT

3.1. Facilities and Work Environment

To investigate human error in maintenance, it is important to understand the responsibilities and work environment of aircraft maintenance technicians. The work environment can greatly affect the performance of technical staff. While having ideal working conditions, such as well-equipped, comfortable hangars for aircraft maintenance, is unlikely given the cost of building and operating these facilities in each of the airline services. Thus, most aircraft maintenance works in non-ideal conditions, including work outdoors, night work in adverse weather. One of the service operating parameters of the aircraft is lighting.

The poor ambient light of the work areas was identified as a significant shortcoming in the investigation of the accidents reported in this report. During the BAC 1-11 disaster, a properly lit workplace may have enabled the maintenance manager to relocate1 an unfilled countersink, which was easily recognized with good education (L-E mismatch).

During the EMB-120 crash, a third shift inspector gained access to the top of the horizontal stabilizer to assist with the installation and inspection of anti-icing lines on the right side of the horizontal stabilizer. He later stated that he did not know about the removal of the screws from the left front edge of the horizontal stabilizer, and in the dark outside the hangar he did not see that the screws were missing at the top of the left side front edge assembly (L-E mismatch).

A large amount of lighting for specific tasks is provided by hand torches or flashlights. The advantages of these lamps are that they are portable and do not require time to adjust. Disadvantages include lack of brightness and the fact that they usually burden one hand, sometimes forcing maintenance or inspection work with only one hand left. One of the problems that is often noted in several maintenance hangars is poor lighting. Often the lighting of the hangar area is provided by ceiling blocks. These hard-to-reach units are often covered with dust or paint, and burnt-out light bulbs sometimes remain indispensable for long periods of time. In addition, the number and location of these blocks are sometimes insufficient to provide good lighting conditions. The lighting in the hangars should be at least 100-150 foot candles to ensure proper lighting.

Maintenance and inspection tasks performed under aircraft structures and in confined spaces create complex lighting problems. The design shades the workplaces from the lighting of the territory, and similarly, the narrow compartments of the equipment will not be illuminated by the surrounding lighting of the hangar. Special lighting should be provided for such situations. Depending on the task, 200 to 500 foot candles are required for lighting. Affordable portable lighting fixtures that can be placed near work areas or attached to adjacent structures to perform specific tasks are available in a variety of sizes and ranges. The use of such lighting systems can help eliminate some of the problems that may arise due to the mismatch between the live program and the environment.

Outdoor maintenance activities, night time requires careful attention to lighting needs. Under such conditions, most of the maintenance of aircraft is performed. There is a sad tendency to rely on flashlights or ambient lighting from open hangar doors for this work, as proper portable lighting is either unavailable or time consuming to obtain and set up. Management should be aware of the importance of providing and requiring the use of adequate space and workplace lighting. This is not a trivial question. Adverse events that occur, at least in part, due to a lack of proper coverage, are often identified in many accidents investigation reports.

Noise is another important factor in the work environment. Aircraft maintenance operations are generally noisy from time to time due to activities such as riveting, operating machinery in hangars, testing engines or running on ramps. Noise can interfere with speech and can have health consequences. Loud or intense noise, as a rule, leads to an increase in the response of the human autonomic nervous system. One of the results may be fatigue. Perhaps more important is the effect of noise on hearing. Regular exposure to loud noise can lead to permanent hearing loss. Lower-intensity noise can cause temporary hearing loss, which can have consequences for workplace safety.

Missed or misunderstood communication due to noise or hearing loss can have serious consequences. Actions that operators can take to address noise problems include controlling noise sources by fencing or isolating mechanisms, isolating noisy activities to reduce exposure, providing hearing protection and use needs, minimizing engine start-up or testing. permissible and measuring noise levels in work areas. Noise monitoring can identify where problems exist, which will allow management to take corrective action. The serious effects of noise should be emphasized so that workers see the need to protect their hearing and control noise where possible. Exposure to noise levels above 110 dB should not exceed twelve minutes over an eight-hour period, and continuous exposure to noise levels of 85 dB requires hearing protection. Noise and lighting levels can be easily measured with relatively inexpensive hand-held meters. These are tasks that can be performed by the operator's health or safety departments or managers who have been trained to use this equipment.

Toxic materials in aircraft maintenance have become more common with the advent of more complex aircraft that use composite materials or other hazardous substances in their structure, such as tank sealants or chemicals for structural bonding. Some non-destructive assessment methods, such as X-rays, are also potentially dangerous. Employees should be informed and trained about the hazards associated with the handling of toxic materials. They must be instructed in proper handling and provided with protective devices such as protective clothing, rubber gloves and goggles.

There are other dangers associated with aircraft maintenance. The main one is working on stands or other work platforms, including mobile buckets or "cherry machines", as they are sometimes called. Because large transport aircraft structures are several tens of feet from the ground, slipping or falling from the work platform can result in very serious injuries. Improvised work stands and carelessly placed ladders on slippery hangar floors should be avoided at all costs. Properly designed and used work support systems will be cost-effective in the long run by reducing the number of errors and injuries of employees.

The above information on noise, toxic materials, workbenches and platforms is a good example of where and how a Liveware and Environment (L-E) interface may be lacking in a service shop. Although it addresses the health and safety of maintenance technicians, it has obvious implications for aviation safety. It is obvious that technicians whose performance is impaired due to the lack of health and personal safety measures are more likely to make mistakes that affect the overall safety of the aircraft. This is of great concern because, as a general rule, the consequences of human error in maintenance are far shifted in time and place.

3.1.1 Initial Maintenance Problems.

When people engage in any activity, human error is a continuation. An aircraft maintenance error does not necessarily occur during maintenance, it can also be a design error, but it is an error that worries maintenance personnel as managers of technical problems in day-to-day operation.

The number of accidents and incidents related to service has increased. An example of this is the consideration of these incidents and accidents in recent years, when the annual average rose to more than 100 percent and the number of flights increased by only 55 percent.

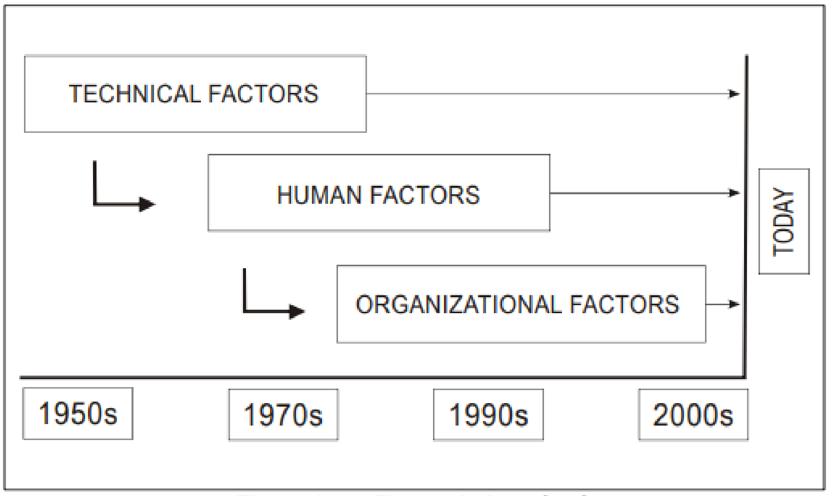

Figure 8. The evolution of safety

The human factor problems that have affected aircraft maintenance inspectors have not been noticed before, but today it is clear that it plays a role in human error, which causes accidents and incidents that play a role in safety in general.

Today, the workload on aircraft maintenance technicians has increased as they have to maintain the old fleet. It is common to meet aircraft that have been in operation for 20-25 years. Intensive inspection is required during the maintenance of these aircraft, as aging gliders are prone to cracks and chips that need to be detected and repaired. This creates stress in the work environment and temporary time constraints due to maintenance economic problems.

In addition to supporting the old fleet, it is necessary to support new aircraft entering the industry. This requires a highly skilled workforce with the right education, as engineers need to have additional knowledge as technology advances.

The safety and efficiency of airline operations become directly related to the work of those who service and inspect their fleet. Two SHEL and Reason models are used to provide an organized and systematic approach to understanding the human factor issues related to aircraft maintenance and inspection.

Human error rather than technical failures has the ability to affect aviation safety. Boeing produced an analysis of the three top casual factors namely:

- Flight crew not adhering to procedures.
- Maintenance & Inspection errors.

- Design defects.

Human error is not unique to aircraft engineering. In the 1960s Human error contributed to 20% of accidents in the industry, and in the 1990s it had increased to account for 80%

Reasons for this increase in error percentage:

*Reliability of electrical and mechanical components has increased but people have stayed the same.

*Aircraft's have become more automated and more complex.

*The increase of aviation system complexity brings about the potential for organizational accidents, in which latent procedural and technical failures combined with operational personnel errors and violations, they then penetrate the defenses as the 'Reason Model' suggests.

3.1.2 Forms of Human error

The error in aircraft maintenance has two forms:

(a) an error that occurs after maintenance due to non-conformities that could not have occurred if maintenance had not been performed, such as damage to the duct when it is used as a support during maintenance.

(b) The second form of error is an error that occurs after a hazardous condition goes unnoticed during maintenance.

For example, the absence of cracks in the design of the glider during the visual inspection. An example of past accidents caused by a human error during maintenance. After analyzing 93 major accidents worldwide between 1959-1983, maintenance and inspection caused 12% of aviation accidents. In some accidents, maintenance and inspection errors are the main cause, in others only a link in the chain of events that led to the accident.

United Kingdom Civil Aviation Authority listed leading maintenance re-occurrence discrepancies in order of occurrence :

- Incorrect installation discrepancies.
- Fitting of wrong parts.
- Electrical wiring discrepancies.
- Loose objects being left in the aircraft.
- Inadequate lubrication.
- Cowlings, access panels & fairings not secured.
- Landing gear ground lock pins not removed before take-off.

Human error errors found in one airline showed that during 1989-1991, the four main categories of maintenance errors were: skip 56 percent, incorrect installation 30 percent, incorrect parts 8 percent and another 6 percent.

Items often omitted during maintenance are often fastenings.

Offers an example of human error when screws were not fastened on an engine during maintenance.

Most frequent recurring maintenance errors are incorrect installations of components and lack of proper Quality Control and inspection.

- Organizational perspective examples of maintenance error and recommendations and findings by the investigative bodies.

- Conclusions after accident analysis in this chapter it was discovered that organizational errors within aircraft maintenance wasn't limited to one region or only one part of the organization.

- The decision maker plays a big role in the organization as they are in-charge of achieving a balance on safety and on-time and cost effective transportation of passengers and cargo.

3.1.3. Information Exchange & Communication

1. Communication is the most important element of the human factor.

2. Maintenance information should be clear and easy to understand.

3. It is important to keep in touch with the aircraft manufacturer and the airline. This message will help to correct or correct the airline that the manufacturer may have.

4. Lack of communication within the airline itself leads to serious shortcomings in the L-L and L-S interface.

5. Engineers working with parts must also complete work cards to avoid inspection or maintenance errors that occur during a change of change when another engineer has to continue previous maintenance work. This will allow maintenance engineers to know what they have been working on and what they are not.

6. Maintenance and quality control should be performed in accordance with the general maintenance instructions.

7. Staff should be encouraged to report hazardous situations or practices.

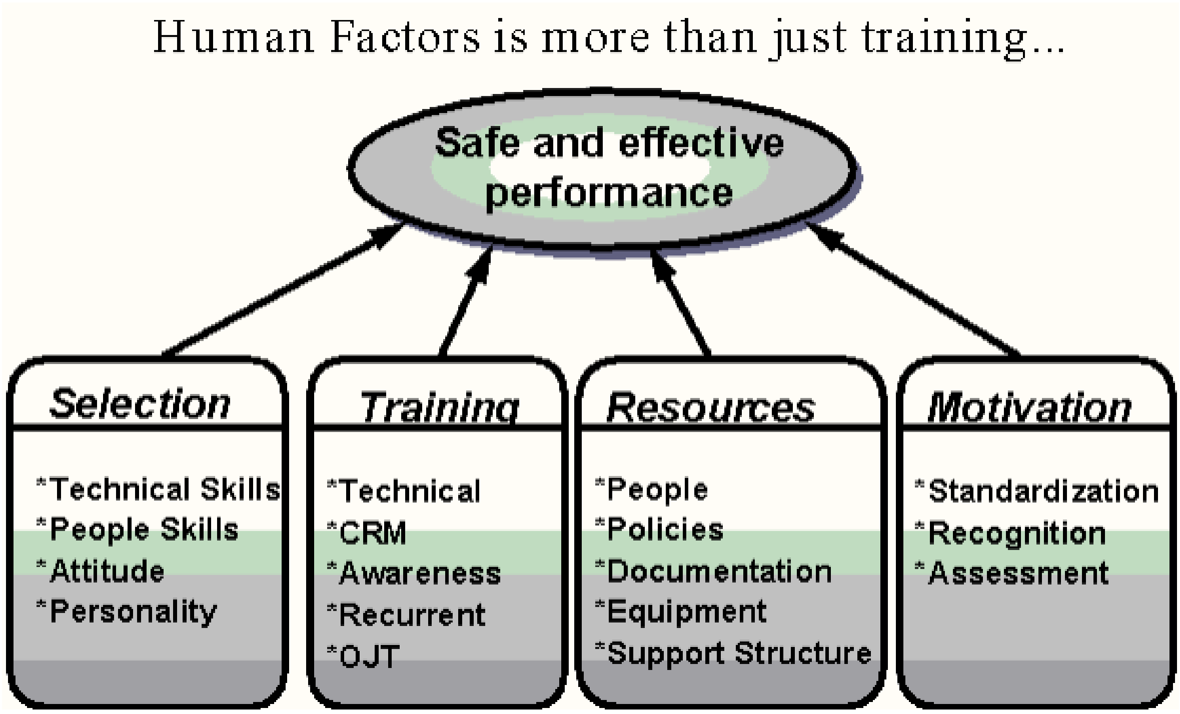

Figure 9. Factors, which influence safe maintenance performance

To understand Human Factor error it´s important to also understand the environment aircraft maintenance technicians work in.

* Lighting is the most important work parameter.

* Noise plays a big part in affecting the environmental factor of the work environment that the maintenance personnel work in.

* Proper training on handling hazardous substances during maintenance should be clearly taught and understood.

* Proper work stations should be used during maintenance.

* Noise, toxic material, work stations are a good example of how L-E (Liveware & Environment) interface flaw can occur.

There are unique characteristics that affect human error in a maintenance environment differently than in other work environments, such as the flight deck or ATC room. Press the wrong button or pull the wrong handle, give conflicting instructions, and the pilot or dispatcher will see the consequences of the error before the aircraft completes the flight. If there is an accident or incident, the pilot is always "in place" at the time of the accident or incident. If an air traffic controller is involved, the ATC is almost always at the scene or in real time. While this important feature may seem obvious to a flight crew / ATC error, it does not always apply to an aircraft maintenance error.

Unlike the nature of "real-time" errors in ATC and flight deck, maintenance errors are often not detected at the time of the error. In some cases, the maintenance technician who made the error may never be aware of the error, as the error may be detected days, months, or years after the error occurred. In the event of a 1989 Sioux City DC-10 engine failure2, a suspected verification error occurred seventeen months before the crash.

When a human error in maintenance is detected, usually due to a malfunction of the system, we often only know the inconsistency of the aircraft. It is rare to know why the error occurred. In the field of aircraft maintenance, there are no recorder equivalents in the cockpit, flight data recorder or ATC cassettes to store details of the maintenance work performed. In addition, maintenance self-report programs have not become advanced programs in the flight environment, such as ASRS, CHIRP, and so on. Thus, in most cases, data to discuss maintenance errors in terms of specific types of human errors is simply not available. Therefore, errors are discussed in terms of aircraft mismatch.

Consider the following scenario: A maintenance technician in New York forgets to install an anti-vibration clamp on a hydraulic tube mounted on an engine. After three months, the pipe suffers from fatigue in flight and leads to the loss of the hydraulic system. After landing in London, aircraft maintenance specialists checked the engine and found that the anti-vibration clamp had not been installed. Do they know why? Most likely not, because the mistake happened three months ago in New York. Thus, a human error is recorded as a "missing clamp".

3.2. Accidents Investigation and Resulting feedback

This lack of causal data on the "place of error" is a problem for the industry, which for decades has been forced to follow an approach to prevention and investigation, strongly biased towards finding a specific causal factor. Looking at the analysis of the causal factors of accidents and their percentage of presence mentioned earlier, it can be seen that the "pilot error" (a popular misnomer called human error by pilots) was broken down into specific failures, such as pilot deviations. , incorrect reaction of the crew, incorrect decision, poor coordination of the crew, incorrect communication with air traffic control, etc. However, in the same analysis, maintenance and inspection receive only one line: deficiencies in maintenance and inspection. Despite all the other errors that can occur during the maintenance of a complex aircraft, every accident related to maintenance falls into this single line. With the exception of major accidents, which are reproducible, the identification of causal factors related to maintenance outside this level is rare.

Maintenance and inspection accidents on BAC 1-11 and Embraer 120 aircraft are an exception, as accidents occurred shortly after active faults were committed. This allowed investigators to focus their efforts on the ground and carefully examine the activities of those concerned as well as organizations. The classic case of "displacement in time and space" was not a factor that slows down, if not interferes with the timely investigation of events. The ability to identify organizational errors, individual human errors, or organizational practices that cause errors was present, making it possible to consider accident-causing practices at their source.

Statistics indicate that organizational or systemic errors in aircraft maintenance organizations are not limited to one organization or region. In the three accidents analyzed here, the behavior of organizations and individuals in organizations before the events was similar.

For example:

• maintenance and inspection personnel failed to adhere to established methods and procedures (active failure);

• those responsible for ensuring adherence to established procedures and methods failed to supervise not in 'one-offs' but in what were symptomatic of longer-term failures (active and latent failures);

• high-level maintenance management failed to take positive action to require compliance with procedures as prescribed by their respective organizations (latent failures);

Maintenance work was performed by personnel who were not assigned to perform the work but started the work on their own initiative with good intentions (active failure caused by two previous hidden failures); and the lack of proper and / or positive communication was evident, extending the chain of errors that led to accidents (hidden failure).

As noted earlier, one of the key elements of an aviation system is the decision-maker (senior management, corporate or regulatory bodies) who is responsible for setting goals and managing available resources to achieve and balance two separate aviation goals: safety and timely and economical transportation of passengers and cargo. If we consider the Reason and SHEL models, it is easy to understand why and where mistakes were made.

The previous section summarizes the functions performed at the individual and organizational levels of aviation maintenance and inspection. However, these simple descriptions do not convey the full complexity of this system. Modern aircraft and their built-in systems are becoming increasingly technologically complex. New methods of testing and diagnosing these systems are becoming increasingly specialized. In addition, the inspection and maintenance of commercial aircraft is organizationally complex; resulting from the socio-technical process in which hundreds, even thousands of people are directly involved. These conditions combine to create a work environment that leads people working in this system to make mistakes. For example, given that there are 14 different types of locking mechanisms in a narrow aircraft seat, the chances of missing a badly locked seat are very high.

Attempts to simultaneously achieve competing goals of security, timeliness and profit lead to implicit time pressure. Organizational / economic pressures can cause operators to disrupt inspection / maintenance methods. The consequences of errors are not immediately apparent (Graeber and Marx, 1993). For example, in one accident, faulty maintenance had no noticeable effect until 17 months after it occurred (NTSB, 1990). Delayed feedback dramatically reduces the ability of operators to learn from mistakes. Such delays also hinder the investigation of accidents, as the situational factors that accompany human error are lost. In addition, because different types of maintenance problems occur randomly for individual operators, it is difficult for any operator to determine what may be a systemic problem in the type or mechanism of the aircraft (cf. Inaba and Dey, 1991).

Aircraft maintenance often involves several days and several shifts, making it difficult to coordinate activities and information between different operators during different shifts. Audits and inspections of quality control and error reporting systems receive data on the results of inspections and repairs. However, they generally do not provide consistent or timely feedback to operators on actual errors. In addition, feedback during inspection training typically focuses on the procedural aspects of the task (e.g., setting up continuous control equipment and troubleshooting rules) rather than providing feedback for other, more cognitive, aspects. inspection tasks (e.g., making perceptual judgments) (Prabhu and Druri, 1992). Given these difficulties, it is not surprising that human operators in this system make mistakes.

Errors in aviation maintenance and inspection can be described in terms of their direct, significant impact on aircraft equipment, the ultimate impact on flight operations (incidents / accidents) and the secondary impact on the airline industry. Further, forms of errors in aviation maintenance and inspection are defined as modes of failure of tasks related to their performance. These terms describe the frequency and forms of human error related to aviation maintenance and inspection.

3.2.1 Alternatives during Maintenance processing

Probably every maintenance organization has technicians who use private notes (black books) as an effective (illegal) alternative to official documentation. The black books clearly indicate the need for another form of support for tasks in line maintenance and routine tasks. Alternatives that offer the same benefits as a black book are technically feasible, although legal issues can be a challenge to begin developing this form of task support. Technicians and their managers differ in their interpretation of the technician's work. The resulting gap in the perception of work is one of the reasons for the time pressure perceived by technicians, and negatively affects compliance with procedures.

There is a double standard in aircraft maintenance: the official and the actual way of working coexist. Technicians and their managers seem to agree that for very simple tasks, the importance of following a written procedure is less. The impossibility of open discussion on these subject forces each technician to determine independently where the boundary separating simple tasks from critical ones passes.

A similar situation can arise with a large number of warnings and caveats in manuals. They are said to mask true information in procedures, and the perception of (experienced) technicians is that warnings are not included for the use of information, but only for reasons of legal liability. If we fail to distinguish critical from non-critical warnings and cautions, we will have to accept the risk that technicians will treat them the same.

It is suggested that this may be the subject of a special study in which manufacturers, researchers and legal experts should work together to find ways to make it clear to an experienced professional what safety-critical warning material is. Procedural inconsistencies, black books and gaps in the perception of jobs are manifested both during work and in basic services. However, the reasons for their occurrence and their appearance may differ between line and basic maintenance. The nature and scale of the human factor problems differ between line and basic services. This requires a different approach and other solutions, perhaps also when teaching people the Human Factor.

Training the human factor is an important step forward. To create lasting changes in attitudes and behavior requires a different form than today. Other categories of staff, in addition to simply certifying staff, must also receive some form of human education. It is necessary to look for cost-effective solutions for learning by integrating the human factor into technical training. The solution to the existing problems of the human factor should not be sought only in education. Organizational training, improved system design, and better maintenance documentation are areas where there is clear potential for improvement. Each maintenance organization will need to develop its own improvement plan that is consistent with the organizational culture and existing management systems. However, with regard to the main bottlenecks discussed in this article, it remains to be seen how far an individual organization can really achieve. It may also be necessary to discuss at the highest (international) level how to achieve improvements across the industry.

In addition to gravity itself, the greatest danger faced by modern aircraft comes from humans, and especially from the well-intentioned but often unnecessary physical contact required by outdated maintenance schedules. We urgently need greater awareness on the part of system developers and manufacturers of the types of human error and errors that ensure the nature of the maintenance task, especially during installation or reassembly. First and foremost, they need to understand that maintenance can be a serious hazard as well as a necessary protection. Until the systems are designed and built with these issues in mind, good maintenance staff will continue to contribute to bad accidents and incidents, as well as huge financial losses.

The main problem with aircraft maintenance is that it requires people to have frequent direct contact with aircraft components. An orthodox engineering approach assumes that maintenance measures are both essential and safe. From an engineering point of view, the optimal level of preventive maintenance is established by summing the costs of both corrective and preventive maintenance, and then determining the level associated with the lowest total maintenance costs. maintenance did not always correct this. Suppose that both of these actions can actually cause serious damage, render previously reliable components inoperable, or simply remove them altogether.

Figure 10 looks at the maintenance issue from a broader perspective-one that includes human as well as technical factors.

Here are plotted (in a very speculative fashion) the risks to the system posed by

(a) neglected maintenance, and

(b) by the likelihood of errors being committed during either preventive or corrective maintenance.

The latter plot is based on the assumption that the likelihood of error will increase as a direct linear function of the amount of maintenance activity. Since only a relatively small proportion of human actions are erroneous, the human failure risk will never rise above a fairly low value. But, as we shall see below, it is not the absolute value that matters, but the relative proportions of the maintenance neglect and maintenance error risks. It is also assumed that these error risks will not change in any systematic fashion over time. Technology may advance, but human fallibility stays the same. In sharp contrast, however, the risks due to maintenance neglect are likely to diminish steadily as manufacturing techniques and the intrinsic reliability of materials improve with technological developments.

Figure 10 shows this by a family of diagonals moving to the lower left corner of the graph. It is clear that if the specified level of maintenance, determined by economic and engineering considerations discussed above, remains relatively constant over time, it will soon reach a point where the danger to the system will be outweighed by even a relatively low error. rate. Previous data on the reasons for stopping engines in flight show that all the most common factors are related to technical problems of the person, and not "without assistance".

Of course, it can be argued that the advent of non-destructive testing and other advanced diagnostic techniques allows aircraft technicians to detect potential technical malfunctions before they occur in flight, so human error remains a major residual failure category. This may well be true, but it does not change the fact that regular human contact with 4-6 million removable parts on a modern aircraft is an unacceptable level of risk.

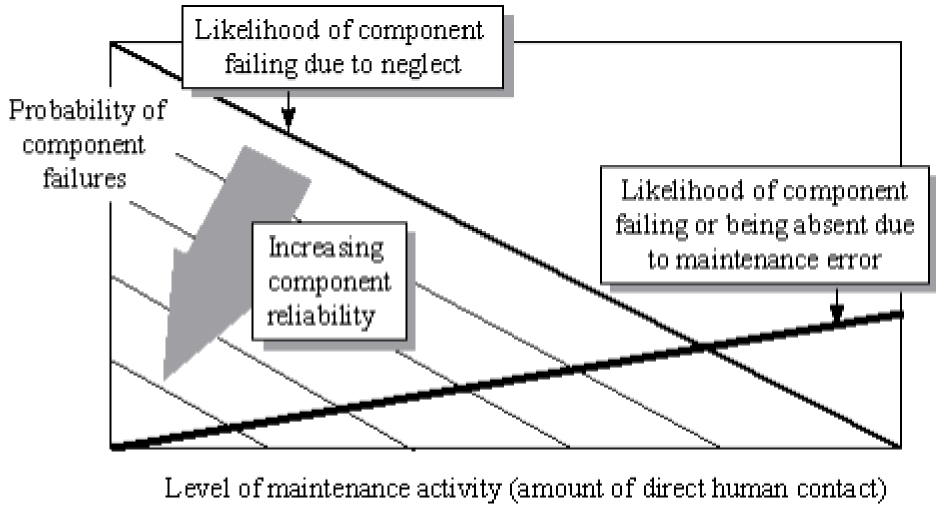

Figure 10

Comparing the risks to the system of component failure due to (a) neglected maintenance, and (b) errors committed during maintenance. The family of diagonal lines advancing to the lower left-hand corner reflect the increasing reliability of components over time.

Ironically, one of the pressures that maintains such a high level of contact with service is the criticality of the security system. A catastrophic failure is unacceptable in commercial aviation. We need to do everything - and see what has been done - to preserve the integrity and reliability of aircraft. But, as we have seen, the touch of a companion can both harm and heal. Aircraft maintenance errors have safety and economic costs. A study by Boeing and members of the U.S. Air Transport Association1 found that maintenance failure was one of the factors, usually among a number of factors, that caused 39 of the 264 (15 percent) major plane crashes from 1982 to 1991.

Specifically, in these 39 accidents:

· 23 percent are due to improper removal / installation of components

· 28 percent are related to a manufacturer's or supplier's error in maintenance / inspection

· 49 percent are related to an error due to maintenance / inspection policy airlines

· 49 percent were related to design.

In addition, these 39 as a result of accidents on board killed 1,429 people. Data from one engine manufacturer, 2 showed the percentage of specific engine events caused by errors and the economic costs to airlines of these events:

· 20 to 30 percent of in-flight engine stops are caused by maintenance errors and can cost approximately $ 500,000 per stop.

· 50 percent of flight delays due to engine problems are due to maintenance errors and can cost approximately $ 10,000 per hour of delay.

· 50 percent of flight cancellations due to engine problems are caused by maintenance errors and can cost an average of $ 50,000 per cancellation. But is it possible to manage a maintenance error? Boeing's analysis of in-flight stop (engine) performance (IFSP) for maintenance errors for twenty different carriers found that speeds differed tenfold between lowest and highest.

Obviously, some airlines are better able to manage these types of maintenance errors than other airlines. In addition, error reduction programs are already in use in some industries. For example, Lorenzo discusses a program to reduce errors in the chemical industry based on changes in productivity factors (PSFs), as defined and discussed by Swain and Guttman. MacDonald and White considered PSFs that lead to airport ramp accidents and incidents and developed a safety program on the ramp, based on changes to these PVB. HONEY DEVELOPMENT Based on the above ideas for preventing and reducing errors, Boeing, working with three of its client airlines - British Airways, Continental Airlines and United Airlines - has developed a process to monitor events caused by errors to determine what contributed to the occurrence of errors so that corrective action can be taken to eliminate or reduce the likelihood of such future errors.

The process is called the Maintenance Error Decision Aid (MEDA). The philosophy of the process is:

Maintenance technicians do not make errors on purpose

Maintenance errors result from a series of contributing factors.

Many of these contributing factors are part of airline processes and can be managed.

Some individual errors will not have specific corrective actions.

3.3. CONCLUSIONS TO CHAPTER 3

The first part of the philosophy is tautological, i.e. if the maintenance technician performed part of the work incorrectly and intentionally, by definition it was not a mistake but a purposeful behavior. However, this was a useful part of the philosophy, as it makes the airline's management think about the causes of errors that are not the technician himself.

The second part of the philosophy that maintenance errors are the result of a number of factors that contribute to this is the basis of the MEDA process. In the literature on human factors are called factors that shape productivity, these contributing factors can negatively affect human productivity.

In addition, there are usually several factors that, working together, ultimately form a mistake. The latter parts of the philosophy suggest that although some errors (about 20 percent) will not have corrective action because the contributing factors are unique and specific to the individual or unique situation, most errors (about 80 percent) will have corrective actions because the contributing factors are under control of the airline management, and therefore they can be changed to eliminate or reduce the likelihood of future such errors. The MEDA process has been field-tested in seven airline service organizations. Based on the results of the field tests, the form of the MEDA results and the implementation training were changed to improve the process. Beginning in November 1995, Boeing began working with its client airlines to help them implement MEDA.

The Qantas E&M Human Factors Program commenced in February 1995 as the result of several ongoing repeat incidents that had occurred over the previous twelve months. A pro-active result of this was the bringing together of seven Aircraft Maintenance Engineers from the aircraft 'frontline' sections to be formed as a Human Factors Steering Group.

The 'frontline' areas were defined as: Brisbane (BNE) Domestic Terminal; Sydney (SYD) Domestic Terminal, International Terminal, Heavy Maintenance, Minor Maintenance; Melbourne (MEL) International Terminal, Heavy Maintenance. Group members were from Mechanical (Airframe/Engine) or Avionic (Electrical/Instrument/Radio) Trades and are classified as Aircraft Maintenance Engineer (AME), Licensed Aircraft Maintenance Engineer (LAME), Senior LAME (Senior Licensed Aircraft Maintenance Engineer), or Maintenance Supervisor with an experience level between eight and 30 years. The group has the guidance and support of a 'Patron' (General Manager Line Maintenance Operations) together with the full backing of the Executive General Manager, Engineering & Maintenance. The group was to be largely autonomous in nature in terms of direction or scope of projects with minimal Management direction other than to 'find ways and means to help our people do their work better' and to 'find out what prevents our people doing their work.' To this end the Qantas Engineering and Maintenance Human Factors Group differs greatly from other airlines' Human Factors Groups in that the highest rank of anybody within the group is that of Maintenance Supervisor, and thus the Qantas Human Factors Group is governed by a philosophy of 'by the engineers for the engineers.' Following various training sessions and an introduction to the principles of Human Factors, the group was left to 'get on with it.' This consisted mainly of reading voluminous amounts of material and various HF meetings proceedings, so that group members could become familiar with the subject.

In a short time, an abbreviation was chosen to help identify the program. Selected by the abbreviation H.E.A.R. A program that is the reduction of human errors and accidents, which, ultimately, are the basic principles of the human factor.

The group usually holds meetings lasting 1 or 2 days every 3-4 weeks to coordinate and plan their work and strategy. Because the human factor is based on knowledge sharing, the two members of the H.E.A.R. The group made a study tour under the British Airways Human Factor Program, spending time in Heathrow and BAMC (Cardiff). H.E.A.R. Members of the group also participated in various conferences, such as the 1995 IATA Aircraft Maintenance Workshop and Exhibition in Sydney, NSW, Australia; The 10th Annual FAA Conference on the Human Factor was held in Alexandria, Virginia, USA in 1996, and the Australian Airlines Ground Security Conference in Sydney, NSW, Australia, in 1996.

CHAPTER 4

INVESTIGATION RESULTS AND THE WAYS OF IMPLEMENTATION

4.1. Current projects, which help to "feel" Human Factor

4.1.1 The role of H.E.A.R. Project

To continue the *floor shop* approach, two members of the group have developed and are now presenting a human factor package for Qantas students, in which students are encouraged to express their concerns openly. The importance and relevance of human factors related to them are explained. In November and December 1995, several members of the H.E.A.R. Members of the group toured all Australian bases to ensure that E&M personnel at the forefront received the same information about the human factor and H.E.A.R. Program. Due to this way of being visible and, in addition, being a peer, it seems that H.E.A.R.

The program has some success. A similar tour is currently planned for 1997, but this time it will focus on managers and senior LAMEs to create a desire to take into account and implement the human factor in their work environment. To date, H.E.A.R. The group has completed several projects not only to create a "feel" of the human factor in Qantas E&M, but also to help staff.

Projects include:

1. NASA/University of Texas Management Attitudes Survey (adapted for Qantas E&M) so that a 'base line' could be established
2. Representation at the 10th Annual FAA Human Factors conference
3. Apprentice Training Package
4. Investigation of Aircraft Cannibalization Methods and a proposed new format
5. Investigation of current ETOPS Maintenance Procedures and development and presentation of a reworked package

6. Investigation of current Accident/Incident Investigation procedures and development and presentation of a reworked package;

7. Development of a Heavy Maintenance Shift Handover package - written and oral

8. Identifying areas that prevent 'frontline people' from doing their job and informing those areas of their responsibilities under the auspices of the 'SHEL' model

9. Development of Staff Induction Programms (for existing staff when transferring to different areas e.g., MEL International Terminal to Domestic Terminal, etc.)

Members of the H.E.A.R. The program realized early on that the human factor was not an exact science or an instant solution; and, therefore, it would be a great requirement to expect the immediate adoption of HF principles by all staff. A long-term approach would undoubtedly be the most successful. Sure, there are questionable Thomas, but H.E.A.R. The group was able to "get to the board early" with several problems.

MEASURING SUCCESS

The Qantas E&M the Human Factor program, although in the early stages, is currently considered a successful initiative. By nature, engineers, especially Australian engineers, are cynical and quite relentless if the promised goods are not delivered. H.E.A.R. The program was perceived as a "different" team in the process, trying to change the climate of the place. However, in this case, as for the Qantas engineers, the composition and independence of the group were skillful. As mentioned earlier, H.E.A.R. The program managed to obtain some "programs", namely: cannibalization procedures, ETOPS procedures, participation in the investigation of accidents / incidents. This helped to give the group valuable trust, as these initiatives and participation were the ideas of the "people". Engineers are also pleased to see that management is involved in the disposal of the H.E.A.R.

The program, not the other way around, the concept of the human factor in Qantas is not a new idea. In fact, in flight operations management, the human factor has been part of the training program for flight crews for over 30 years, and for flight attendants for approximately five years in the form of C.R.M. Like most other organizations, the idea of the human factor for E&M staff has only recently emerged, and although Qantas' approach is different from all others, we believe it is best for them and their people. Australians have a culture of interrogation (probably from our past convicts) and are always concerned that everything new represents valuable change and value. It can now be argued that given the recent past successes and support of the H.E.A.R. The Program will be given at least the same time as the existing Flight Crew Human Program.

Perhaps this is our motto that best describes our approach: "If you are not part of the solution, then you are part of the problem," which not only emphasizes the importance of people's actions but also their inaction.

4.1.2. Main aspects of H.E.A.R

IMPROVING SAFETY HEALTH IN E&M.

In 1995 Qantas formed H.E.A.R. (Human Error and Accident Reduction). Created from a group of engineers from departments that are the last barrier to protection from the "human factor", their task was to eliminate the consequences of human failures - accidents and incidents. E&M's response to incidents and accidents is exemplary. A lot of effort is spent to "correct" so that the same mistake never happens again. Procedures are being improved and those who have been victims of human error are being treated fairly and become central to a vigorous awareness-raising program. Is the problem solved? Not at all! The reality is that E&M responds to random events for random reasons. Given that the reactive process is well managed, implement a proactive process in a timely manner to complement it.

A proactive process against human error will include:

· determining the type of error;

· measuring how serious the problems are; and

· the purposefulness of remedial action.

A proactive process will improve what James Reason calls "health safety." This is our organizational resistance to human failures. The immediate task is to determine how healthy we are. We need to do the equivalent of a "test" just as we would go to the doctor. If incidents and accidents are the result of active and organizational covert failures, then good safety is the result of eliminating these failures before the event. It is argued that E&M would do well to focus on twelve (12) main error reducing conditions (ERCs).

1. EFFECTIVE COMMUNICATIONS. Communication is more than saying something to someone. It involves the transfer of information and understanding from one person to another. It is successful only when it is understood by the recipient as intended by the sender.

2. CAREFULNESS. This quality, which consists of good "flying skills". Endurance, fuss, attentiveness, diligence and caution. These things eliminate complacency.

3. KNOWLEDGE AND EXPERIENCE. You need to make sure that the right person is assigned to perform the task. We need to make sure that those who do not know "how" to learn.

4. VIGILANCE. Where concentration is totally focused. Distraction is either eliminated or is effectively managed.

5. EFFECTIVE STRESS MANAGEMENT. Stress is a reaction to physical or psychological tension. The reaction needs to be managed.

6. CONTINUOUS QUESTIONING OF HOW WE DO THINGS. We have good rules and bad ones. Some of them arose as a result of previous incidents. Their use may or may not be effective. We need to eliminate the bad and look for the new good ones.

7. EFFECTIVE TEAMWORK. Teams should be coordinated with each team member, knowing their role and trusting other team members. Effective teams perform better than individuals and are less likely to make mistakes than bad teams or individuals.

8. PHYSICAL & MENTAL ALERTNESS. An exhausted person has the equivalent performance of a drunk.

9. NECESSARY RESOURCES. Without the necessary resources, additional pressure is applied to a situation.

10. EFFECTIVE MANAGEMENT OF EXTERNALLY IMPOSED PRESSURE. This is an issue for supervision. If allowed to break through the supervision defense barrier stress is allowed to develop in an individual.

11. ASSERTIVENESS. Engineers are the last protection against organizational failure. If an organizational failure or error has overcome all other protective barriers and has been identified by the engineer, he needs the skills of perseverance to voice the problem. Especially the problem with those who feel vulnerable: students. Junior traders and new employees. CRM for junior QF pilots has proven to be useful when flying with capricious old pilots. E&M has a few picky old engineers. Strategies need to be developed to remove the bark from capricious old engineers; and those who do not encourage middle-class engineers to become old capricious engineers.

12. SITUATIONAL AWARENESS. In knowing what is going on in a given situation and being able to project what may happen if nothing is done about it. Historically a problem for E&M when things are about to move. e.g.:

· an aircraft is about to be towed into a hangar and contacting docking; or amongst light poles.

· functionals where thrust reversers, landing gears and flight controls are moved whilst other maintenance is still being performed.

Currently, E&M performance is measured in terms of profits, costs (including equipment and aircraft damage) and schedule. E&M should include 12 error reduction conditions (ERC) in our measured parameters. Then he must respond to weaknesses. The answer will be more important than the act of measuring or the size of the problem.

H.E.A.R. suggests that the department head and his “key people” regularly ask themselves how their department evaluates the 12 ERCs. Give a score from 0 to 10. Recent major and minor incidents and recent misses should be a guide. H.E.A.R. has successfully enhanced its reputation and has had considerable success in convincing engineers that they are vulnerable to the human factor. This is a bottom-up approach that is ingenious in design. The invitation to the active participation of management is complemented by a top-down approach.

Change is perceived as painful and is only ever implemented by active intervention. Measuring the problem generates the NEED. When a given department analyses their results they:

· accept that THEY have a problem of defined magnitude;

· accept OWNERSHIP of their problem; and

· originate STRATEGIES that suit local needs.

Subsequent incidents in the analysis of elements of the human factor 12 ERC can be compared with the estimates they gave to their department. This underscores any error of subjectivity. It also removes the department's remuneration higher than the real one.

While H.E.A.R. encourages engineers to acknowledge their vulnerability to human factors and adopt recommended strategies to combat them, there is a reluctance to do so. Chief among these is that they feel they may be ignored or criticized for achieving a goal that may run counter to our current spending, profit, and schedule goals. Even if this is not the case, they will act differently than their peers. In short, they need to be rewarded, knowing that despite these obstacles they face, first-level management will appreciate their efforts. For the same reasons, the efforts of managers will not be transparent, and he will be more inclined to achieve these goals.

THE CONS. Estimates are very subjective. For this reason, the "key people panel" should be cycled frequently. It would also help extend ownership of the problem. Individual managers may be threatened by comparisons between departments. In an effort to completely get rid of the subjectivity of ratings, we could get a cumbersome document. Poor assessment of the department can be unfairly reflected on the head. What should be reflected in the manager is his management of identified weaknesses.

WORKPLACE HUMAN FACTORS AND ERGONOMICS

This third part completes the error control puzzle. The previous sections were used to collect data on errors and inform our employees about their role in reducing human errors. The principles of the human factor and ergonomics (HF / E) address inconsistencies in the Human / Maintenance interface.

Several projects currently address HF/E-related issues in our work environment:

(1) Task Analytic Training System (TATS),

(2) Structured On-the-Job-Training (SOJT), and

(3) Aircraft Maintenance Information-Task (AMI-Task).

The following sections will discuss each of these initiatives, as well as future plans related to the human factor and ergonomics. Analytical Task Preparation System (TATS) Originally provided by Boeing, TATS uses task analysis techniques to break a task into its component parts.

The purpose of this program is to assess what information needs to be provided (in the form of on-the-job training) to a new person in the area so that the person is considered competent to perform the task. This technique uses people who are already completing tasks, dividing the tasks into groups, evaluating the steps and information needed to complete the task, and developing a task aid that is used for on-the-job training.

Structured on-the-job training (SOJT).

The need for a structured on-the-job training project was driven by the Federal Aviation Administration.

In 1995, there were concerns that mechanics were assigned to tasks for which they had not received formal training. At the time, Northwest had informal on-the-job training, with workers doing work training those who did not. The SOJT was designed to formalize the OJT by providing a structure. The purpose of this program is to assess what information needs to be provided (in the form of on-the-job training) to a new person in the area so that the person is considered competent to perform the task. The method uses people who are already performing tasks. With a facilitator who guides them, this group breaks down the tasks, evaluates the steps and the necessary information, and then develops a tool to perform the tasks that will be used during the training. To date, all control hangars in Minneapolis and Duluth, Minnesota and Atlanta, Georgia, have completed the project design phase. The implementation process is currently underway.

The work cards created for use at Northwest Airlines have been implemented with several features to clearly delineate the individual work steps and skills required to perform these work steps. Duplicate access was virtually eliminated from the work package of the aircraft due to the automatic generation of access work cards using a database of regular work cards scheduled when visiting the aircraft. In addition, the availability of Aircraft Maintenance Manuals in digital format (in the same desktop publishing system currently under development) will allow direct links to be established between the Aircraft Maintenance Manual and the airplane work card information. This will speed up the processing of revisions and allow you to more thoroughly check the workcard information without adding resources.

Other Human Factors / Ergonomics Projects There is currently a joint effort between our human factor specialist and the Department of Safety, Health and Environmental Management (SHEM) and the Process Improvement Department. All these efforts are aimed at modifying the physical aspects of work that negatively affect a person's ability to work.

MAINTENANCE HUMAN FACTORS INITIATIVES

Maintenance Resource Management Training as part of our efforts to reduce human maintenance errors, Delta is nearing completion of an initial maintenance resource management (MRM) training course for all maintenance personnel. Such courses will provide awareness and instruction on key skills in communication resource management, decision making, planning, workload management, situational awareness management and crew coordination. In line with the main focus on safety, the MRM course will make extensive use of real-life accidents and incidents as examples to illustrate and discuss. Gordon Dupont's "Dirty Dozen Maintenance Errors" and will be used to provide a framework for discussing how failures in basic resource management skills can eventually lead to injuries and equipment damage. Training performance metrics are considered critical to the success of our MRM training program in terms of desired changes in attitudes, employee behavior, and overall productivity. The baseline study of employee attitudes was developed with the assistance of Dr. Jim Taylor of the Institute of Security and Systems Management at the University of Southern California. The survey was adapted from the Crew Resource Management / Technical Operations Questionnaire (CRM / TOQ) used by Dr. Taylor in previous post-training attitudes among service personnel.

The CRM/TOQ is derived from the Cockpit Management Attitudes Questionnaire (CMAQ), which was originally developed to assess flight crew attitudes and subsequently modified for use with maintenance personnel. The CRM/TOQ includes a battery of items designed to tap employee attitudes about leadership responsibility, communication & coordination, recognition and management of stress, and the willingness to voice disagreement. In addition, items measuring respondents' perceptions of safety practices in Technical Operations were included in the survey, as were items that capture attitudes about goal setting and goal attainment.

A similar survey will be conducted among employees shortly after they have completed the MRM training course and at regular post-training intervals to assess the immediate and long-term impact of the training on attitudes. In addition, we recognize that the purpose of MRM learning is not simply to change attitudes, but rather to influence behavior change. Therefore, Delta is working with Dr. Taylor and other airlines to identify and establish behavioral measures and operational performance indicators that can be used to assess training effectiveness.

Selection and training of the chief mechanic Probably no other group of employees has a greater influence on the daily work of technical operations than our leaders at the forefront: leading mechanics and foremen. These individuals are responsible for managing resources on the floor of the hangar or on the flight line to ensure that the technical, safety, reliability and customer service objectives are met. In addition, the success of behavioral-based training programs, such as MRM, depends heavily on the support of leaders at the forefront. To the extent that front-line leaders support and reinforce the behaviors they teach in the curriculum on a daily basis, the program will be successful. If the principles and skills of behavior are not established, training will be only minimally effective in changing attitudes and behavior.

It became apparent to management that, although the overall productivity of the leading mechanics was high, there was unacceptable variability in the productive capabilities of these key personnel in hangar maintenance operations. Moreover, areas where management saw a need for improvement were not technical skills but rather non-technical skills such as planning, workload management and decision making. This prompted a review of the selection criteria and training program for leading mechanics and foremen in the hangar maintenance department.

In the past, leading hangar mechanics have been nominated and elected by a majority vote of their colleagues. Obviously, this approach did not always guarantee that the best qualified candidate would get the job! Currently, candidates for the positions of leading mechanics are nominated by a majority vote of their peers, and the three best candidates are interviewed and selected by a selection committee of management. Although the current selection process is an improvement over the past, we have implemented a research program to systematically develop selection criteria and develop a curriculum that better meets the needs of our leading mechanics.

As a first step, the leading mechanics in our Atlanta hangar maintenance department, avionics, hydraulics, and painting underwent a CRM / TOQ-like survey discussed in the previous section (Maintenance Resource Management Training). The survey also included items related to the desired leadership style and several open-ended questions on topics such as work difficulties and expected learning needs. As an independent work, we also asked managers in each of the departments involved to evaluate their leading mechanics on various performance parameters. Responses to the survey will be correlated with performance evaluations to determine the desired characteristics of the attitude.

We are currently in the process of encoding and analyzing survey data. We have completed a preliminary analysis of the content of the answers to the open-ended questions, and the sample results for these questions seem to confirm our expectations that the most difficult aspects of working as a lead mechanic and the least respondent are not technical problems. Summarized in the table are the answers to the questions: "What is the most difficult part of your work?", "What aspects of your work do you think you were least prepared for?" and “What are the most important skills you need to be effective in your current position?” show that interpersonal and other resource management issues are considered the most complex (Table 1).

Table 1 Responses to Survey Questions from a Sample of Lead Mechanics

What is the most challenging part of your job?	No. of responses
Human relations/dealing with people	22
Meeting "ready times"	12
Motivating mechanics	7
Coordinating different departments	5
Workload (# of aircraft)	4
Dealing with the corporate 'system'	4
Staying current with technical issues	3
New hire employees	3
Time management	3
Constant changes	3
Doing everyone's job	2
Other (1 each)	4

What aspects of your job do you feel you were least prepared for?

Human relations/dealing with people	23
Paperwork	12
Computers	11
Lack of training	5
Many skills to know (avionics,eng.,etc.)	4
Policies and procedures	3
Other (1 each)	4

What are the most important skills you need to be effective in your current position?

People skills	30
Communication skills	27
Technical skills	17
Computer skills	10
Listening skills	6
Organizational skills	5
Decision making skills	5
Management/supervisory skills	5
Leadership skills	4
Coordination skills	3
Motivational skills	2

Leading mechanics' answers to this set of questions reinforce our awareness that there is an additional set of non-technical skills that leading mechanics must master to become effective leaders. As our data and random experience have shown, technical knowledge is necessary but insufficient for effective leadership. As a result, we conduct further research to identify specific behavioral components in each of the skill areas that contribute to being an effective lead mechanic. Our findings will eventually be incorporated into the curriculum for new chief mechanics and allow us to develop a better set of tools for identifying and preparing prospective candidates for chief mechanics at the beginning of their careers.

4.2. Maintenance Error Reporting Programs

As we noted earlier, the goal of our human effort is to reduce human error that results in service-related injuries and damage. Therefore, it is very important that we develop real and reliable performance indicators of the system that relate to this goal and the behavior that ensures this performance.

We participate in the Air Transport Association Subcommittee Working Group on Maintenance and Inspection, which focuses on determining system performance indicators related to human error management. We are now also reviewing the functions and capabilities of our existing incident reporting and tracking system, our quality assurance audit processes, and our Continuous Analysis and Surveillance (CAS) program to determine if the functions of these programs can be adapted and consolidated. record behavioral pre- and system failures that contribute to incidents and accidents. In addition, we are considering using available ready-made incident reporting and tracking systems, such as the Boeing Maintenance Error Deciding Assistance Tool and the Aurora Fault Management System.

It is also important that we develop mechanisms and a culture of safety that facilitate two-way communication in identifying, reporting, and resolving problems related to workplace maintenance errors. These efforts will require us to review our internal disciplinary systems, the role of regulators, and all recent uses of the Aviation Safety Reporting System (ASRS) by our service personnel.

In our organization, it is necessary to cultivate a culture at the grassroots level, which will support open reporting of errors and incidents, without fear of the response of the leadership of the "police on the go". We are optimistic that one way to develop a reporting culture is to use our Continuous Improvement Teams (CIT) program. These teams focus on identifying and implementing safety improvements in the process and workplace in technical operations. We believe that the CIT program can also be used to identify, report, and address the human factor.

4.2.1. Ramp Human Factors Initiatives

Although the focus of this workshop and these materials is on the application of the human factor to maintenance operations, we believe it is worth briefly discussing some of the current human factor initiatives in our airport ramp operations. While the overall model that governs our human factor efforts on the ramp is the same, the working and learning environments for ramp staff represent a different set of constraints and opportunities for integration. For example, aircraft maintenance activities surrounding the arrival or departure of an aircraft are relatively scenario-limited and limited in time and space.

Thus, task performance is relatively easy to monitor and evaluate - unlike many maintenance tasks, which require coordinated multi-departmental activities over hours, days, or weeks. As a result, one of the initiatives described below involves real-time learning and assessment of resource management skills on the ramp. Such a program would be difficult to implement during many maintenance operations, but it may have the potential for certain tasks (such as engine changes). Therefore, the following sections are provided to illustrate other methods by which the human factor can be used to reduce human error.

Ground Operations Manual (GOM) In the spring of 1996, Delta introduced the Ground Operations Manual (GOM) to increase the procedural standardization of operations on the airport ramp. Prior to the release of GOM, it was recognized that there was significant variability in the handling of aircraft procedures throughout the system and that this variability contributed to unacceptable levels of preventable land damage.

It was customary for new employees to learn procedures through verbal coaching at work. Many station-specific procedures were never recorded and passed on orally from experienced to inexperienced workers. This training method worked effectively as long as Delta had an experienced, stable workforce. However, when cost-cutting initiatives were introduced in the early 1990s, many experienced employees accepted early retirement offers and left the company, taking this "corporate knowledge" with them. This, combined with the increased use of contractual services, has led to a disruption of previously reliable transmission of procedural information.

It soon became apparent that clearer means of providing procedural guidance were needed; thus, GOM was developed.

The GOM describes role expectations (in terms of the specific behavior that can be observed) for each ground crew member involved in ramp control procedures. It was recognized early on that behavioral expectations should go beyond technical indicators and should include expectations for effectiveness in traditional areas of resource management skills. As a result, the first section of the GOM is called the Human Factor and contains clear behavioral expectations in the areas of communication, crew coordination, workload management, planning, situational awareness, and decision making. For each of these areas, the skills to define a general concept, behavioral goal, and specific behavioral expectations for team leaders / lead agents and all team members are included in the GOM.

Communications Definition: the exchange of thoughts, messages or information through language, signals or writing. Activities, both verbal and non-verbal, used to transfer information between team members. Talk about anything you see that is dangerous, incorrect, or inappropriate to the procedure. If necessary, stop the operation. Any deviations from the instructions or procedures should be reported immediately. Some keys to proper communication:

Team Leader/AIC/ALA

- Establish and reinforce communications with all team members
- Conduct briefings on operational requirements and expectations
- Ensure that all team members understand their roles
- Communicate changes in a timely manner

All Team Members

- Listen actively and ask questions when unsure
- Use standard terminology and signals
- Give and accept constructive feedback
- Know what is expected of you

Classroom Training

With the development of an explicit set of observable behaviors for each of the skill areas in GOM, we have established a set of behavioral standards that can be learned. In the next step, we began developing curricula designed to raise awareness and develop skills in each of the six areas of resource management. Our goal is to introduce and strengthen the concepts and skills of resource management throughout the training careers of our ground operations personnel.

New Hire Training

All new employees working on the ramp are required to complete a basic training course on ramp operation. Resource management skills are integrated into this course to ensure awareness and skills development from day one at work

Ramp Resource Management Training

This course is designed for all current ramp and management staff, and will provide an overview of the concepts and skills of resource management that are covered in GOM. The course will highlight - using real accidents and incidents - how skills failures can lead to injuries, ground damage and negative impact on customer service.

Huddle for Excellence Recurrent Training

All Delta ground crews involved in the maintenance of aircraft in the gate area are required to hold a "Meeting for Excellence" before the arrival or departure of each flight. During this "here" the proper control procedures of the aircraft are checked, tasks are assigned, and the gate area is checked for the presence of FOD and ground handling equipment. Under the Huddle for Excellence program, all personnel are required to undergo annual periodic ground handling training. We use this annual recurring training as an opportunity to strengthen our resource management skills and address human concerns that are of particular concern.

Resource Management OJT

The recently and successfully completed a pilot program at our Atlanta center provided training and evaluation of workplace resource management (OJT) behavior. A team of selected ground operations personnel was trained in resource management skills and instructed in monitoring, evaluating, and training in resource management skills. Using a resource management behavior assessment form designed for use on the ramp, this team spent a week in each gate area, evaluating and training the work of ground crews.

Earlier this week, the team conducted a pre-training assessment of the ground crews that were observed. The team then spent four to five days working and training ground crews on the desired behavior. An evaluation was conducted at the end of the week after the training, and a further evaluation was conducted one or two months later.

Preliminary analysis of behavioral assessments shows that OJT coaching has led to a steady increase in the use of desirable resource management practices; and seemingly desirable behavioral changes correlate with a reduction in land damage. We are currently working to further develop this program and expand participation at stations outside Atlanta. We are encouraged that this program has the potential to provide continuous improvement in resource management skills. In addition, performance evaluations obtained by coaching teams can provide a basis for tracking performance improvements and undesirable behavioral trends over time. This information can be used to review or improve our training programs and procedures, or to identify additional resource needs related to ramp operations.

4.3. CONCLUSIONS TO CHAPTER 4

The initiatives we have implemented so far in our maintenance and ramp work are the beginning of a comprehensive approach to reducing human error by integrating the principles of the human factor. This approach recognizes that in order to be successful, we must go beyond resource management training to areas such as recruitment, policies and procedures, and recognition / evaluation programs. Our experience shows that the principles of the human factor are applied in various fields. However, the organization must be flexible in its integration methodology.

An initiative that works well on a hangar floor may not work well or be easily applied to a ramp or component shop.

The standards and recommended practices (SARPs) in Annex 1 and Annex 6 require appropriate regulatory action by aviation regulators. This manual contains practical information and recommendations that are regulated by the authorities to develop and implement regulations and guidance materials on the human factor in accordance with the annexes. Their implementation by operators and maintenance organizations should increase airworthiness by reducing human error.

Snook's theory of practical drift is used as the basis to understand how, in aviation, the baseline performance of any system ―drifts away‖ from its original design when the organization‗s processes and procedures cannot anticipate all situations that may arise in daily operations. During the early stages of system design (e.g. ATC airspace, introduction of specific equipment, expansion of a flight operation scheme, etc.), operational interactions between people and technology, as well as the operational context, are taken into consideration to identify the expected performance limitations as well as potential hazards. The initial system design is based on three fundamental assumptions: the technology needed to achieve the system production goals is available, the people are trained to properly operate the technology, and the regulations and procedures will dictate system and human behaviour. These assumptions underlie the baseline (or ideal) system performance, which can be graphically presented as a straight line from the date of operational deployment until the system is decommissioned. Once operationally deployed, the system performs as designed, following baseline performance most of the time. In reality, however, operational performance is different from baseline performance as a consequence of real-life operations and changes in the operational and regulatory environment. Since the drift is a consequence of daily practice, it is referred to as a ―practical drift. The term ―drift is used in this context as the gradual departure from an intended course due to external influences.

A practical drift from baseline performance to operational performance is foreseeable in any system, no matter how careful and well thought out its design planning may have been. Some of the reasons for the practical drift may include: technology that does not always operate as predicted; procedures that cannot be executed as planned under certain operational conditions; regulations that are not applicable within certain contextual limitations; introduction of changes to the system, including the addition of new components; the interaction with other systems; and so forth. The fact remains, however, that despite all the system‘s shortcomings leading to the drift, people operating inside the practical drift make the system work on a daily basis, applying local adaptations (or workarounds) and personal strategies ―beyond what the book says.

CHAPTER 5
LABOUR PROTECTION: WORKING CONDITIONS DURING AIRCRAFT MAINTENANCE

5.1. Theoretical introduction and the issue of working condition.

In accordance with Article 3 of the Constitution of Ukraine and the Law "On Protection labor "the basic principle of public policy is the priority of life and health of workers in relation to any results of production activities. Working conditions and safety, their condition and improvement are important tasks social policy of any modern industrialized state. Democratization of society, the transition to market economic relations require a radical improvement in working conditions, health and safety, ensuring healthy and safe working conditions, reliable protection of the population and objects of economic activity from significant consequences industrial accidents and catastrophes in the agro-industrial complex of Ukraine. This is what requires a radical change in the attitude of society as a whole labor protection, improving the quality of education of officials and specialists of all levels and population of the country.

Detection and analysis of dangerous and harmful factors on production. Determination of their effect on the body of workers. Impressive factors are understood as such factors of life environments that, under certain conditions, harm both humans and systems life support of people, lead to material damage. Depending on the effects of specific affecting factors on the human body they are in in some cases are divided into harmful and dangerous. Harmful factors are called such vital factors environments that lead to deterioration of health, decline disability, illness and even death as a result of the disease. Such factors of life are called dangerous factors environments that lead to injuries, burns, frostbite, etc. damage to the body or its individual organs and even to sudden death.

Although the division of striking factors into dangerous and harmful is enough conditional, because sometimes it is impossible to attribute any factor to one or another group, it is effectively used in occupational safety for the organization investigation and accounting of accidents and occupational diseases, setting up work aimed at developing measures and means of protection workers, prevention of injuries and morbidity at work. By the nature and nature of the impact of all dangerous and harmful factors are divided into four groups: physical, chemical, biological and psychophysiological.

Their main characteristic:

Physical:

- increased air velocity;
- high or low humidity;
- increased or decreased atmospheric pressure;
- insufficient lighting;
- collapsing structures;
- increased level of static electricity, etc.

Chemical:

- chemical elements, substances and compounds that are in different ways physical state (solid, gaseous, liquid);
- which in different ways enter the human body (through the organs breathing, through the gastrointestinal tract, through the skin and mucous membranes);
- which by the nature of action emit such substances (toxic, narcotic, irritating, suffocating, sensitizing, carcinogenic, mutagenic, affecting reproductive function).

Biological:

- macroorganisms (plants and animals);
- microorganisms (bacteria, viruses, rickettsiae, spirochetes, fungi, the simplest).

Psychophysiological:

- physical overload (static, dynamic);
- neuropsychiatric overload (mental overload, analyzer overload, monotony of work, emotional overload).

Dangerous and harmful factors are often hidden, implicit or difficult to detect or recognize. This concerns any dangerous and harmful factors, as well as sources the dangers that give rise to them.

A source of cognitive information about dangerous and harmful production factors, types of work, objects, equipment, high-risk equipment that affect the conditions and safety at work for the student - the executor can be acts of complex inspections and checks, acts about accidents and occupational diseases, prescriptions of state bodies supervision, acts of investigation of accidents, fires, minutes of operational meetings where reports on the implementation of measures for labor protection, fire were heard safety, passports on the technical and sanitary condition of structural units enterprises, analysis of safety and industrial sanitation, occupational injuries and accidents at the enterprise, etc.

It should be studied the sources of cognitive information, discovers dangerous and harmful production factors, types of works, objects, machines, mechanisms, high-risk equipment that affect the conditions and occupational safety at the enterprise. Determining the effect of negative factors production environment of the enterprise on the body of workers[2].

To facilitate this task, the student-performer needs share information on hazardous and harmful production factors enterprises for the reasons of their occurrence and analyze them:

a) organizational: lack or poor quality of training on issues labor protection and fire safety; lack of control; violation of requirements instructions, rules, norms, standards; non-compliance with protection measures labor; violation of technological regulations, rules of operation equipment, equipment; violation of norms and rules of planned preventive repair of equipment and facilities; insufficient technical supervision of dangerous works; use of equipment, equipment and tools for other purposes;

b) technical: non-compliance with safety requirements or malfunction production equipment, equipment, tools; imperfection technological processes; design defects of the equipment, imperfection or absence of protective barriers, safety devices, alarm and blocking means.

c) sanitary and hygienic: increased content of working areas in the air harmful substances; insufficient or irrational lighting; elevated levels noise, vibration, infra- and ultrasound; unsatisfactory microclimatic conditions; the presence of various radiations above the allowable values; violation of the rules of personal hygiene, etc.

d) psychophysiological: erroneous actions due to employee fatigue due to excessive weight and intensity of work; monotony of work; sickly condition of the employee; negligence; inconsistency of psychophysiological or anthropometric data of the employee used equipment or work performed.

5.2. Measures for prevention

Basic measures to prevent and eliminate the causes of production injuries and occupational diseases, accidents enterprises are divided into:

a) organizational measures: proper organization of work, training, control and supervision of labor protection; compliance with labor legislation, regulations on labor protection and fire safety, introduction of safe methods and scientific organization of work; carrying out reviews, lectures and visual agitation and propaganda on health and safety and fire safety; organization of planned and preventive repairs equipment, facilities, technical systems.

b) technical measures: these include measures for industrial sanitation, industrial and fire safety.

Measures for industrial sanitation: provide for the creation of a comfortable microclimate by installing appropriate heating and ventilation systems air conditioning;

thermal insulation of buildings and technological equipment; replacement of harmful substances and materials harmless;

- sealing of harmful processes;
- noise reduction, infrasound, ultrasound, vibration, electromagnetic and electrostatic fields, ionizing radiation;
- arrangement of rational lighting;
- providing the necessary mode of work and rest, sanitation and consumer services.

Industrial safety measures:

- introduction of safe equipment;
- mechanization and automation of technological processes;
- using safety devices, automatic locking means;
- correct and convenient location of equipment controls;
- development and introduction of automatic regulation, control and management systems technological processes;

- introduction of fundamentally new harmless and safe technological processes.

Fire safety measures: introduction of fire prevention systems and fire protection systems.

5.3. Common Aircraft maintenance safety issues

Because of the potentially dangerous work environment of aircraft maintenance, mechanics are at more of a risk than in other career fields. Working on aircraft means working high above the ground, moving heavy objects, using powerful machinery and being near hazardous chemicals — not to mention the long-term risk of exposure to vibration and noise. However, with the right equipment and safety precautions, your mechanics can significantly lower the chances for injury [1].

So why do accidents still happen even with excellent maintenance routine planning and proper equipment? It almost always comes down to employee complacency and not following procedures.

While there are times when even the best preparation can't prevent a mistake, making sure your mechanics are healthy, follow safety procedures and don't cut corners will significantly reduce the chances of them getting into an accident.

One risk for any worker who's involved in a potentially dangerous industry like aircraft maintenance is the effect of 'shift work.' When workers have set shifts, it means they might have to work despite not being fully physically or psychologically fit. And since some aircraft maintenance routines require mechanics to work non-traditional hours, the risks for employees not being physically and mentally prepared to perform safe work is much higher. It's important to realize these limitations of your maintenance team and adjust accordingly. Some of the potential hazards from shift work include:

Fatigue and Sleepiness: Irregular hours of work can mean your mechanics may not get all the sleep they need. Coupled with long or strenuous maintenance, this can lead to inefficient and unthorough work.

Stress: Personal and work life can be stressful and have people thinking about things other than the task at hand. Distraction from stress can be dangerous if a technician isn't paying attention to a detailed maintenance operation.

Medical Problems: Health problems like gastrointestinal and cardiovascular issues can arise from interruptions caused by irregular work hours.

Age: Older employees may have a more difficult time adjusting to irregular work hours or a changing schedule [3].

It's important to communicate with your employees to identify any problems they have. The best MRO managers find solutions that allow for efficient work and healthy, happy maintenance technicians.

BE PREPARED FOR AIRCRAFT MAINTENANCE SAFETY

The best way to avoid accidents and ensure quality aircraft maintenance is to plan. Detailed planning is vital for thorough maintenance, as well as employee safety.

Additionally, frequent employee safety training is the best way to educate your crew and keep them vigilant. Here are some aircraft maintenance safety topics to include both in your training and in your overall safety plan:

REVIEW RISK MANAGEMENT PRACTICES

When on the job, employees should do their best to keep their mind clear of distractions and anything that will take attention away from their work — even the most experienced mechanics get distracted sometimes. By following risk management practices, technicians can avoid simple mistakes that can lead to severe accidents. Remind your crew that it's a good idea to double check even simple maintenance tasks to make sure not to forget anything.

FOLLOW THE APPROPRIATE PROCEDURES

Maintenance technicians should always follow approved data and procedures when performing any maintenance operation. Service manuals are essential references with detailed information about how to complete each task and any specific tools required [1].

Also, keep in mind that for maintenance items that aren't included in your service manuals, it's a good idea to find references for your mechanics so that they are all using the same standardized, approved procedure.

USE SAFETY SIGNS

Any reminder of safety protocol is a good idea. That's why clearly-displayed signs that remind technicians to adhere to basics — like wearing a safety harness when working on top of wings and fuselages — is both a cost-effective and consistent method of pushing safety to the forefront of your team's mind. Also, remember that the use of safety flags and other caution signage is a great way to promote safety when your technicians might otherwise be getting complacent working in a familiar space.

ENSURE TEAM COMMUNICATION IS EFFECTIVE

Just because you haven't had an accident occur in your hangar lately doesn't mean your team is immune from one tomorrow. By regularly holding safety meetings and bringing up safety issues whenever you communicate important information to your personnel, you'll go a long way toward being proactive instead of reactive.

It always helps to ask your crew if there are any improvements they think will help make their job safer. Your team appreciates having their opinion valued, and fostering a work atmosphere based on safety helps reduce complacency.

BE PREPARED FOR THE WORST

From clearly marked eyewash units and first aid kits to fire suppression equipment and emergency exits, you must be ready to respond to accidents when they happen. And make sure all members of your team — from the most senior to the most junior — are fully trained in the use of emergency equipment, as this is crucial for being prepared for a worst-case scenario. Remember — in an emergency, every second counts.

Safe aircraft maintenance means not cutting corners. Here's how the pros minimize the chance for injury:

USE PROTECTIVE EQUIPMENT

Aircraft have many sharp edges and moving parts as well as hazardous fuels and other toxic liquids. In contrast, the human body has no protection against extreme heat, sharp metal objects and caustic or noxious fuels and fumes. This is why stressing the regular and consistent use of personal protective equipment — PPE — is number one on this list.

You can’t replace your sight, hearing or well-being if it’s taken from you due to unprotected contact with heated surfaces, flying metal shards or dangerous chemicals. For this reason, safety goggles, hearing protection, sturdy clothing and even breathing apparatuses must be used by technicians whenever appropriate [4].

USE RESPIRATORY PROTECTION

It’s easy for seasoned mechanics to forego standard safety protection because of their comfort and extensive experience on the job. But everyone should take proper precaution, especially when working on landing gear sections and brake replacement. These areas contain asbestos and can contribute to the development of asbestos-related diseases such as mesothelioma. Some mechanics won’t use respiratory protection because there’s no apparent threat, but long-term exposure can lead to serious health issues.

USE AIRCRAFT MAINTENANCE EQUIPMENT

Besides equipping your maintenance technicians with the proper tools, giving them the right ground support equipment is just as crucial to safety and efficiency. Safe access to a work area is essential for any maintenance job, and aircraft maintenance stands are the only solution for aviation work. They provide mechanics with secure access to even the most awkward areas. Aircraft equipment that’s specifically designed for the task at hand is a great way to reduce slips, falls and other workplace injuries.

The seriousness of this issue is backed up by statistics from the Bureau of Labor Statistics, which reports that 17 percent of occupational fatalities in 2017 were the result of falls in the workplace. When you choose JE Technology Solutions, Inc. to supply your aircraft equipment, you get ground support equipment that’s fully compliant with OSHA standards. What’s more, we offer built-in fall protection and provide integrated power supplies for tools.

USE THE RIGHT TOOLS

Specific maintenance tasks can require unique tools. And while your mechanics can probably improvise and get the job done anyway, specialized tools exist for a reason — they help get the job done correctly. It’s important to let your employees know that it’s better to inform you about the need for a tool rather than try to get the job done without it, as improvising can lead to a compromised aircraft.

If you only need task-specific tools occasionally, you may be able to rent them to avoid purchasing and storing them when they're not in use.

RETURN TOOLS TO THEIR STORAGE AREAS

When your technicians complete a work day or a task, it's a good idea to return all tools to their proper storage areas. A misplaced tool can be dangerous if it finds its way into the wrong part of an aircraft. We recommend creating a checklist for all tools needed for a task so that they can be accounted for when they are put away, or at least the mechanics can consult the list to ensure they don't leave anything where it shouldn't be.

One tool that has no substitute is a fire extinguisher — one should always be easily accessible for your technicians. While this one is obvious, too often the fire extinguisher is out of reach or nonexistent. For personal safety and for protection of valuable assets, everyone needs easy access to fire prevention tools.

REMOVE JEWELRY

You've probably seen a training film or two with images of hands missing fingers due to technicians not removing wedding rings before working on aircraft. These images should serve as sufficient warning, but be sure to back them up with regular reminders for your employees to remove all jewelry before getting started on any maintenance work.

5.4. CONCLUSIONS TO CHAPTER 5

Analysis of hazardous and harmful factors of production is aimed at development and management decisions by managers at all levels enterprise management; on the system account of indicators of a condition of protection labor; obtaining data on the reasons for non-compliance with regulatory requirements - legal acts on labor protection; development of a set of organizational, sanitary and hygienic and technical measures aimed at elimination identified shortcomings.

The solution to this problem is impossible without proper training agro-industrial complex on labor protection. Professional education is designed to provide the future specialist with knowledge, skills and skills of safe professional activity, in particular during performance management actions, in the design or development of new processes, implementation specific production actions, technological operations, etc. Graduate higher education institution must be able to use laws and others normative legal acts, current branch normative and technical documentation on labor protection, assess the state of readiness of the enterprise to accident-free operation within its competence according to the established criteria and indicators to:

- develop organizational and technical measures that ensure safe performance of works;
- to prepare workplaces for safe performance of works;
- apply in practice individual and collective remedies working;
- comply with the requirements of safe operation of equipment and equipment;
- to provide fire safety of objects;
- be able to use primary fire extinguishing means;
- follow the rules of personal hygiene and implement measures to compliance with the requirements of industrial sanitation, improving working conditions for workers places;
- make decisions on labor protection within their own powers;
- to carry out identification, research of conditions of origin and development emergencies and ensuring coordinated action on them warnings on agro-industrial facilities in accordance with their own professional responsibilities.

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CHAPTER 6
ENVIRONMENT PROTECTION.
THE MAIN ISSUES OF NOISE POLLUTION AND ITS MANAGEMENT

6.1 Balanced Approach to Aircraft Noise Management

Aircraft noise is the most significant cause of adverse community reaction related to the operation and expansion of airports. This is expected to remain the case in most regions of the world for the foreseeable future. Limiting or reducing the number of people affected by significant aircraft noise is therefore one of ICAO's main priorities and one of the Organization's key environmental goals.

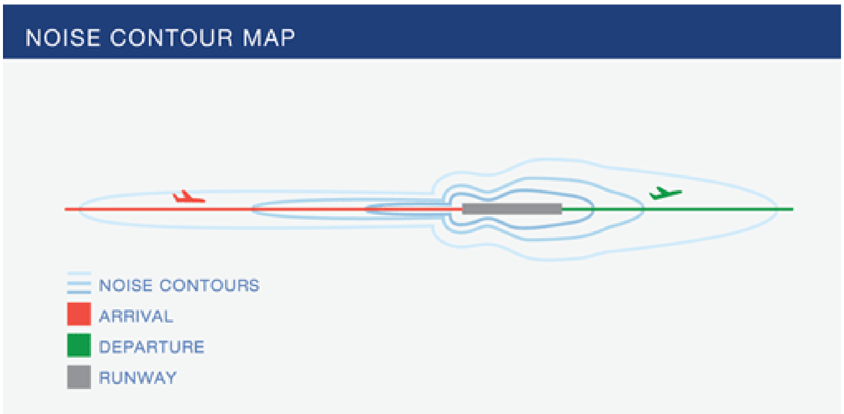

Fig.11 Noise Contour Map

The main overarching ICAO policy on aircraft noise is the Balanced Approach to Aircraft Noise Management, adopted by the ICAO Assembly in its 33rd Session (2001) and reaffirmed in all the subsequent Assembly Sessions (reference: ICAO Resolution A39-1 Appendix C). Detailed guidance on the application of the Balanced Approach is provided in the ICAO Doc 9829, Guidance on the Balanced Approach to Aircraft Noise Management.[1]

The Balanced Approach consists of identifying the noise problem at a specific airport and analyzing various measures available to reduce noise through the exploration of various measures which can be classified into four principal elements, described in Figure 1. The goal is to address noise problems on an individual airport basis and to identify the noise-related measures that achieve maximum environmental benefit most cost-effectively using objective and measurable criteria.

An important pillar of the Balanced Approach to Aircraft Noise Management is the reduction of noise at source. Aircraft noise ("noise at source") has been controlled since the 1970s by the setting of noise limits for aircraft in the form Standards and Recommended Practices (SARPs) contained in Annex 16 to the Convention on International Civil Aviation (the "Chicago Convention") [3]. This continues to be the case today. Noise provisions appear in Volume I of Annex 16. The primary purpose of noise certification is to ensure that the latest available noise reduction technology is incorporated into aircraft design and that this is demonstrated by procedures that are relevant to day-to-day operations. This aims to ensure that noise reductions offered by technology are reflected in reductions around airports.

6.2. Noise Standards

6.2.1Noise Standards for jet and large propeller aeroplanes

Based on the recommendations of the "Special Meeting on Aircraft Noise in the Vicinity of Aerodromes" (1969), draft International Standards and Recommended Practices for Aircraft Noise were developed and became applicable in 1972. These Standards define three reference measurement points for noise certification, which are illustrated in Figure 1. The Standards also set noise limits as a direct function of Maximum Take-off Mass (MTOM) in order to recognize that heavier aeroplanes, which were of greater transport capability, produce more noise than lighter aeroplane types. This is the Chapter 2 Noise Standard contained in Annex 16, Volume I. More details on this legacy ICAO Work are provided in the ICAO Environmental Report 2019[1].

Following the introduction of Chapter 2, much higher bypass ratio jet engines were introduced into service. Not only did this new technology deliver improved fuel efficiency, it also resulted in reductions in engine noise. This allowed for the ICAO noise standard to be made more stringent in 1977. In the following years, further noise reduction technologies were incorporated into engine and airframe designs which led to incremental improvements in aircraft noise performance and this resulted in further stringency increase of the noise standards.

In February 2013 the CAEP/9 meeting recommended an amendment to Annex 16, Volume I involving an increase in stringency of 7 dB (cumulative) relative to the current Chapter 4 levels. In 2014, this recommendation was adopted by the ICAO Council as the new Annex 16, Vol I, Chapter 14 noise standard for jet and propeller-driven aeroplanes. This new, more stringent standard is shown in Figure 2, (along with the previous ICAO noise standards for reference) and this will be the mainstay ICAO Standard for subsonic jet and propeller-driven aeroplane noise for the coming years. It is applicable to new aeroplane types submitted for certification on or after 31 December 2017, and on or after 31 December 2020 for aircraft less than 55 tonnes in mass.

6.2.2 Noise Standards for light propeller aeroplanes

Noise Standards for light propeller aeroplanes were first included in Annex 16 in 1974. Currently, these Standards are contained in Annex 16 Vol I Chapter 10, which are restricted to propeller-driven aeroplanes not exceeding 8,618 kg maximum certificated take-off mass.

This Standard is based on a single take-off reference noise measurement point, which is located at a distance of 2 500 m from the start of take-off roll. As is the case for larger aeroplanes, the Standards also set noise limits as a direct function of Maximum Take-off Mass (MTOM).

6.2.3 Noise Standards for helicopters and tiltrotors

Noise Standards for helicopters were first included in Annex 16 in 1981. Currently, the Standards applicable to helicopters are contained in the Chapters 8 and 11 from Annex 16 Vol I. Chapter 8 is applicable to all helicopter types; whereas

Chapter 11 provides an optional simplified certification procedure for light helicopters with a maximum certificated take-off mass of 3 175 kg or less.

More recently, in 2014 the ICAO Council adopted noise Standards for tiltrotors, which were included in Chapter 13 of Annex 16 Vol I [2].

6.2.4 Noise Standards for Supersonics

Currently, Annex 16 Vol I only includes noise standards for supersonic aeroplanes for which the application for Type Certificate was submitted before 1 January 1975. These are provided in Chapter 12 of Annex 16 Vol I. Work is ongoing in ICAO to develop new noise standards for supersonics, as described in more detail here.

ICAO continues its efforts towards developing a Standard for future supersonic aircraft, and discussions continue on the sonic boom measurement schemes and procedures. The goal is to establish technical flight test procedures for enroute (sonic boom) noise certification. These would be in addition to the certification requirements for the landing and takeoff (LTO) conditions.

During the CAEP/11 cycle (2016-2019), progress has been made on identifying certification measurement locations for assessing sonic boom noise on the ground; selecting an appropriate noise metric for use in a Standard that assesses sonic boom noise and shows favourable correlation between outdoor measurement and indoor human response; and evaluating the benefits of using sonic boom predictions in supersonic noise certification in addition to physical measurements. Research Focal Points (RFPs) also continue to inform the work of CAEP with details on important research associated with supersonic flight and guide the selection of metrics and measurement locations.

6.3. AEROPLANE NOISE TECHNOLOGIES

6.3.1 Key issues for noise reducing

In its eleventh cycle (2016-2019), CAEP conducted an independent expert (IE) review to evaluate aeroplane noise goals by 2027 and 2037. More information on the IE review can be found in ICAO Doc 10127 (2019). The main IE conclusions regarding noise reduction technologies are as follows:

For modern large aircraft, Single Aisle and Twin Aisle, jet noise is a secondary noise source even at departure, with fan noise dominating. For smaller aircraft, business jets and small regional jets, the noise from the jet may still dominate at departure, as it does for many older aircraft. Jet noise has been reduced by reducing jet velocity to improve fuel burn, but because jet noise is now a secondary source, further improvements in fuel burn will not bring automatic substantial reductions in noise.

A key technology for reducing fan noise is acoustic wall treatment, and liners in the inlet and bypass duct provide essential attenuation. Work continues to improve liner performance, but the task of maintaining current levels of liner attenuation will be challenging, given the incentives to make the intake and bypass duct shorter in relation to diameter, and to reduce nacelle length for fuel burn reasons.

Airframe noise is the largest noise source at approach for modern large aircraft, mostly from the landing gear. Potential airframe noise reductions are very dependent on aircraft category, design and operational characteristics, and the exploitation of this potential will be driven by multiple constraints.

As engines get larger in relation to aircraft size, corresponding to lower fan pressure ratio, it becomes more important for the engine and the aircraft to be designed together as an integral unit. The optimization of the aircraft needs to include acoustic design as well as design for minimization of fuel burn and emissions.

The scope for noise technology reductions of the conventional tube and wing configuration, particularly in large aircraft, now appears to be limited, and the potential additional benefits of acoustic design optimization will need to be properly assessed. Novel configurations, or even some very advanced tube and wing configurations, may bring new noise reduction opportunities, but at the same time these will introduce significant challenges of different nature, which will also need to be addressed.

6.3.2 Helicopter noise technologies

As part of the technical monitoring effort, CAEP conducted a status review of the noise technology advancements of helicopters between 2000 and 2015 to highlight the developments since the last helicopter noise assessment report conducted in 2001 (during CAEP/5) [3]. The review included examining both noise reduction technologies and the costs associated with those technologies. The results of the helicopter status review can be found here. The report includes an overview of international noise technology programs and research initiatives, key noise reduction technologies of modern helicopters, and the status of advanced noise reduction technologies currently being tested in research programs. Constraints and challenges to incorporate both current noise reduction technologies and promising new technologies are also considered.

One important issue that the Special Meeting considered was the noise metric to be used in aeroplane noise certification. There are three main factors that influence the human perception of a noisy event (such as an aeroplane overflight): the amplitude (or volume), the frequency content (high/low pitch), and the duration of the event. Therefore, the challenge faced by the Special Meeting was to define a metric that would capture these variables and represent appropriately the human response to the noise from one aeroplane overflight. Since the main objective of the certification Standards is to compare technology levels of different designs, the Special Meeting agreed that the noise metric to be used should have maximum accuracy and validity in representing the human response to noise. The Special Meeting considered the use of existing noise metrics at the time, however it was agreed that traditional noise metrics lacked the precision required for aeroplane noise certification. As a consequence, a new noise metric was proposed, the EPNL (Effective Perceived Noise Level), which takes into account all the physical variables associated with human perception of aeroplane noise: the different response to sounds of different frequencies and intensities, the presence of predominant irregularities in the frequency spectrum ("pure tones"), and the duration of the event.

Traditional noise metrics such as the A-weighted noise level (dB(A)) are based on the addition of an attenuation factor to the measured sound pressure levels, in an attempt to represent the variable sensitivity of the human ear to sounds of different frequencies.

However, the dB(A) representation of the human ear includes some simplifications to facilitate its electronic implementation in sound metering devices. On the other hand, the EPNL correlates sound pressure levels with perceived noisiness by means of the Noy Scale, which provides a more accurate representation of the human sensitivity to noise.

Figure 12 below illustrates how the dB(A) and the Noy scale represents the variability of human ear sensitivity to frequency. It can be seen that the Noy Scale (on the top) presents a much more refined representation of the human ear response.

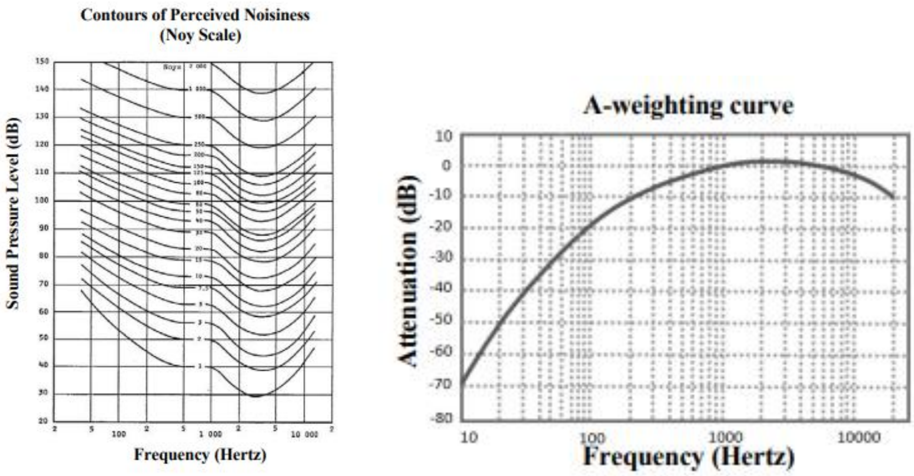

Figure 12. Variability of human ear sensitivity

6.4. DESCRIPTION OF SCHULTZ AND NATIONAL CURVE

6.4.1. The threshold of significant aircraft noise exposure and the FAA's noise goal

In 1976, the Secretary of Transportation and the Administrator of the FAA issued the Aviation Noise Abatement Policy (ANAP), the first comprehensive aviation noise abatement policy in the U.S. In defining the "aircraft noise problem," this policy characterized aircraft noise exposure of DNL 65 to 75 dBA in residential areas as "significant" and DNL 75 dBA or more as "severe," and related these noise exposure levels to previously used interpretations of expected community actions based on case studies [5].

The ANAP also identified DNL 65dBA as the noise exposure level above which aircraft noise "create[s] a significant annoyance for most residents," but it did not provide any additional information supporting this characterization [1].

Since the issuance of the ANAP, the FAA has used the DNL 65 dBA threshold as the basis for its "noise goal" of reducing the number of people exposed to significant aircraft noise around U.S. airports.

6.4.2 Rationale for a New Survey

While the Schultz Curve remains the accepted standard for describing transportation noise exposure-annoyance relationships, its original supporting scientific evidence and social survey data were based on information that was available in the 1970s. The last in-depth review and revalidation of the Schultz Curve was conducted in 1992. More recent analyses have shown that aviation noise results in higher annoyance than other modes of transportation. Recent international social surveys have also generally shown higher annoyance than the Schultz Curve. These analyses and survey data indicate that the Schultz Curve may not reflect the current U.S. public perception of aviation noise.

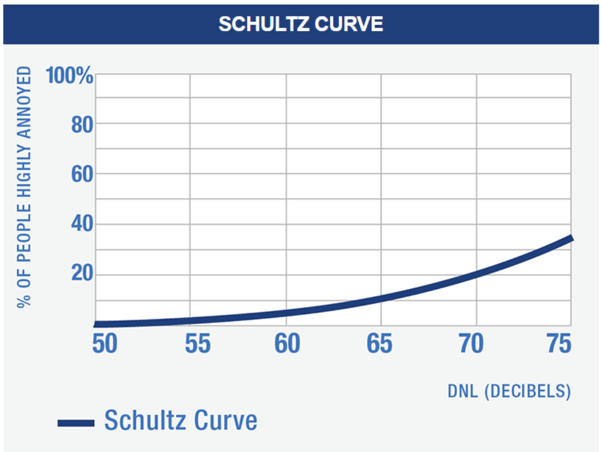

Figure 13. Schultz Curve

To ensure that FAA's continued efforts to reduce the effects of aircraft noise exposure on communities is based upon accurate information, FAA conducted a nationwide survey to measure the relationship between aircraft noise exposure and annoyance in communities near airports.

This survey would capture the community response to a modern fleet of aircraft as they are being flown today and it would use best practices in terms of noise analysis and data collection. The responses from the survey have been used to create a new National Curve [2].

The Survey results show that there has been a substantial change in the public perception of aviation noise, relative to the Schultz Curve, and will ultimately inform future FAA noise initiatives.

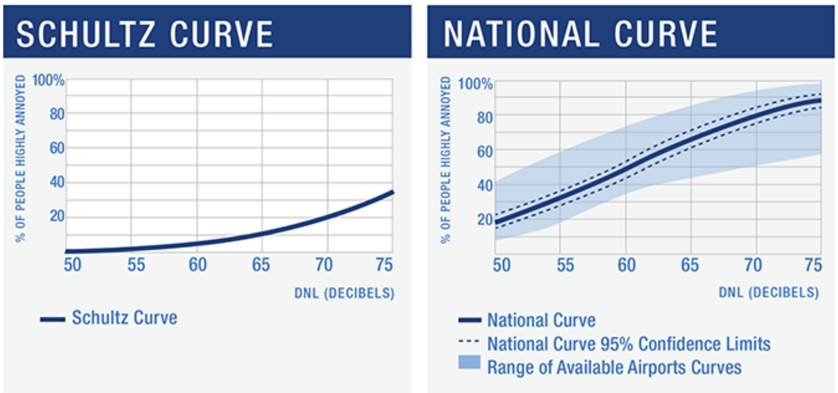

Figure 14. Schultz and National Curve

The new Survey was designed to use a consistent approach across each airport community surveyed. This has allowed for an enhanced ability to provide additional statistical information about the new results, such as the 95% Confidence Limits and range of results from each of the 20 airports, as shown on the plot above. This was not possible with the older Schultz Curve.

The majority of phone survey respondents who were likely to be annoyed by aircraft noise indicated that they have experienced being "Startled", "Frightened", or "Awakened" by aircraft at home. Those who were bothered, disturbed, or annoyed by "General Traffic Noise" or "Smells" were also more likely to be annoyed by aircraft noise.

All three prediction methods also show good agreement in the predicted peak aircraft system noise level, typically within 3-4 dB, for both approach and departure.

However, increasing differences, approaching 5-10 dB, could be observed at the far forward and aft angles. These larger differences between the three predictions are believed to be mostly due differences in the shielding predictions. Differences in the prediction of some component source levels were also observed, primarily for airframe noise sources. This was also identified and discussed in the companion paper.

6.4.3. Efficiency observation of method implementation

Exposure–response functions relating a noise indicator (e.g., maximum SPL) to a sleep outcome (e.g., awakening probability) can be used for health impact assessments and inform political decision-making. Subjects exposed to noise typically habituate, and exposure–response functions derived in the field (where subjects have often been exposed to the noise for many years) are much shallower than those derived in unfamiliar laboratory settings. Unfortunately, sample sizes and response rates of the studies that are the basis for exposure–response relationships were usually low, which restricts generalizability.

One of the additional tools used by airports and regulatory authorities are sound level contour maps, often just called noise maps. Using a combination of sound level measurements and appropriate sound mapping software, an airport can establish expected noise levels and determine, for example, locations where noise mitigation is needed. Looking down upon a map of the airport, the highest sound levels occur immediately next to the runways and along the primary aircraft takeoff and descent ground tracks. Moving away from these highest levels, decreased noise is found. Such noise maps can be very useful for assessing current and future noise exposure within several kilometers of airports.

This section will only provide the most basic information. For those who wish to dig deeper, there are a number of available references that explain the finer points. Noise, or any type of sound, consists of fluctuations in pressure, p, measured in pascals (Pa), which is a force per unit area. Human hearing is extremely sensitive, and people hear very well over a wide range of pressures. Hence, to put this wide range into a more reasonable scale, logarithms are used. The SPL is defined as

$$L\mathrm{p}=\mathrm{SPL}=20\log10(p/p\mathrm{ref})$$

As you can see the logarithm to the base 10 is used, and the symbol utilized is L_p, indicating the level of the pressure. The reference pressure p_{ref} is a threshold of human hearing and equals 20 μPa. A much larger pressure corresponding to a loud sound might correspond to 100 dB or higher. Very often to measure noise, an additional frequency weighting is used. Human hearing is not equally sensitive across all frequencies, and the most popular method to at least partially compensating for this is the A-weighting curve. A-weighting emphasizes the frequencies to which the human ear is most sensitive and attenuates the low frequency and very high frequency components of the sound. The A-weighted SPL is denoted L_A. This metric is used commonly in assessing a wide variety of noise types, and is often described with the unit dB(A) or dBA.

6.5 CONCLUSIONS TO CHAPTER 6

Fan noise is the dominant departure noise for modern large aircraft whilst it is important at take-off for small aircraft; fan noise dominates engine noise at approach for all aircraft. Reduction in fan pressure ratio is likely to lead to a reduction in fan noise, both forwards and rearwards. Beyond reducing fan tip speed, further fan noise reductions are challenging. Extensive dedicated research (involving full engine ground and flight test demonstrators) combined with 3D unsteady, viscous analysis of the whole gas-path (air intake + fan + OGV + struts + bypass duct) can be expected to bring some additional gains. Better acoustic liner technology will help, but against this, the intake and bypass duct will get shorter in relation to diameter and this will reduce the area amenable to treatment.[1]

Results according to the Noy Curve: a new National Curve was created by combining the Survey responses from the question on "Noise from Aircraft" with the modeled aircraft noise levels. Compared with the existing Schultz Curve, the new National Curve shows a substantial increase in the percentage of people who are highly annoyed by aircraft noise over the entire range of aircraft noise levels considered, including at lower noise levels.

When comparing the two curves, a variety of factors should be considered. Both analyses were conducted using the best survey data and understanding available at their time. However, many changes and advances have occurred in the 40 years since the Schultz Curve was created.

Potential factors for these differences still need to be explored; but to provide additional insight, mail survey respondents were also invited to participate in a detailed phone survey aimed at understanding the underlying reasons for annoyance to aircraft noise.

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CONCLUSIONS

The ADAMS research project examined the nature and scale of the human factor problems in aircraft maintenance in Europe. A high level of commitment to safety was found in each of the organizations that participated in the study. However, ADAMS found that in approximately one-third of all cases, technicians deviated from the established procedures of the Maintenance Manual. Technicians do not see the need to refer to official documentation when it comes to routine tasks. For these tasks, first refer to the manual to find detailed information.

Most technicians agree that extracting information from maintenance manuals is cumbersome: structure, (high) level of detail, and errors in the text are often criticized. Almost half of the people in basic care who did not follow the procedure provided by the instructions said that there was a better or easier way to do the job. It is not yet clear what forces technicians to perceive written procedures in this way. More effort should be made in developing the system and procedure to specifically understand the cognitive expectations of the maintenance professional.

CURRENT INITIATIVES TO REDUCE ACCIDENTS AND INCIDENTS ASSOCIATED WITH HUMAN ERROR

Many aspects of human factors are associated with the operational safety of commercial airplanes, including the following:

design factors associated with aircraft controls, aircraft system controls, warning systems, air traffic control systems, flight deck, passenger seating and egress, etc.

Operational factors associated with the selection and training of flight crews, crew assignment policies related to the distribution of experienced personnel and the minimization of flight crew fatigue, checks on crew members' health, and policies on preflight information.

Maintenance factors related to training maintenance workers; the clarity of maintenance procedures; and designing aircraft equipment and maintenance tools to make it easier for workers to perform maintenance, avoid errors, and detect abnormal conditions.

National and international regulatory factors associated with airworthiness standards, separation standards, and communications standards.

Current processes, which are both thorough and complex, have resulted from a large accumulation of flight experience, analytical and computer studies, and reviews of human factors. All of this information represents a complicated web of interrelated factors that makes it difficult to define a clear and simple road map for progress. Complexity, however, is inherent in many human factors issues.

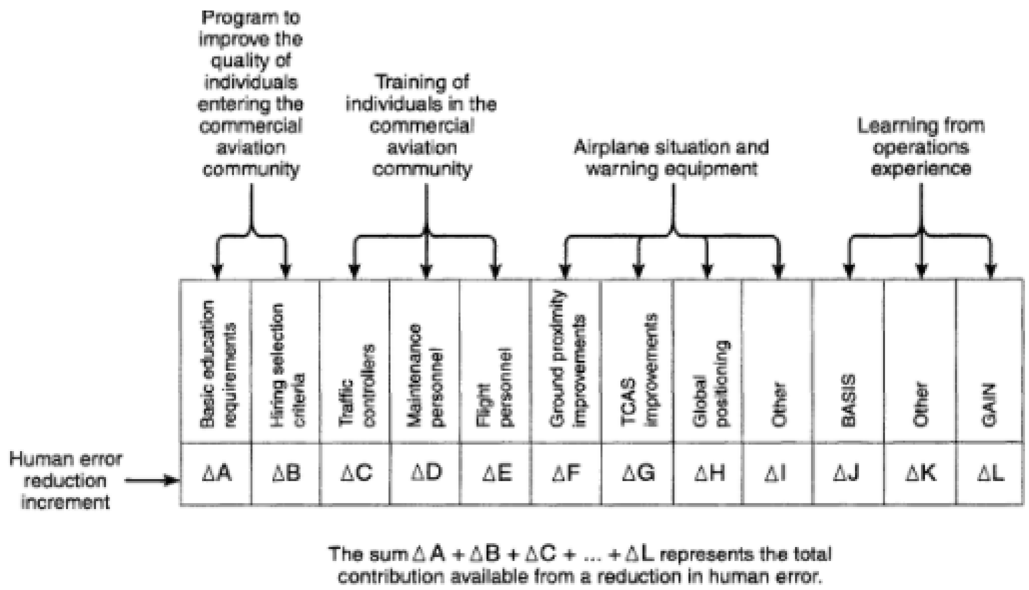

Figure 15. Human error areas of distribution

Additional work in fields such as cognitive science and fundamental neuroscience is progressing rapidly and is likely to offer valuable insights in the near future. The potential benefits of relying more on cognitive science are explained by James Reason (1990) and, in a more philosophical sense, by David Chalmers (1996). Turning to cognitive science to improve the understanding of issues associated with situational awareness has two major advantages. First, it should encourage the development of processes and systems that would improve the selection and presentation of necessary information, assigning to automated systems the tasks that systems do best and allowing people to continue doing the tasks that people do best. Second, it should help define the type of automation that can reduce the workload of flight crews and air traffic controllers in the crucial moments when a situation must be assessed quickly and accurately.

IMPROVING THE EFFECTIVENESS OF THE FAA'S HUMAN FACTORS PROJECTS

Harnessing the growing body of human factors knowledge will enhance the FAA's efforts to reduce the number of incidents and accidents by reducing human error and improving the ability of flight crews and other personnel to prevent accidents associated with other causes. That is one of the tasks of the FAA's Human Factors Study Group. This group appears to be reasonably well coordinated with the JAA (Joint Aviation Authorities) Human Factors Study Group and will operate indefinitely. Close coordination between these two groups is important in an environment that is becoming increasingly aware of the value of international harmonization of airworthiness standards and procedures. Coordinating the work of both groups with similar study groups sponsored by ICAO and other certifying authorities would also be worthwhile.

The membership of the FAA Human Factors Study Group should be reviewed and adjusted, if necessary, to ensure that it has strong representation from the fields of cognitive science and basic neuroscience. Strong representation in these areas would help the study group form a cohesive framework for understanding the very large number of human factors studies that are now under way, and it would enhance the ability of the group to recommend actions based on the results of these studies. Some of these studies are associated with enhanced ground proximity warning systems, improved traffic collision avoidance systems, and other aspects of developing crew-centered cockpit designs.

Finding 1. Maintaining situational awareness is the key to preventing the vast majority of serious incidents and accidents associated with human error.

Major Recommendation. The FAA should support and accelerate efforts

(1) to define the minimum data required by the flight crew to maintain adequate situational awareness during all phases of flight and reasonable emergency scenarios and

(2) to determine how this data can be presented most effectively.

Recommendation 1. The FAA should ensure that its human factors projects, especially the FAA Human Factors Study Group, include strong representation in the fields of cognitive science and basic neuroscience.

Recommendation 2. Advances in understanding human factors should be quickly applied to the key task of reducing the role of human errors in incidents and accidents, particularly with regard to improving the situational awareness of operational personnel and improving the effectiveness of maintenance personnel. The FAA should strongly support its Human Factors Study Group and other projects that contribute to this task.

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