OVERVIEW REGARDING HUMAN FACTORS IN AVIATION

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Rezumat. *Tehnologia ne-a arătat o creștere exponențială a automatizării în ultimii ani, însă, oricât de mult ar încerca producătorii de aeronave să automatizeze activitatea de zbor, tot apar evenimente cu implicații majore pentru siguranța zborului. În peste 80% din accidentele aeronautice, performanțele limitate ale piloților, tehnicienilor sau a controlorilor de trafic aerian au avut un rol decisiv. Acest studiu își propune să analizeze factorii care influențează performanța umană în toate etapele în care o aeronavă se poate găsi, în raport cu 4962 de evenimente de aviație din perioada 2000-2020, extrase din sistemul de raportare a siguranței aviației din S.U.A (A.S.R.S.). În ziua de astăzi, perspectiva celei de-a IV-a revoluție industrială ne obligă să punem accentul pe volumele mari de date ce ne înconjoară pentru analize mult mai complexe și rezultate mult mai precise.*

Abstract. *In the last years, technology experienced an exponentially increase, but no matter how much the aviation manufacturers tried to automate the flight activity, events with major implication for flight safety continue to appear. In over 80% of the aviation accidents, the limited performance of the pilots, technicians and air traffic controllers played a major role. The purpose of this study was to analyse the factors which influence the human performance in all stages of flight, taking into consideration 4962 aviation events from 2000 to 2020, downloaded from Aviation Safety Reporting System (ASRS). Nowadays, the perspective of the 4th industrial revolution constrains us to insist on using big data for much more complex analyses and much more accurate results.*

Keywords: risk management, aviation safety, Dirty Dozen, Shell Model

1. Introduction

A known fact is that 80% of aeronautical incidents are produced due to human factor errors.[1] Therefore, experts are in a continuous research in order to identify new solutions for aeronautical safety improvement and methods to prevent human

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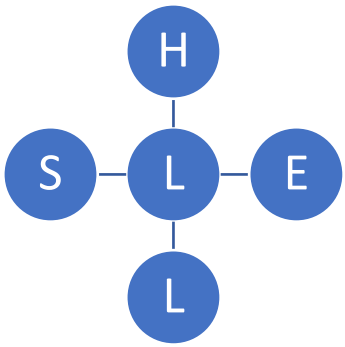
errors. Eliminating the risks due to the limitation of human factors requires first of all their understanding.
Hence, the most common cause of aviation accidents is represented by the behaviour, the limits and the performances of the aviation staff.
In 1972, Professor Elwyn Edwards developed the Shell model for human factors in aviation business [2-3], see Figure 1.



1. S – Software
2. H – Hardware
3. E – Environment
4. L – Liveware

Fig. 1. Shell model for human factors

The shell elements are:

1. Hardware: equipment, tools, and other physical resources used for the maintenance activity.
2. Software: non-physical resources used for maintenance: procedures, politics, books, flight logs.
3. Environment: a set of factors which influence the environment where staff operates (climate, temperature, vibrations, noise), but also the socio-economic and political set of factors.
4. Liveware: teamwork, communication. In the picture presented above, the central element of 'liveware' is defined as the core of the model and refers to the human being and its characteristics: knowledge, attitude, culture, stress conditions, etc.

Moreover, we have knowledge about the interaction between elements:

A. <u>„ Liveware" - „ Hardware"</u>

This 'human-machine' interaction must be designed in such a way that the operation of the machine is based on human characteristics, in order to limit potential errors.
Therefore, the user interface of a technical system must be smart designed to indicate information that is easy for a human being to process.

Assessing the risks arising from human-machine interaction is very difficult to analyse due to the different abilities of humans to adapt and become familiar with a technical system.

B. „ Liveware" - „ Software"

Regarding this interaction, the main problem is the lack of documented information or their misinterpretation. That is why the standard operation procedures must be completed, accessible, easy to understand and easy to be applied.

C. „ Liveware" - „ Environment"

In general, to prevent the risks due to the human-environment interaction, a series of auxiliary tools are used. These facilitates the flight and maintenance activity of pilots or technicians. On the other hand, this type of interaction also includes the strict wearing of personal protective equipment.

D. „ Liveware" - „Liveware"

Interaction between people mainly refers to the potential risks that arise from a faulty collaboration within a team. It is not enough for people in a group to be well prepared. Inappropriate communication or the personality of each individual can be the sources of catastrophic errors in the aeronautical industry.

2. Human factor in aviation maintenance

Over the time, the aviation industry developed a set of factors that influence human performances in aircraft maintenance activity, also known as 'Dirty Dozen'.
Nowadays, these factors provide an extremely useful guidance of maintenance staff for identification, awareness and avoidance of possible errors in the maintenance process.

Table 1. Dirty Dozen presentations [4-5]

1	*Lack of communication*
Most of the time, the lack of a proper communication is the main reason behind an accident. The communication process has 3 elements: transmitter, receiver and the communication channel. The transmitted instructions can be inaccessible or unclear. In verbal communication, both the transmitter and the receiver could have a subjective interpretation of the exchanged information. Thus, one of the risks is that the message cannot be correctly processed by the receiver. That is why in aeronautical industry it is recommended that the important information to be organized as written instructions.	
2	*Complacency*
The complacency in any situation, is a common condition among aviation technicians, mostly in the case of experienced ones. Due to the routine, they may lose the capacity to realize the consequences of their activities. Too much trust in their own capabilities could lead to superficial treatment and/or non-compliance with applicable procedures. To properly carry on the maintenance activity, it is recommended:	

- Technical staff should always work following the technical instructions. - Technical staff should never consider an operation well executed until it is verified. - Technical staff should never certify activities that are not fully executed
3 *Lack of knowledge*
In aerospace industry, the requirements regarding the staff's training and qualification are extremely strict. Hence, in aircraft exploitation, only qualified personnel can be involved. However, some maintenance activities require an intensive training, adapted to technician's learning capability. The lack of experience both for the hands-on activities and theoretical knowledge could lead to unwanted errors.
4 *Distraction*
The distraction could refer to any factor which can determine the technician to deviate from his activity. Some distractions cannot be avoided in maintenance activity (noise, working equipment, opening and closing doors). Others can be avoided or at least postponed until the end of the task. People have the tendency to think in advance, that is why in the moment in which we come back to an activity after a distraction, there is the risk to consider that we are in a more advanced state than we really are. In aviation, this kind of error could lead to catastrophically events. However, the risk of skipping a step during a process is high, so it is recommended to use a checklist to minimize this risk.
5 *Lack of teamwork*
Ensuring the airworthiness of an aircraft, it is always the result of teamwork. This team effort leads to better results, only if each member of the team synchronizes its tasks with the other members. It is not enough that the members to be well prepared, there must be a collaboration, cohesion and flexibility. Also, the teamwork implies trust and good communication skills.
6 *Fatigue*
Fatigue is a natural reaction to physical or mental stress and has the effect of diminishing the ability to concentrate. Regardless the field of activity, the lack of concentration, caused by fatigue can lead to major negative effects. In aviation, staff fatigue can lead both to work accidents and failure to perform the tasks. That being said, the fatigue is a state which must be controlled and monitored carefully by task distribution, taking into account the capacity of each individual.
7 *Lack of resources*
Qualified staff, specific equipment, documents, time, parts are resources without which the maintenance activity cannot be performed in safety and maximum quality conditions. The lack of resources could lead to usage of improvisations for finishing their activities. In this industry improvisations are strictly forbidden due to the major negative consequences that could appear. A resource management plan adapted to maintenance needs it is necessary to maintain the quality standard.
8 *Pressure*
Pressure is custom in this field and it should not be regarded as an issue, but as a challenge for each technician to prove their qualities. However, the pressure in an aircraft maintenance organization is sometimes too big, because each hour in which an aircraft stays on ground leads to huge losses for the economical operator. The need of ensuring quality, availability and profitability leads to a major pressure in each company. On the other hand, there are maintenance structures in which the routine appears. If too much pressure reduces the expert's performances, too little pressure can induce a state of relaxation and distraction which can also lead to decreased performance. That is why, the management must maintain an optimum level of pressure.
9 *Lack of assertiveness*

Assertiveness is the human quality to express an opinion in a respectful and firm manner. The aggressive communication and incapacity to express an opinion in a civilized way compromises both the message and the relation with the speaker. Regardless of the place in the organization hierarchy, the staff must present their opinions, needs and feelings in a productive and positive manner.	
10	*Stress*
The stress caused by different situations encountered at the workplace can affect the behavior of the technical staff, including their capacity of being productive. Stress management is vital in this activity and it is achieved through direct involvement of the management. Communication, additional days off or the alternation of high intensity periods with low intensity periods are just a few methods for reducing the stress.	
11	*Lack of awareness*
There are situations in which, because of the daily routine, the staff loses from sight the overall picture and it is not aware of the risks. Once the personnel are familiarized with a maintenance process a decreased alertness appears. Also, there is the risk that, in the evaluation process of the aircraft's technical state, the real danger of a malfunction is not realized and that situation is being treated with superficiality.	
12	*Norms*
In any organization there are instructions, procedures and rules which define the organization and process of activities. According to the organizational culture, there are a series of unwritten rules derived from existing procedures and instructions. These specific rules can change over the time according to management influence, work experience and other factors. Some of them can be helpful and others could have negative effects due to uncontrolled documentation. Subjectivism is not allowed in aerospace industry, so therefore it is recommended that each activity to be standardized by elaborating procedures and continuous monitoring of their applicability.	

3. Analysis of the factors that influence human performance in the flight stages of an aircraft – case study

ASRS is world's largest database which includes data provided by the aviation first line staff, including pilots, air traffic controllers, mechanics, flight attendants and dispatchers. This database stores different aeronautical accidents and incidents from the last 30-40 years. Also, the system offers plenty of searching criteria and sorting such as the events can be organized by type of aircraft, main cause, weather, incident location, etc. [6]

The downloaded data consist of 4962 aviation events from 2000 to 2020 which had as common cause the human factor. Furthermore, there were selected only the incidents which had information regarding the stage in which the aircraft was.

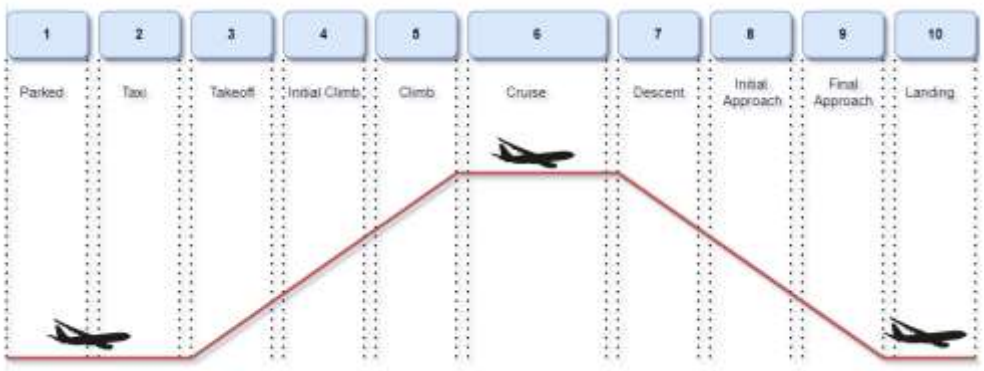


Fig. 2. Communication Breakdown

The data were structured according to the stage of the aircraft and the main human factor that led to the incident. In this approach, a matrix with 9 columns (event name, 7 human factors and flight phase) and 4962 rows resulted. The following results were derived from this matrix:

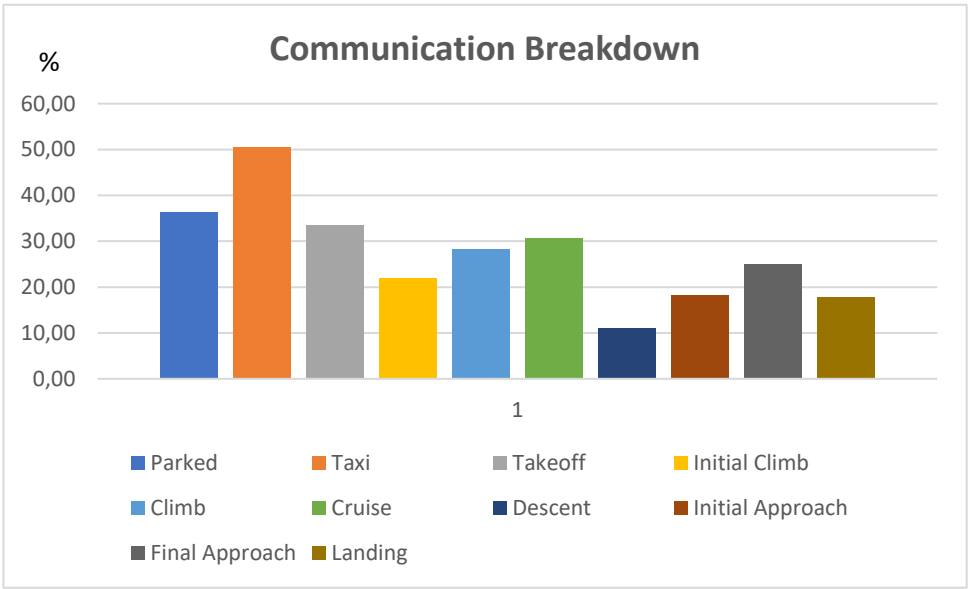


Fig. 3. Communication Breakdown

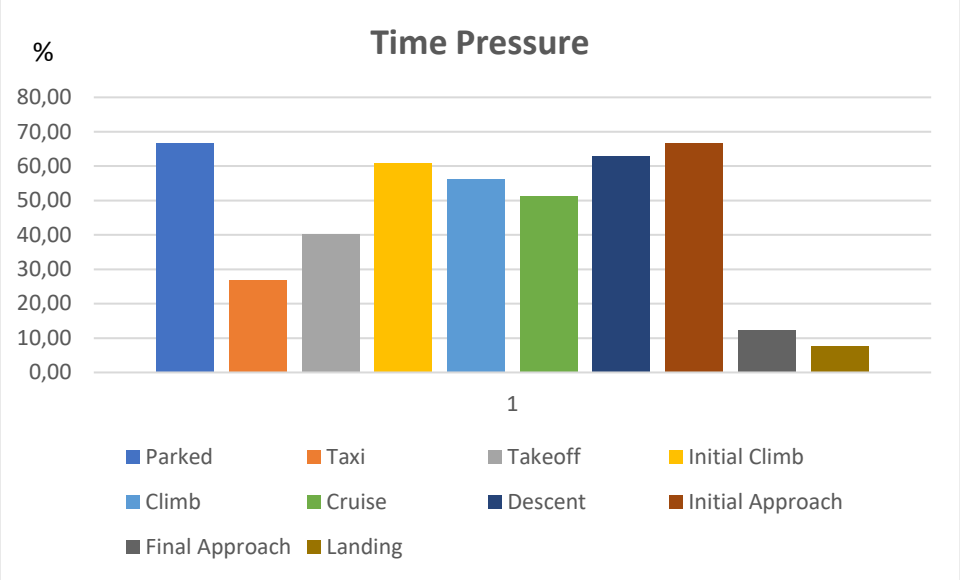


Fig. 4. Time Pressure

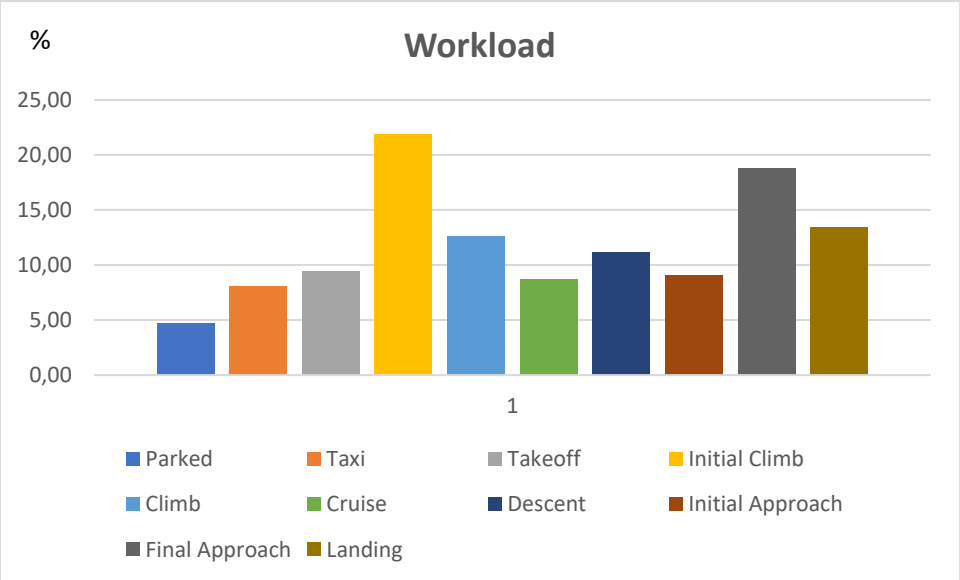


Fig. 5. Workload

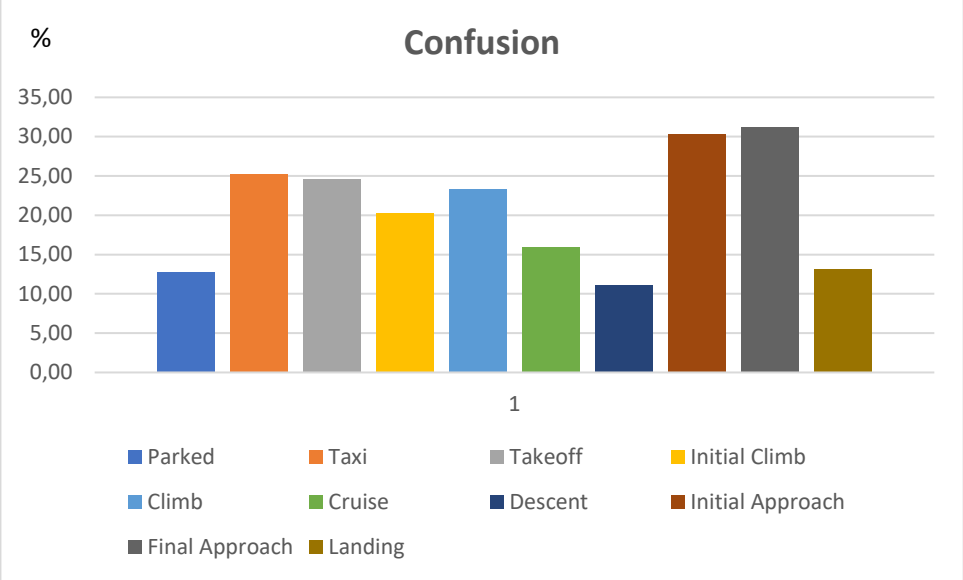


Fig. 6. Confusion

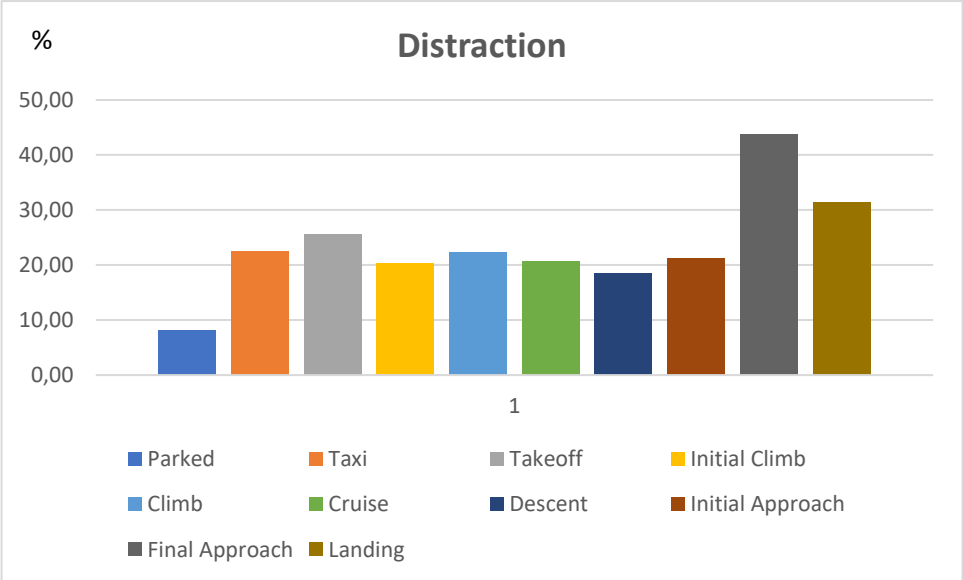


Fig. 7. Distraction

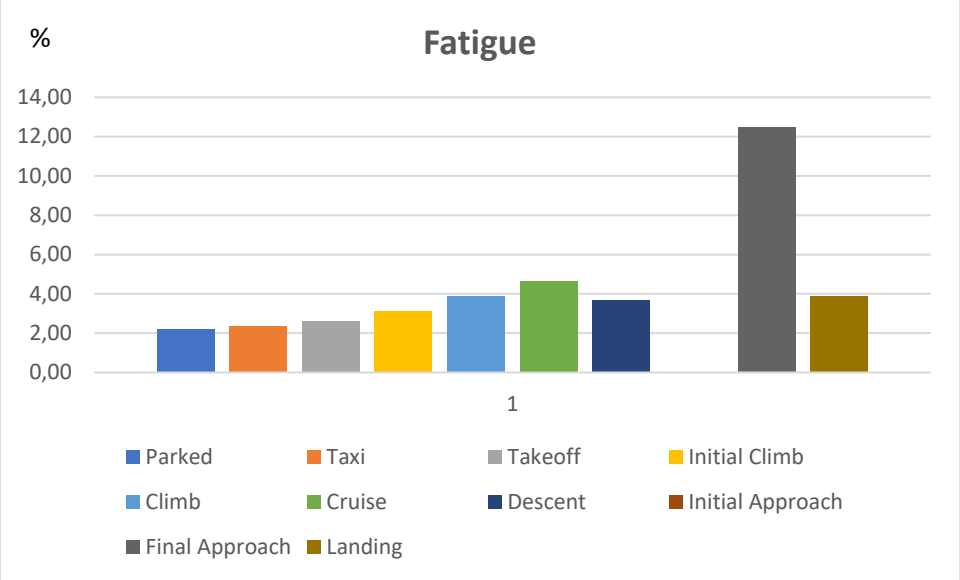


Fig. 8. Fatigue

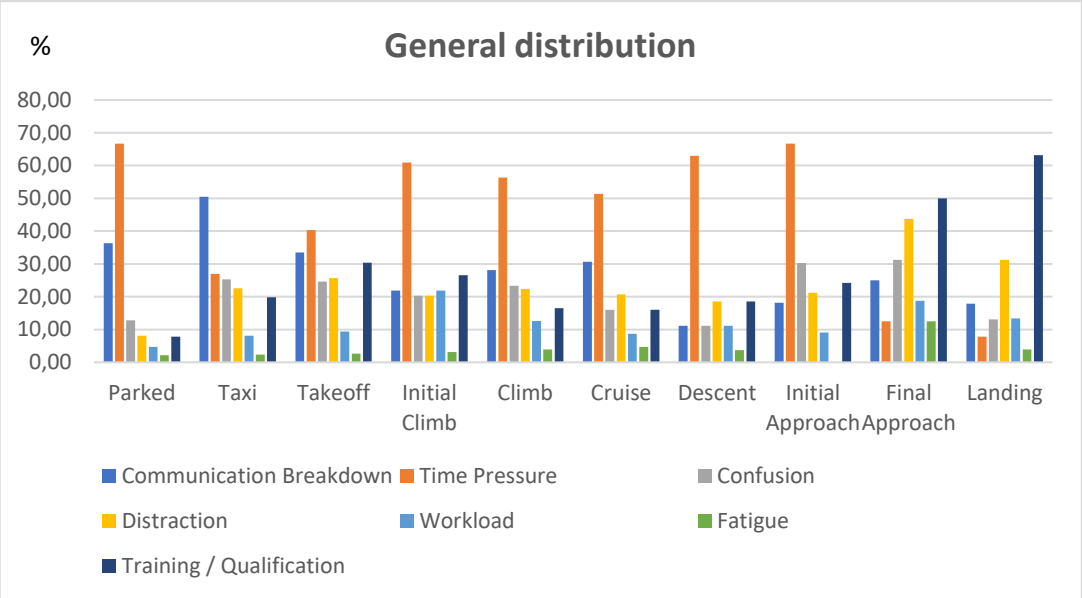


Fig. 9. General distribution

Conclusions

The majority of aircraft events occurred on ground, during the maintenance and landing phase while time pressure is the dominant factor in 7 of 10 stages in which an aircraft can be. When the aircraft is on ground, time pressure and miscommunication are the main factors for incidents.
On landing, over 60% of events occur because lack of training. Risk assessment of aircraft maintenance and human factor limitations is a necessary activity in risk management. Identification, awareness an avoidance of possible errors from maintenance process is performed using 'Dirty Dozen'.
To sum up, the influence of the human factor in the management of maintenance and aeronautical activities is particularly important. Understanding the influence of the human factor is also necessary in elucidating the investigation of an aeronautical catastrophe. The methods by which the contribution of the human factor in an aeronautical accident is identified are in continuous development and are the subject of a second stage of the present study.

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