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# The Role and the Place of Human in the System of Human – Machine

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**Operational reliability of machines and equipment is one of the important indicators for evaluation of performance, quality and reliability of the technical system itself. The aim of monitoring the reliability of the technical system is to rationalize and optimize modes and concepts of operation, maintenance and repairs, to reduce the economic and material costs. The aim of the article is to point out the human role in the human-machine system.**

*Keywords: reliability, human factor, human - machine function, human failure, human error*

## Introduction

Aviation accident, road traffic accident, collisions and accidents in rail or ship transportation - is it a technical failure or a failure of a human factor?

Investigation committees, police forces and law enforcement agencies often address this issue. In response, they invite practitioners, designers, industry experts and scientists to find the answer. However, especially in accidents involving fatal injuries and the cause of an accident can not be diagnosed on the basis of the testimony of the participants, the verdict is frequently the result of a human factor failure.

That is why it is necessary to ask yourself the question:

"What needs to be done and how to ensure that this failure does not occur or, how and by what means eliminate the human factor at as low a level as possible? "

The answer to this question is to solve the relation between man and machine, and we understand man in this system as a psychological, physiological and social system, but in essence unique and specific.

Reliable and safe operation of the machine, equipment (transport) is the result of the reliability of its nodes or elements. However, consideration should also be given to the reliability of the performance of a person, which is sometimes more important than the reliability of the technical elements of the system.

To a large extent, human action is an important element in assessing the resulting reliability. More than in other areas of life, this is particularly true for air traffic.

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## 1. Solution for relation human-machine

The resulting reliability can be expressed by the reliability of technical components and the reliability of human performance itself.
Thus,

$$S_S = S_L \, . \, S_T \qquad (1)$$

where

$S_S$ – resulting system reliability
$S_L$ – human reliability
$S_T$ – reliability of technical components

Operating failures and accidents are not only the result of a failure of the technical system but also a consequence of human error. If a technical device fails to perform the required function, it is because it was wrongly designed, mistakenly produced, incorrectly installed or insufficiently maintained. However, it is problematic to identify the causes of human failure. But if we know the nature of human failure and we can define it, we can reduce its negative impact. We know this by identifying and eliminating the factors that contribute to these errors. It is therefore necessary to know their nature and the causes of their origin.

We can consider two approaches to solving the interaction of the human-machine relationship. In the first case, we adapt the technical equipment for a person. However, this method is rather a replacement and is difficult to implement in the field of air traffic.

The second way addresses this process with a somewhat elaborate methodical approach, which contains the exact objectives, intent and tasks that a man-machine system has to fulfill. The goal is to determine the exact tasks between the human-machine subsystems.

The methodological tool of the whole process is an analysis that includes description and analysis of requirements, adjustments and analysis of the characteristics of the individual control and reporting elements of man and machine. At the next stage, we consider the actual realization of the technical possibilities, the possibilities of man and the limitations, or the critical places, which could be the cause of system failure and the occurrence of possible human errors.

An important step in this process is the assessment of the model situation of the individual tasks, the technical adaptation to man, his psychophysiological requirements, the influence of the external working environment, the conditions of activity, The need to know and analyze all links and limiting factors of the surroundings and environment is aimed at achieving a balance between the subject and the object. It is, therefore, a systemic view of man in the human-machine system, based on the biological-cybernetic system.

### *1.1 Man in the management system*

Man receives the amount of information he has to process and turn into the characteristics of psychomotor responses (eg, piloting of aircraft).

When assessing the flow of information, it is important to remember that:

- Man is a system in which information is collected and processed,
- man gives a certain importance to each information according to it's content,
- the system uses predictions, that is, the ability to predict a certain development of the situation.

The amount of stimuli coming from the outside environment and their information value are of some significance for the subjective feeling of fatigue and thus directly affect the reliability of the performance of the person.

Very important are the questions associated with the thought and decision process, their course and circumstances, which affect the thinking activity of a person in a positive or negative sense. These processes may be positively influenced by, for example, experience, rehearsing certain model situations to address the situation. It can be negatively affected by errors in information flows, e.g. lack of information, excessive amount of information, decoding information, and so on.

Operational activities of airline crews place high demands on the memory component, which uses readiness, resourcefulness, determination, balance, and ability to remain calm.

Human performance is also negatively affected by external factors that increase fatigue (monotonic noise, inappropriate air conditioning, vibration, etc.), work organization, rest time and other stress factors (consciousness, social factors, cabin air isolation, uncertainty cause by lack of mediated information and others).

Increasing the reliability of human factor is the systematic monitoring and elimination of serious and critical human faults and mistakes. In order to ensure the reliability of the man-machine system, it is necessary to keep in mind the fact that the reliability of a technical device such as an aircraft cannot contain wide range of human behavior. It is therefore necessary to take into account certain limitations on the part of the human being so that we can:

- optimally divide roles in a human - machine system,
- exclude from the work situation those elements which may affect the performance of a person negatively or at least limit their occurrence
- Back up those places in the system that are critical.

### *1.2 Human role in human - machine system*

In the human-machine system, a human has a communication, control, and regulation role. It is understood as a multipurpose factor that has great adaptability and flexibility. Nevertheless, human possibilities are limited. It is therefore necessary to consider the possibilities of the person on the one hand and the possibilities of the technical equipment on the other. It is necessary to judge which roles it is better to entrust to the person and which to the machine. The stability of human possibilities is variable depending on the influence of internal conditions and the external environment. Therefore, in designing the human-machine system, attention is focused on working conditions, their adaptation and solutions, so that they themselves are not the source of various errors and disturbances that would adversely affect human's performance and the reliability of the system itself.

In order to be able to design a system with the required reliability, a lot of information and data have to be gathered at the design stage of the machine, not only for production, but also for operation and maintenance management.

Assessment of the impact of a human factor on the reliable management of operating modes of aircraft and airport machines is based on an analysis of the requirements and conditions arising from the role of man in the human-machine system. The requirements considered concern, for example, visual, auditory and other sensory inputs and processes.

It is convenient to divide the approach to human factor reliability into two parts:

1. area of projection, production and testing,
2. area of operation, repairs, care and maintenance.

Both approaches are basically the same, the difference is in the way of collecting information to determine the probability of occurrence of errors, human failure and their consequences. Based on this information, we will identify critical cases. These are then used for the preferential solution and recognition of error factors, and also as an objective measure for the amount of financial and material costs that will need to be spent. We obtain information not only by monitoring the operation of critical components, testing system operation, subsystem and individual elements, but also by evaluating the long-term operation of the system. Obtained data are gradually creating a database of data to be used for analytical purposes. The methodology is based on an assessment of the role and performance of a man and the likely consequences of his potential mistakes. It is assumed that variable parameters affecting human performance are relatively constant and that the consequences of human error can be deduced at a certain time-scale of the system.

System time phases:

1. Allocation and description of all operations performed by the attending staff,
2. time limit of actions and their implementation at the prescribed time,
3. Determining the severity of each act and operation in question.

The scheme in Figure 1 expresses the individual components of human factors and factors that affect human performance.

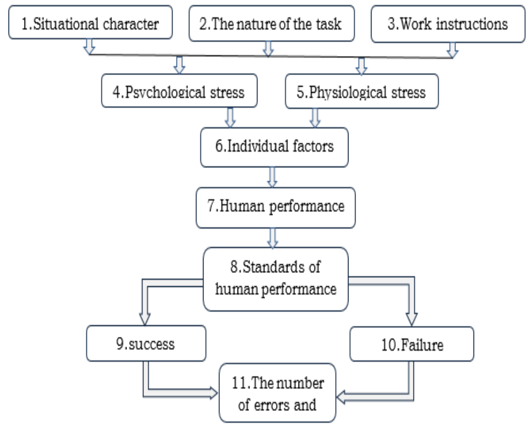


Figure 1 Components of human performance

1. Characteristics of the situation - temperature, humidity, noise, vibration, overload, environmental cleanliness, working hours, breaks, superiors, assisting colleagues, organizational structure, authority, responsibility, communication, rewards, recognition, etc.
2. Task characteristics - task severity, task range, information load, motor skills (speed, strength, precision), prediction, memory, knowledge of the result, repeatability of the task,
3. Work instructions - required procedures, verbal or written communication, caution, working methods, habits, orders, regulations.
4. Psychological stress - task speed, degree of risk and danger, responsibility, loss of prestige, monotony, inconsistent instructions, disturbing moments (noise, glare, blink, motion and others).
5. Physiological stress - fatigue, pain, discomfort, hunger, thirst, extreme temperatures, coldness, pressure extremes, oxygen deficiency, movement limitations and others.
6. Individual (organic) factors - experience, training, skill, personality and

intelligence, motivation and personal attitudes, physical condition, influence of family factors and other external factors.

7. Dimensions of human performance - accuracy, response time, duration of response, personal aspects, results of activity.
8. Human Performance Assessment Standards - Required output quality, quantity per time unit, time required to perform a task, accuracy, consistency.
9. Success - the right ratio of quality - quantity, recognition, results.
10. Errors, failures, - incorrect quality / quantity ratio, material and financial loss, injuries.
11. Number of errors and failures - Frequency of errors and faults, failure of man, errors in technique, operational disorders, consequences, loss of position, financial and material damage.

### *1.3 The effect of human factors on care, maintenance and repairs of aviation and airport equipment*

Basic information on the aircraft, airport equipment and other equipment is provided by the crew. Its experience and expertise depend on how accurately it identifies the disorder and what action needs to be taken to eliminate it.
By correctly and accurately assessing the failure, we can quickly fix the problem or, by mistake, make it even worse.

Fault information passes through different organizational stages, where they can be refined but also distorted. Care must therefore be taken not to circumvent the information by unprofessional intervention or negligent access. The correct flow of information is one of the basic requirements that greatly affect the quality of maintenance, repair of either aviation or airport operating technology. Therefore, increased attention needs to be paid to ensure a reliable flow of information.

Disturbances need to be considered from a wider perspective. It is also necessary to address the degree of danger and possible consequences, including economic difficulty.

The economic challenge needs to be assessed in terms of:

1. cost of human labor (qualification, number of people, time to repair)
2. cost of materials,
3. cost of overhaul repair.

The degree of safety must be assessed in terms of:

1. consequences for the health of the crew and the occupants,
2. consequences for the health and property of the environment,
3. consequences on machinery, aircraft, ground equipment,
4. consequences on the technical environment.

The quality of human performance in the maintenance and repair process is affected by many factors:

1. having enough time to complete the repair,
2. sufficient staff with professional qualifications,
3. suitable machinery,
4. equipping workstations with tools and preparations,
5. the conscientiousness and care of the responsible personnel,
6. adherence to good technological procedures and prescribed techniques,
7. personal relationship with the machine or the device,

8. sufficient spare parts and necessary materials.

## 2 Causes of human factor errors

When analyzing the reliability of system elements we also monitor the factors of contradictions in the human-machine system. Some contradictions may cause psychological or physiological stress to a person. If the stress level is high, there are a large numbers of errors and performance degradation. At low levels, on the other hand, quality and quantity can be reduced, for example, monotonous work, poor control, and so on.

An important part of the human - machine reliability analysis is the analysis of errors in which human activity is analyzed as a probability of occurrence of errors and the potential severity of their consequences. In this analysis, human failure is defined as a failure at a specific time and under specific conditions.

Each activity needs to be analyzed to identify possible errors. The probable consequences of individual human failures can be determined using functional schemes, logical diagrams, or other graphical and mathematical expressions.

The likely consequences of each human error can be broken down by the availability of information into several groups.

1. Human failure with catastrophic consequences

They are affected by environmental conditions, operator failures, design, manufacturing deficiencies, faulty technology, etc., which can significantly impede the operation of aviation and aerospace technology, resulting in the destruction of machinery, aircraft, equipment, environment and surroundings, or death or serious damage to health

2. Failure of a person with severe consequences

This can result in substantial damage to the machine, equipment, or severe damage to health.

3. Failure of a person with moderate consequences

Results in damage to the machine to a certain extent (without significant damage) and injuries to people and attendant personnel.

4. Failure of man with light consequences

The result is a machine malfunction or minor injury to personnel.

### *2.1 Human error severity index*

We can increase the safety and reliability of the technical or technological system by identifying and excluding potential sources of critical human faults. We can use the severity index as the guide number expressing this effect. It is the number expressing the potential impact of a certain error on the occurrence of a certain failure.

It is determined by:
1. probability of failure,
2. the probability of the severity of the failure as a result of a human error.

Using the index, we can set the order of error severity, prioritization, and scope of effort to identify human error sources.
It is defined by:

$$C_{Ei} = E_i \, . \, F_i \, . \, S_i \qquad (2)$$

Where

CEi - is the potential of the human error of an *i* class to the degradation of the system,
Ei - the probability of occurrence of an *i* class error during the performance of the task,
Fi - the probability of system degradation resulting from an *i* class error,
Si - the severity of the consequences expressed by the number 0 to 1.

The probable severity of the consequences of errors is given by a number from 0 to 1. The natural numbers indicating the degree of relative severity are determined by estimation based on all available information, including the analysis of the consequences of errors. The value of severity, which is determined on the basis of experimental data, is assigned to them.

### *2.2 Exclusion of human error resources*

After determining the severity index for the activity being performed, each activity is analyzed to identify likely sources of human error. The relative scale of the severity index serves as a basis for setting the priorities, the amount of costs and the scope of work to eliminate the sources of error.

Based on the severity index, we can perform simulated measurements and studies. We can also make various adjustments that will include, for example, suggestions for:

1. division of roles between man and machine,
2. Changes in the design of the system,
3. Changes in the work process,
4. Changes in the working environment,
5. Changes in technological processes,
6. Changes in motivation,
7. Changes in control activities and others.

### *2.3 Technical safety research*

The objectives of the technical safety research activity can be further developed through the active security with various forms and methods to prevent the possibility of an active threat. By eliminating or at least reducing the threat potential by eliminating threat sources, it is possible to create appropriate conditions for technical security. It is possible, for example, in the form of working practices and emergency scenarios using model situations and prevention.

It is essential to learn from the knowledge about the maximum allowed load on the human organism. The prevention system needs to be addressed as a set of indicators and properties based on ergonomics, physiology requirements, occupational hygiene, skills and experience, aesthetics and lifespan. Applying the psychological and sociological aspects of safety in transport, and not just transport, is a prerequisite for harmonizing the relationship between man and machine.

A comprehensive approach to addressing this relationship requires:

- an engineering-medical-psychological approach, that is interdisciplinary cooperation of these components,
- a socio-psychological approach with an emphasis on the organization of work and working conditions in transport.

An effective analysis of the safety and reliability of a human factor and an analysis of its failure in specific work activities should be objective in human factor research.

For example work injury analysis of drivers say that up to 80% of the causes of various accidents and injuries (not just due to traffic accidents) have been caused by a human factor. Therefore, through the penetration of transport through the human aspects of transport safety solutions, a new perspective can be realized and new direction of research in the field of transport safety can be determined. The aim will be to identify, analyze and evaluate the risks of accidents and threats to drivers of vehicles, pilots of aircrafts and so on.

Creating optimal working conditions and working environments (understood in the broad sense) should focus on the sources and causes of their violations and consequently on the direct performance of analytical activities that should be transferred to the areas of development, construction and creation of new security technologies. Research and development results should be directly used in the manufacturing, operation and service sectors. The structure of methodologies must take into account:

- identification and structuring of risk factors,
- the organization of factors depending on the degree of potential threat,
- analysis of the risks and foreseeable consequences,
- a system of risk mitigation measures,
- a decision-making strategy with a view to achieving an acceptable risk
- specification of initiating hazard and threat factors
- Formation of relationships of potential threats, triggering and regulatory mechanisms with possible consequences,
- the development and amendment of generally binding safety and security legislation and standards,
- principles, rules and guidelines for safety,
- safety requirements for operational and technological procedures,
- the principles and methods of identifying, classifying and assessing adverse working process factors,
- Categorization of threats,
- proposals and procedures to address the current security situation,
- operation safety management systems,
- education and training systems,
- and requirements for human factor.

It is clear from this review that the outputs of such research are of an intangible nature, but they are of great socio-economic significance and their aim is to prevent and secure safety, prevent accidents and disturbances, protect life and health, protect the environment and economic values.

The use of this research will be carried out by transferring them into the decision making process, applying them in the legislative process, and their application in the development, production and operation of transport machinery and equipment.

## Conclusion

The purpose of the paper was not to detail the factors that affect the reliability of human performance, but to point out the possibilities and procedures to address the issues of reliability and safety in transport. This is only possible through the proper integration of technical and human factors, with human safety factor in transport systems having its exceptional place and position.

There are and there will be in the future different forms of failure and occurrence of man-made errors in the human-machine system. We start from the fact that man is a human being. It is, however, our responsibility to study the human influence in the human-machine system, which is the basis for determining the proportion of man in the system and his impact on the quality of maintenance and repair.

Comprehensive monitoring of the reliability and service life of machines, machinery and equipment can create favorable conditions for continuously increasing the efficiency of any monitored system, including aircraft and aerospace technology.

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