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# ANALYSIS OF THE OPERATION OF THE GROUND HANDLING AGENT IN THE ASPECT OF SAFETY

## Analiza operacji wykonywanych przez pracownika obsługi naziemnej w aspekcie bezpieczeństwa

***Abstract:*** *The role of the human factor in aviation is a critical element for the safety of flight operations. It is described by methods such as SHELL and BowTie, which propose solutions to minimize the risk of occurrence of aviation events. The work presents the development of these concepts by introducing the method of testing the predisposition of airport staff using a specialized system which is the Polipsychograph - a system dedicated to designing and carrying out psychological tasks testing human mental, cognitive and motor skills in connection with the assessment of his professional capabilities. The work contains the results of 40 tests performed on employees dealing with airport ground handling on a daily basis. Research has shown that the employee's predisposition depends on the quality of work entrusted to him. The paper presents a method of assessing the psychophysical predisposition of an employee allowing him to be directed to work corresponding to his qualifications.*
**Keywords:** human factor, handling, airport

***Streszczenie:*** *Rola czynnika ludzkiego w lotnictwie stanowi krytyczny element dla bezpieczeństwa operacji lotniczych. Opisują go takie metody jak SHELL oraz BowTie, które proponują rozwiązania w celu minimalizacji ryzyka występowania zdarzeń lotniczych. Praca przedstawia rozwinięcie tych koncepcji poprzez wprowadzenie metody badania predyspozycji personelu lotniskowego przy użyciu specjalistycznego sytemu, jakim jest Polipsychograf – przeznaczonego do projektowania i przeprowadzania psychologicznych zadań testujących sprawności umysłowe, poznawcze i motoryczne człowieka w związku z oceną jego możliwości zawodowych. Praca zawiera wyniki 40 testów wykonanych na pracownikach zajmujących się na co dzień obsługą naziemną portu lotniczego. Badania wykazały istnienie zależności predyspozycji pracownika od jakości wykonania powierzonej mu pracy. W pracy przedstawiono metodę oceny predyspozycji psychofizycznych pracownika pozwalającą na skierowania go do pracy odpowiadającej jego kwalifikacjom.*
**Słowa kluczowe:** czynnik ludzki, obsługa naziemna, lotnisko

# 1. Introduction

The human factor in aviation was noticed recently, because in the seventies, when there was a close relationship between man, machine and the number and cause of mistakes [7,16]. Until recently, the concept of the human factor was closely connect-ed with the ergonomics of work. According to the Polish Ergonomic Society, ergo-nomics is an applied science aimed at the optimal adaptation of tools, machines, devices, technologies, organization and material working environment, as well as common-use objects to the requirements and physiological, psychological and social needs of a human being [2]. In other words, projects created taking into account the principles of ergonomics help to maintain the prescribed health and safety standards of employees. Ergonomics is a concept preferred by European countries, Australia and New Zealand. However, Americans in the same concept preferred to use the term "human factor". Currently, these concepts are used by Americans alternately. In Europe, the term "human factor" is used more liberally and applies to all human fac-tors that affect the preparation and implementation of all kinds of tasks and includes issues related to areas such as ergonomics, psychology, natural environment, etc. Therefore, in relation to aeronautical activity, ergonomics is often treated as a sub-discipline of areas related to the human factor, excluding those related.

# 2. Definition of the human factor and selected methods of counteracting aviation events

The human factor in aviation was noticed recently, because in the seventies, when there was a close relationship between man, machine and the number and cause of mistakes [7, 16]. Until recently, the concept of the human factor was closely connected with the ergonomics of work. According to the Polish Ergonomic Society, ergonomics is an applied science aimed at the optimal adaptation of tools, machines, devices, technologies, organization and material working environment, as well as common-use objects to the requirements and physiological, psychological and social needs of a human being [2]. In other words, projects created taking into account the principles of ergonomics help to maintain the prescribed health and safety standards of employees. Ergonomics is a concept preferred by European countries, Australia and New Zealand. However, Americans in the same concept preferred to use the term "human factor". Currently, these concepts are used by Americans alternately. In Europe, the term "human factor" is used more liberally and applies to all human factors that affect the preparation and implementation of all kinds of tasks and includes issues related to areas such as ergonomics, psychology, natural environment, etc. Therefore, in relation to aeronautical activity, ergonomics is often treated as a sub-discipline of areas related to the human factor, excluding those related to design.

In the basic ergonomic model of Man - Machine - Environment, man plays a fundamental role in all phases of the "life" of the machine (eg an aircraft) by influencing it

- the human factor. This role may be positive, but it may also be negative by bringing, for example, an undesirable air event - a negative action or lack of action perceived as positive (including corrective) in a specific task situation. Man can also find himself in a situation in which he will not be able to counteract emerging threats by resisting their predictable consequences [17].

The reason for this state may be, among others: time deficit, lack of skills, lack of knowledge, or having insufficient means to oppose the developing situation threatening the safety of the task (technical failure, error in handling, construction error, etc.). Thus, the concept of the human factor should be perceived in the relations between man - operator (pilot, air controller, aviation mechanic, etc.), and other areas appropriate for the operation of machines (aircraft) [8]. A similar approach to the concept of "human factor" is presented by the International Civilian Aviation Organization (ICAO) [10].

In the ICAO documents, we find that the term "human factor" is so wide that it is difficult to define them uniquely. It is treated in a multidisciplinary approach and focuses mainly on interactions between members of aviation organizations - people, and their work and life environment, as well as providing solutions for a good fit to the work environment. In this sense "human factor" is recognized as a source of knowledge from a wide range of scientific disciplines, such as psychology, physiology, anthropometry, biomechanics, biology, chronobiology, design, statistics, etc. Ergonomics is a concept often used instead of "human factor", but only in relation to man-technique relations [3].

## 2.1. SHELL - model

A commonly recognized model referring to the depictions of interactions between man and elements of the aviation system in the organizational and operational context, allowing a deeper understanding of the "human factor" is the so-called the SHELL model (fig. 1). For the first time, the SHELL model was developed and described by Edwards in 1972, and then it was completed with the second element L by Hawkins in 1975 and since then is referred to as SHELL.

Man - operator ($L_1$) is not an equally predictable and reliable element in operation as certified devices occurring in the aviation work environment due to the fact that as a natural person it has certain possibilities and limitations. Therefore, this model refers to the interaction between its central element $L_1$ and its other components, ie S, H, E and $L_2$. However, it does not refer to interactions occurring outside areas directly related to the human factor, i.e. S-H, S-E and H-E [4].

The man ($L_1$) present in the central point of the model is the element susceptible to adaptation to the surrounding environment, including the legal - procedural and training (S), technical (H), broadly understood work environment (E), aerospace personnel ($L_2$). Therefore, on the one hand, the possibility of adapting the above elements of the model to humans (design stage) is considered, on the other hand the possibility of adapting a man to the elements of the model (design, implementation and operation) is considered. the occurrence of a dissonance between a human being and the other four elements of the

model, as part of the interactions that occur, usually leads to human error during the preparation or implementation of air operations.

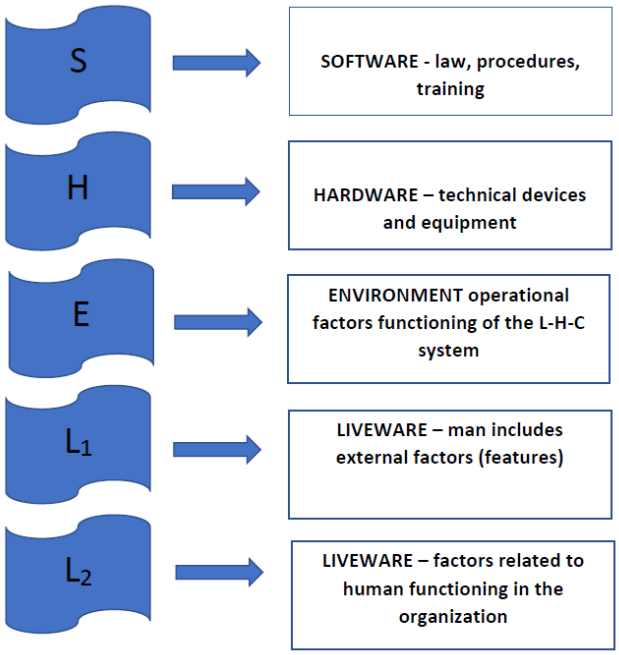


**Fig. 1.** Shell model designation. Source: own study based on [10]

## 2.2. BowTie method

Another method developed to counteract hazards and minimize the risk of a human factor is the BowTie method. This method was developed at the University of Queensland in Australia. The name comes from the shape of the diagram (fig. 2) by means of which the threats together with the potential causes of their occurrence and the consequences, along with proposals of measures that may limit them, are properly represented. The creation of this technique was a response to the need to introduce a method for effective risk control. The BowTie method is designed to provide a clear and understandable visualization of the relationship between the causes of events and prepared measures that minimize their negative effects. In the most common use, the ultimate goal is to demonstrate control of event, safety and environmental hazards [5].

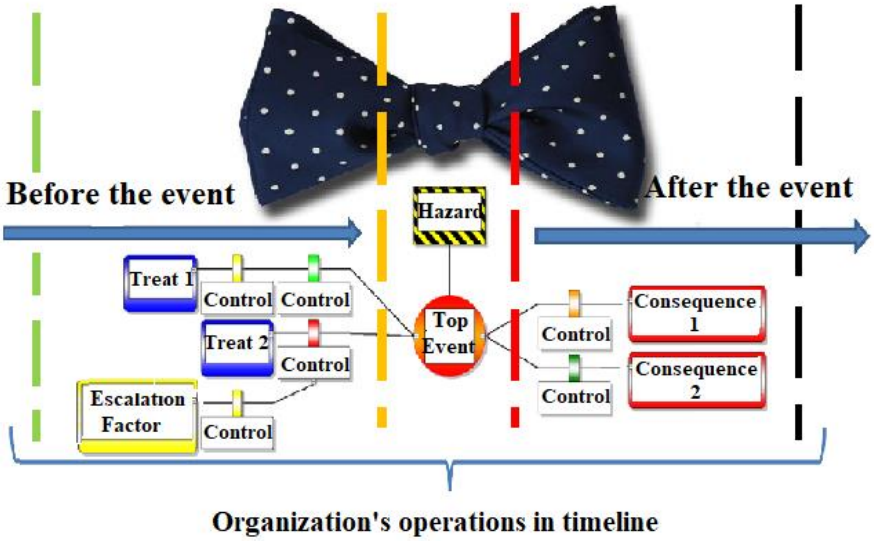


**Fig. 2.** Diagram showing the operation of the BowTie method [26]

The BowTie method consists of 7 essential elements that illustrate how it works:

- Hazard,
- Highlight event (Top Event),
- Causes of the culmination event (threats),
- Consequences,
- Barriers: preventive / recovery barriers,
- Factors for reducing the effectiveness of the above-mentioned barriers (escalation factors),
- Control methods for the above-mentioned factors (escalation factor controls).

This tool allows to describe, through specified key elements, the risk management process in graphical form. Models are active, editable and can be part of the "security library" and SDCPS (Safety data collection and processing systems) of the organization.

# 3. Analysis of aviation events arising in the field of ground handling of aircraft in 2015–2017

Security problems in the area of airports and ground handling services were identified by the Aerodromes and Ground Handling CAG[1] . They were taken from the event data

[1] Collaborative Analysis Group.

(EASA[2] and ECR event base), as well as from the experience and expertise of CAG members[3]. Where possible, dedicated questions for the ECCAIRS[4] database were developed for each Security Problem in order to identify events related to each Security Problem. The ERCS[5] chart (fig. 3) shows the number of events in the ECR for each Safety Problem (in case it was possible to prepare an appropriate query for the ECCAIRS database) [5].

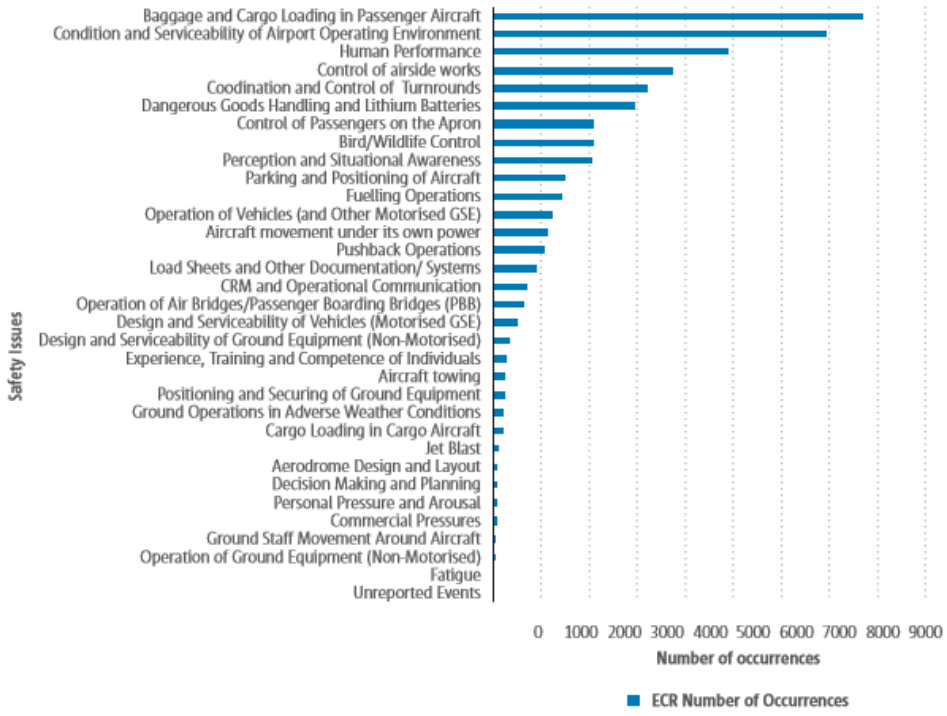


**Fig. 3.** ERCS Chart No. 23 - Number of ECR events per airport and Safety problems of ground handling - 2015-2017. Source: EASA ASR 2018

**Loading of luggage and goods on passenger planes** is the main Safety Problem (considering the number of events in the ECR). It has also been recognized as the most important Safety Problem by members of the Joint Analyzes Group in the field of Aerodromes and Ground Handling (CAG). Therefore, he was chosen as the first problem to be analyzed / assessed in the Safety Risk Management Process (SRM), which started in 2017 [26].

[2] European Aviation Safety Agency.
[3] Polish Civil Aviation Authority, Report on the state of civil aviation safety for 2017, Edition 2018.
[4] European Co-ordination Centre for Accident and Incident Reporting Systems.
[5] European Risk Classification Scheme.

The second Safety Problem, which is being assessed in the SRM process, will be "Ground Staff Movement Around Aircraft". The number of ECR instances in relation to this Safety Problem is low, but this is due to the limitations of the ECCAIRS taxonomy, which does not yet have the right types of events to clearly capture such risks, and the inadequate level of reporting by the ground service organization. Figure 4 shows an overview of ERCS of accidents and serious incidents for each Safety Problem.

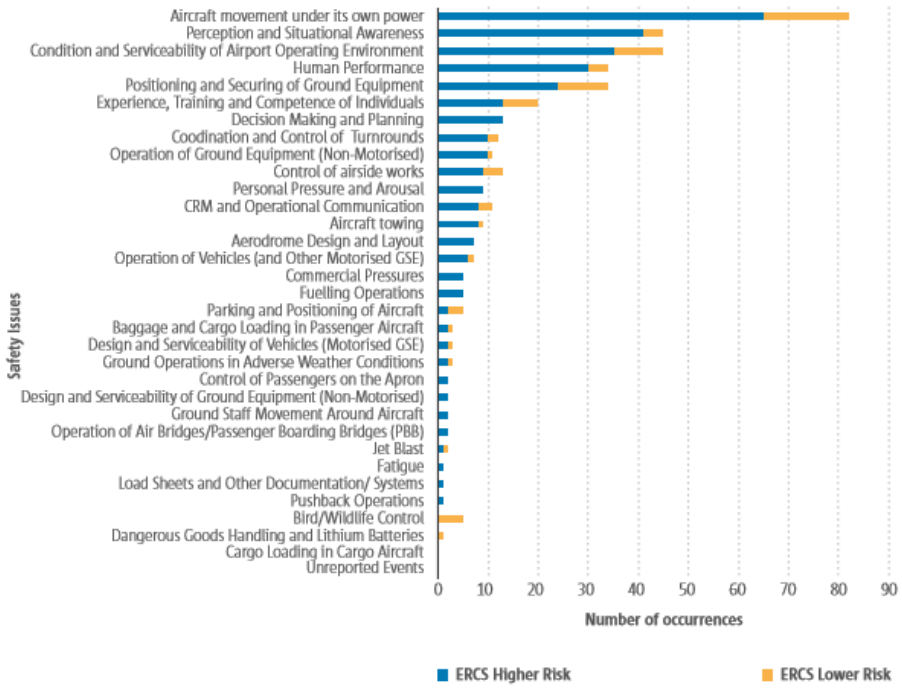


**Fig. 4.** ERCS - Number of events per given Safety Problem and severity according to ERCS - accidents and serious incidents in 2015-2017. Source: EASA ASR 2018.

The blue color indicates an event with a higher risk, dark-yellow while those with a lower level of risk.

The presented Safety Risk portfolio is based solely on data on events, mainly accidents and serious incidents, collected in the EASA database (2015-2017). After the full implementation of the European System of Risk Classification (ERCS), it will be possible to carry out such an analysis of incident data in ECR, which will be more useful when researching the causes of these events. The common Analyzes Group on Aerodromes and Ground Handling (CAG) has given each Security Problem a description that defines more precisely what needs to be addressed.

Therefore, the most important Safety Issues for Civil Aviation in the area of ground handling have been defined:

- Planning and decision making;
- Loading of luggage and goods;
- Perception and situational awareness; Experience, training and individual competences of people; CRM and operational communication;
- The design and infrastructure of the airport;
- Control and coordination of operational rotation on the board (Control and coordination of turnarounds).

At the same time, Security Issues particularly related to the human factor have been distinguished [25]:

- Decision making and planning;
- Perception and situational awareness;
- Experience, training and competences of people.

Many issues related to the human factor also apply to the study of the relationship between psychophysical psychological and physical predispositions of individuals performing specific tasks, and the right selection of staff to carry out these tasks according to their natural or learned skills [6]. For this purpose, a test with the use of a device called a Polipsychograph was made at Katowice International Airport.

# 4. Dependences of the human factor on the psychophysical predisposition of the staff

## 4.1. Review of the literature

Considerations over the cause of the human factor in aviation have inspired the scientific world to carry out various research in this area. Many theories justify the existence of a human factor and models illustrating the relationship between the human factor and the risk of an event threatening health or life. This model was proposed by Trimpop, Kerr, Kirkcaldy [24], in which he assumed that the perception of risk is a resultant of personality influence and assessment of the situation. Risk assessment is not just about "dry" profit and loss calculation, but the subjective physiological and emotional feelings have an impact on this assessment. This concept shows that situational assessment may be different depending on the type of risk a person has to deal with, but does not show the impact of psychophysical predispositions to the performance of specific job duties.

In turn, the concept of instrumental and stimulating risk of Zaleśkiewicz [24] presents an approach in which risk taking may have two motives: (1) pleasure (risk of stimulation), (2) achievement of some important goal (instrumental risk). The stimulus risk, on the other hand, is to trigger a strong stimulation of the body, eg extreme sports, drugs. It is

characterized by low levels of self-control. It is the willingness to experience positive emotions that decides about taking a risk.

Instrumental risk is treated only as a tool on the way to the goal. This type of risk is not associated with emotions and pleasures. It is controlled because there are no spontaneous activities and taking risky actions is often the result of a cold calculation.

In particular, the risk associated with the existence of a human factor is noticeable in aviation. There are many uncertainties, uncertainties, which make up the risk definition [19]. In aviation, it is associated with the threat of losing some valued by human values: life, health, material goods. On the other hand, the perception of risk is influenced by personality factors and situational factors [20].

The next element in the literature that accompanies the human factor is stress. It has two interesting properties: it occurs when it encounters an obstacle and disturbs the functioning of the individual. Stress is understood here as a reaction to a difficult situation [12]. According to Lazarus and Folkman, stress should be understood as a specific relationship between a person and the environment, which is assessed by the person as aggravating or exceeding its resources. A condition sine qua non of stress is the assessment of whether it can cope with a difficult situation [13, 14, 15]. The appearance of an obstacle causes a decrease in the probability of reaching the goal. However, it depends on the conditions of susceptibility to stress or high resistance to its effects. Strelau [20] writes: "Personally, I am in the position that the cause of the individual's stress is the imbalance between the requirements for the individual and his capabilities (ability) to meet these requirements." The requirements of the environment are treated as stressors or situations that cause stress. The ability of the individual to deal with the requirements depends on the following characteristics: intelligence, knowledge, special talents, skills, personality and temperamental traits, experience in stress-inducing situations, coping strategies, physical appearance characteristics, current physical condition and mental unit. According to the Strelau's Regulatory Temperament Theory, people with a low level of reactivity are characterized by a high demand for stimulation, and as a result are predestined to act in situations of high stimulus value. On the other hand, people with a high level of reactivity prefer subdued stimulation activity [22].

In turn according to Hobfoll, "Stress arises when (1) there is a threat of loss of resources, (2) there is a real loss of resources, (3) investing a significant amount of resources does not bring the expected profit" [9].

It was also found that the deterioration of the individual's functioning under stress increases the likelihood of making the wrong decision (Campos, 2001, Dekker, 2003; Graham-Rowe, 2003; Marx, Graeber, 2001; Prince, Browers, Salas, 2001; Reason, 1990; Wiegmann, Shappell, 2001). Regardless of whether the stress is objective or subjective, whether the risk is objective or subjective, stress and risk have an impact on making a mistake, because they affect the human factor, that is, the human being and the perception of the situation. In aviation, the human factor is primarily considered in the context of the safety of aircraft, crew and passengers [18].

Considering the relationship between the human factor and an undesirable aviation incident, underlines the inadequacy of the activities of operators - pilots and other aviation personnel, who are closely related to the system of organization, security and flight operations to the situation at a particular stage of the flight. The activity understood in this way usually leads to an undesirable aviation event [23].

This is the case when the threats caused by a factor independent of man, despite the real possibilities, have not been removed or reduced to an acceptable level. Each action is the result of a specific decision and the related decision-making process.

The factor determining the occurrence of an undesirable aviation event is usually the occurrence of several consecutive errors in the management system of the aviation organization, shortcomings in servicing the aircraft, air traffic control and/or operator airplane crew faults. The reasons for wrong decisions made by the pilot-operator are usually found in particular stages of the investigation into them, taking into account the particularly complex characteristics of the aviation system and its surroundings. Therefore, when considering the causes of undesirable aviation events, mistakes made by the aircraft crew at particular stages of making and implementing decisions are usually treated as the main factor resulting in more or less serious consequences [1].

The concepts presented above raise issues that are very important for safety in civil aviation. They point to the existence of the main elements closely associated with the human factor. This article expands this problem by showing the dependence of psychophysical predispositions of a specific professional group on performing official duties in ground handling of aircraft.

Five people were subjected to the tests, employees of the handling agent with varying experience and age. 40 tests of varying degrees of difficulty were carried out to examine the employees' ability to respond to given stimuli. These tests were to determine the model of an employee who, when performing his work under specific external conditions, positively prognoses in the area of work in a way without exposure to events that may have a negative impact on health or life.

For this purpose, people who have been evaluated by superiors on the scale: best, good, medium, bad and very poor are selected for the tests, guided mainly by the criterion of quality of reliability and conscientiousness in the performance of the commissioned work. There is, of course, a very subjective evaluation which in addition to the abovementioned the criterion does not take into account the actual skills of the employee.

The assessment of superiors can be the result of only the employee's attitude towards work. These tests, in correspondence with the tests carried out, may allow to exclude a situation in which the employee is poorly evaluated only because he / she does not have the appropriate psychophysical predispositions to perform a specific job.

This excludes the existence of so-called bad will of the employee, and the employer may allow to make a conscious and objective decision regarding the transfer of the employee to work corresponding to his qualifications.

## 4.2. Research tool – Polipsychograph

The research was carried out with the use of a system dedicated to design and carry out psychological tasks testing mental, cognitive and motor skills of a man in connection with the assessment of his or her professional abilities or the diagnosis of possible deficits of various origins. This system is used to measure psychological and psychophysiological variables of the examined unit. The tested efficiencies are recognized in the context of the accompanying reactions and physiological processes manifesting themselves through the skin-galvanic reaction, depth and frequency of breathing, the pulse rate - which allows additional interpretation of the obtained data. In both cases, apart from a ready set of test and rehabilitation tasks, it is possible to independently design own test or rehabilitation tasks (due to their substantive content, form, presentation rhythm, etc.). Thanks to this, it is possible to individualize the diagnostic or rehabilitation process. The device can therefore also be used to test research hypotheses in scientific research in the field of psycho-physiology.

The system consists of three basic elements. They are:

– Computer (portable or stationary),
– Control program,
– Psychophysiological State Meter.

In the system, the computer has the functions of programming and controlling both the diagnostic and therapeutic processes. His software enables flexible selection of test tools depending on the studied sphere and is open in nature. This means that they can be gradually expanded with new applications or modify existing ones. Figure 5 shows the visualization of the device.

**Fig. 5.** Illustrative image of the Polipsychograph

## 4.3. Psychophysical predisposition ground handling staff

40 tests were carried out on employees who deal with ground handling of the airport on a daily basis. Individuals were evaluated by supervisors generally as good or very good employees, who stand out from the others praised by the management of the company in terms of conscientiousness and reliability in the performance of their duties. Only in relation to Employee no. 5, the supervisor made an assessment with the value "average". During the tests, the basic psychophysical skills of employees, which are necessary for their work, were examined. The most important skills that are necessary for the work carried out by employees, the managerial staff mentioned the skills of memorizing, logical thinking, concentration, psychomotor skills and spatial perception. In such areas, tests on employees were carried out. The following types of tests were performed:

- test of addition (three tests with varying degrees of difficulty),
- number test (involving the number indicated on the matrix by the system),
- complex coordination test (consisting in the fastest possible selection of the correct result of adding two displayed digits),
- simple coordination test (consisting in verification of motor coordination by properly pressing the key assigned to the number displayed on the screen),
- line test (consisting in determining the number of lines displayed on the monitor), literal recording test (consisting in remembering a string and recreating it from the memory).

All tests except the last ones required work on time, while the decisive criterion for the evaluation of all test results was the speed of the decisions made and their correctness. The results of the tests carried out in the field in question are presented in tab. 1.

**Table 1**

**The results of tests performed using the Polipsychograph. Source: own study**

| | **effective time of employee 1** | **effective time of employee 2** | **effective time of employee 3** | **effective time of employee 4** | **effective time of employee 5** |
|---|---|---|---|---|---|
| Test 1 | 20,21 | 17,23 | 18,44 | 18,06 | 17,79 |
| Test 2 | 15,90 | 17,52 | 15,15 | 11,35 | 18,13 |
| Test 3 | 30,29 | 19,38 | 21,67 | 26,65 | 42,06 |
| Test 4 | 92,33 | 48,91 | 44,74 | 54,87 | 60,99 |
| Test 5 | 59,84 | 60,02 | 59,97 | 59,96 | 60,00 |
| Test 6 | 44,80 | 49,40 | 57,74 | 45,06 | 83,04 |
| Test 7 | 59,86 | 59,93 | 59,98 | 59,88 | 59,92 |
| Test 8 | 212,69 | 232,03 | 253,68 | 152,18 | 256,19 |

The table shows the effective test time for each employee expressed in ms. Fig. 6 shows the graphical variation of the results of tests carried out on handling employees. As we can see, most of the time they have been tested, they devoted to solving the test no. 8 - regarding the literal literacy, which required demonstrating the ability to memorize the sequence of numbers and their memory from time to time.

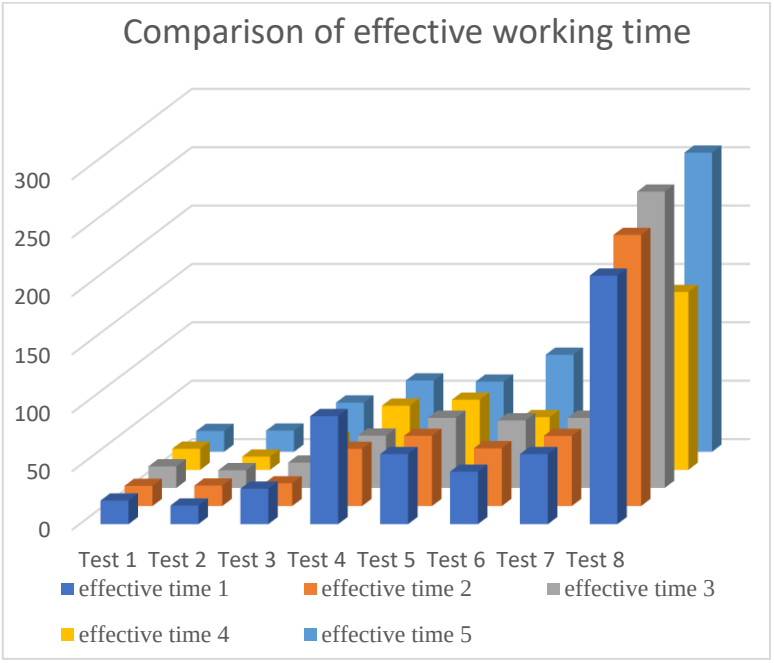


**Fig. 6.** Comparison of the effective test time

In turn simple arithmetic caused the lowest cognitive impact on the participants of the test, which directly translated into both the test result (100% correct answers) and the test time. Although here we can also notice some deviations from the standards presented by the other test participants. Employee no. 5, while solving test 3, needed almost twice as much time to perform a fairly simple mathematical operation. It can be assumed on this basis that in the case of the need to solve a real problem during the performance of official duties, this relationship will occur in an identical manner. A similar situation in the case of the same employee can be noticed while solving test 6. Here, too, this employee stood out from the test resolution time group.

As the opposite of the situation described above, we can present the results of employee no. 4, who performed all tests the fastest from the whole group of people tested. He showed special efficiency during test 8 - memorizing the literal, where it was necessary to remember the sequence of numbers displayed on the screen. This ability can in practice directly translate into the organizational skills necessary for proper and orderly performance

of duties according to a strictly defined plan and order of tasks. It is worth emphasizing that this skill is very important when working on aircraft servicing, where a high degree of organization of tasks is required at a strictly defined time.
This dependence allows in turn to define the general standard of predisposition of employees dedicated to work in ground handling of aircraft at the airport.
In addition to time as the main criterion for assessing the results of tests carried out on ground handling employees, the number of errors made during tests is also significant for the overall assessment of test results. During research, you can notice a certain type of regularity. All subjects gave a correct answer to test tasks no. 1,2,3,4,5 and 7, while test no. 6 was correctly performed by only 4 out of 5 people. The greatest difficulty for all subjects was solved by test no. 8, where none of the respondents correctly solved all elements of this test. The test results are presented in tab. 2

**Table 2**

**List of errors made in relation to the number of test tasks for tests no. 6 and no. 8**

| | **result of employee test no. 1** | **result of employee test no. 2** | **result of employee test no. 3** | **result of employee test no. 4** | **result of employee test no. 5** |
|---|---|---|---|---|---|
| **Test no. 6** | 9/9 | 9/9 | 7/9 | 9/9 | 9/9 |
| **Test no. 8** | 6/14 | 8/14 | 10/14 | 11/14 | 9/14 |

In test task no. 6, only one employee no. 3 out of 9 questions included in the test, for 2 gave an incorrect answer. The task consisted in counting the horizontal lines displayed on the monitor and was supposed to demonstrate the subject's skills in terms of spatial perception. This test is directly related to the practical skill of the employee to correctly deduce the spatial arrangement of objects, which is an essential feature when maneuvering on the apron of the airfield among standing aircraft.
In turn, test no. 8 showed at the same time that the same employee number 3 distinguished himself from the remaining employees taking second place from the angle of correctness of answers given to questions requiring the use of short-term memory. This means that such an employee will perform much better when performing duties consisting in organizing and planning work, rather than implementing physical activities using dedicated equipment for ground handling of aircraft.
At the distinction during the test no. 8, however, the employee no. 4 deserves to be shown, which showed its versatility in the field of spatial perception and tasks requiring mental work with the use of elements of remembering and logical reasoning. This employee will work both during physical work while servicing airplanes as well as while performing duties related to mental work. A detailed analysis of the correctness of answers provided during tests no. 6 and 8 is shown in fig. 7.

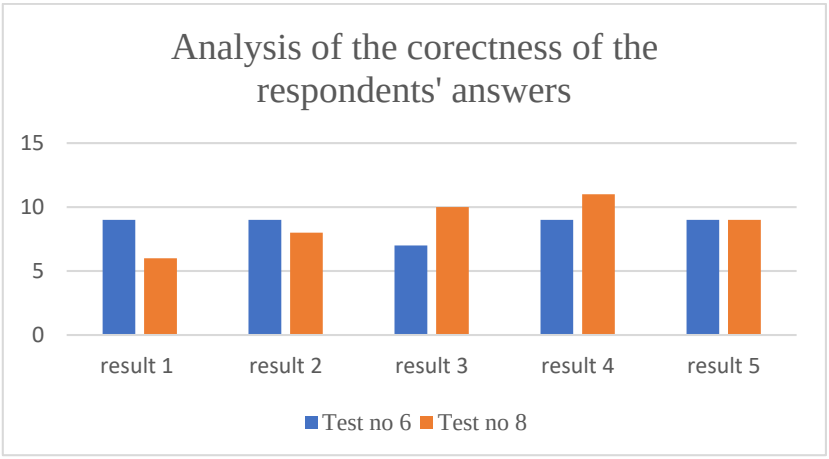


**Fig. 7.** Comparison of the results of correctness of respondents' answers

The weakest result was achieved by employee no. 1, who in test no. 8 indicated only 6 correct answers from 14 given during this test. This result predisposes him primarily to work related to the direct performance of duties when servicing airplanes. This claim is all the more justified because during test no. 6 it reached the maximum number of points.

## 5. Analysis of psychophysical predispositions of the ground handling employee

The conducted research showed a certain dependence in the scope of the possibility of assessing the predisposition of the employee to perform tasks related to ground handling of aircraft. The importance of this issue is all the more important because it is about the safety of aviation operations. The statistics quoted above show that the human factor is still the largest proportion of the sources of aviation events on a global scale. One of the most important activities at the airport is ground handling, where under constant pressure of time, one to several dozens of aircraft are simultaneously serviced. Among such traffic crowds and hundreds of people performing simultaneously their duties in the airport's maneuvering area, it is not difficult to find an aviation event (Regulation of the European Parliament and of the Council (EU) No. 376/2014).

Therefore, it is extremely important to select the right staff with the appropriate practical preparation, but also more importantly, the appropriate psychophysical predisposition allowing to minimize the risk of an event occurring with the participation of the human factor.

Conducted research with the use of a specialized tool allows you to gain valuable knowledge in the psychomotor opportunities of a given person and allows you to create an employee model for a specific professional group. In the scope of this work, employees of

the handling agent were examined. The results of the tests carried out together with the subjective one may be the basis for the substantive and objective evaluation of the work performed by a given person.

The examined persons performing the tasks of the ground handling agent related to the operation of the aircraft were also subjected to subjective assessment by the superiors. The results of this assessment are presented in tab. 3.

**Table 3**

**The results of employees' assessment made by superiors**

| | **Employee 1** | **Employee 2** | **Employee 3** | **Employee 4** | **Employee 5** |
|---|---|---|---|---|---|
| **evaluation:** | good | very good | good | very good | medium |

At the same time, based on the models developed during additional research using independent participants from different professional groups, who were repeatedly subjected to the same tests on the device and at different time intervals, it was possible to develop indicators and a mathematical model by means of which specific linguistic values were assigned to the linguistic numbers.

The numerical range for assessing the predispositions of employees was defined as follows (tab. 3).

**Table 4**

**Numerical ranges of employee predisposition assessment**

| | |
|---|---|
| < 60ms | very good |
| 61-75ms | good |
| 76-85ms | medium |
| 86-95ms | average |
| 96 >ms | inappropriate |

The starting point for the assessment was the effective time of tests performed. At the same time, as mentioned above, the test time itself without taking into account the number of errors made by the respondents is not a reliable assessment. For this reason, additionally, a mathematical formula was applied that allowed taking this variable into account:

Ct – effective test time
LpB – the number of mistakes made
W – Result / Total

$$W=Ct+LpB \tag{1}$$

By substituting the values obtained during the tests and assigning them to the proposed formula (1), we obtain the following assessment of the predispositions of the subjects (tab. 5).

**Table 5**

**Assessment of the predispositions of the examined persons**

| | **Employee 1** | **Employee 2** | **Employee 3** | **Employee 4** | **Employee 5** |
|---|---|---|---|---|---|
| **average test time** | 66,99 | 63,05 | 66,42 | 53,50 | 74,77 |
| **number of errors** | 8,00 | 6,00 | 6,00 | 3,00 | 5,00 |
| **result** | 74,99 | 69,05 | 72,42 | 56,50 | 79,77 |

Assuming the sum of the effective time of tests and the number of mistakes made during the tests by the employee, we obtain a measure of its predisposition for the work performed in the field of ground handling of the airport.

## 5.1. Verification of the analysis results

In order to make an objective assessment of the employee's predisposition to perform the ordered work and compare his psychomotor skills with the employee's supervisor's assessment, the results obtained from both the subjective assessment of the managerial staff and an objective calculation of the results of the tests, including the mathematical model, were verified. The results of this analysis are presented in fig. 8.

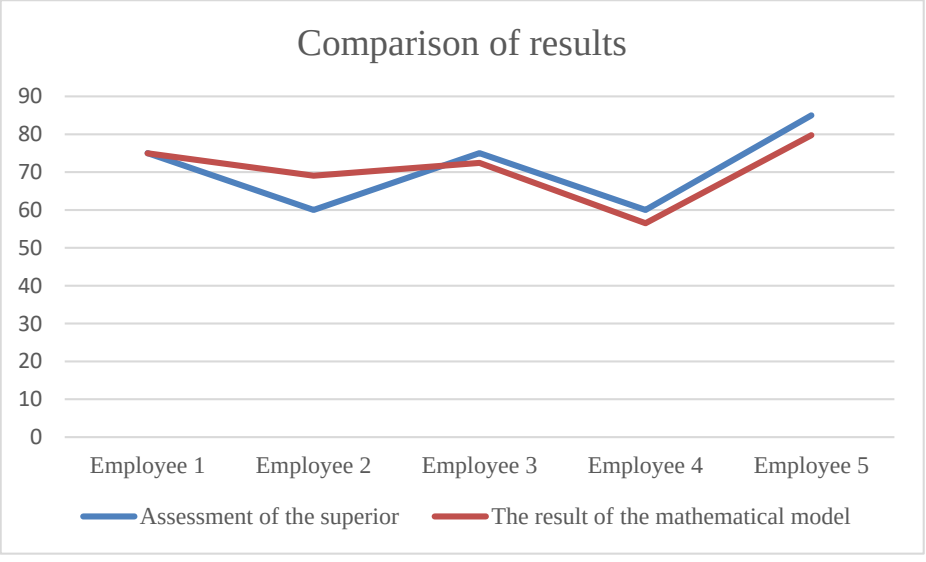


**Fig. 8.** Comparison of the results of the supervisor assessment and the mathematical model

**Table 6**

**Comparison of the results of the supervisor assessment and the mathematical model**

| | Employee 1 | Employee 2 | Employee 3 | Employee 4 | Employee 5 |
|---|---|---|---|---|---|
| **Assessment of the superior** | 61 - 75 | <60 | 61 - 75 | <60 | 76 - 85 |
| **The result of the mathematical model** | 74,98935986 | 69,05355739 | 72,42039988 | 56,50044476 | 79,76669865 |

As we can easily see in fig. 7 or tab. 6, the assessments of persons directly supervising the work of persons undergoing tests correspond with each other except for Employee no. 2, which was assessed by the linguistic variable with the value "very good". Meanwhile, according to the mathematical model proposed to assess the predisposition of the employee to perform tasks related to the servicing of aircraft, Employee no. 2 received the "good" value.

Bearing in mind the fact that the ratings of the remaining employees overlap with the mathematical model and are within the given ranges of values, the justification for this discrepancy should be seen in several areas. The reason for this could be:

1. Error in the assessment by the superior.
2. Error in the assessment by the model.
3. External factors influencing the employee test result (stress, fatigue, too loose approach to the test).

In connection with the above, in order to clarify the nonconformities, an interview with the employee's supervisor no. 2 was conducted again, during which the superior of the above-mentioned The employee admitted that Employee no. 4 is more predisposed to the duties entrusted to him than Employee no. 2, although he is also well perceived by the employer. Doubts in the assessment came from a relatively small difference in the assessment made both by the supervisor and in the mathematical model.

This is a very interesting observation. Subjective assessment may be burdened with an emotional error, whereas the analysis of predispositions made by the Polipsychograph provides objective data based on the actual skills of the employee.

# 6. Summary

The statistics of aviation accident investigation indicate that the human factor is still the weakest element of the aviation system. They also indicate the need to carry out permanent preventive activities aimed at improving the level of flight safety, especially in relation to areas related to the so-called human factor. This is not just the deaths of flight crews or passengers, but also huge material losses. The use of increasingly safe, but also complicated aircraft systems in a task environment characterized by a high level of variability causes that higher and higher demands are placed on their crews and security teams.

The model of assessing the predisposition of an employee to perform the duties of a ground handling agent presented in the work is a supplement to previous work related to minimizing the risk of occurrence of threats as a result of the human factor. In addition to theoretical considerations, based on the analysis of the sources and causes of the occurrence of aviation events, one should point to the need to use an objective, specialized tool that will allow assigning employee duties adequately to his skills. This method may also allow to support the decision-making process in the area of employee assessment by the supervisor, who may also be affected by the error.

This was confirmed during the verification of employee 5's predisposition, where the assessment made using the Polipsychograph and the mathematical model differed from the assessment made by the employee's supervisor. Another argument in favor of the use of such an employee appraisal method is the exclusion of a situation where despite the efforts, the employee will continue to make mistakes and will not be satisfactorily fulfilling the assigned tasks.

Such a person will be negatively assessed by the employer, who may not always be aware that the employee is not guided by bad will and attitude to work, but he simply does not have the appropriate predispositions to cope with the duties entrusted to him. The issue related to this problem has a wider context if we take into account the fact that as a result of such an event an air event threatening human health or life will occur [11].

The paper presents the results of tests carried out on employees who deal with ground handling of the airport on a daily basis. They were people rated by supervisors generally as good or very good employees, who stand out from the others praised by the management of the company in terms of conscientiousness and reliability in the performance of their duties. The conducted research showed a certain dependence of the psychophysical predispositions of the employee on the tasks performed by him related to ground handling of aircraft. Based on the models developed during the research using independent participants from different professional groups, who were repeatedly subjected to the same tests on the device and at different time intervals, it was possible to develop indicators and a mathematical model by means of which specific linguistic values were assigned to the linguistic. Assuming the sum of the effective time of tests and the number of mistakes made during the tests by the employee, we obtain a measure of its predisposition for the work performed in the field of ground handling of the airport.

The issue of the relationship between the organization of work of airport personnel and the frequency of occurrence of aviation occurrences at the work is a topic widely discussed in the literature. However, in contrast to commonly described methods, the author proposed to supplement them by studying also the psychophysical predispositions of airport personnel. The proposed method of assessing the psychophysical predisposition of the staff allows for planning the right personnel to perform specific tasks in line with the actual skills and abilities of a particular employee. These actions, in turn, combined with the right organization of work, can have a measurable positive impact on improving the safety of aviation operations and realistically counteracting the risk of a human factor in civil aviation.

Nevertheless, unwanted aviation events should be treated as those that mark the successive stages of development of areas related to flight safety. We should treat experiences from them and preventive recommendations as a source of knowledge for building new and enriching existing strategies to prevent mistakes made by air personnel. These activities should be carried out at all levels of the aviation organization, with particular emphasis on personnel directly involved in the preparation and implementation of aviation tasks.

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