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SELECTION PROCESS AS A KEY HUMAN ASPECT IN AIR TRAFFIC CONTROL

Summary. The article deals with the characteristics of the provision of air traffic services (in member states of European Civil Aviation Conference (ECAC)), as one of the main subject supporting global tourism, as well as with the selection of suitable candidates for the air traffic controller profession and the means and methods that are being used for the selection of eligible candidates. The authors present an original elaboration of approaches to selection processes in the Czech Republic in the context of the current development of European security and the perception of the human factor as a critical element of security and safety in air transport. In doing so, the authors use content analysis, as the results of empirical surveys present the results of discrete research surveys and evaluations based on explorative methods.

1. INTRODUCTION

The significant growth of the economy in a number of countries, together with the liberalization of civil air transport currently, represents a significant impulse for the development of tourism, practically oriented almost in all countries of the world. This trend is confirmed by the WTO, ICAO and IATA statistics. Indeed, this increase is associated with an adequate increase of air traffic on short, medium and long routes. In addition, with the massive development of jet aircraft use in the 1950s, the demand for air traffic control has considerably increased, reflecting the need for major changes in air traffic management and air traffic safety, the number and qualifications of air traffic controllers and requirements for their language skills [1]. With regard to the requirements of ensuring maximum safety, the financial characteristics and the complexity of the air transport system, there is a high level of sophistication in which air traffic control services are provided. The theoretical and practical training of air traffic controllers has a direct effect on the safety and efficiency of airspace use and thus plays a role as one of the key factors in the overall air transport system [2].

The main task of air traffic control is to provide a safe environment for air traffic [3]. This means providing specific services to the users of the given airspace and designated airports in the territory of the particular state, taking into consideration the international nature of air transport in accordance with international standards and, above all, the maximum safety of air traffic while maintaining both financial and capacitive efficiency. This is a highly professional and psychologically demanding profession, characterized by working in a complex information environment, which combines above-

average requirements for some of the performance and personality qualities of the candidate. Owing to the responsibility for the safety and fluency of air traffic controller's (ATCO) day-to-day operations, the theoretical and practical preparation of future ATCOs is one of the key factors in the air traffic as well as the overall air traffic system.

2. LITERATURE REVIEW

A paired comparison approach by Lin, P. H., Hale, A. R., and van Gulijk, C. [4] provides an approach to integrate management factors into risk analysis. The authors focus on comparison quantification to differentiate and prioritize a set of management influences to reduce human or technical failure, and to quantify the size of different management influences on risk by combining it with Bayesian belief nets (BBN). The BBN model of Causal Modeling for Air Transport Safety (CATS) has been used as a case study and enables better reflection in risk analysis of management functions as specific actions which can be taken by managers to maintain safety in critical activities.
Batteau A.W. [5] examines the anthropological issues posed by commercial aviation, an industry that in less than a lifetime has changed the meanings of space and place and has altered fundamental perceptions of global civilization. That approach begins with a critical examination of the concept of "human factors" as the standard industry approach to the human role. It notes that the representation of flight, as a mass transportation mode, has not kept pace with the global deployment of this technology across multiple cultural regions. The author notes that commercial aviation, as a large-scale technological system, has been deployed on a global scale, yet is only weakly governed by United Nations bodies and multilateral arrangements among air carriers and concludes with the observation of a process of technological peripheralization, arguing that technologies that promise an escape from economic marginalization can often promote technological marginalization.
The Human Factors Analysis and Classification System is applied to define a framework intended to identify focal areas for the safety community to mitigate similar future system failures. The results demonstrate an effective methodology for evaluating the quantitative relationships between symptomatic and latent causal factors, which are not readily apparent based solely on occurrence rates. Furthermore, the results also clarify the differences in causal factors between the selected general aviation and air carrier pilot operations. The usefulness of the framework, transferability to other domains and possibilities for future research are discussed [6].

According to the authors Chang et al [7], breakdown analysis of civil aviation accidents worldwide indicates that the occurrence of runway excursions represents the largest portion among all aviation occurrence categories. Their study examines the human risk factors associated with pilots in runway excursions, by applying a SHELLO model to categorize the human risk factors and to evaluate the importance based on the opinions of 145 airline pilots. The study integrates aviation management-level expert opinions on relative weighting and improvement-achievability to develop four kinds of priority risk management strategies for airline pilots to reduce runway excursions. The empirical study based on experts' evaluation suggests that the most important dimension is the liveware/pilot's core ability. From the perspective of frontline pilots, the most important risk factors are the environment, wet/containment runways and weather issues like rain/thunderstorms. Finally, this study develops practical strategies for helping management authorities to improve major operational and managerial weaknesses so as to reduce the human risks related to runway excursions.

Joshi J. P. [8] discusses "Human Factors Vital" as a crew resource management (CRW), a procedure and training system in systems for airline pilots. It informs that CRW focuses on improving the technical proficiency of air crews. Moreover, it reports that CRW assigns the "Pilot-in-Command" final authority with respect to the disposition of the aircraft. Stress on improving interpersonal communication, minimizing human errors and enhancing situational awareness of the airline crews are also discussed in CRW. With the new-generation airliners offering high levels of technical reliability, human error has increasingly become the leading cause of accidents. Investigation into accidents have revealed that the underlying cause is not only human error on the part of the commander and his crew but is also attributable to errors or failures at various stages in the life cycle of the aircraft. Failure on

the part of the regulator, management, air traffic control (ATC), dispatch and the meteorologist have been contributory factors. Research into the functioning of the human brain has revealed its limitations.

The following are some of the significant memory-related problems that human beings, including pilots, are inclined to suffer from:

1) Absent mindedness – forgetfulness attributable to lack of attention.
2) Blocking – temporary loss of memory manifest in a query, "Did he clear us to land?"
3) Transience – forgetting information with time evident in a question "What is the approach frequency?"
4) Mis-attribution – forgetting the source of the information.
5) Suggestibility – developing a false memory because of new information received during retrieval.
6) Bias – unconscious reshaping of memory owing to personal beliefs or mood.
7) Persistence – negative distortion of memory of a traumatic event.
8) Memory changes – memory changes from person to person and also within the same person owing to reasons like physical and emotional health, stress, quality and duration of sleep, diet and age.
9) Inattention blindness—things to which attention is not directed are not perceived. Inattention blindness is affected by the following factors:

- Lack of conspicuousness – all warnings in the cockpit are designed to be conspicuous so as to attract attention
- Mental workload and task interference. Low workload and the effects of automation, low arousal and low performance.

10) Fixation is a cause factor in many aviation accidents. Fixing of attention on something leading to inadequate availability of attention resources to maintain situational awareness.
11) Limited processing capability of the brain vis-à-vis massive inputs from the five senses. In aviation, the eyes and ears including vestibular apparatus and seat of the pants are the most effective sense organs. As an example, in the human visual system, the amount of information coming down the optic nerve is estimated to be around ten million bits per second. This far exceeds the capacity of the brain to process and assimilate, which is under 40 bits per second. Limitations of the working memory of the brain are akin to the RAM in a computer [8].

3. AIR TRAFFIC CONTROLLER'S PROFILE

The profession of an air traffic controller is a highly professional and demanding job, which is associated with superior personal responsibility [9]. The job requires a high degree of professionalism, persisting systematic training and continuous lifelong education [10]. High demands are placed on the long-term targeted focus of attention. The difficulty of this work lies mainly in the decision making under time pressure, a high degree of stress (possible heavy casualties because of hundreds of people on board of the affected aircrafts, and high financial losses on the aviation technology) and irregular working hours (shift work, work on weekends and holidays).

European Organisation for the Safety of Air Navigation (Eurocontrol) methodology assesses the proficiency of air traffic controllers based on four main pillars:

- Aptitudes and abilities
- Personality
- Knowledge
- Skills [11,12]

Aptitudes, abilities, and personality are psycho-diagnostically measurable; their quality depends mainly on the genetic aptitudes of the particular individual, and partly on the quality of his/her previous upbringing (education and training etc.). They form the necessary foundation for the professional development and are especially important during the selection process of suitable candidates for the profession of an air traffic controller.

It is possible to develop knowledge and skills through high-quality training. The results depend on a variety of factors, for example, quality of students, study conditions and quality of the educational process (including the methodological and didactic level).

3.1. The selection process

As one of the key factors, which precedes the individuals' training for the job of the air traffic controllers, it is necessary to consider the selection process of potential candidates. This is usually implemented through the selection procedure [13]. Its individual rounds, including the number, may vary slightly in different states of ECAC. The differences in the requirements and approach as well depend on if the air navigation service provider (ANSP) is civil or military. However, according to the recommendations by Eurocontrol, the selection process should include at least the following:

- Required level of education
- Aptitudes testing
- Medical testing
- Evaluating the language proficiency – English language [3]

The aim of the selection process is to find the candidates who are sufficiently mature (educationally, physically and mentally), so that they would be able to acquire, retain and demonstrate the required relevant theoretical and practical skills.

In many Eurocontrol member states, the aptitude test called First European Air Traffic Controller Selection Test (FEAST) is used for testing. This test should reveal the skills needed for the performance of an air traffic controller. However, as the content of this test is also contradictory, some ANSPs prefer their own monitoring systems for the recognition of required skills; alternatively, they outsource some parts of it. The advantage of using own systems is the ability to create a system that reflects accurately the nature and requirements of the concrete ANSP. Another advantage lies in the possibility of immediate modification of the system so that it would reflect the current results of outputs based on the analysis of training needs and development. Nevertheless, to clearly demonstrate the advantage of either approach would be possible only on the premise of a detailed analysis of the success rate. Unfortunately, this is unfeasible, because the successfulness does not depend only on the quality of selected students and on the training process itself but also on the circumstances that often cannot be directly affected (such as economic or personal).

As an example of deviation in success rate, see Fig. 1, which shows the statistic of some ANSPs. Values represent the percentage success of obtaining ATCO license of persons who have successfully passed the selection process and been accepted into course. Owing to the sensitivity of data, the providers are called ANSP 1 to ANSP 6. No data for ANSP in some year means that there was no training realized or the training was still in progress. Noteworthy is ANSP 3, as it is a provider that uses its own selection system and therefore there is a direct link between selection and subsequent practical training. ANSP 5 uses a selection system created by ANSP 3, but training is realized by its own training centre. Other providers use the FEAST test to select eligible candidates and have own training centres.

Logical reasoning offers the hypothesis that individuals eligible for the ATCO training should have a common profile that is a function of the characteristics of individuals performing this profession. The experiment was carried out as part of the doctoral thesis of the author [14], where one of the goals was to find a basic profile of these individuals based on certain common characteristics. Subjects participating in the experiment were selected specifically owing to certain common characteristics:

- Sex;
- Education;
- Age;
- Very superior intelligence, in means of scoring above 130 in international validated Mensa test (Mensa Czech Republic members).

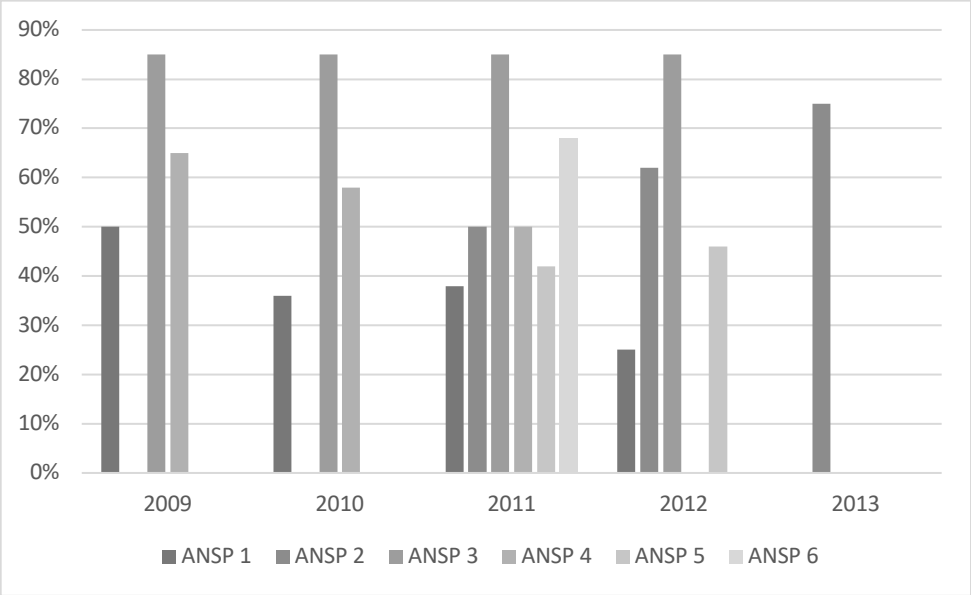

Fig. 1. ANSP success rate statistic

The battery of the professional simulation tasks / tests was focused on the following aptitudes and skills essential for ATCO:

- Memory
- Spatial imagination
- Mathematical / numerical reasoning
- Planning / decision making
- Multitasking
- Performance capacity

Fig. 2 shows results of each test according to the profile characteristics.

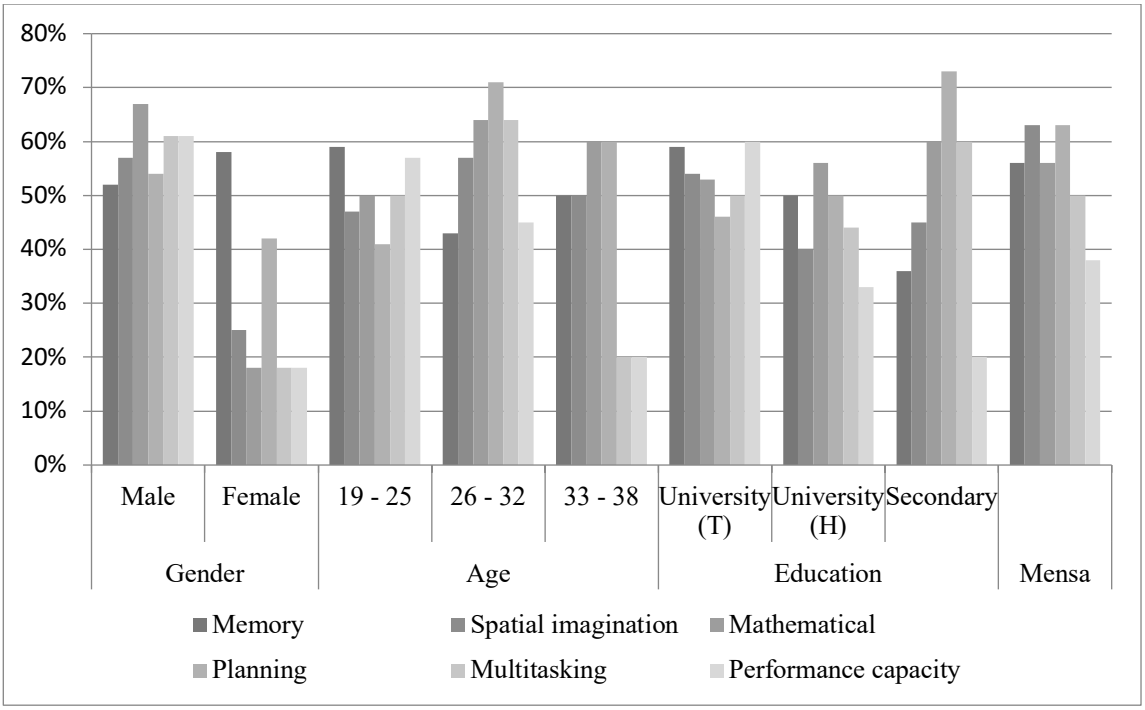

Fig. 2. Profile characteristics results

Based on the analysis of fig. 2, we are able to determine the characteristics of the profile that evokes a higher probability of success in the selection procedure for the profession of ATCO. Average success values are shown in table 1.

Table 1

Profile group success rates

Sex	Male	59%
	Female	30%
Age	19 – 25	51%
	26 – 32	57%
	33 – 38	43%
Education	University (technical)	54%
	University (humanities)	46%
	Secondary	49%
Mensa		54%

Based on results of the experiment, shown in table 1, we are able to say that the best combination of specific profile characteristic is male, age 26 to 32 with technical university education and above-average intelligence.

It is necessary to say that some scientists in the USA have expressed the opinion that further empirical studies that would support the approach of the so-called taking intelligence into consideration are needed instead of dealing with theories that put into context the general mental abilities (GMA[1]) and the performance of the individual. Nevertheless, it would be firstly convenient to verify such an opinion with a study whether and what influence would take intelligence into consideration, with respect to the cognitive skills in the scope of selection system of air traffic controllers, as a few-years-older paper published on the topic [15] of performance prediction shows that the best way possible on how to predict the success of individuals for a particular job is a system based on three selection techniques: a test of cognitive abilities; test of future work content and so-called Biodata[2].

3.2. Realisation of practical training with the synthetic training devices

The practical training takes place on various types of specific synthetic training devices (so-called simulators) designed to adequately simulate the environment and situations close to real airspace. From the position of air traffic controller - student, the simulator used differs substantially only in the way of simulating the environment; the degree of deviation of certain physical properties of simulated aircraft from reality, e.g., aircraft performance (horizontal speed, vertical speed, radius of turns and maximum cruising level); and reaction time of required manoeuvre.

The aim of practical training on simulators is to acquire and subsequently develop the following basic skills:

- Situation awareness
- Planning
- Reaction time
- Stamina
- Communication
- Radar vectoring
- Using vertical speed

[1] A term used for description of the level, which reflects how an individual learns, understands instructions and solves problems [16].

[2] Data obtained through the method of associations of answers on certain questions about life and work experience, as well as opinions, values, beliefs and attitudes that reflect the historical perspective of the individual. On the basis of biodata, certain patterns can predict the future behavior of the individual [1717].

The exercises are designed in such a way that the student would learn to solve the basic types of situations that can occur in real-life airspace.

After the student completes the exercise, the assessment by the training instructor follows. The specific aspects that were intended in the given exercise are evaluated (loss of separation, compliance or rules and agreements, an overview of the overall situation, planning, response to unexpected situations, etc.). The instructor assesses the exercise according to the way in which he/she would solve the situations. Here, however, the assessment influences the subjective view of the instructor, which can have many variables influencing it. These include experiences, different environments and access in previous locations of air navigation service providers (civilian, military, different Eurocontrol member state, a non-member of Eurocontrol) as well as the psychological momentum of the instructor.

The subjective point of view has a significant influence on the assessment of the student's performance by the instructor in the given exercise. The possibility of reducing the influence of subjectivity is the creation of a system functioning either in an already defined simulator environment or directly as an autonomous simulator that would perform an automatic evaluation of its performance on the basis of the specified conditions within the exercise. At the same time, multiple objective regression and correlation analyses would provide additional objective data on interdependence and intensity of dependency (capacity, response, efficiency, planning, etc.) in relation to the number of targets (simulated aircraft). The design of the suggested basic feasibility model is illustrated in Fig. 3.

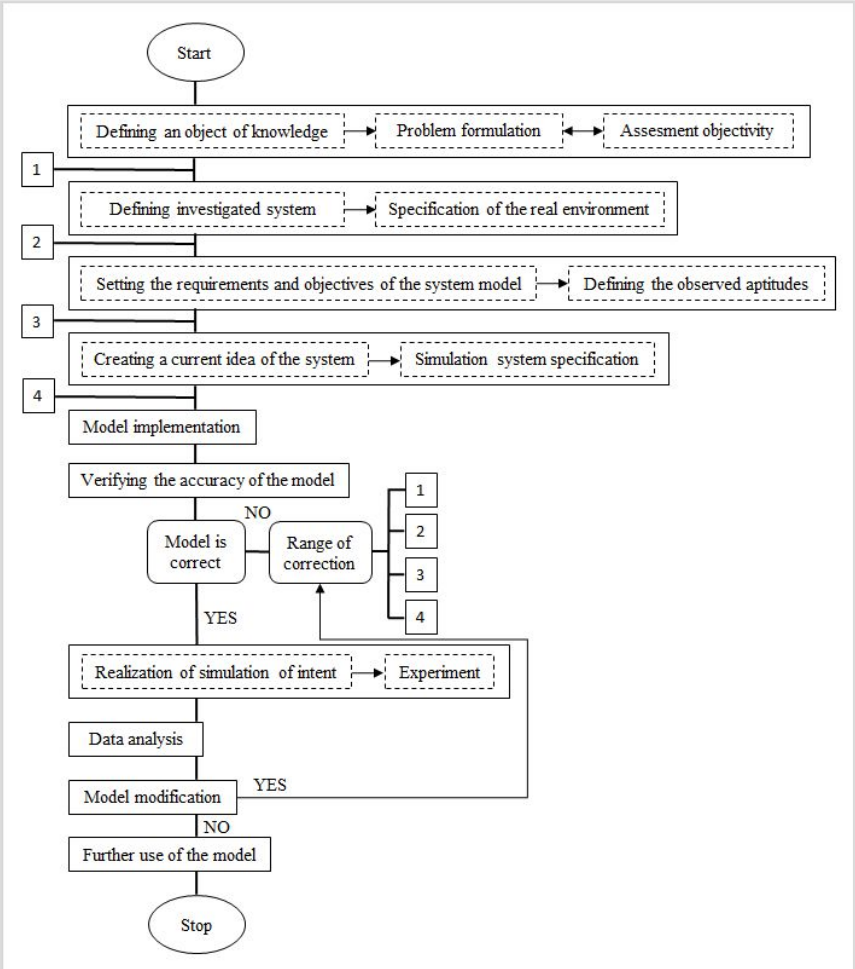

Fig. 3. Feasibility model of subjectivity reduction

The authors have not encountered any automated system that would be used to reduce the influence of subjectivity. Fig. 3 then shows author's original design of an automated system, which could be a way of at least partial reduction of the influence of subjective assessment of the instructors. Its

feasibility, effectiveness and consequent usability must first be verified in the experiment on a sufficient number of appropriate subjects and environments. For this, it seems to be the most appropriate the part of practical training called "basic training", where ATCO students learn basic methods of air traffic control in a simplified airspace 11s. In the case of positive results of these experiments, the next phase would be an application to the continuing part of the practical training called “PRE-OJT” (on-the-job training), which is still carried out on simulators, but with the actual airspace of the given ANSP. So to say, the mentioned feasibility model in Fig. 3 was neither used in real training environment nor as an experiment, it is just the first theoretical draft.

4. USED SCIENTIFIC METHODS AND RESULTS

The thesis was based on the analysis and hypothesis that current systems of the selection of ATCO candidates are in some part insufficient. Correspondingly, those used systems do not take into account some crucial criteria of assessing aptitudes of individual candidates.

The part “Selection of suitable candidates for ATCO job” dealt with the definition of the ATCO profile by means of description and analogy. By synthesis, the desired aptitudes are selected and defined from the information, which is monitored within the selection system proposed in the thesis.

The main part was focused on creation of a selection system for monitoring of desirable aptitudes. It was based on an experiment on implementation, verification and validation of the selection system for the selection of Czech Republic’s military air traffic controllers. The evaluation of success was based on the method of analysis-synthesis, and subsequent assessment of the desirable level of aptitudes is based on induction; therefore, the determination of general conclusions is based on identified knowledge. When evaluating some tasks, it was necessary to use the logic methods [18]. This was used to analyze certain outcomes related to influencing the outcome by combination of profile characteristics.

The results of the experiment are represented in Fig. 2 and Table 1, where we can see the profile characteristics that evoke the higher possibility of obtaining ATCO license. With taking into consideration the specifics mentioned in the article, we can, by logical reasoning, assume that such a level of aptitudes should be sufficient for distinguishing between suitable and unsuitable candidates for ATCO training. However, as we can see in Fig. 1, this might be not enough regarding higher percentage rate in obtaining the license. Therefore, we need to focus on the other parts, in means of practical training, like suggested subjectivity reduction during the training and use of biodata as part of the selection process.

5. CONCLUSION

With intensive globalization, there is a need to ensure safe and effective ways of moving people across different world destinations. Air traffic control is one of the basic building blocks for air transport, which is currently the most efficient in terms of safety and speed of transport; it is a system consisting of three basic elements: hardware, software, and human resources. As part of human resource management, it can be clearly stated that the development and growth of individuals' performance potential cannot be done in the same way as it is with hardware and software. It is not possible to update a better version of the software in humans, and in case of aging, it is not possible to exchange hardware for more sophisticated one. Therefore, the main areas of work with resource sources are the adequate selection system and the subsequent high-quality theoretical and above all practical training. In the field of selection system, with reference to the success rate of people completing ATCO training, it is right to believe that the current potential of standard systems for assessing required aptitudes is approaching its borders. Based on these findings, and based on the current ATCO selection and training knowledge, it would be advisable to focus further attention on selecting suitable candidates for the use of biodata (shared profile characteristics), identifying the ability of subjects to develop (in terms of practical skills required for ATCO job), and in the part of

practical training, focus on the influence of instinctive thinking on decision making and the reduction of the subjective assessment rate.

Based on the aforementioned issue and the authors' research results, we can conclude that psychological tests are undoubtedly important as a psycho-diagnostic tool, able to detect unwanted psychic and performance characteristics of the individual for the profession of air traffic controller, such as emotional lability, distractibility when administering power and low level of responsibility. Aptitudes related to this profession are probably not associated only with certain personality qualities but they are rather given by the individually different configuration of the performance and personal qualities. Psychological tests cannot prove whether the candidate has the aptitude for air traffic controller job. For this reason, psychological tests cannot themselves be an effective criterion in the selection process. The selection procedure should be accompanied by professional simulation tasks. The battery of professional simulation tasks must be optimally designed so as to focus on the appropriate talent to the profession. On this basis and with the use of psychological tests, we can choose individuals who will with higher probability handle the demands of the preparation and training as well as the profession itself.

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