



Testing Aptitudes as Part of the Selection Process of Air Traffic Controllers by the Czech Armed Forces

D. Langr^{1*}, V. Kalvoda² and V. Pokorný³

¹ Air navigation services CR, s. p., Jeneč u Prahy, Czech Republic

² 261st Control and Warning Centre, Hlavenec, Czech Republic

³ Institute of humane sciences, Newton College, Brno, Czech Republic

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Abstract:

The article concerns with a process of the air traffic controllers (ATCo) selection in the Czech Armed Forces. It describes current state of this process and balances it briefly against the civil sector and some NATO armies. The text comes out from the assumption that the air traffic control profession is the profession specific by its work content and workload and so it has special requirements on its candidates. The authors occupy themselves with the thought of how effective is the process of the air traffic controllers selection without testing the candidates' aptitude to use simulation technologies.

Keywords:

Process of selection of ATCo, testing of aptitudes, professional simulation tasks, simulation technology.

1. Introduction

Air traffic controller profession is a highly professional and mentally demanding job. It is characteristic by work in a complex information environment with high requirements for resistance to fatigue, stress, monotony, but also for other aspects of personal and power dimension of man, as well as above-average personal responsibility. With regard to the responsibility for the safety and continuity of air traffic, individuals chosen for the job should be selected according to the criteria that will be able to reveal the extent of their talents for this type of profession.

The selection procedure is necessary to focus on the search for individual professional and personal qualities. Saliger et al. [1] mentions individual professional quality, unique variant of skills, dispositions, features and resources within the competencies of the profession and the system. It is therefore important to ensure proper selection of high-quality and professionally competent individuals. The specific

* Corresponding author: ŘLP ČR, s. p., Navigační 787, Jeneč u Prahy, Czech Republic, phone: +420 777 995 058, E-mail: davidlangr@europa.com

objective is to find candidates with a good study prerequisites, who are also sufficiently mature physically and mentally so that they are able to acquire, retain and demonstrate the relevant theoretical and practical skills.

According to Dean [2], the best system selection system is based on three selection techniques, which are: an aptitude test, a test of future job content and BioData. BioData may be useful in the selection process because of their ability to indicate the likely future behavior based on past behavioral patterns of the candidate. BioData used in the selection of Air Traffic Controllers in the US were dealt with by Fox [3]. The author has come to a very interesting and in this regard a positive finding. Those interested in this area we would thus bequeath to her dissertation work. Like Dean [2], Eurocontrol and the Federal Aviation Administration (FAA) agree that in the selection process, it is important to monitor and evaluate aptitudes that are required for the profession of Air Traffic Controller and in this way to detect and weed out those individuals who would most likely not be able to meet the demands of the profession.

Abilities are characterized as congenital "morphological or functional difference" operative in a certain performance. Performance in this sense is understood as a certain level of the task and is determined by both internal and external factors. In terms of internal factors Nakonečný [4] stated central abilities (perception, memory, attention, learning and thinking), various transient states (motivation, mood swings, fatigue, etc.), the properties of sensory organs and motor skills and learning skills acquired. Among the internal factors affecting performance we can further include personality traits, as well as resources as mentioned by Saliger et al. [1]. All of the above differences and their mutual configuration for each individual vary. Saliger et al. [1] to this effect, with reference to G. W. Allport, emphasize the extreme individualism and uniqueness of the personality of the individual. Therefore it cannot be assumed that there is the only one combination which is decisive for this profession. It will probably be a whole range of such individual combinations of personality traits, psychophysical dispositions and motivation to exercise.

Requirements for candidates applying for the Air Traffic Controller job which are currently applied by the Czech Armed Forces arose from the requirements for admission to the University of Defence, where there is a theoretical part of basic training. It is the fulfillment of the criteria of the admission procedure to the military 5-year master's degree program. The inclusion of students in the study module of Air Traffic Control is carried out in the 6th semester and is based on their academic performance. Before the placement of students to a study module, they have to be assessed for medical and psychological fitness in the Institute of Aviation Medicine. After graduating from the University of Defence they go to a systematized job position in the context of Air Traffic Control of the Czech Armed Forces. Compared to civil claims and demands of some NATO armies (ie. Portugal and France) in this area, the Czech Armed Forces does not use so-called professional simulation tasks – tests of aptitudes for the Air Traffic Controller profession. Such simulation tasks in their essence represent a test of talent combined with a test of future career tasks, as stated by Dean [2]. Such tasks are able to create an optimal interface load / performance, making it possible to identify the degree of aptitudes for air traffic control.

2. Research Method

Based on the comparison of the selection procedure of Air Traffic Controllers in the of the Czech Armed Forces and the civilian sector as well as certain NATO countries, we

asked ourselves whether the personality questionnaires and performance test (psychological questionnaires and tests) are adequate selection criterion to identify the talent or its absence for the profession. On the basis of this question, the research was conducted on 38 probands. Through e-mails, the students of the University of Defence in Brno and members of the Mensa Society were addressed. Probands first underwent a series of professional simulation tasks on synthetic training device CASS UNOB that simulates the movement of aircraft radar position in the desired area. After performing professional simulation tasks probands were presented with a battery of standardized personality and performance tests. On the basis of the result achieved in professional simulation tasks, they were divided into two groups based on their score; if they scored above or below the calculated average result achieved (hereinafter, "below average" and "above average" probands). Subsequently, the statistical test results of psychological tests compared the two groups to determine whether the results themselves of "above average" and "below average" subjects differ

2.1. Simulation Tasks/Tests Battery

The battery of the professional simulation tasks / tests designed by Ing. David Langr [5] was focused on the following aptitudes and skills essential for Air Traffic Controller: memory, spatial imagination, mathematical / numerical reasoning, planning / decision making, multitasking and work under a pressure. Batteries contained a total of 6 sections, each of which focused on one of the following talents:

- **„Memory“ test** was focused on the ability to take over and for specified time to retain the information associated with the current situation on the radar display, and on the ability to take and store sensory picture of the position of the aircraft. There were a total of four jobs in which probands screen simulated aerial situation, monitored for 2 minutes, which generally consisted of 12 targets. After the expiration time, probands were required to enter the flight level of individual goals or sector in which they are located, or both these requirements (depending on specification).
- **„Spatial imagination“ test** was focused on the proband's ability to orient in three-dimensional space. In this task, they observed static situation including 20 aircrafts for 8 minutes. The aim was to draw the front and side of 10 set aircrafts during these eight minutes.
- **„Mathematical / numerical reasoning“ test** was testing the individual's ability to perform basic arithmetic operations on the rapid and adequately precise calculation of the horizontal speed, vertical rate of climb / descent and distances. This was a set of tasks divided into two parts. In the first part, 16 static aircraft at different speeds and altitudes were projected on the screen. The task was to solve the given numerous tasks relating to the aircraft or groups of aircraft. In the second part, the aerial situation consisted of 10 static targets displayed for 10 minutes. The task of the subjects in this section was solving two assignments in the order of aircraft in flight to the relevant points.
- **„Planning / decision making“ test** was focused on the ability to evaluate and select the most suitable alternative solution so that the solution was effective with respect to the further development of the situation and best fulfill the preferences. There were three exercises in which they were shown three different maps composed of two runways and marked points connected with tracks and each other. The assignment was to write the path of aircraft over the points to the

desired runway in the order and subject to certain rules. Total time for fulfilling the task was 10 minutes for the first two jobs, and 15 minutes for the third.

- **„Multitasking“ test** was focused on the subject's ability to perform independent tasks relating to the operation of aircraft at one part of the radar display and simultaneously to monitor and process information from another part of the same radar display. It was a task in which subjects should lead 4 aircrafts by commanding headings through 2 corridors without disrupting borders. During this assignment on the screen in chronological order appeared more separate tasks that probands should have adequately solved. Each of these tasks has been seen only after a certain time. The total task time was 33 minutes.
- **„Performance capacity“ test** is based on a combination of tests "Memory", "Planning / decision making" and "Multitasking" where the nature of the role played an important role in the proband's ability to make decisions and set priorities under pressure. It was a simulation in which the task of the subject was to manage air traffic in a simplified model of an imaginary airspace. There were a total of 8 aircraft that entered gradually into airspace and that proband directed by the commanding headings. The space was also gradually entered by aircraft, flying along a defined route, which could not be controlled by the proband. The task was to vector handled aircraft in the specified order through several points (also in a defined order). In addition proband had to comply with the rules relating to the loss of separation of aircrafts, disruption of borders of the airspace, entering the restricted area, etc.

2.2. Psychological Test Battery

Battery of psychological tests consisted of standardized questionnaires and tests used to meet the needs of psychodiagnostics. Performance tests focused on those aspects of individual performance qualities that Air Traffic Controller should have at a higher level than the average population. The characteristics which the tests were concentrated on were attention, working memory capacity and mental manipulations of information. Personality questionnaires were focused on the level of representation of different motivational aspects and examination of basic personal qualities common (though to varying degrees) for all individuals. Despite the fact that the battery of psychological tests may not coincide with the tests used in the selection of Air Traffic Controllers at the Institute of Aviation Medicine, one can assume that similar results would be achieved even when using other standardized tests and questionnaires. Batteries consist of the following questionnaires and tests:

- **Numeric rectangle** is a non-verbal performance test of optical observation or visual attention and speed. It is based on the assumption that visual perception is determined by internal factors such as the condition and quality of the nervous system, the degree of concentration, focus and attention oscillations, the level of visual perception and memory. The aim of the test is to identify those numbers in a complex stimulating field where these numbers are randomly distributed [6].
- **D48 Domino** is a nonverbal intelligence test focused on fluid intelligence. The basic elements of test tasks are domino game tables arranged according to different rules, while one of these tables is empty. The number of the tables in each part of the test is different and is ranging from 4 to 14. The task of test subjects is to find the rule according to which these tables are compiled and to determine how the table should be added to the empty space. Each test task is

based on different rules. Although the test works with the numbers and is based on the principles of sequences of the numbers, the solution requires almost no mathematical knowledge [7].

- **Attention test d2** is time-limited test of selective attention and mental concentration, which measures the speed of processing, compliance and quality of performance in distinguishing similar visual stimuli, thus allowing to determine the individual performance of attention and concentration. Motivational site of performance is penalized by the number of complaints processed in a given time, site of management focus represents a degree of precision, and the ratio of these two components can draw conclusions about the level of activity, stability and consistency of performance, fatigue, level of attention and control of distracting influences [8].
- **NEO five-factor personality inventory** is a personality questionnaire based on five-factor model of personality, which is based on a factor analysis lexicon of natural languages. The method measures how individual differentiates and provides information on five broad dimensions of personality - neuroticism, extraversion, openness to experience, agreeableness and conscientiousness. Respondents respond to a total of 60 items, 12 of which are assigned to each dimension.
- **LMI Achievement motivation questionnaire** is a personality questionnaire, which is based on the view that the motivation to exercise cannot be understood as a delimited construct, but rather as a construct which participates in various aspects of personality. Achievement motivation determines the degree of motivation for achieving personal and professional goals, which is influenced by ambition, independence, self-control. The questionnaire consists of 170 items, which are assigned to 17 rocks / dimensions [9].

Of the total group of 38 subjects, 12 scored above the average. Subsequently, for every personality and performance test *Student's t-test difference between the sample mean and known diameter base* was conducted which was set at a significance level of 0.05. This statistical test verifies if the null hypothesis, which claims that the sample ("above average" probands) comes from the basic ("below average" probands), is valid [10].

3. Results

Results were evaluated separately for each test and for clarity they are listed in the tables and interpreted.

3.1. D48 Domino

Probands scored in this test as follows:

Tab. 1 Proband scores in D48 Domino

Parameter	“Above average” probands	“Below average” probands
	Interval/average/standard deviation	Interval/average
Raw score	31-42/35.42/3.35	26-41/33.27

Tab. 2 Result of Student's t-test for D48 Domino

Parameter	Outcome of the Student t-test (t values)
	Critical t value = 2.201
Raw score	2.22

Thus, we reject the null hypothesis and we can say that in the Domino D48 test was statistically significant difference between gross scores "above average" and "below average" subjects. The "above average" probands scored higher. Their results suggest more evolved ability to search algorithms and relationships between objects, which can be related to the ability to predict future development of the situation and its adequate solution.

3.2. Numeric Rectangle

Probands in this test reached the following raw scores of which mean and standard deviation were calculated:

Tab. 3 Scores of probands in Numeric Rectangle

Parameter	"Above average" probands	"Below average" probands
	Interval/average/standard deviation	Interval/average
Raw score	16-22/19.33/1.70	11-22/17.77

Tab. 4 Result of Student's t-test for Numeric rectangle

Parameter	Outcome of the Student t-test (t values)
	Critical value = 2.201
Raw score	3.19

This result exceeds the critical value, therefore we reject the null hypothesis. There was found a statistically significant difference between the scores "above average" and "below average" subjects in this test (in favor of the probands "above average"). These probands scored in the upper third attainable score, from which one can derive a higher optical observation capacity and oscillation attention, which may facilitate orientation in complex radar situation.

3.3. Attention Test d2

This test consisted of a total of five parameters. Raw scores, averages and standard deviations of the individual parameters are summarized in the following table:

Tab. 5 Scores of probands in Attention test d2

Parameter	“Above average” probands	“Below average” probands
	Interval/average/standard deviation	Interval/average
Total number of examined items	409-627/520.25/57.11	244-644/496.23
Number of mistakes	7-58/22/16.68	2-78/27.77
Percentage mistake rate	1.20-9.30/4.11/2.84	0,47-11.15/6.23
Concentration performance	160-251/198.75/26.62	133-268/185.35
Total performance	401-578/498.25/50.85	166-641/468.46

Student t-test was performed for each parameter separately, while we got the following results:

Tab. 6 Results of Student's t-test for Attention test d2

Parameter	Outcomes of the Student t-test (t values)
	Critical t value = 2.201
Total number of examined items	1.46
Number of mistakes	1.20
Percentage mistake rate	2.59
Concentration performance	1.74
Total performance	2.03

Based on these results and taking into account the critical value of all parameters, except for percentage mistake rate, we accept the null hypothesis and state that in the results of the "above average" and "below average" subjects in these parameters, there was no statistically significant difference. At the percentage mistake rate we reject the null hypothesis and we can say that "above average" probands achieved on average a smaller percentage of mistake rate.

The results of "above average" subjects show that they have the right blend of qualitative and quantitative performance, higher levels of mental concentration, good selection of attention and good visual discrimination skills of irrelevant stimuli in the visual field of similar stimuli. However, with regard to the results of the statistical test, the results of the "above average" subjects do not differ from substandard probands. Based on this, therefore, it is not possible to recognize probands with a tendency to cope with the demands of professional simulation tasks.

3.4. NEO Five-factor Personality Inventory

The questionnaire contains 5 scales in which probands scored as follows:

Tab. 7 Scores of probands in NEO five-factor personality inventory

Scale	“Above average” probands	“Below average” probands
	Interval/average/standard deviation	Interval/average
Neuroticism	0-24/6.00/7.35	3-29/13.13
Extraversion	22-47/23.92/14.01	20-49/33.67
Experience openness	14-33/17.42/10.47	8-31/23.67
Kindness	14-38/19.58/11.79	38-67/30.47
Conscientiousness	28-40/23.25/12.62	25-44/35.40

Due to lower recoverability of the questionnaires (NEO five-factor personality inventory and LMI Achievement Motivation Questionnaire), we was forced to evaluate and interpret results of less subjects than we evaluated and interpreted in the performance tests. Factually 8 from 12 "above average" subjects' questionnaires and 15 from 26 "below average" subjects' questionnaires were evaluated. This is the reason for utilization of different critical value in the following tables.

Tab. 8 Results of Student's t-test for NEO five-factor personality inventory

Scale	Outcomes of the Student t-test (t values)
	Critical t value = 2.3646
Neuroticism	2.75
Extraversion	1.97
Experience openness	1.69
Kindness	2.61
Conscientiousness	2.72

When comparing the results with the critical value t we reject the null hypothesis scales on neuroticism, agreeableness and conscientiousness. On the contrary, we take it on the scales of extraversion and openness to experience.

On the scale of neuroticism "above average" probands scored significantly lower than the "below average" probands, which was confirmed by a statistical test. Thus they have the optimal mental balance up to the extraordinary resistance to mental exhaustion, the ability to handle stressful situations and adequate experience of feelings associated with guilt, fear or sadness. In the case of proven difference on the scale of conscientiousness, "above average" probands have a healthy ambition, diligence and ability to establish and transform goals.

In the case of extraversion scale, in the "above average" subjects we could deduce the appropriate action in relation to other people, overall preference of companionship against loneliness, higher up significant optimism, energy and security. However, their results in that scale do not differ from the "below average" subjects who achieved the similar results. We have reached the same finding in the case of range openness to experience.

3.5. LMI Achievement Motivation Questionnaire

The questionnaire contains a total of 15 scales. Achieved raw scores in each scale with "below average" and "above average" subjects are shown in Tab. 9.

The results of Student's t-test do not exceed the critical value t (see Tab. 9). For this reason, we accept the null hypothesis for all scales and we can say that in the result of LMI questionnaire was not statistically significant difference between the two sets of subjects.

Tab. 9 Results of LMI Achievement motivation questionnaire

Scale	"Above average" probands	"Below average" probands	Outcomes of the Student t-test (t values)
	interval/average/ standard deviation	interval/ average	Critical t value = 2.3646
Persistence	30-62/48.25/8.63	27-53/47.20	0.34
Dominance	37-65/51.38/8.47	33-62/51.07	0.10
Involvement	31-51/39.38/7.18	29-53/41.13	0.69
Trust in success	38-67/54.63/9.67	30-60/52.13	0.73
Flexibility	35-62/51.00/8.60	42-63/53.00	0.66
Flow	33-65/49.25/10.30	31-59/46.67	0.71
Fearlessness	27-55/43.00/9.79	29-59/47.87	1.72
Internality	31-64/48.38/9.96	26-63/49.07	0.20
Compensatory effort	38-53/47.50/5.70	35-62/49.20	0.84
Performance pride	50-69/57.25/6.46	46-62/55.07	0.96
Willingness to learn	35-55/44.88/6.39	38-54/45.80	0.41
Preference of difficulty	31-65/42.25/9.93	38-55/46.60	1.24
Self-activity	36-65/47.63/8.99	26-56/45.87	0.55
Self-control	38-49/43.63/4.15	32-58/45.93	1.57
Status orientation	43-68/53.88/8.74	28-63/51.27	0.84
Competitiveness	34-58/43.63/11.17	26-60/43.80	0.04
Single- mindedness	35-52/45.13/5.35	30-61/48.07	1.56

Results of the "above average" subjects in the LMI survey point to a greater concentration at work, the ability of the administration of stable performance and ability to cope with difficulties with adequate energy expenditure. Self-esteem of the "above average" subjects is largely dependent on the performance, and they prefer heavier tasks dependent on the higher level of the skills. However, these qualities that the questionnaire LMI attributes are not significantly different from those held by the "below average" probands. We cannot say that on the basis of these results we can

recognize the probands who will be successful in the professional simulation tasks with a higher probability than others.

Regarding qualitative point of view, some raw scores of "below average" probands in performance tests, in which there was shown a quantitative difference, reached higher or equal value compared with "above-average" probands. Thus, although these individuals achieve above-average results in a battery of professional simulation tasks, they have similar performance qualities as probands with above-average results. Similarly, we could talk about gross score in the desirable / undesirable personal qualities for the Air Traffic Controller job (e. g., neuroticism, conscientiousness, perseverance, etc.)

4. Summary

In the preparation and the training of Air Traffic Controllers, it is the fundamental to work in a complex information environment and continuous cultivation of knowledge and skills. The aim of this process is to train an individual capable of stable and efficient performance in a complex IT environment, which often goes beyond the professional competence curriculum [11]. To achieve this goal, it is important to start making preparations to focus attention on the proper selection of candidates. The point is to establish such criteria which can chose candidates who will be able to cope with the demands of the preparation / training and profession, not only with higher probability, but also in the time interval defined for the preparation and training.

With the development of simulation technology the trend in the selection of Air Traffic Controllers in the civil sector and in the environment of some NATO armies became a professional simulation tasks method. It represents an aptitude test combined with a future professional tasks test. On the basis of its content and the opportunity to provide the desired ratio of workload / performance these tasks enable to verify that the candidate has the required potential / talent for the profession. The Czech Armed Forces currently adopt the reserved attitude to the professional simulation tasks in selecting of Air Traffic Controllers. That led us to the question regarding to what extent the selection procedure based on psychological tests can be effective.

Based on the above-mentioned issue and the 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 liability, distractibility when administering power, low level of responsibility, etc. 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. Selection procedure should be accompanied by professional simulation tasks, such as suggested by Dean [2]. 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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