Psychological Readiness of Air Traffic Controllers for their Job

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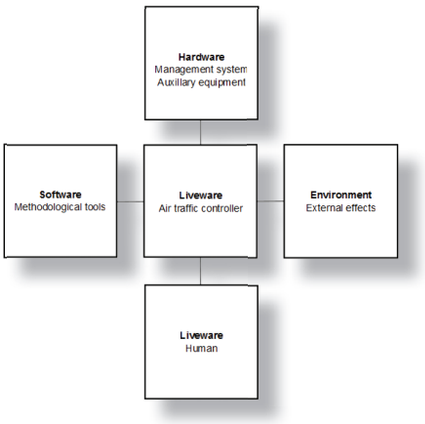
Summary

This article highlights the importance of examining human factors in aviation, especially in air traffic control. It analyzes the factors affecting performance of air traffic controllers (ATC) and increase or decrease of security. The aim is to eliminate the risk factors affecting air traffic controllers in the working and the training phase.

KEY WORDS
air traffic control
human factor
reaction time
safety

INTRODUCTION

Currently, considerable resources are being invested in aviation safety and in clarification of the causes of air crashes in order to prevent their recurrence, or even for their elimination. Performance of air traffic controller is influenced by many factors. The focus in most cases is on the work of aircraft crew on the basis of data from the black boxes, records of correspondences, and activities of the crew. Based on the findings, conditions that led to creation of the event are subsequently modeled on pilot simulators. However, less attention has been paid to errors caused by air traffic controllers. [2]



In implementation of the programs of the future European system of organization, ATC remains an area of "human factor" that is the least sophisticated. Though the assumption that a person - operator - air traffic controller will be in a new and technologically improved system continues to occupy a central "role", subprograms of "Human Resources" remain in the envisaged improvement stages of ATC systems at the level of general statements. Attention is paid to human factors and procedures only in general, which can provide sufficient motivation and concentration in terms of highly automated system issues affecting the safety of flight operations. This is not probable due to weak funding of this area, but also mainly due to the lack of knowledge about the need for robust and efficient preparation of man - air traffic controller.

CIRCADIAN RHYTHM

In pursuing the performance of air traffic controllers, it is necessary to address performance in various stages of the day. During the day, people do not have the same amount of vigilance. There are two peaks and two valleys of vigilance every day at the same time, called circadian rhythms. The circadian rhythm determines the maximum alertness to be before the midday, between the 7:00 and 12:00 o'clock, with a peak at 9:00 a.m.. Another peak is in the early evening, between 16:00 and 20:00, with a peak at 18:00. Between 13:00 and 15:00, the body and mind want to relax and sleep. The vigilance valley at night covers the period between midnight and 6 in the morning. Every person has his rhythm shifted slightly, but the basic shape remains the same. [1]

ATCo TRAINING CENTRE

In our conditions we train air traffic controllers on simulator LETVIS. The

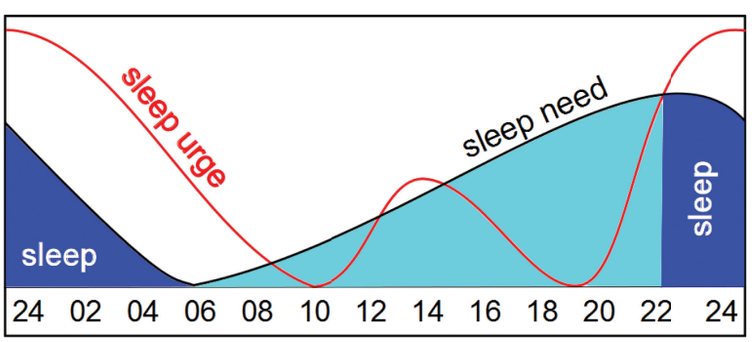


Fig. 1. Circadian rhythm

Fig. 2. ATCo training centre (ATCo stations)

Fig. 3. ATCo training centre (Pseudopilots stations)

simulator is designed for practical training of ATCo and simulates direct air traffic radar control. The simulator is used to test theoretical knowledge in aviation communications, to test practical knowledge of vectoring aircraft to land or to take off in compliance with safety rules and sequenced flow. The ATCo assesses a range of knowledge and skills in order to improve their preparation. LETVIS SIM system is designed to simulate a wide range of civil and military movements in the airspace. The system fully replaces the actual system for data processing and air traffic control. The situation is displayed on ATCo monitors and pseudopilots where pseudopilots simulate pilot actions based on commands issued by ATCo. Simulation centre contains two versions of the simulator, where one version consists of two ATCo departments and two pseudopilot departments that are configurable separately or in a single unit allowing complex radar control at several workplaces at the same time. This version is called a LETVIS RDP / NX 8.5 RC for pseudopilots and LETVIS RDP / SIM NX 8.5 for ATCo, where the operating system is OPENSTEP 4.2 and the system is mounted on identical tables for staff of air traffic control. Newer version consists of only two departments, instructor and ATCo fixed with general office machines labeled LETVIS RDD 9.2A for the instructor and LETVIS RDD 9.2N for the ATCo.

THE VERIFICATION DEVICE

A verification device has been designed at the Flight Preparation Department in order to measure the response time in answering randomly generated tasks. The verification device monitors the subject's rate of reaction, the correct motor function, and the reaction to audio and visual stimuli. The verification device includes: Monitor with 1280x800 px resolution, PC, 3 hand-operated buttons, 2 foot-operated buttons, keyboard with numerals 0-9, and MBED. Individual components are shown in Figure 2. After running the test, the screen shows three sectors. In each of the sectors, 2 yellow, 2 blue, and 2 green points of the same size and shape are shown. Within each sector, a red point of the same size can also appear. A pair of points of the same color is spaced 150 px apart. In each sector there may be approximation of the same colored points by 30 px.[3][5] The system randomly generates six tasks:

1 * button left hand-operated (H1)
1 * button middle hand-operated (H2)
1 * button right hand-operated (H3)
1 * button left leg-operated (L1)
1 * button right leg-operated (L2)
1 * button for sound (sound 0-9)

At the start of each new set of 6 tasks, the system automatically launches beeps at regular intervals of 2 seconds. The maximum number of beeps is set by the software to be limited to 9. The system evaluates correct and incorrect answers. If there is a convergence of two points of the same color in sector 1, the system considers the pressing of button H1 for the correct answer. If there is a convergence of two points of the same color in sector 2, the system considers pressing button H2 as the correct answer. If there is a convergence of two points of the same color in sector 3, the system considers the correct answer as button H3. If a red point appears in sector 1, the system considers the pressing of the foot L2 button for the correct answer. If a red point displays in sector 3, the system considers the pressing of the foot L1 button as the correct answer. If a red point appears in sector 2, the system considers the correct answer as pressing of the SOUND 0-9, depending on the number of beeps. The time for getting the correct answer is limited by the software to 60 seconds. If the correct answer is not entered in due time, the system writes the letter N (unanswered task) to the file, as well as the number of incorrect responses to the task, and

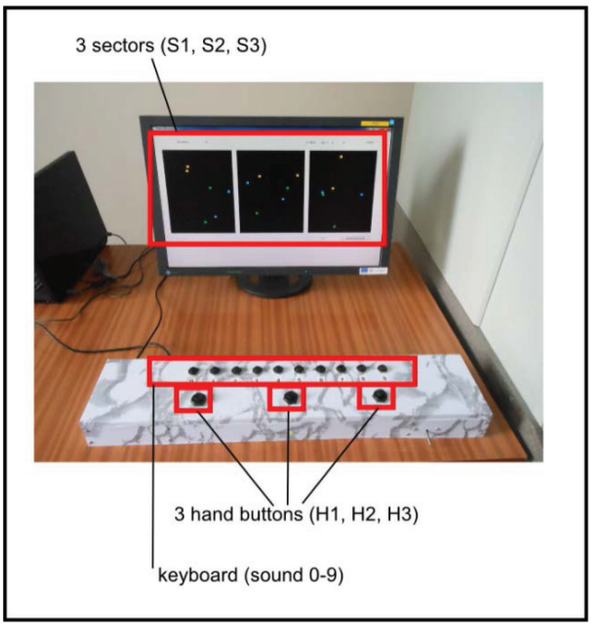


Fig. 4. Monitor and hand buttons of Verification device

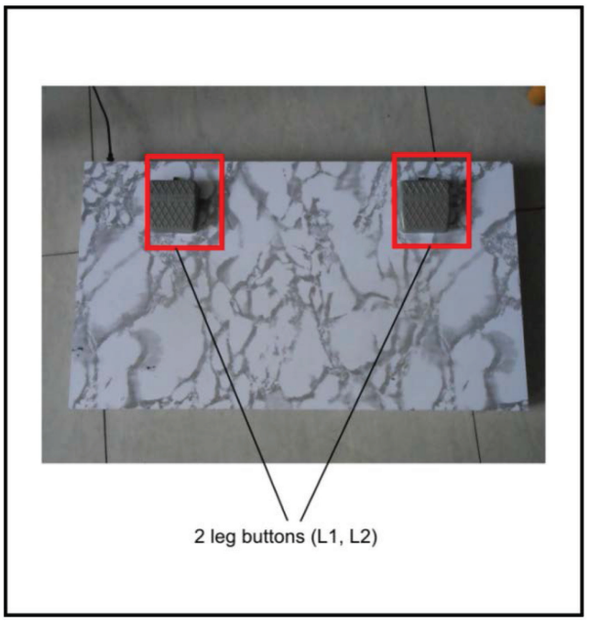


Fig. 5. Leg buttons of Verification device

then generates a new task. The system is fully automatic and does not require any additional control persons who would oversee the fairness of the test.

MEASUREMENT OF ACTUAL PSYCHOLOGICAL READINESS

To measure the actual psychological readiness of air traffic controllers, the verification device described in Section 3 was used. 20 students in their final year of studying air traffic management at the Faculty of Aeronautics TUKE were used as the test subjects. All test subjects received theoretical training, health checks, and have a valid language certificate. Therefore, they are fully qualified to hold the ATCo. Measurement of current psychological readiness of air traffic controllers took place in a 24 - hour cycle. One test group contained 10 students, who were tested for the verification device every hour for 24 hours. Testing took place from 6 in the morning and ended at 6 the following morning. In addition to the testing process, the test subjects did not engage in any mentally or physically demanding work. It should be noted that the students were already familiar with the authentication device from the previous test. Therefore, there was no need for further training for the testing. The experiment was repeated with 10 subjects after the interval of two weeks. Figure 3 shows the resulting course of 30 subjects tested during 24 hours of testing.

THE ERROR RATIO

During the air traffic control, the correctness of the decision of air traffic controllers is more important than the speed of the decision. Therefore, during testing on the verification device, greater emphasis was placed on the accuracy of the answers than on the rate of the reaction. For an objective assessment of the current psychological readiness, an error ratio was set. The error ratio expresses reliance of the incorrect responses, reaction time, and the total number of tasks. To determine the error ratio, the least squares method was used, resulting in the following relationship:

$$\alpha = AT^* (NT+4^*NE) \quad (1)$$

α = error ratio
AT = average time per task
NT = total number of tasks
NE = total number of errors

CRITICAL POINT

For testing of the psychological readiness of the air traffic controller, 95% confidence interval for the mean error

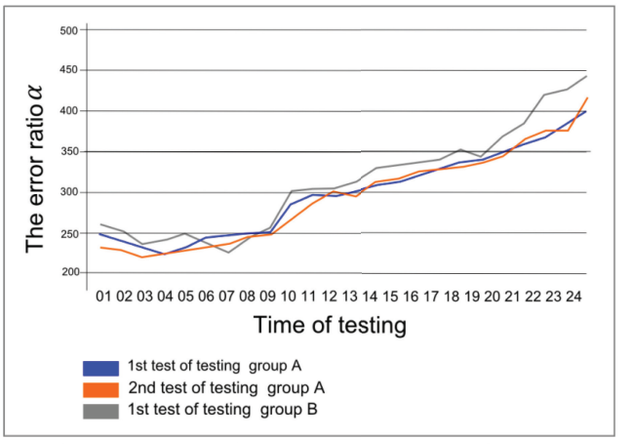


Fig. 6. Testing of air traffic controllers during the 24-hour test period

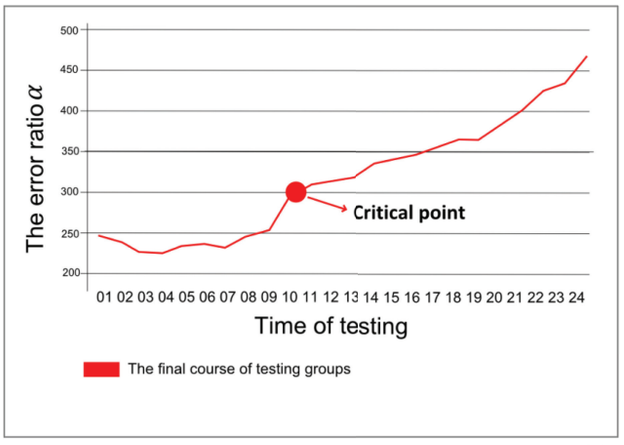


Fig. 7. Final course of testing groups and critical during the 24-hour test period

ratio was constructed. It was assumed that the random selection error ratio has normal distribution Nμ, σ2, where μ is the mean and σ2 is the variance (standard deviation) of the error ratio. The normal probability distribution was used because under the law of large numbers (central limit theorem), every probability distribution converges to the normal distribution with a sufficient number of attempts. The random selection is formed by random variables X1, X2, ...,Xn – error ratios of samples 1, .., 30

1001-α% confidence interval, in general, can be expressed as:

$$\left(\overline{X}-\frac{s}{\sqrt{n}}t_{1-\frac{\alpha}{2}},\overline{X}+\frac{s}{\sqrt{n}}t_{1-\frac{\alpha}{2}}\right)$$

$$\left(\overline{X}-\frac{s}{\sqrt{n}}t_{1-\frac{\alpha}{2}},\overline{X}+\frac{s}{\sqrt{n}}t_{1-\frac{\alpha}{2}}\right) \quad (2)$$

X - selective median

S - selective standard deviation of random variables

t - student distribution with n-1 degrees of freedom at significance level α = 0.05

$$\left(\overline{X}-\frac{s}{\sqrt{n}}t_{1-\frac{\alpha}{2}},\overline{X}+\frac{s}{\sqrt{n}}t_{1-\frac{\alpha}{2}}\right)=(295;308)$$

Error ratios of the tests are made of random variables

$$Y_1, Y_2, \dots, Y_n \; Y_1, Y_2, \dots, Y_n .$$

If

$$\overline{Y} \in \left(\overline{X}-\frac{s}{\sqrt{n}}t_{1-\frac{\alpha}{2}},\overline{X}+\frac{s}{\sqrt{n}}t_{1-\frac{\alpha}{2}}\right).$$

The lower limit of the confidence interval can be set to 0, since below the mean error ratio – as the lower limit of the confidence interval – means better mental condition. Thus, in the test program, the condition $\overline{Y} \in (0; \overline{X} + s/\sqrt{n}\, t_1(1-\alpha/2)) = (0; 308)$ was tested to decide whether the air traffic controller is mentally prepared to do the task.

SUMMARY

The testing of the actual psychological readiness was attended by 20 managers-students. 720 separate tests were performed, containing 300 tasks and the resulting waveform is shown in Figure 4. The studied subjects reached the daily maximum performance after two hours of testing. Loss of concentration and reduced work performance have been observed after eight hours and reached a critical value after twelve hours of testing. The error ratio curve showed an upward tendency. Therefore, it can be assumed that the results would deteriorate if longer testing was performed. It must be noted that the studied subjects did not engage in challenging activities, which would be present in real operation, where the emphasis is on great concentration and attention. Under such conditions, this could shift the border of the critical value between the 6th and 8th hour.

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