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THE LEVEL OF DANGER IN CONTROLLED AIRPORT SECURITY

The functionality of the aircraft complex is determined by quality and safety. This is defined by the relationship between the entities airport – aircraft – airspace. Operational safe management and control at the airport is a directed action of independent factors. Their expression is embedded in the feeling of security and safety of each air traffic participant. Fulfilment of the ethical characteristics of security requires the implementation of management so that the control at the airport is carried out in the relevant security zone. Construction of a safe state can be achieved if the chosen method of safety experiments will faithfully reflect the real error in the control of air transport. The correctness of safety control procedures can be verified by simulation and models built on a physical basis. The motive of the article is to show one way of effective identification of errors in the management of security controls actors of air transport.

Keywords: airport, security, control system, probability, sensitivity, danger.

Introduction. Analysis of recent research and problem statement. The security experiment for airport control reflects in control experiments the content-accurate way of scientific examination of the objective fact about the findings of danger is a way of verifying the veracity of subjective (own) judgments about hypotheses and theories based on safety theory [1]. Instead of the term experimental verification is often used in theories of security and in determining the level limit control concept. The development and continuous improvement of airport control equipment are inconceivable without carefully carried out successful security controls. [2]. Such knowledge also increases the requirements for flight safety, which is a condition that is encoded in the reliable operation of airport control systems. This fact highlights the importance of understanding the hierarchy of safety [3]. When researching the security of airport complexes, security checks are performed, preceded by a control plan. The control plan assumes the airport security service to set the security level. The nature of the chosen control requires a specific form. The type of safety features must, of course, be assigned to the cognitive hazard detection method. The basic precondition for performing inspections is a set time, which with a certain probability determines the intensity of danger detection.

Materials and methods of research

The sequence of detection of dangers by control mechanisms. The process of finding hazards in the airport control process has a random character according to the sensitivity of

the control system, which can also be investigated by methods used in reliability theory. An example is the time of detection of danger, which is an analogy of the time of its detection.

The published article [4] showed the applicability of the mathematical apparatus for the readiness of the control safety system for the experiment to find the danger. The security control method at each security hierarchical level includes a number of specific additional sub-controls, the arrangement of which is presented in figure 1.

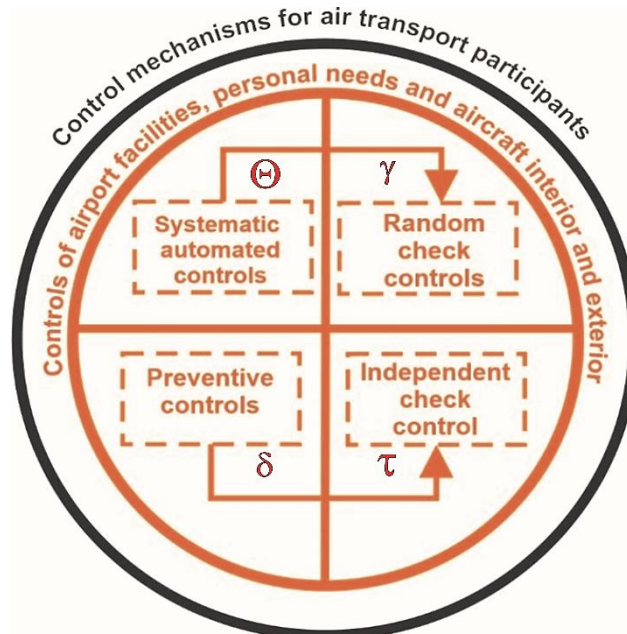


Fig. 1. Type hierarchy of airport security controls

When setting up a mathematical model of the correctness of security controls for hazard detection, we assume that all inspected parts of air traffic participants and objects are characterized by a certain possibility of how to detect (find) a potential danger. In general, however, this is not so clear-cut. The probability of turning safety into danger also depends on the sensitivity of safety control systems. Assume also that some controls are independent, i. they do not only depend on direct checks but also the periodic acquisition of information from other security systems (information service) [5].

To create a mathematical model for the identification of the hazards it is necessary to determine the probability of detection of danger. These controls can be expressed in the following forms: Θ ; γ ; δ ; τ ; on time interval $\tau \leq t \leq d\delta$. It is necessary to accept this condition at the specified interval in which we perform unit control of the j -type of security control. In the following, we will accept the fact that the danger has not been detected until now $t = \delta$. When checked is $\Theta_j(\delta) = \text{constant}$. Let us determine $P_j(t)$, i.e. the probability that the hazard was not detected even after the time t has elapsed, in time units of the airport security inspection process. From the above statements, it is possible to focus on the probability that the danger has not been detected even in time $t + dt$. Then the probability of finding a danger will be [6]:

$$P_j(t + dt) = P_j(t)[1 - \theta_j dt] \tag{1}$$

From equation (2) it is possible to write a differential equation for $P_j(t)$:

$$\frac{d}{dt} \ln P_j = -\theta_j \tag{2}$$

Equation (2) is a fundamental equation in describing the process of finding (detecting) a problem in the safety of aircraft systems.

Solution (2) for $P_j(t)$ It has the form:

$$P_j(t) = P_0 \exp[-\theta_j \cdot t] \quad (3)$$

where P_0 – is the probability of not detecting the dangerous at first j -th of control [1].

Let us now point out the complexity of performing the security control carried out on the air traffic participant. Several targeted security sub-checks will be used. Let these checks have durability t_j and be characterized by the intensity of the detection of the safety deviation θ . Also, assume that the number of unit checks contains a - combined security controls Θ ; γ ; δ ; τ see figure 1.

For such a case, fundamental equation (2) has notation [7]:

$$\frac{d}{dt} \ln P_j(t) = \begin{cases} -\theta_1, & 0 \leq t \leq t_1 \\ -\theta_j, & t_1 + \dots + t_{j-1} \leq t \leq t_1 + \dots + t_j \\ -\theta_k, & t_1 + \dots + t_{k-1} \leq t \leq t_1 + \dots + t_k \end{cases} \quad (4)$$

The complete probability of finding a security problem during the security check is described by the equation:

$$P_j(t) = P_0 \exp\{-\theta_1 t_1 - \dots - \theta_k t_k\} \quad (5)$$

Let us denote the general control time of one air traffic participant with a safety system as:

$$\tau_e = t_1 + t_2 + \dots + t_k,$$

and relative time values for each j -type of a check (protected area, mode area, passenger check-in, etc.) as:

$$a_j = \frac{t_j}{\tau_e}, \quad (6)$$

In this case, it is possible to write (6) in the formula:

$$P_e(\tau_e) = P_0 \exp\{-(\theta_1 a_1 + \dots + \theta_j a_j + \dots + \theta_k a_k) \tau_e\} \quad (7)$$

or

$$P_e(\tau_e) = P_0 e^{-c + p \{-\theta_e \tau_e\}} \quad (8)$$

where

$$\theta_e = \theta_1 a_1 + \dots + \theta_j a_j + \dots + \theta_k a_k \quad (9)$$

In equations (8) and (9) it is possible to interpret the probability of security control of this type. This is done at a specified point in time during the entire security check.

Because a number of controls are performed at each security level at the airport, many security issues can arise. This is because they are intrusions into the security system. It is possible to reliably determine their detection intensity for each hierarchical security level. For this reason, in order to create a mathematical model for solving the area of probability finding of a potential degree of danger, it is generally possible to use a continuous model (10) written [9]:

$$P(t) = a + p \{-\theta_1 \tau_1 - \dots - \theta_i \tau_i - \dots - \theta_n \tau_n\} \quad (11)$$

where:

τ_i – the security check time is at the i - th security level

n – the number of checks in the hierarchy of danger.

Equation (11) allows us to write the probability of finding a dangerous at the i -th level of the check in the form:

$$P_i(t) = \exp\{-\theta_1 \tau_1 - \dots - \theta_i \tau_i\} \quad (12)$$

By comparing (11) and (12) at the i -th safety level, we obtain the initial value of the probability of not finding (not occurring or not detecting) the danger at the beginning of the level of control for the duration τ .

$$P_{0i} = \exp\left\{-\sum_{n=1}^{i-1} \theta_n \tau_n\right\} \quad (13)$$

The first experimental security checks confirmed the correctness of the compilation of airport checkpoints and met expectations. It turned out that the use of 5 control checkpoints creates preconditions for further use of the same control mechanisms. These reliably suppress the impact of dangerous leaks in the environment of airport facilities [6]. In addition, it was possible to create a time-space for imitation of danger, by which we randomly check the control machines with signalling whether the skill and attention of the operators of security checkpoints are at the required level of protection. [8].

Evaluation of security input control data for the airport. Designing the modelling of each airport control system is an important process for the safe operation of the airport. With the help of these systems, risks and hazards at airports are minimized. Distinguishing safe zones and initial stages to distinguish initial hazards are another area of concern [9]. Included in this problem area are detection safety sensors that can predictively select:

- responses to basic security intrusions into areas with the importance of protection from air traffic controllers from security control systems,
- deployment of more accurate safety control systems
- own findings and observations [10].

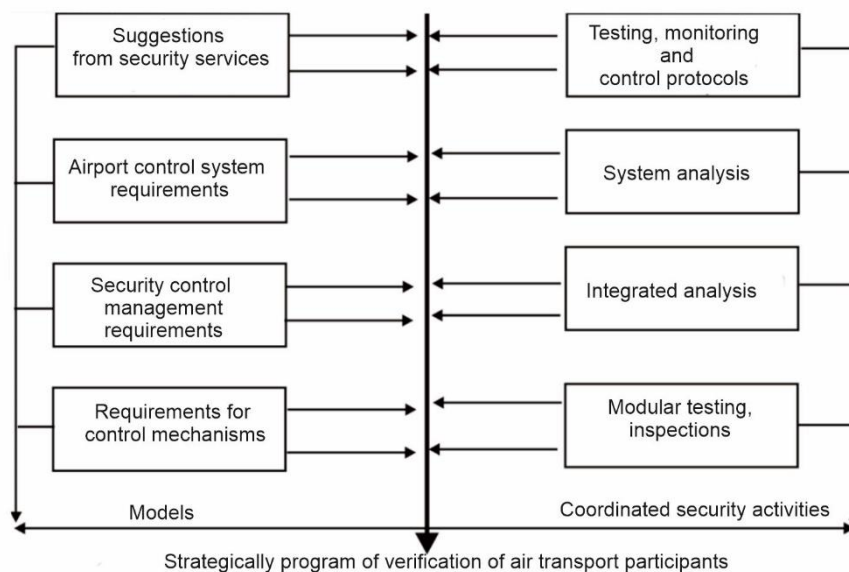


Fig. 2. Verification strategy for air transport participants

The question of choosing the most suitable control mechanisms is formed by the regularity of the dichotomy. It uses the analysis of finding hazards in the airport complex in its local parts. The emerging increase in airport security breaches requires new progress in localizing the functionality of the entire security control system. Such a direction indicates a change in the reliability of the observed (controlled) system in achieving the area of a successful solution of finding a hazard. If the functional reliability of the airport in security decreases, a

critical condition arises, which will affect the correct operation of the security control. At airports, it is clear that we need to demand the highest value of the trouble-free operation of security control systems from the control mechanisms in place [11]. The composition of each control mechanism affects the quality of control at the airport where it is implemented.

Here is an experimental example that has the character of further monitoring of the hazard. This theoretical level clearly determines in which direction it is necessary to set the security model fig. 3. This is clearly possible only by the mathematical expression of possible problems expressed by probability theory with the necessary imagery, which will show the application in practice. Any such control mechanism needs to be addressed in a comprehensive way to describe complete security at the airport [12].

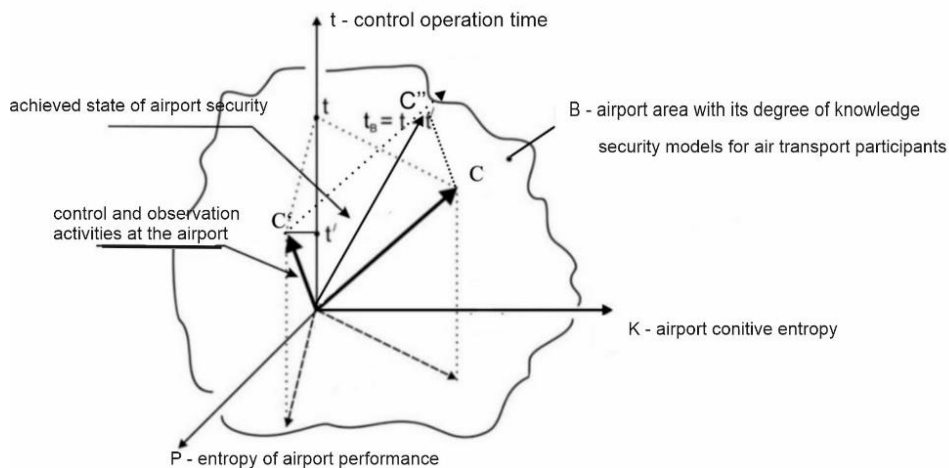


Fig. 3. Determined entropy for airport security models

The problem of degradation of airport security shows that an isolated assessment of the security problem, in general, is unjustified. The space of the airport is described in the coordinate system by the entropy of time, the degree of knowledge of security control systems and their operation. These airport management activities with precise models control the security hierarchy at the airport [13].

For us, it is necessary to know and examine the resulting vector *C* - the state of security at the airport. This vector requires knowledge of the input properties of security mechanisms at the airport [6]. We can measure points in space in a given coordinate system with changing coordinates of the airport security vector. Then all coordinates of the points in the airport space change. This makes it possible to investigate the clear causes of the security degradation of the airport complex if we have accurate values [14].

With a sufficiently long inspection time at the airport, the probability of finding danger is approaching zero. Thus, even with the position of reality during long inspections, the success of finding danger is accurate. In real conditions, we try to shorten the time of security checks [15]. This is possible mainly at higher hierarchical security levels of airport facilities and complexes. In this case, we approach the value of the lower limit of safety, which can be determined in advance [6]. If the specified control value is known, then the mathematical model of the comprehensive security control will take the form:

$$P_i(t) = \exp\{-\theta_1\tau_1 - \dots - \theta_i\tau_i\} \quad (14)$$

The elements of the probability of detection of danger are arranged in series (for example, the number of passengers before inspection). When the highest level of danger is found, the whole series of checks is interrupted. Control mechanisms are being introduced in the whole area of airport complexes [8]. Assessment of the state of security at the airport Košice, we have chosen an example of using actors of air transport (passengers) and aircraft type Airbus A – 320.

The input values are:

$t_{aui}=0:3:100$; minutes; period of one security check:3min, number of checks per aircraft A 330:200 passengers;

$l=5$; Number of serially connected passenger security checkpoints; the sum of the values of the potentially dangerous elements found (pocket knife; scissors; weapon, etc.) converted into working hours during the year of the security inspector, according to the numerical order of the airport inspection posts:

$S=\text{sum}([5\ 1\ 6\ 3\ 1]/10.^4)$;

$\text{thetat}=S.*t_{aui}$; exponent,

$Plt=2.718.^{(-\text{thetat})}$;

$\text{plot}(t_{aui},Plt,'r+')$,hold on,

$\lambda=0.1473$; at $i=100$ minute;

$\text{plot}(t_{aui},\lambda,'k')$,hold on,

$\text{xlabel}('time\ of\ control\ at\ the\ level\ of\ finding\ dangerous\ elements')$,

$\text{ylabel}('Initial\ probability\ of\ subsequent\ security\ check')$,

$\text{title}('Probability\ of\ non-danger', 'FontSize', 12)$, $\text{legend}('lambda')$,

hold off,

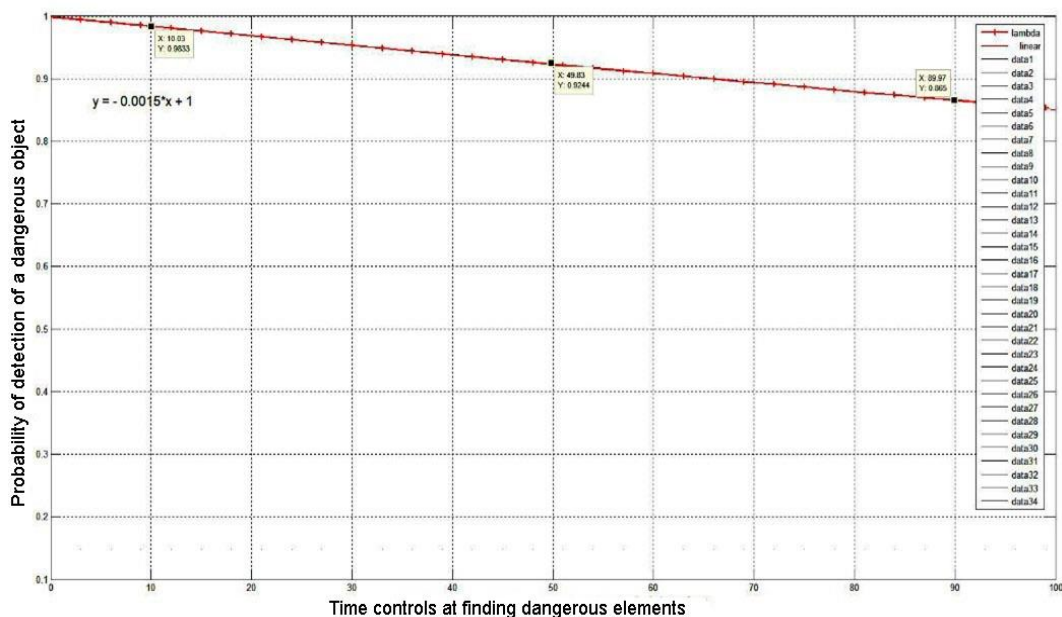


Fig. 4. Nonoccurrence probability of danger

The task was to determine the initial value of the probability P_{0i} thus finding a dangerous element in a passenger. The result shows a simulation of a mathematical model (14) in the MATLAB programming environment, the output of which is also the residual probability in one-time control unit.

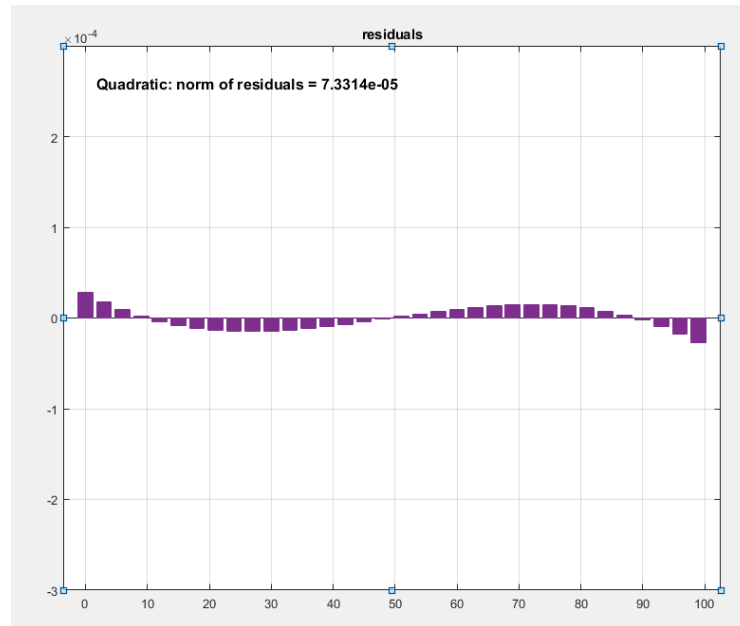


Fig. 5. Residual dangers progress in the control of passengers on a sample of 100 passengers

Conclusion. As can be seen from Figure 5, with a sufficiently large inspection time and control safety positions of 5 or more, the probability of finding a degree of danger is approached to zero. The control mechanism used with the required probability of non-occurrence of danger at the end of the experiment lasts $t = 100$ min. The median time to non-dangerous is $T_{st} = 10; 50; \text{ and } 90$ minute at 200 passengers. As follows from the applied MATLAB program, the meantime of non-occurrence of danger is at the level $7.3 \cdot 10^{-5}$ which is a small expected value in the number of residues of Fig. 4. In real conditions, we try to shorten the time of passenger screening. This is possible especially at higher hierarchical levels of airport security with the help of sophisticated security systems. These must be installed in a sufficient number of inspection posts. In this case, we approach the value of the lower limit of safety, which can be determined in advance. The control system detects the degree of danger if there is an element of danger with the character of the probability of occurrence of danger. No higher dangerous was detected in the observed sample at the time of the experiment when $t = tk = 100$ min.

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РІВЕНЬ НЕБЕЗПЕКИ В КЕРОВАНІЙ БЕЗПЕЦІ АЕРОПОРТУ

Функціональність авіаційного комплексу визначається якістю та безпекою. Це визначається взаємозв'язком між суб'єктами аеропорт – літак – повітряний простір. Безпечне управління та контроль в аеропорту – це спрямована дія незалежних факторів. Їх уособлення закладено в відчутті загальної безпеки, а також безпеки кожного учасника повітряного руху. Виконання етичних характеристик безпеки вимагає здійснення управління, щоб контроль рівня безпеки в аеропорту здійснювався у відповідній зоні безпеки. Побудова безпечного стану може бути досягнута, якщо обраний метод експериментальних досліджень щодо рівня безпеки достовірно відображатиме реальну помилку в управлінні повітряним транспортом. Правильність процедур контролю безпеки можна перевірити за допомогою моделювання та моделей, побудованих на фізичній основі. Основна мета статті полягає в тому, щоб показати один із способів ефективного виявлення помилок в управлінні органами контролю безпеки повітряного транспорту.

Ключові слова: аеропорт, безпека, система управління, ймовірність, чутливість, небезпека.