MODEL DESIGN OF THE AIRPORT SECURITY PROTECTION

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The paper discusses the possibility of using the "Point Method" for comparison of specific alternatives and the "Queuing theory" in a centralized system to ensure the security of civilian airports for simulation needs, which makes it possible to design, balance, debug and test the security system before it is installed, because to ensure security at airports considerable investment is needed. The system simulation process will provide the ability to track, analyze and visually present the results and metrics such as workload, waiting times, resource utilization and response times.

K e y w o r d s: Airport security system, Queuing theory, Centralized security system

1 INTRODUCTION

Protection of airports against all acts of unlawful interference is always a priority alongside all efforts towards ensuring quality services related to air transportation and alongside the operational security of airport facilities themselves.

One way to test the effectiveness of airport security systems is to create a model for process simulation which can detect the critical spots that are normally difficult to detect. It is also possible to simulate all the conditions affecting the airport security system.

After verifying the structure and compliance of the model with the real system (verification of the model), by experimenting with the different variations of the model it is possible to find such a configuration that will best meet our requirements for the security system.

There are several reasons why to prefer simulation before gaining experience by experimenting with real systems - it is cheaper, it is faster (simulation time can run much faster than real time), we can test many more possible variations, it is safe (it is possible to test also catastrophic scenarios), we can analyze also systems which are only planned and do not yet exist and so on.

2 POINT METHOD

The essence of this method is the comparison (evaluation) of specific alternatives, depending on the criteria and the actual selection of the best type of protection (of the system), and its application in the security system in the perimeter of the airport. The goal is to determine an optimal solution that will obtain the best evaluation.

When evaluating and proposing the solution the following operations are repeated:

- Design and selection of criteria
- Choice of technical means (elements)
- Identification of the secured object, space
- Decision on the optimal variant

The choice of criteria for evaluation is not easy. Assessment of the suitability or unsuitability of using a certain type (or alternative) of protection in the airport security system will be specific to each airport. It depends on various factors, e.g.: the actual status of the airport and its facilities, the importance of the airport, options of possible interference with airport security and on other internal and external impacts defined in the security analysis of security systems. It is pointless to select as criteria properties which cannot be defined at the given stage. Based on technical parameters, economic indicators, influencing factors and other criteria we can identify units and values that can be used to measure certain characteristics. The evaluation of criteria is based on their suitability or unsuitability for the respective requirements and for application in the airport security system. For the optimization process it is necessary to determine an evaluation scale, for example: ("Suits very well" to "does not suit). In the assessment and evaluation of criteria, point values are allocated to individual evaluation statements, e.g. (1, 2,.., x), where x - is the number of statements.

2.1 Task Elaboration

The last operation in the evaluation is the processing of evaluation scores of the particular criteria chosen into a total score. There are several ways to do so, ranging from a simple adding up of the points to extremely complicated methods of processing.

Table 1 Point method

	k_1	k_2	k_3	.	.	.	k_n	$\sum k_{i,j}$
Alternative A_1	$k_{1,1}$	$k_{1,2}$	$k_{1,3}$	.	.	.	$k_{1,n}$	$\sum k_{1,j}$
Alternative A_2	$k_{2,1}$	$k_{2,2}$	$k_{2,3}$	.	.	.	$k_{2,n}$	$\sum k_{2,j}$
Alternative A_3	$k_{3,1}$	$k_{3,2}$	$k_{3,3}$	.	.	.	$k_{3,n}$	$\sum k_{3,j}$
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
Alternative A_m	$k_{m,1}$	$k_{m,2}$	$k_{m,3}$	.	.	.	$k_{m,n}$	$\sum k_{m,j}$

Where:
a) Alternatives A1, A2, A3,...,Am stand for possible alternatives,
b) Criteria k1, k2, k3,...,kn stand for specific (given) criteria,
c) ki,j is a point value of the criterion kj and alternative Ai
Where:
a) alternatives A1, A2, A3,...,Am represent possible alternatives,
b) criteria k1, k2, k3,...,kn represent determined criteria,
c) ki,j is the point value of criterion kj of alternative Ai where i=(1,2,3,...,m) and j=(1,2,3,...,n).

The sum of point evaluation of criterion ki with alternative Aj is expressed by:

$$\sum_{j=1}^{n} k_{i,j} \tag{1}$$

where i = (1,2,3,...,m)

After adding up the total point values of the individual alternatives, as the optimal alternative, which is suitable for further development, the one with the maximum (or minimum) number of points is chosen.

$$A_{opt} = \max_{1 \le i \le m} \sum_{j=1}^{n} k_{i,j} \tag{2}$$

which is the maximum score of the given alternative, or the optimal variant of the proposed alternative with maximum score of each criterion.

The optimal alternative using a mathematical model can be determined by linear programming. Mathematical approach to the solution is part of a program based on the mathematical formulation of the criterion of optimality - special-purpose linear function and restrictive conditions expressed by linear equations.

The mathematical solution of this model is the choice of the optimal alternative from a number of possible variations in accordance with agreed criteria and constraints.

The mathematical model reflects the structure of the examined object, i.e. a set of its elements (criteria and constraints) and the related links between them.

3 QUEUEING THEORY

The queuing theory, which is defined as an efficient algorithm in a centralized airport security system deals with the quantitative evaluation of the systems able to satisfy the requirements of the collective nature at the breach of the security system.

In structural terms, a centralized airport security system consists of a set of monitoring and control devices. Output signals and data from the devices are brought into one centre, which in case of receiving a signal of intrusion into the protected area or space will take action for its protection, or for prevention or arrest of the intruder.

A centralized airport security system uses as the basic technical device large-capacity exchanges – centralized protection panels, or special security units. They are used as the control centre of protection of objects which are protected by stationary electric alarm systems.

Into centralized system of airport security belongs the set of objects and airport facilities, which are secured by means of electronic security systems and are connected to the central security panel. The network of protected objects, buildings and restricted areas can include the objects which are particularly significant and other facilities at the airport pictured in the figure. 1

It is desirable to build and operate a centralized airport security system with minimum cost for building new transmission networks; at the same time blocking of the transmission of alarm information via the main transmission system which will host the security system must strictly be avoided.

A centralized security system must have a separate transmission path for each technically protected object or area of the airport, enabling employment of the following system possibilities when digital transmission of information is used. In the event of disruption of the transmission path to one technically protected object, all other transmission routes to other technical objects remain working reliably.

A full diagnosis of the entire transmission chain, from the technically protected object to the evaluation device. Two-way communication for transmitting the information from the technically protected object centralized security panels and vice versa. Transmission of alarm information in so-called real time with minimum delay from demand for transmission of signals, that will allow early intervention of the airport security squad.

Monitoring of centralized security panel operators, (i.e. evaluating and validating the alarm information received). Monitoring and saving of all alarm information and archiving it for the length of time necessary. Precise records of the time of protection of individual objects.

The use of existing networks, thus minimizing the construction costs for large-scale security systems.

The utilisation of centralized security systems for objects protection is now widespread in almost all developed countries around the world and brings several advantages in terms of quality control and protection provided. From past experience in operating the centralized systems at civil airports, it is clear that that the system given is an effective and efficient tool, particularly in fighting crime, thefts and burglaries, for prevention and monitoring.

Since the appearance of requirements for operating the system are random nature regarding the time, the stream of requests (orders) for operation is also based on random principle.

In most cases, also the length of servicing a single requiremnt is random. Compression of requirements may result in queue creation or denial to service, if the queue is somehow restricted. This restriction may be defined by the waiting times in the queue, by the total period of presence in a centralized system of protection, by the number of requests and so on. Dilution in the requests flow may lead to inefficient downtime of individual channels or of the entire operating systems. Depending on the number of operating channels and their efficiency, the centralized system performs as a whole, which allows it to more or less successfully service the stream of requests of the various elements of the airport security system model.

Inevitably the questions arise:

- How thick the stream of operating requests for a given number of channels operating can be,
- how many operating channels the centralized system must have to be able to operate with acceptable number of requests waiting,
- what is the average queue length at the given number of channels,
- what will be the average downtime of individual channels and of the whole system,
- what is the probability of a request not being serviced,
- what is the relation between the operating requests stream and the stream of the requests actually serviced, etc...

The simulation program for how to use the queuing theory in the centralized system of the airport security is listed in the attachment.

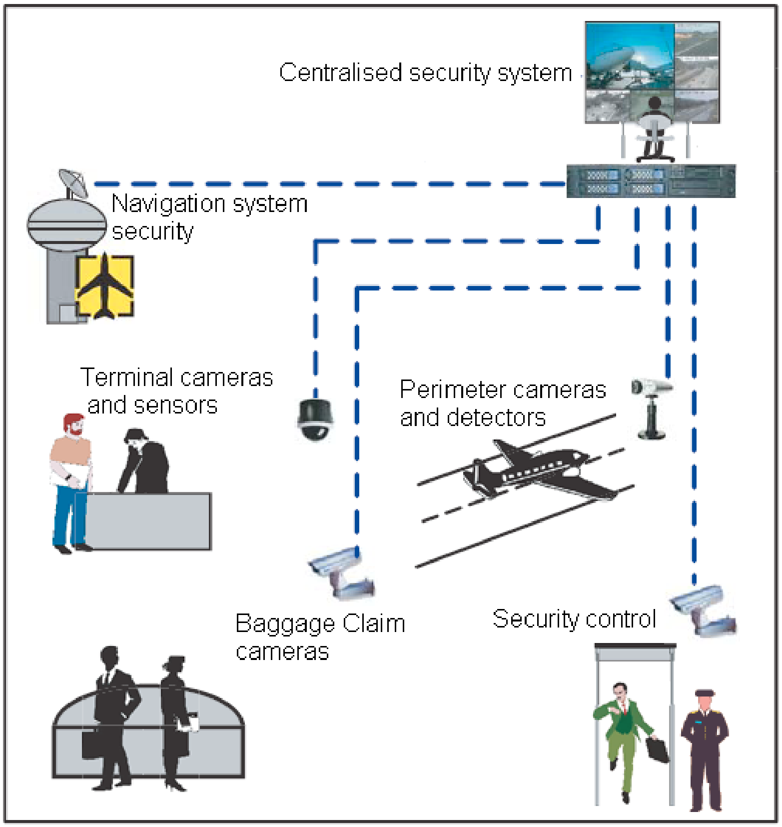

Figure 1 Centralized security system

3.1 The efficiency of the centralized system when using the queuing theory

The centralized airport security system has a certain efficiency, which allows it to service the flow of requests more or less successfully. The performance of the centralized system depends on the relationships between the variables that define the activity of the queuing system, i.e. relations between the number of operating channels, density of the request stream for operating, the median of operating time and mean waiting time. The probability of rejection of service, which is crucial for assessment of the centralized system performance, relies on these values.

A request from the queuing system will be serviced when at least one operating channel is available at the time when the request enters the system or when the channel becomes free at the time of the request pending in the queue. The probability of this phenomenon carries the value of (1-PN) in the system with limited delay, and (1-Pn) in the system with rejection. Values (1-PN), and (1-Pn) respectively therefore reflect the service ability of the queuing system utilization.

Service ability can be expressed by:

- relative service ability

$$q = \left(1 - P_N\right) \cdot 100 \quad [\%] \tag{3}$$

giving a percentage of the service requests of the service requests stream

- absolute service ability

$$Q = \left(1 - P_N\right)\lambda \quad [\text{request/time}] \tag{4}$$

giving the density of service requests stream, where **λ** is the density of service requests stream.

The service capacity of the queuing system is only one of many possible ways of expressing the performance of the centralized security system. For example in terms of destruction of the stream of objectives the service ability of the system, designed for its destruction, is crucial for assessing the performance of the system. In general, there are also systems in which - in addition to service activities - performance is characterised by further properties of queuing service.

They are for example the following:

- mean number of service channels occupied, which expresses the yield rate of servicing channels,
- mean number of requests for service pending in queue, or delay median of requests in queue, which characterize the need to wait for service,
- requests pace median in the servicing system, which characterizes the speed of servicing a request.

The model of a centralized system of airport security is a set of individual sub-systems, which are able to work independently, but their efficiency can be increased when output data from these subsystems are continuously processed and evaluated by one control unit. After data enter the centralized control system, control unit will enable to assess the degree of potential risk, or the danger based on the criteria defined, it will decide on further steps for threat elimination, Fig. 2. Decision process criteria are defined by following:

- Emergency airport plan
- Airport security program

These important documents define airport security and service units operation, which directly or indirectly participate in the control or selection of activities necessary to ensure security during emergency situations.

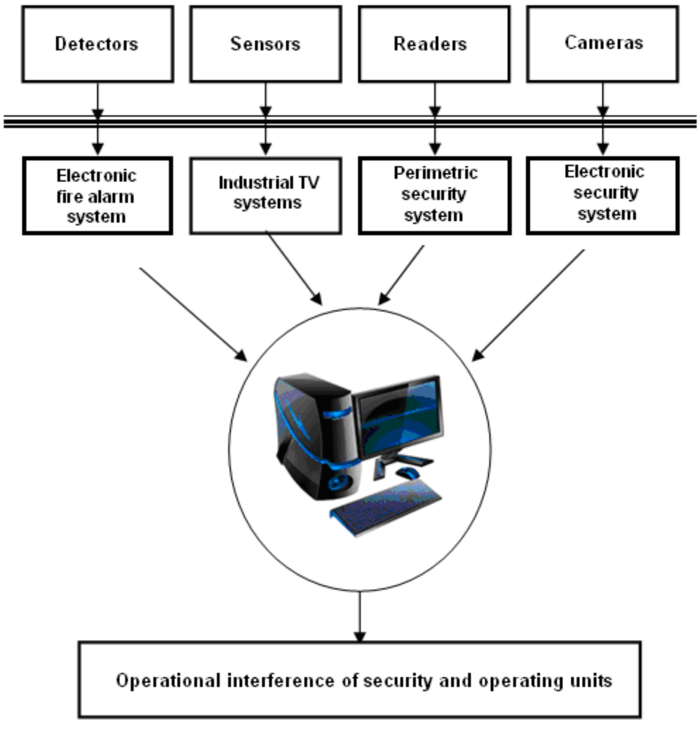

Figure 2 Centralized system model proposal

5 CONCLUSION

The main objective of the used methods and developed methodology is to address the issue of finding and determining the optimal alternative (option) for protection of buildings, facilities and the perimeter of the airport, with regard to defined criteria and limiting conditions and using the queuing theory in a centralized security system. Utilising new technologies in security systems is accompanied by increasing complexity of the proposed hardware and software solutions to the problem. The complexity of systems and functional security requirement bring up a need for a new approach to the specification of functional requirements. In this area semi-formal and formal methods are used, based on mathematical modelling, formal logic and graphic records.

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