PRACTICAL RESEARCH OF THE ANALYSIS AND AUTOMATION OF THE WORK OF THE AIRPORT SYSTEMS ON THE BASIS OF MATHEMATICAL MODELS AND SIMULATION MODELING

Vershinina Maria ,Okhremenko Alexandra

Saint- Petersburg State University of Aerospace Instrumentation
Saint-Petersburg, Russia

E-mail: marusenitsa@gmail.com
aaohremenko@gmail.com

In modern world the fastest and the safest way to get the destination is air transportation. People are traveling for business or personal goals.

At any airport there is a luggage system which is responsible for transportation and baggage allowance. Sometimes luggage may lag behind a passenger or remain unidentified. In this case, suitcases are sent to special areas, where luggage will be manually identified by airport employees.

Each airline strives to ensure that passengers are delivered to the destination in the most effective way. Achieving of this goal is closely connected to the precise organization of the airport. Modern conditions of market of the air transport require airport enterprises to improve the quality of services provided to carriers and users of airport. The main objective is to reduce the time spent on servicing and meeting the requirements for safety and regularity of traffic. The main goal is to reduce the time that aircraft spent on service and requiring the rules for safety and regular of traffic. This goal may be achieved by using information technologies [1,2,8,9]. The peculiarity of the aviation industry is that every airport has its own distinctive features. One of the directions of practical solutions is the development of perspective mathematical models and the use of simulation computer simulation.

The purpose of this paper is to describe the mathematical model for calculating the reliability of the luggage system of the airport and the construction of a simulation model for the technological processes at parking sites of servicing aircraft.

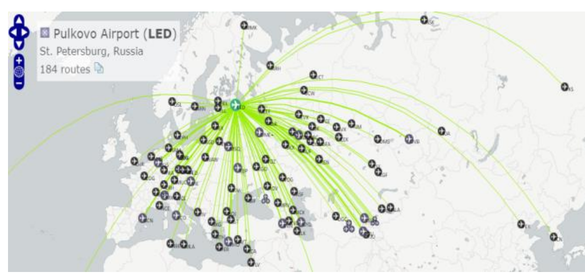

Figure 1 - The geography of flights from airport (based on openflights.org data)

Technology service flights have been considered as part of the proceedings of the research. Also scheduling ground-handling services including critical path operations equitable for the vast majority of types of aircraft has been examined and an analysis parameters of the technological processes of aircraft ground handling had been made, stochastic models of technological operations included in the technological schedule was constructed.

Simulation model of technological processes of ground handling includes:

1) Algorithm for the implementation of the aircraft maintenance process, describing the sequence and relationship of the operations forming it;
2) Models of individual technological operations, including statistical distributions of the basic parameters of operations such as time duration, the number of special vehicles used. Restrictions on model details require that the model created reflects only that set of technological operations, which is fundamentally important in the optimization of the transportation service process and that meets IATA requirements [8,9].

As a result of the simulation has been processed, visualized and interpreted the results of a computer-assisted computer experiment. The simulation was conducted for the full range of services provided by airport for this aircraft, using largest number of special equipment.

The aircraft model Boeing 737 that was chosen for the research is currently one of the most popular type of passenger aircraft. Boeing 737 and its modifications are represented in aircraft parks of all major airlines of the world. The simulation model has based on the aircraft maintenance schedule, in accordance to which operational planning and preparation for flight management are carried out[3,4,5].

Modeling was performed using the software package AnyLogic [2,5]

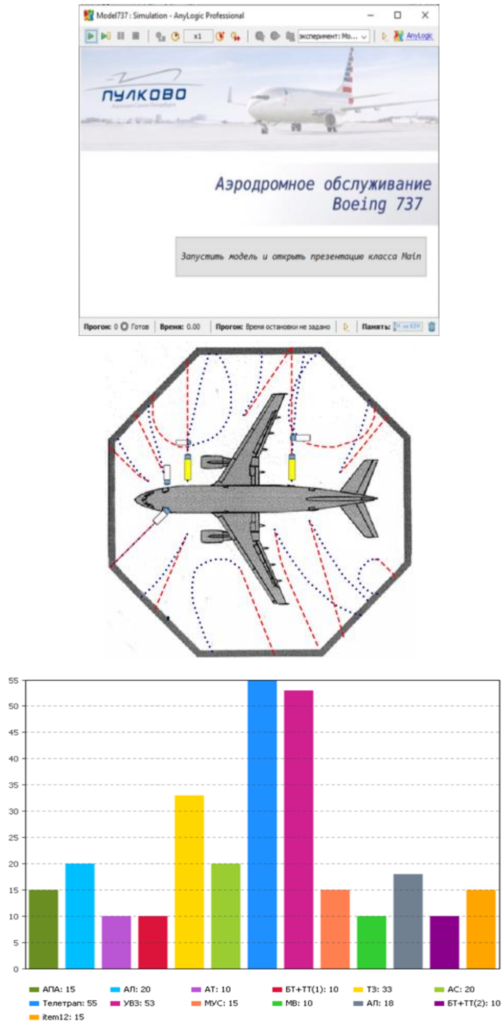

Figure 2 - The result of the simulation. Time diagram of aircraft maintenance

This approach allows organizing the realization of operations of the maintenance of flights, and monitoring the implementation of these operations. This is achieved by splitting one process into elementary components - technological operations.

The model also helps to solve the tasks of operational planning and automation of decision making aircraft handling.

The advantage of the model is that it allows to analyze the processing process by adjusting the model parameters, in other words, state of the system while changing the route of movement of each vehicle, duration of one of the operations or entire process, makes possible to predict the behavior of the system.

In practice, this method will significantly improve the level of flight safety, operational efficiency due to well-coordinated interaction of services, which will increase the efficiency of the ground handling system at the airport, help to avoid malfunctions and reduce the risk of collision of special vehicles.

The conclusion from the simulation results is that, with proper implementation of the norms and maintenance instructions, the system works in a coordinated manner, ensuring efficient allocation and utilization of airport resources. These units of special vehicles and equipment not interfere with the operation of neighboring maintenance facilities, while driving through the service area they do not create congestion or collision between themselves. The problem zones in the ground handling area of this aircraft haven't been found, which confirm the rationality of using the current aircraft maintenance schedule. On the basis of this software tool, it is possible to play various possible non-regular situations.

Another important key step is the airports' luggage system. Duaring of this research, the baggage system of the airport was studied; the mathematical model of the system was selected.

During the research the scheme of baggage transportation at the airport was clarified. The majority of passengers hand over their luggage to the cargo holds of the aircraft at the check-in counters. At one of the four so called "islands" of registration all of the bags are registered and weighed, and also receives an individual code mark. At the system bags are scanned and inspected by the means of various apparatuses several times. If the suitcase does not cause suspicion, it is getting to the sorter for delivery to the aircraft. If there are some doubts, then suitcases get additional inspections, and even may be pass a manual search.

The baggage system of the airport consists of many elements. It includes conveyors, elevators, inspection devices, x-Rays, scanners (different scanning angles), sorters, vertisorters and much more [3,6,7]. Each of these elements can fail, it is important to organize such a scheme of the system, so that the luggage system does not interrupt while doing through. Figure 2.1 shows the general scheme of moving baggage through the system: 1 - check-in counter; 2 - scanning of suitcases and bags; 3- examination of luggage for explosiveness and radiation background; 4 - manual examination of baggage; 5 - baggage sorter; 6 - the luggage yard; 7- the formation of luggage for delivery to the flight; 8 - baggage forwarding area.

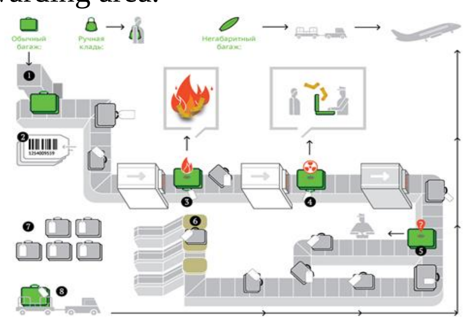

Figure 3. Overall plan for moving baggage through the system

Some of the conveyors of the system have a reversible movement in order to switch the movement of luggage to another direction.

Regardless from which "island" the baggage arrived from, received from the arrived plane or from the reception of oversized baggage, it passes through all stages of inspection and processing and is sorted in the direction. All goods at the system pass through an identical path through similar links in the system.

The baggage system of airport is a system with permanent redundancy [2,4,6]. Analyzing the layout of the baggage system at airport, the elements of the system were identified and some of them were combined into blocks. For example, the check-in counters of each "island" are connected in parallel to each other and are integrated by a connecting conveyor. Each "island" has two exits, so it's advisable to divide the "islands" into two parts. Two parts of the "island" are connected to each other in parallel - the goods from one half can always be transferred to the other with the help of a reverse conveyor.

Computation of the reliability of the system is calculated on the basis of the construction of the structural diagram. Each block can contain only those elements that correspond to one statistical distribution. The structural scheme of reliability is a graphic representation or representation in the form of logical relationships, the conditions when the system and the object are working. When for the functioning of the system it is necessary that all the units are working, then this corresponds to a block diagram in which all blocks are connected in series. Calculation of the reliability of the circuit with a serial connection of elements is carried out by the multiplication of reliability. There is also a parallel block diagram in which the elements are connected in parallel way.

As a result reliabilities of the system at the outputs of the sorters. "P" is the reliability of different groups of elements:

$$PEX1 = 1-(1-P10)(1-P23) \quad (1)$$

$$PEX2 = P9 \quad (2)$$

$$PEX3 = 1-(1-P15)(1-P21) \quad (3)$$

$$PEX4 = P11 \quad (4)$$

$$PEX5 = 1-(1-P8)(1-P22) \quad (5)$$

$$PEX6 = 1-(1-P20) \quad (6)$$

The final formula of reliability (outputs to the sorter are connected in parallel):

$$P = 1-(1-PEX1)(1-PEX2)(1-PEX3)(1-PEX4)(1-PEX5)(1-PEX6) \quad (7)$$

At the end of the journey, luggage aredelivered to the sorter, connected in series to all outputs.

The probability of failure-free operation according to statistical data on failures is estimated by the expression described by formula (8)::

$$P_c(t) = e^{-\lambda_c t} \quad (8)$$

n(t) is a number of elements that have not failed by the time; N is the number of all products involved in the process; P (t) is the statistical estimation of the probability of failure-free operation of the product.

The failure rate according to statistical data on failures is determined by the expression indicated in formula (9):

$$\lambda(t) = \frac{\Delta n(t)}{N \cdot \Delta t}, \quad (9)$$

Δn(t) is the number of failed elements on the time interval (t, t+Δt); F (t) is the statistical estimate of the failure rate of the elements; Δt is the time interval.

The baggage system of airport consists of 934 elements. Statistical data on the number of failures of elements for 157 days are substitute to developed mathematical model. The final reliability of the system is 0.41. The baggage system existing at the airport has sufficient reliability to ensure efficient work of the airport.

The model developed in this research can be used in the future to appraisal the reliability and efficiency of the baggage system existing at the airport, as well as to identify the most susceptible elements in the system.

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