INFLUENCE OF AIR TRAFFIC ON FLIGHT DELAYS

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ABSTRACT

One of conditions for securing flight safety is a restriction on intensity of an air traffic flow within the sector of air traffic services, as well as of the flows in the section of the route, in the route crossing points, at the aerodrome. To assess the capacity and to identify periods of peak load during the study, statistical traffic intensity data values within 14 days

were analyzed. Data collection was carried out at Vnukovo airport in August 2015. The information on the number of departing, arriving and delayed flights with hourly intervals was organized by a number of criteria, a summary table on intensity and regularity of air traffic was drawn up. Measures to «smooth the peaks», based on the total cumulative practice, were offered.

<u>Keywords</u>: civil aviation, airport, air space, capacity, air traffic intensity, regularity of flights, flight delay, ATC, ATS, ATM.

Background. Standard of permissible aircraft intensity for each of the elements of the air traffic services system (ATS) is defined by the value of capacity. The capacity is a boundary (limit) amount of air flow intensity, which ATS authority shall ensure in accordance with the procedures, that safety levels are not jeopardized [1]. The capacity for the dispatch centers (ATC sectors) is expressed in the number of aircraft per hour (AC / h), which are served in the airspace. In evaluating (calculating) the capacity the following factors are taken into account:

• complexity of the structure of a control area, control station (sector);

 controller's workload, including performed tasks on air traffic services and coordination;

 types of used communication systems, navigation and surveillance systems, the degree of their technical reliability and availability as well as the availability of backup systems;

• availability of automated systems and complexes of ATS, as well as warning functions;

• any other factor or element that contributes to the workload on a controller (for example, the established norms of separation of AC; speed of AC, the size of the zones served).

The number of aircraft serviced by ATS authority shall not exceed the number of aircrafts, flight control of which can safely be provided in the prevailing conditions [2]. A particular attention should be paid to the functioning of the system elements in conditions of maximum load. Since the values of the intensity on the day interval is characterized by considerable volatility, the execution of restriction is controlled, as a rule, for the so-called peak hours, i.e. hours, when there is the greatest load on ATS system.

Objective. The objective of the authors is to consider the influence of air traffic intensity on flight delays, based on the data of Vnukovo airport.

Methods. The authors use general scientific and engineering methods, statistical method, calculation, graph construction, comparative method, evaluation methods.

Results.

Assessment of air traffic in the airport area

To quantify the processes in ATS system an important characteristic of a rate of reception of aircrafts is used (the intensity of air traffic is the number of aircraft received in this area per unit time). Average intensity value is determined as the first derivative of the average traffic density over time [3]:

The research was financially supported by Russian state scientific foundation in the framework of the project 15-08-05424.

$$\lambda(t) = \frac{dP(t)}{dt},$$

where $P(t) = \frac{N(t)}{V}$ is traffic density, a ratio of the

average number of aircrafts, simultaneously in the service area N(t) to the volume of this zone V. In practice, the intensity is considered for simplified expressions, relating the total number of aircrafts, entered in ATM area per unit time of their entering:

$$\lambda(t) = \frac{\Delta N(t)}{\Delta t},$$

where $\Delta N(t)$ is a number of aircrafts, which are under management in the period under consideration; Δt is a time interval, in which the figure is calculated.

To evaluate the performance of air traffic regularity the following methodological sequence was used. The value $\Delta N(t)$ was obtained by monitoring the traffic situation at Vnukovo airport (the basis was the daily timetable, which is the result of pre-tactical planning [4], and its actual implementation). The observation period lasting 14 days was selected in August 2015, as this month has a high intensity of air traffic. Thus, during the observation period $T_{obs} = 14$ days the total number of flights was $N_{tot} = 6626$, among which departing $N_{dep} = 3327$, arriving $N_{ar} = 3299$. For a more detailed analysis data were recorded every hour and were summarized in 14 tables (one for each day of observation). Pic. 2 is a summary table of the total air traffic intensity during the observation period.

Analysis of air traffic regularity

Air traffic regularity is a ratio of the number of flights performed during the period T in accordance with the schedule to the total number of flights in the same period. The main practical interest is the analysis of the causes of the smallest value of regularity min $\rho(t_k)$. Only such an analysis makes it possible to develop a list of effective measures to improve its value. Obviously, ρ is directly dependent on the number of flights delayed.

Analysis of regularity of air traffic at Vnukovo airport was conducted with the following assumptions:

• The number of delayed flights on departure N_{del} was calculated in accordance with the algorithm shown in Pic. 1. Delayed flight was a flight, in which the difference between a calculated time of retracting pads t_{pl} and the actual time of departure t_{dep} exceeds 15 minutes [5].

• Flights, which arrived with a time delay from the planned schedule, were not taken into account, as their number is insignificant (arriving flights have priority over the departing and the main reason for their delay – delay in the airport of departure).



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Pic. 1. Algorithm for registration of delayed flights.

To analyze the impact of air traffic intensity on regularity, the number of delayed flights was recorded at intervals of 1 hour during the observation period to compare with the number of flights on arrival and departure, registered in the same interval. The data obtained were added to each of 14 tables. Pic. 2 is a summary table for the entire period of observation.

To visualize the results of the analysis on data from a summary table a graph of intensity and regularity of air traffic at Vnukovo airport for the period of observation was constructed, shown in Pic. 3. In this graph, the horizontal axis is a daily time scale, vertical – a number of flights.

The graph shows that there are two peaks of intensity of air traffic in the morning and evening hours. The major delays of departing flights occur at the same time. The interest of airlines to carry out flights in the morning and evening hours is due to the greater commercial workload (demand for) of the beginning and end of the day due to the work schedule of clients. This applies, of course, to business aviation. In case of delay on arrival, aircrafts, which are on the ground and waiting for departure on the schedule, will be waiting in the queue. Clearly, to reduce delays it is required «to smooth peaks». With the current air traffic intensity this can be achieved by increasing the

capacity of the elements that limit the intensity and by redistributing flows of departing and arriving aircrafts. **Minimizing flight delays**

One of the possibilities to smooth the peaks is to introduce some regulations aimed at even distribution of air traffic intensity. For example, in European airports there is a practice, when users of the airspace before filing a flight plan may get acquainted with a slot reservation table. A slot means time allocated at the airport to a flight to perform the operation of the aircraft's arrival or departure on a specific date or period. An example of such a table is shown in Pic. 4.

Horizontally, days are divided into hours, and vertically, an hour is divided into twenty-minute intervals. The cells are filled with data about capacity on the basis of already filed flight plans. That is, the table informs the user of the airspace of the number of remaining places at one time or another. In the most loaded cells there is a high probability of a flight delay, so been pre-acquainted with this table, the airspace user may submit a flight plan to the least loaded cell.

After analyzing this table, taking into account air traffic intensity statistics for a certain period, it is possible to present it in a way, as shown in Pic. 5.

The grey shaded cells correspond to time slots with the largest delays and the highest intensity according to the statistical data for the period of observation. Statistical data should be updated on a daily basis and have an opportunity to be represented in different formats: in two weeks slots, in month slots during the summer and winter navigation.

Conclusion. The article describes the quantitative characteristics of ATS system. To identify them, air situation at Vnukovo airport had been observed for 14 days. The observation period was selected in August which is the month of the highest intensity of air traffic.

For the analysis the data were recorded in the table, each of which corresponded to a certain day. A summary table of the results of observation was presented. Based on the analysis' results a graph of intensity and regularity of air traffic at Vnukovo airport was built. According to it the peak intensity hours were revealed, in which regularity of air traffic has the worst

Air Traffic Intensity												
time												
number of flights	00.0000.59	01.0001.59	02.0002.59	03.0003.59	04.0004.59	05.0005.59	06.0006.59	07.0007.59	08.0008.59	09.0009.59	10.0010.59	11.0011.59
departure	18	17	19	45	78	122	242	333	320	241	98	121
arrival	23	34	33	67	189	204	190	57	102	73	141	170
delayed on departure	1	3	3	14	30	59	141	191	171	129	46	56
Air Traffic Regularity												
time number of flights	12.00 12.59	13.00 13.59	14.00 14.59	15.00 15.59	16.0016.59	17.0017.59	18.0018.59	19.0019.59	20.00 20.59	21.0021.59	22.00 22.59	23.00 23.59
departure	138	140	134	205	197	166	252	138	115	130	43	15
arrival	138	186	235	285	244	157	193	111	148	146	99	74
delayed on departure	71	82	78	148	138	77	142	67	55	74	27	4

Pic. 2. Summary of intensity and regularity of air traffic during the observation period.

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Pic. 3. Graph of intensity and regularity of air traffic at Vnukovo airport for the period of observation.

time number of flights	00.00 00.59	01.00 01.59	02.00 02.59	21.00 21.59	22.00 22.59	23.00 23.59
00-19						
20-39						
40-59						

Pic. 4. Slot reservation table.

time number of flights	00.00 00.59	01.0001.59	02.0002.59)3.0003.59	04.0004.59	05.0005.59	06.00 06.59	07.0007.59	38.00 08.59	9.0009.59	10.00 10.59	11.0011.59
00-19								-				
20-39												
40-59												
time	12.59	13.59	14.59	15.59	16.59	17.59	18.59	19.59	20.59	21.59	22.59	23.59
number of flights	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00
00-19												
20-39												
40-59												

Pic. 5. Slot reservation table reservation with account of statistics.

indicators. Intensity peaks occur due to the greater commercial workload experienced by at this time.

For «smoothing» of air traffic intensity peaks it is offered to use international practice, in which the users of the airspace before filing the flight plan may get acquainted with slot reservation table. It is also proposed to add to this table feedback that takes into account the statistics of regularity of air traffic over a certain preceding period, giving airspace users more detailed information for filing a flight plan.

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Article received 27.06.2016, accepted 25.08.2016.

• WORLD OF TRANSPORT AND TRANSPORTATION, Vol. 14, Iss. 4, pp. 168–175 (2016)

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