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Interrelation of the Problems of the Aircraft Fleet Development and the Improvement of the Air Traffic Control System

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Abstract

In the article the problems of air transport have been identified. Among these problems, the congestion of airports and airspace and the need for development and modernization of the airport network are of particular importance. In this regard, the authors consider the improvement of the air traffic control system (ATC system) by

integrating existing ATC systems into a single global system with the use of unified international standards, rules and procedures.

The article also specifies the main indicators characterizing the dynamics of the development of the air transport industry in Russia and abroad.

Keywords: **Passenger Turnover; Air Traffic Control System; Flight Safety**

INTRODUCTION

Presently, a steady increase in the number of aircraft operations, an increase in the network of airfields and airports, including international ones, can be observed both at the national and international level.

The rate of growth of passenger and freight traffic of national airlines advanced global trends for more than 15 years. A sustainable growth of traffic allowed Russia to restore its share in the global air traffic. At year-end 2012, Russia had 3.5% of passenger traffic and 2.5% of cargo turnover in the global air service system. Both segments showed a positive trend against the background of a stagnation among the world's indicators in 2002-2013 [1].

Despite the global crisis in 2008-2011, the rate of passenger traffic growth of national airlines averaged 11.4%, and freight traffic growth averaged 6.1% per year, steadily for over 10 years. In the period of 2001-2012, the growth dynamics remained unchanged. In 2012, passenger traffic approximated 196 billion passenger-kilometers, while the freight traffic approximated 5.1 billion passenger-kilometers, which is 23% higher than the operating results of 1990 on passenger turnover and almost twice higher – on freight turnover [2].

Upon results of activities of the Russian civil aviation, passenger turnover amounted to 226.8 billion passenger-kilometers in 2015, provided that 92 million passengers have been carried.

METHOD

Characterizing the global air transport industry, it can be noted that by the middle of the second decade of the twenty-first century air transportation achieved the indicators of ensuring 18% of global passenger turnover. Passenger air travel generates above 79% of the total revenues of the airlines in the world. International air transportation provides more than 60% of global passenger turnover [3, p. 71].

Air transport revenues in 2013 amounted to 708 billion US dollars. This is 4.3% more than in 2012.

In 2013, in the global air transportation market the growth of performance indicators of air transport continued, as noted by a number of international governmental and non-governmental organizations. Thus, according to experts, the total number of passengers carried in 2013 increased by 5.1%. This is more than 3.1 billion in absolute terms. Note that the global market has grown by about one third over the past 7 years, i.e. this amounts to 1 billion passengers per year in addition [3, p. 72].

A number of positive factors contributed to a steady growth of passenger traffic worldwide. These factors are as follows:

- A growth of the global economy;
- An increase in the mobility of population;
- Development and application of new business models by the airlines, that better meet the needs of the segments;
- A significant increase in passenger traffic was accompanied by a slight increase in the cost of jet fuel.

The importance of civil aviation in provision of long-distance passenger service tends to increase every year. Due to a large extent of the territory and geographical location, this factor is essential in ensuring the mobility of citizens [4, p. 15].

Already in 2012, passenger turnover in air transportation exceeded passenger turnover in railway transportation by more than 70%, despite the fact that this indicator was twice lower in 2000 (Figure 1) [5].

There is a growing importance of air transportation in provision of air services in the regions of the Far North. The main factors of the growth in passenger traffic in Russia and CIS countries can be identified:

- A significant potential of national passenger air transportation that is not used to the full extent, as well as the fact that the majority of population is concentrated in the territory in the 3-4 hour flight from Moscow;
- An upward trend of indicators of mobility of the population in the region up to the average indicators in developed countries;
- An integration of national economies into the global economic system, etc.

However, since the spring of 2014 in the Russian air traffic market a trend towards a slowdown in the growth could be clearly observed, which completely stopped in December 2014 [7].

The situation was aggravated by a circumstance that growth cessation occurred unpredictably fast, as a result of the crisis, and most Russian airlines were not ready for this.

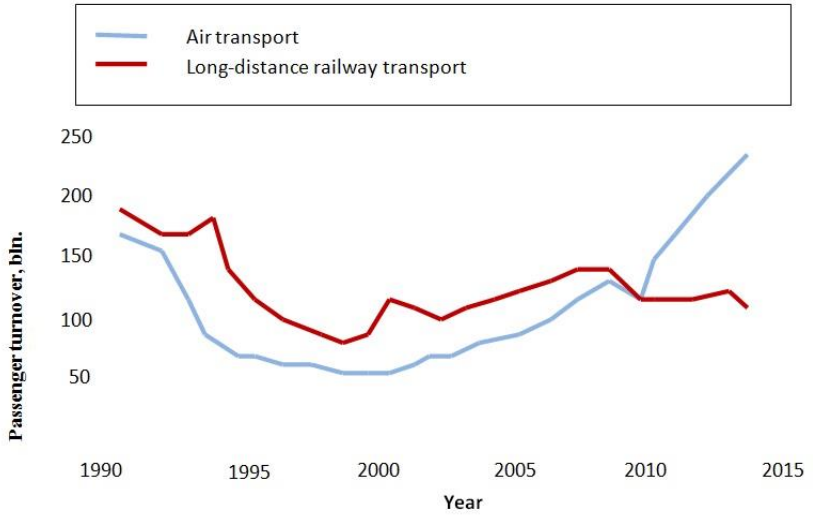

Figure 1: Comparative indicators of railway and air transport in Russia [6].

The crisis with regard to civil aviation is considered external; its cause lies in the deterioration of the economy in Russia because of international sanctions, as well as the significant depreciation of the ruble, which causes a significant reduction in demand for air transport. Over the past 12 years, the number of air carriers decreased 2.4 times. In 2014, there were 123 airlines in Russia (Figure 2) [8, p. 16].

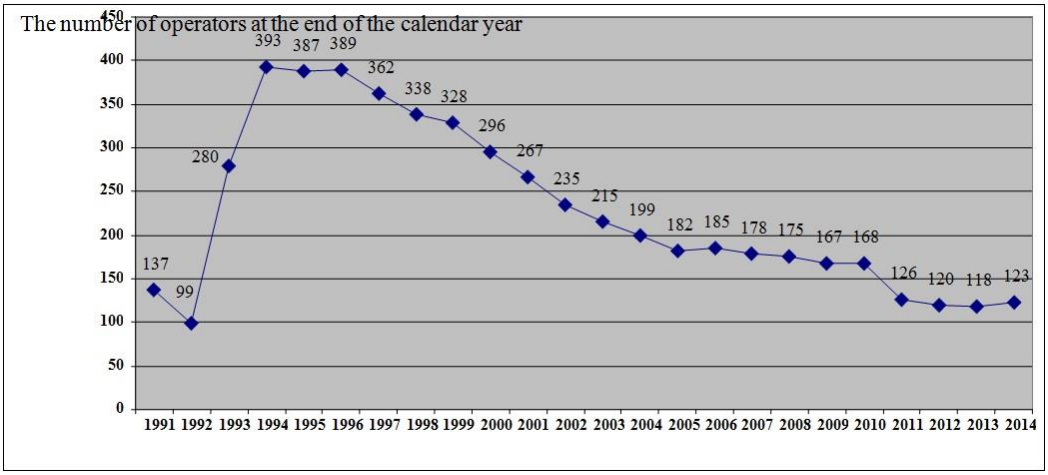

Figure 2: Dynamics of the number of airlines in Russia.

New air carriers often left the industry as quickly as they entered it. For the period of 2001-2005, the number of airlines reduced by approximately 9.3% annually. For the period of 2006-2011, the rate of reduction slightly decreased and amounted to 5.7% per year [9].

RESULTS

There is an objective law: when there is no flow of new passengers, airlines compete for the categories of passengers who regularly use air transport services. However, this situation has a negative impact on the profitability of air transport in the whole industry. Loss-making activities of the Russian air transport is the consequence of the struggle for a small category of regular passengers. According to various estimates, this category ranges from 5 to 10 million people. Since 2011 Russian airlines end up their economic activity incurring losses in the average dynamics [3, p. 74].

In 2014 there was an increase in national air transport services, but it is caused by changes in the statistics as a result of the annexation of Crimea. If previously flights to Crimea were international, now they are national. The situation is exacerbated by the fall of the ruble, which affected a substantial increase in lease payments for foreign aircraft, fixed in dollars. The carrying capacity of the national airlines have been calculated on the growth in demand, as a result a proposal appeared in substantial excess [1, p. 6].

A high concentration of air traffic between several major market participants is a characteristic feature of the Russian air transport market. Thus, about 80% of passenger traffic has been implemented by 4 leading airlines: "Aeroflot Group", "Siberia Group", "UTair Group", and "Ural Airlines". A similar trend was noticed in 2003, when 6 leading airlines began to control 60% of passenger traffic. The number of carriers implementing 90% of passenger traffic has changed from 37 to 18 only for the period from 2000 to 2011 respectively [10, p. 99].

The concentration of the largest airlines in the industry has increased; a share of 4 largest airlines is about 65% [2].

In air freight operations there is a similar situation, where three largest airlines share 75% of the market. Besides airlines engaged in commercial air transport, there are enterprises in Russia, performing only aviation operations, the number of which amounts to 148. 53 air operators have a General Aviation Air Operator Certificate. A significant part of the aircraft fleet in the general aviation belongs to entities that have no Air Operator Certificate [11].

On international routes, cargo is transported mainly in free luggage containers in the passenger aircraft. Cargo turnover in Russia has reached the maximum values in the history of national civil aviation in 2012. In 2013, the rate of cargo turnover decreased by 1.3%. The volume of traffic on international routes prevails over national traffic volume both in the passenger and cargo segments [3, p. 71].

Airline mergers, establishment of joint operation lines, alliances, associations of regional and global carriers are the most important changes.

However, at the same time the number of air accidents and fatalities on air transport is increasing. As noted in the analytical report of the flight safety status for 2014 and for the period of 2010-2014, prepared by the Interstate Aviation Committee, the main factors of air accidents included deviations in the actions of aircrew and flight ground services. The share of these factors in the total number of accidents is 85 [12].

At the same time, ensuring the safety of various transport systems is one of the most important scientific and technical problems.

Safety indicators largely depend on the age of operated equipment.
Today, the average age of the aircraft involved in the transportation of Russian airlines is from 6 to 15 years. Upon this indicator, the Russian fleet cannot be characterized as outdated, since the average operation time of the jet aircraft in the world is about 25 years, and the main reason for its write-off is not physical wear and tear, but high fuel-consuming and growing costs of maintaining flight and technical validity and, as a consequence, the economic inefficiency of air transport services [13, p. 246].

The low degree of competitiveness and fuel efficiency of the previous generation aircraft, mainly of national production, as well as outdated Western models, is a major cause of accelerated write-offs. According to experts, the process of renewal and replacement of outdated aircraft in the period up to 2031 will require supply of 1960-2370 units of aircraft of local, regional and long-distance classes, with the prevalence of single-aisle mainline aircraft. The demand for cargo aircraft will be much less significant – 260 units [14].

Trends in the Russian aircraft fleet are characterized by the following indicators.

Regional planes with a capacity exceeding 19 seats and long-distance aircraft (42%) take a large part in the commercial aircraft fleet. The proportion of civil helicopters is about 43% of the total number of aircraft. The passenger aircraft fleet operates 86% of all transport operations, while helicopters operate 90% of flights in the interests of economic sector [4, p. 17].
Modern Russian aircraft fleet is represented by planes Tu-204, Tu-214, Il-76TD-90VD, SSJ-100, AN-124-100, AN-148, AN-38, AN-140.

The average operation time of long-distance passenger planes is 13.8 years, regional planes – 27.4 years, cargo planes – 22.8 years, light aircraft – 27.2 years. National previous generation aircraft is the oldest: Tu-154, Yak-40, AN-24, IL-62, AN-2, AN-12, as well as international aircraft – B-747-200, B-737-200, which average operation time is over 25 years [15].

The proportion of the older generation aircraft that are still in operation has dropped to 4% for the past two years. According to experts, this must immediately affect the economic and environmental performance indicators of air transport.

The volume of new passenger aircraft supplies in the Russian fleet, which demonstrated the dynamic expansion over the past 10 years, is rapidly growing. In 2011, total supplies amounted to 149 aircraft, all in all for 4 years (2008-2012) the national air fleet was supplied with 540 modern passenger aircraft of Western production and 50 new national aircraft, i.e. the volume of supplies was equal to 147 aircraft per year on average. During the same period, eight Russian cargo aircraft and fourteen international aircraft have been provided. In 2012, the Russian aircraft fleet included 133 passenger aircraft, including 15 up-to-date national and 114 Western aircraft [1, p. 7].

Year's results in 2014 for Russian aircraft manufacturers are characterized by a number of indicators (Table 1):

In volume terms the volume of production and supply of national aircraft is characterized by the following values:

- United Air Transport Corporation JSC sold 47 aircraft, including six aircraft An-148, one aircraft Be-200, thirty-six aircraft RRJ (SSJ-100), three aircraft Tu-204 and one aircraft IL-96.

Table 1: Russian aviation industry [14].

Supplies of Russian civil aviation industry			
Indicator	**2013**	**2014**	**Changes**
The volume of sales of aviation equipment (bln rubles)	55.6	67.4	+11.6 (increased by 20%)
The volume of production of civil aircraft engines (bln rubles)	10.3	12.4	+2.1 (increased by 40%)
The volume of cooperation-based supplies (bln rubles)	28.1	35.1	+7.0 (increased by 24%)

- Aviacor JSC provided two supplies of An-140 aircraft.
- Production Association "Polyot" – a branch of the Federal State Unitary Enterprise "State Space Research and Production Center named after M.V. Khrunichev", produced three aircraft AN-3.
- SmAZ JSC supplied one aircraft SM-92T for general-purpose aviation.

Thus, the Russian aviation industry produced and sold 53 civilian aircraft in 2014.
The Russian Helicopters Holding Company, JSC set the task to produce 52 civil helicopters in 2014. At the same time, supplies have been increased for the Defense Ministry of the Russian Federation in the framework of the planned public procurement [16, p. 5].

So far the supply of national regional and light multipurpose aircraft is limited and presented only by aircraft families AN-148 and AN-140.

In total for 2014 75 new aircraft have been supplied, seven of which are for general aviation. The largest number of aircraft purchased includes equipment aged between 13 and 19 years, and only 30% is relatively new aircraft, which have been in service up to 6 years.

The number of foreign-manufactured aircraft has significantly increased over the last decade in the aircraft fleet of the Russian airlines. For example, in 2000 their number was only 46 units, while in 2012 there were 593 foreign-manufactured aircraft, which include 579 passenger and 14 freight aircraft [17, p. 26].

The proportion of long-distance passenger aircraft is 76%; they are presented to the greatest degree in the foreign aircraft fleet. In the regional aircraft fleet, the proportion of foreign-manufactured aircraft is less significant (about 30), but it also continues to increase. The proportion of foreign-manufactured aircraft in Russian cargo aircraft fleet is negligible as yet, it is about 13%.

A significant decline in the number of regional aircraft was mainly caused by the withdrawal of a large volume of low performance aircraft Tu-134 from the market and the use of the long-distance aircraft as a substitution. It is noted that 2009 was a pivotal year for mass write-off of outdated regional aircraft and its replacement by new samples. In 2010-2012, the proportion of the regional aircraft fleet was growing steadily in the total volume of aircraft operated, while the outdated aircraft families, especially Tu-134 and Yak-40, were withdrawn from the market [14].

Performance characteristics of Western-manufactured aircraft meet the market needs to the maximum extent. The fuel consumption of the foreign aircraft purchased on lease to replace the outdated national aircraft is about half lower per unit of transport work performed. Even the most modern Russian developments implemented in the planes of the aircraft families SSJ-100, Tu-214 and Tu-214, are somewhat inferior to the best Western models in terms of fuel efficiency, the frequency of required maintenance and repair [10, p. 101].

Thus, the situation in the Russian aircraft fleet in terms of operational lifetime proves the tendency to "rejuvenate" the lifetime of aircraft operated, but average flight hours exceed Western countries [7].

As noted in the specialized publications, 2014 has become a turning point – for the first time in the modern history the most part of procurement included modern aircraft, namely 55% in the first half year and 56% in the first eight months. Whereas, for comparison, in 2010 the new aircraft amounted to less than 15% of supplies.

Both economic factors and operational problems also have a significant impact on the safety of air transport operation. The situation is exacerbated by inadequate infrastructure capacity, i.e. the inability of airports, air traffic control ground aids and navigation land approach systems to serve the growing volume of international traffic.

Nowadays, the intensification of Asian carriers such as Etihad Airways, Korean Air has become an important trend in the development of air transport on the European market through the acquisition of shares in European airlines. For example, the acquisition of a loss-making carrier Jat Airways by the Asian airline Etihad Airways.

The growth of the national economy needs in air transport causes a constant increase in traffic. The pressure on the air traffic control system (hereinafter – ATC system) and the requirements for coherence of ATC authorities are increasing worldwide.

For Russia, these issues are of particular importance due to the unique size of its territory and the fact that a number of important international routes pass through it, as well as flight services provided by the Russian ATC authorities through the Northern Sea Route and in the Far East.

DISCUSSION

Forty mln flights on the aircraft in the airspace of the Russian Federation are conducted annually. If we take into account an expanding list of routes and aircraft trails of the country, through which follow wide-body aircraft with an increased passenger capacity, an increase in the aircraft flight speed, the opening of new airports, it becomes obvious that in the aviation development the focus is increasingly shifted towards improving flight safety and efficiency systems. Among such systems in the past decade the Air Traffic Control (ATC) is more significant. The solution of complex, integrated and comprehensive aviation problems such as improvement of flight safety, regularity and efficiency, is only possible when this system is highly efficient.

At the national level, the rules for airspace organization for ATC purposes, interaction of aircraft commanders with ATC authorities become stricter and the methods of control get improved, etc.

Tasks of air traffic control present a set of tasks of different difficulty levels including complex tasks at the level of the entire ATC system as a whole and a specific list of tasks for each ATC area. The interrelation and structure of such tasks are extremely complex and, to some extent, derived from the main purposes of the ATC system, its subsystems and components, ensuring their level-by-level achievement.

The main tasks of such central element of the ATC system as the Traffic Service are as follows:

- Organization and constant improvement of the structure and interaction of subsystems and elements of the ATC system (airspace division, improvement of the service structure, selection and placement of radio equipment of ATC and air navigation, etc.);
- Rational planning and provision of aircraft flights in all ATC areas; direct air traffic control at all stages;

- Ensuring safe distance between aircraft and the adoption of timely and appropriate measures to prevent their collision on the ground and in the air during the flight in compliance with the Instrument Flight Rules, Visual Flight Rules (VFR) and special VFR;
- the adoption of timely measures to assist the aircraft crews when suffering distress and in special cases in flight;

Provision of all related ATC authorities and aircraft crews with the information on the flight regime and control over its observance;

Monitoring the level of organization, the quality of traffic planning and direct ATC in order to improve the structure and functioning of all subsystems and elements of the ATC system. This includes the analysis of the flight safety status in the ATC, the regularity of flights and other indicators of the air traffic service.

The main tasks are subdivided into smaller ones which should be addressed by each of the structural units – units of the air traffic service.

Other subsystems and elements of the ATC system also have a rather expanded list of specific tasks, implementation of which ensures the operation of this subsystem or an element in accordance with their objectives and limitations in the ATC system. As for a communication subsystem, the main group of tasks is related to the specified requirements for the acceptance rate, reliability and noise immunity. Statement, methods and findings of the study of these tasks constitute some areas of applicable communication theories, radar systems, etc. If we consider the ATC system as a whole, it is also characterized by a set of tasks which largely unite groups of tasks of subsystems and elements of the ATC system [1, p. 8].

Basically, the ATC system tasks are grouped around the tasks of the ATC organization, which include tasks of organization of the ATC system structure, the structure of air traffic and its control; air traffic planning when the tasks of flight planning of a single aircraft, some aircraft and the entire air transport flow are combined; direct ATC. When grouping similar tasks, there occur some difficulties of referring them to the tasks of organization, planning or direct ATC.

The importance of task grouping lies in the fact that it is followed by the selection of the element in the structure of the ATC system, which solves this task and is responsible for the quality of these solutions. Therefore, it is important to deeply and comprehensively study the ATC tasks at all levels of the ATC system.

Controllable and controlling elements can be distinguished in any control system. Separate aircraft and their flows – a set of aircraft – can be distinguished in the ATC system as controllable elements. Respectively, such elements as a radar controller, a flow control manager or an air traffic manager are controlling elements.

The control system is different from any other system due to the presence of at least two elements such as control and feedback objectives. The control objective is defined as a flight program for certain aircraft, keeping flow performance of a set of aircraft in specific proportions with other characteristics of the ATC system such as, for example, an acceptance rate of the ATC zone.

The orientation of the control system involves achievement of these objectives. The meaning of its operation is to impose a state that meets a certain specified objective upon a controllable element. The development of effective controlling commands and signals is possible only if the control system knows any deviations of valid states of the system element control from the specified values. The values of the deviations enter through feedback channels. Therefore, the principle of feedback is used in the vast majority of control systems and, in particular, underlies all ATC processes. Thus, a radar controller monitors the implementation of his commands by using an indicator of the position-radar station which closes the feedback loop.

For example, the meaning of the group of tasks related to the direct ATC is clearly seen in the description of highlights of the operation of the simplest ATC system loop. The simplest loop is considered the smallest closed control loop of the system, including a flight operations officer, radio aids, information flows, aircraft and crews of the aircraft, which may directly control air traffic. The division of the simplest loop into smaller elements and objects deprives it of the property of being closed, i.e. violates the necessary conditions under which it can perform control functions, thus the simplest loop serves as a source indivisible element of the ATC system. Practical implementation of the simplest loop is any traffic control station with its scope of responsibility.

In this regard, the examination of examples of structures and basic functions of the existing ATC systems, especially in industrialized countries, where the traffic intensity is high, is of particular interest.

An exemplary block diagram of the state ATC system of the USA is shown in Figure 3.

The Federal Aviation Agency (FAA) is responsible for the management and use of the airspace, including the ATC organization, flight planning, flight operations and the direct ATC. This Agency carries out its functions by means of subsystems responsible for the ATC organization, planning and development of management programs and monitoring their implementation, direct management. The range of issues under the responsibility of the FAA is very wide – from the development of requirements and programs for production of new aircraft, including aircraft for transportation, navigation systems and ATC, and up to the airports construction and development programs. In this case the issues related to the ATC and, in particular, those reflecting the structural construction of the ATC system are of the greatest interest.

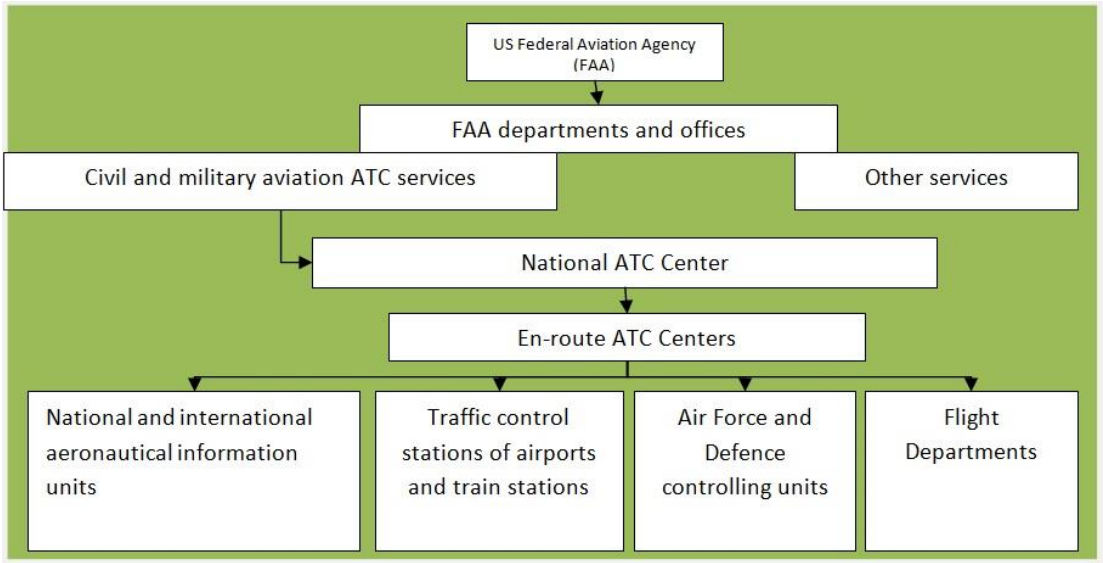

Figure 3: A block diagram of the state ATC system of the USA.

CONCLUSION

Thus, the ATC system combines the functions of organizational management and planning systems, aircraft flow management and control of dynamic objects in their entirety.

The basic functional tasks solved by the ATC system are as follows:

- Prevention of collisions between aircraft in the air and with obstacles on the ground;
- Providing a high acceptance rate of ATC zones;
- Providing aeronautical information for safe and efficient flight operations;
- Organization of warning in search and rescue of aircraft suffering distress.

In accordance with the objectives listed, the structure of the US ATC system includes the National ATC Center, which coordinates the work of en-route and airfield ATC centers and flight control centers of the US military aircraft. En-route ATC centers provide prior and current flight planning, coordination of plans en-route and direct ATC. Traffic control stations of airports and airline hubs perform prior and current flight planning, flight operations and direct ATC in airports. The composition of traffic control stations in airports usually includes the approach control units, runway supervisory units performing land approach and ground taxi operation control. National and international aeronautical information units provide pilots and controllers with the aeronautical, meteorological and other information necessary for ensuring the flight safety and regularity. Flight departments perform planning of flights and control of general-purpose aircraft movement, which includes personal, administrative, hospital, trainer and other

aircraft.

In recent years, the Russian Air Navigation System has undergone a full-scale upgrade that provides an opportunity to gradually implement advanced aeronautical technologies [1, p. 5].

Unfortunately, so far the Russian airfield network is in crisis: though a negative process of reducing the number of the airfield network has stopped, recovery and development has not begun yet. The number of airfields also remains a half times less than it was at the beginning of the twenty-first century.

However, the situation in the airfield network tends to be recovered. Ongoing comprehensive efforts on the airfield network modernization necessarily involve improvement of the quality of services for air traffic control, which means the recovery of a high level of airfield services.

At the same time, according to some experts [3], the existing ATC system developed in the USSR is optimal and economically feasible up to date. It was built by analogy with the block diagram of the state ATC system of the USA, which in the 80s of the last century already included 20 en-route centers, approximately 160 traffic junction centers and 350 aerodrome control units. At those times, the number of aircraft in the US airspace was about 14,000 during peak hours. In Korfue in 1978 in the USA about 175,000 flights were performed every day, thus the ATC system was required to perform approximately 169,700 operations. It should be noted that, according to statistical data for the period of 1977-1978, the number of erroneous operations was no more than 2-3 operations per day.

International air travel is a promising and fastest-growing segment of the global air transport market. Upon the forecasts of the International Civil Aviation Organization (ICAO), the number of passengers carried per year up to 2030 will exceed 6 billion people.

The congestion of airports and airspace and the need for development and modernization of the network of airports and improvement of air traffic management system through integrating the existing ATC systems into a single global system in compliance with unified international standards, rules and procedures are of particular importance among other problems of air transport.

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