Transcontinental Arctic Aviation in the 19th-21st centuries: goals, objectives, prospects for development

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Abstract. The purpose of the article is to analyze the role of transcontinental Arctic aviation in the development of the Arctic. The analysis is based on scientific papers written by Russian and foreign authors and archival documents of the 19th-21st centuries. The main focus of the article is on the Arctic (polar) and transcontinental aviation. The use of aviation for geographical research, the development of special types of aircraft, the construction of airfields, as well as the specifics of personnel training are reviewed. The article discusses the history of the aviation use for the needs of the Far North, its goals in the past and prospects for the future. The facts from the biography of the heroic explorers of the North and the participants of those events: scientists, geographers, pilots, military and government leaders (Chkalov V.P., Baidukov G.F., Belyakov A.V., Bogdanov A.N., Lebedev A.S., Ignatiev A.A., Stalin I.V., NagurskyYa.I., and others) are given. The authors analyze the effectiveness of achieving scientific, geographical, economic, military, and other goals in the Arctic zone. The concept of aviation use depends on the socio-political situation in the Arctic states. The authors consider the needs for civil aviation equipment in the Arctic in the period 2021-2032.

1. Introduction
The exploration of air space began relatively recently. In the 19th century people took the first steps in aircraft design, and in the 20th century the engineers developed the aviation industry to the scale that made the space closer. In the 21st century the development of aviation and space industry continues to gain momentum and performs an increasing range of tasks.

The article analyzes the role of transcontinental Arctic Aviation in the development of the Arctic. The analysis is based on scientific papers written by Russian and foreign authors and archival documents of the 19th-21st centuries, with its main focus on the Arctic (polar) and transcontinental aviation.

Due to the harsh climate and lack of communication with the rest of the world, the Far North has always been hard to explore. However, the importance of the Arctic has always been recognized by the countries of the Arctic zone, with their main interest and goals determined by the socio-political system in these countries. In the 19th and 20th centuries, scientific, economic and military studies were the main goals in the exploration of the Arctic [1], [2], [3], [4], [5], [6], while at the turn of the 20th – 21st centuries, tourism became one of the objectives in this area [7], [8].

The researchers from different countries such as Russia, USSR, UK, Sweden, France, USA (P.K. Pakhtusov, V.Y. Vise, I.D. Papanin, J. Simpson, N. Nordenskiöld, T. Wulff, P. Victor, E. Kane and others) have claimed that it is extremely important to do more research into the geography and nature...
of the Arctic [1], [2], [3], [7], [9], [10], [11]. The research was conducted both at the expense of the government, scientific societies, and through the private initiative of some researchers. This resulted in a large number of scientific papers and in many geographical discoveries, such as new fossil fuel fields and new types of flora and fauna.

The feasibility of economic development of the Arctic has long been a debatable question as it required large initial investment. At a meeting of the State Duma, in 1912, somebody claimed: «The North has never asked for any assistance, and if you arrange it, it will give you high income and no problems» [1]. There were also many economic reasons for the Arctic exploration such as abundance of minerals, forests, and seafood [1], [2]. Russia has now focused its attention on the ocean shelf, which is a more challenging task even compared to the tasks set by the polar explorers and the government of the 20th century [12].

The military goals of developing the Arctic have always been on the agenda of international powers. For Russia, this region has always been important in military terms, so in the 16-17th centuries a ban was imposed on travelling by sea from Arkhangelsk to Mangazeya, for security reasons and to protect the Russian borders from English and Dutch sailors [1], [9]. With the beginning of the World War One the development of the port of Arkhangelsk began and it became necessary to build a modern port of Murmansk. During the World War Two, the military importance of the Arctic increased (22.8% of goods delivered to the USSR via lend-lease passed through the Arctic) [13], [14]. During the Cold War, the role of the Arctic in ensuring the country's defense capability along the Northern borders has changed. In the 21st century, the technical and military space security in the Arctic region has increased due to the use of space satellites to ensure communication with both aircraft and ground and underwater objects) [15], [16].

The goal of developing tourism in the Arctic is closely related to those mentioned above. The idea of tourism is closely associated with the intention to pass the knowledge about the Arctic to the broad audience (to familiarize them with the geography, flora and fauna and the beauty of the islands, archipelagos and age long ice, etc) [7], [17]. On the other hand, tourism provides additional financial resources that can be used for the development of the region. At the same time, other Arctic states are interested in the tourist activity on the border territory in terms of military security, since this opens up more opportunities for military intelligence, as well as for reducing the military activity of the other side. This clearly follows from the fact that the US demonstrates its interest in organizing tourism in Russia, while limiting the presence of Russia and China in its sector [18], [19], [20].

2. Findings

The use of aviation for the exploration and development of the Arctic would not have been possible without the development of aircraft in the 19th century. The use of the latest achievements in science and technology has become possible due to the innovators, who first put forward the idea of applying a new technology and then implemented it. The Russian officer and pilot Y.I. Nagursky was the first to make a flight in the Arctic in 1914 for the search of the expeditions of polar travelers G.Y. Sedov, V.A. Rusanov and G.L. Brusilov which were lost in 1912-1914. The flight started from the Olginisky camp, continued over Novaya Zemlya, Franz Josef Land, Rudolph Island, Litke Peninsula, Russian Harbor, Northern Island of Novaya Zemlya Archipelago, Kara coast, with the stop-over at Pankratiev Island, and landed at the Cross Bay [4].

Today, we still have to take into account the difficulties of flying operation in the Far North, but the previous experience shows that it was possible to conquer the Arctic even on an open, low-speed, uncomfortable plywood plane.

In the early 20th century, the difficulties of using aviation in the Arctic were primarily related to the underdevelopment of aviation in the country and the lack of due attention to its prospects. First, aviation of that period was considered as a sport rather than means of transport. Secondly, there was no clear evidence of the economic feasibility of using aircraft. Moreover, there was certain counteraction in this area caused by the personal interest of some officials in purchasing airplanes from foreign suppliers, rather than establishing their production in our country. Sometimes, some
expensive foreign made components were stolen while being transported. О подобных фактах вредного ведения дел пишет в своих мемуарах А.А.Игнатьев. А.Игнатьев gives examples of such cases in his memoirs: «The total debt of Russia to France was over 27 billion francs, but little money went to Russian national economy, most of it never left four Paris banks due to the scams on the Russian loans» [21]. World War One forced open new transport routes: «Involvement of all Balkan countries in the war demanded a new organization of maritime transport, first to Arkhangelsk, and later to Murmansk, which was a great achievement because the transport routes via Arkhangelsk were closed for half a year due to the lack of icebreakers. Moreover, transportation by rail from Arkhangelsk to Petrograd and Moscow was so poorly developed that, according to the French, who visited this port, in 1916 they travelled on the sled along the covers of boxes with French aircraft components, covered with snow and sent by me in the summer of 1915! Meanwhile, air cargo required fast delivery. Aviation technology developed so rapidly that the planes were becoming obsolete during their transportation from Paris to the Russian front, and the German aircraft invariably outperformed them» [21]. This happened in the conditions of war, when the aircraft were urgent needed.

The negative experience of the pre-revolutionary army was taken into account by the Soviet government, so the aviation industry received a lot of finance and attention (as airplanes were to fly over the coast and ocean at any time of the year). The Air Force of the Workers ‘and Peasants’ Red Army, Scientific Research Institutes (Central Design Bureau of the All-Union Aviation Association, Flight Research Institute, etc), the Society of Supporting Defence, Aviation and Chemical Construction (OSOAVIAHIM), the system of personnel training as well as different specialized plants (mass production aircraft manufacturing plants, aircraft pilot production enterprises, aircraft repair plants, engine building plants) (Trial design plant №156, №18, and others) were created at that time [3]. Due to the ambitious tasks of modernizing the country, which aroused common enthusiasm, and the necessity to ensure independence from foreign countries, active development of the Northern Sea Route began. For its development, in 1928 the North Siberian state joint stock company «Komseverput» was set up, and in 1932 the Main Directorate of the Northern sea route (MDNSR) was established [22]. Fleet and navy, ports, scientific stations, polar aviation and airfields were under the authority of the MDNSR [23], [24].

The importance of aviation in the Arctic was again proved when rescuing 104 members of the O.Y. Schmidt’s polar expedition on the icebreaking steamship «Chelyuskin», which was squeezed and crushed by ice at the Bering Strait. On April 16, 1934, the USSR’s highest award was established: «The highest rank of distinction is established - the conferment of the title of Hero of the Soviet Union for the personal or collective merits to the country associated with the heroic feat» [3], [25]. Seven polar pilots were the first to receive the new honorary award on April 20, 1934, the «Trud» newspaper reported: «Appreciating the unprecedented heroic work of the pilots who rescued the «Chelyuskin»}, the Central Executive Committee of the USSR has made the decision to confer the title of Heroes of the Soviet Union to Lyapidevsky A.V., Levanevsky S.A., Molokov V.S., Kamanin N.P., Slepnev N. T., Vodopyanova M.V., Doronin I.V.» [26]. The establishment of the title «Hero of the Soviet Union» and awarding the polar pilots for the results of the expedition prove that the Government highly appreciated the importance of developing the Far North. These flights revealed certain technical problems associated with the conditions of the Far North (engine failure, icing of sight glasses, poor design resistance to strong winds, etc.).

The development of the Arctic was very much due to the work of highly qualified specialists: pilots, technicians, mechanics, and radio operators. The Soviet Union paid great attention and allocated a lot of resources to the specialists’ training [27]. Thus, pilot V. P. Chkalov, technician A. N. Bogdanov, command leader I.P. Antoshin, mechanic Proshlyakov, navigator A.V. Belyakov, and many others were trained in the Gatchina aviation school and airfield [28], [29]. The high quality of technical specialists’ training is proved by the fact that A. N. Bogdanov later on entered the Leningrad Institute of railway transport. During the Great Patriotic War he became Chief of Staff of the 14th Division of Armored Trains, and was awarded the Order of the USSR for supporting the troops [Central archive of the ministry of defense of Russia. Fund 33 inventory 690155 file 610 list 7],
The purpose of military intelligence, 1942-1943, the pilots flew on the flight of war aircraft. The second non-stop flight from Moscow to Vancouver (USA) over the North pole was made in 1937 [28], [29], [Central archive of the ministry of defense of Russia. Fund 33 inventory 690155 file 610 list 7].

The great Patriotic War of 1941-1945 was the period of active development of the Arctic aviation, new airfields were built, and the Air forces and Air defense forces were equipped with modern fighters, strike aircraft, and attack aircraft (PE-8, Tu-2, MiG-3, La-11, and others). The goals set for aviation included the protection of the Northern territories of the USSR, the defense of cities and military facilities, the air raids of enemy objects, and the protection of naval convoys [14]. It was also needed to develop special aircraft for the Arctic region. Due to these facts, new fields of development were introduced in the existing special design bureaus (Experimental design bureau named after A.N.Tupolev) and new research institutes and design bureaus were established (Experimental design bureau named after O.K.Antonov).

In 1952, Stalin ordered an urgent formation of 100 divisions of jet strike aircraft based on modern Tu-16, Tu-95 and M4 in order to strengthen the defense of the Northern borders of the USSR from external invasion [24]. Increasing the Soviet military presence in the Arctic was a necessity in the harsh conditions of the beginning cold war and the ongoing war in Korea. During this period, both battle-hardened Li-2, PE-2, and Il-12 aircraft and new developments of the Tu-4 and An-2 were sent to the Arctic to guard the USSR [24].

The pilots performed daily flights in the Arctic zone for the purpose of military intelligence, weather analysis, transport missions, and combat duty. The aircraft, in addition to the usual ammunition, were periodically provided with nuclear warheads. For example, in 1957 the radio-operator gunner A.S. Lebedev made flights on the Li-2 bomber with such missions, according to his flight book [31, 32]. New requirements for weapons required new developments of aircraft with updated tactical and technical characteristics (greater load capacity, flight range, etc.) [24], [33].

The development of aviation technology led to the absolute world leadership of the USSR in this area. By 1990, the Soviet Union had the largest aviation fleet in the world, and some civil aviation aircraft could be used for military purposes in the case of war [34]. The development of aviation industry, military and civil aviation increases the national defense. The use of foreign aircraft sharply reduces the overall combat readiness of the country, due to the lower quality of the machinery exported to other countries (which reduces its usability for military purposes). In addition, the Russian Federation suffers from economic losses caused by the registration of imported foreign aircraft in offshore zone [35].

Today, Russia is developing its presence in the Arctic region with the focus on Polar aviation. After the bankruptcy of the «Antonov» plant famous for its Arctic developments of AN-74 was announced [36], [37], the Russian Federation has doubled its efforts to develop aircraft models of Il-112 and Il-114 at the facilities of the Aviation complex named after S.V.Ilyushin [38]. The «Tupolev» plant will also work for the Arctic aviation needs [39]. The estimated global demand for civil aviation equipment for the period from 2013 to 2032 is 35280 units, and the predicted civil aviation market for the Arctic is no more than 2% of the total volume [40], so the need for civil aviation equipment in the Arctic in 2021-2032 will be about 758 units. For regional aircraft with less than 90 seats, the need for new airplanes will amount to about 20 units (the expected market volume is $ 0.8 billion). The demand for narrow-body types of aircraft (90-230 seats) will amount to 247 new aircraft ($22.9 billion). The demand for wide-body aircraft types will be 450 units ($11 billion) for small airplanes (200-300 seats), 33 units ($11.9 billion) for medium size airplanes (300-400 seats), and 8 units ($28 billion) for large airplanes (more than 400 seats) [40].

The development of special aircraft industry for the Arctic in Russia was determined by the need to introduce special tactical and technical characteristics of aircraft: the development of frost-resistant
fuel systems, specialized landing gears (wheeled, pontoon, ski) for the use in the Far North, development of the effective anti-icing system and reliable equipment maintenance in the conditions of -40°C, as well as the development of special design features to overcome mountain ranges in the conditions of rarefied air.

The world aircraft market is represented by many countries including Russia. The major aircraft manufacturers such as the Airbus (Netherlands), the Boeing Company and Lockheed Martin (USA), Safran (France), BAE Systems (UK), Aviation Industry Corporation of China AVIC (China) are also interested in the civil aviation market for the Arctic. The regions of the Far North has always aroused interest of other Arctic states, both in terms of economic development and military purposes (as early as in 1912 the Norwegian city of Varda on the border with Russia was provided with electric power and had telephone communication, due to the absence of a Russian port on the Kola Peninsula and the need for Russian merchants to sell goods abroad at bargain prices) [1]. The importance of the Russian Arctic for foreigners is demonstrated by the research done into the Russian and Soviet exploration of the Arctic, the establishment of special universities and departments abroad, as well as the state funding provided by the military departments (the US Office of Naval Research, the US Air Ministry, and the US army) for the study of the USSR's activity in the Arctic [22].

The analysis of a great number of works (more than 108,000 publications for the period 1947-1975) [22] and the generalized material of Soviet researchers allowed foreigners to get acquainted with the Arctic without their own research and respond timely to the changing situation in the region in their political, economic and military interests. General E. Goodpeister calculated the plan of attack on the USSR in the case of a conflict with the United States (during the cold war) through the territories of the Far North, due to the lack of radio-location stations (RLS) using strategic strike aircraft [22], [24], [41].

In the 1990s, a number of publications revealed the interest of some foreign countries in the USSR enterprises and resources, including in the Arctic region [44]. The development in the Arctic shelf zone continues, and the development of the region opens up huge economic opportunities and advantages [12]. The ongoing reconnaissance of Russian territories by the US and other countries' aircraft and satellites, as well as the attempts to conduct special operations [8], [43], [44], [45], [46] force Russia to intensify the use of modern aviation and space technologies in the Arctic.

In terms of navigation and space satellites, the Russian Federation currently takes the leading position. Our scientific and military developments ensure independence from the influence of foreign states on the technosphere [47], [48], [49]. To ensure the security of the state's borders against enemy aircraft and missiles, we began using radar and aviation in the 20th century. The rapid technological development made it necessary to take up-to-date defense measures. The original plan to secure the Northern border of the Soviet Union with aviation and the need to locate 100 divisions of jet strike aircraft with airfields lost its relevance after the introduction of strategic missiles. At the same time, the timely development of long-range (transcontinental) strike aircraft made it possible to unload existing airfields, making some of them jump airfields, and to provide central aircraft bases far from the country's borders for security reasons. To solve the problem of radars in the Far North it was decided to use aircraft with radar on board, instead of building local radars, which required new developments [23]. The US stronger missile defense has once again raised the problem of the use of aircraft in relation to the Arctic region. Moreover, a lot of attention is paid today to space developments [16], [43] especially since the decree of the President of the Russian Federation on August 1, 2015 created a new branch of the Air and Space Forces of Russia [52].

To solve the problem of building new airfields in the Arctic, the military construction organizations as well as the MDNSR were used. Thus, in the early 1950s, a special construction department needed to build hundreds of airfields. To accommodate one hundred divisions of the aviation industry, it was necessary to increase capacity for the rapid replenishment of the aircraft fleet, and it became clear that the production plan should be exceeded by more than 10,000 strike aircraft [3], [24]. In the 20th century, many airfields were built in the Russian Arctic, and special platforms were prepared for taking off from ice floes, shingle spit and mud ruts. The choice of safe and convenient locations for
aviation requires a serious study of the geographical and geological features of the region, as well as
the study of the ice cover and atmosphere effects [10], [11], [45], [51], [52]. New technical
requirements make it necessary to constantly upgrade airfields and runways, and develop mobile
aerodrome systems for land and water-based operations. Today, the task of building and modernizing
airfields is solved through the state order systems, as well as by attracting private investment, since
the regional authorities, air carriers and businesses are interested in developing air transport [24], [40],
[53].

3. Conclusion
So, the development of transcontinental Arctic Aviation in the 19-20th centuries includes several
stages. The period from the 19th century until 1913 is the first period of using aviation in the Arctic,
associated with the exploration of the territories during the rescue expeditions. The second stage of
aviation use in the Arctic is associated with the period of 1934-1937 when a number of technical
problems of aircraft use in the Arctic were identified and subsequently solved. The third stage was the
Great Patriotic War, which was unfolding also in the Arctic region, and resulted in the increasing use
of military aviation in this region. The fourth stage is the second half of the 20th century and the
peaceful development of the Arctic, which is largely provided by aviation and has a great national
economic importance. Then, transportation tasks came to the fore in order to maintain mining,
construction and development of new cities and industrial centers, provision of polar expeditions, etc.
The solution of these tasks required the development of infrastructure and the construction of polar
aviation aircraft. The fifth stage to a large extent includes the tasks of the previous stages, but implies
a higher technological and organizational level of solving the problems in the Arctic. Thus, the idea of
creating polar aviation in our country was not put forward immediately. Initially, the aircraft fleet
consisted of standard aircraft models, and after the war it was replenished with already outdated
models of strike and transport aircraft. Later, as Arctic aviation grew into an industry, special Arctic
aircraft models were designed, which are constantly upgraded following the development of science
and technology.

Transcontinental Arctic aviation in the 19th – 21st centuries is constantly developing due to the
influence of political, economic and military factors. With the technical progress, the activity of
different countries in the Arctic is also increasing. At all stages of aviation development, the most
pressing issue still remains, which is the industrial development and production of new types of
aircraft and aviation equipment. Introduction of new technologies in aircraft engineering can solve
current problems in the field of economy, army and science. The competent and timely application of
new technologies in the Arctic region will ensure the leading position of the Russian Federation in the
Arctic. The comprehensive assessment of the previous experience, current needs and production
facilities will help to minimize costs and improve the efficiency of the national aircraft and aviation
equipment in the Arctic.

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