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USSR and Russia Passenger Airplane Production in 20th Century

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***Abstract* — For the first time, data are presented on the production of passenger airplanes in the 20th century in the USSR and Russia, divided by years, and also about their passenger capacity. The ups and downs of output are analyzed, the connection with the processes in the global aircraft industry is shown. It is noted that the growth in the production of passenger airplanes continued until 1980. During next five years it decreased by more than three times, this is the pre-perestroika period. During the time of perestroika, from 1986 to 1992, production grew again. A crushing decline in the passenger aircraft industry in Russia occurred in 1994–1996. The article lists its possible causes. It is shown that the developers responded to this decline with an increase in activity, which cannot be considered effective behaviour in a time of sales reduction and a shortage of working capital.**

Keywords* — *airplane manufacturing, passenger airplane, aircraft industry, passenger capacity, weight ratio, design quality, USSR industry, history of the 20th century

The author collected information about the models of passenger airplanes built in the 20th century in the whole world and about their production: 3560 records on the output of 1533 airplane models by years. As a result, for the first time, the quantitative dynamics of production and development of passenger airplanes in the world was built.

As far as the author knows, no total data on the production of passenger airplanes in the world have been published before. For the first time, information about the production of serial models of passenger airplanes in the 20th century in the USSR and Russia was collected in the book [1], in which the author also took part, but there was no summary data in it. In this paper, the numbers from [1] are refined, especially for the last quarter of a century.

Foreign literature contains statistics on the production of certain types of passenger airplanes and the results of the activities of individual companies (for example, [2]–[4]), but not summary data. At the end of the 20th century, meaningful analytical reviews on the production of civil airplanes in the world began to appear, we will point out one of the latest [5]. Around 1970, the Jane's yearbook began to systematically publish fairly accurate information about the production of aircraft in Western countries [6]. But for earlier periods, there is little information and it is very scattered. There is no or almost no information about the output in monographs dedicated specifically to passenger airplanes construction (for example, [7]–[9]).

Passenger airplanes after 1941 are defined in accordance with the gradations of the FAA (US Federal Aviation Administration), adopted in the documents of the FAVT (Russian Federal Air Transport Agency) and the Ministry of Transport of Russia [10]. For the pre-war period, these criterions are too strict: such famous types as the Junkers F13 or the Dornier "Komet" do not fall into the passenger category. It was impossible to rely on normative documents at that time, they just did not exist.

Here a passenger airplane is considered to be an airplane carrying at least three people in a closed cabin (ANT-2 is not suitable – it took only two passengers, but all Kalinin's monoplanes are already suitable). The upper period boundary was chosen so that the "passenger" cathegory includes the production monoplane "Stal-2", designed for four passengers and built specifically for the regular lines of the Soviet Civil Air Fleet.

Since 1931, the lower limit has been raised to six passengers, since 1936 – to seven. The raising of the border in 1936 is due to the fact that otherwise the numerous pre-war British de Havilland D.H.89A biplanes would have been classified as passenger, and the D.H.89A Mk.4 and 5 built after the end of the war, carrying the same six people, would already be classified as general-purpose aircraft. The French Caudron C.445, designed for six passengers and produced both before and after the war, would have found itself in the same situation.

Numerous Soviet Polikarpov U-2, Shavrov Sh-2, Polikarpov P-5, carrying passengers on local airlines, are not considered passenger airplanes in the article. All VIP and corporate airplanes that can carry the above minimum number of passengers are referred to as passenger airplanes in the article.

Sources of data on passenger airplane models and their release, broken down by types, are listed in the bibliographic guide [11]. All numbers given in the article, unless otherwise indicated, are calculated by the author. The completeness of the collected data was checked by comparisons with the available partial results, for example, the production of passenger airplanes by "Douglas" and "McDonnell Douglas", calculated according to [6].

In total, 2.23 million airplanes were built in the world in the 20th century [12], including almost a million "non-combat" ones. The adjective "non-combat" instead of "civilian" is used because it is difficult to separate military transport airplanes and airplanes used for military pilots training from civilian ones. Therefore, the category of "non-combat" includes all unarmed airplanes despite tankers and military reconnaissance aircraft. Thus, for the most part, the world airplane industry in the 20th century worked for military customers.

A million ‘‘non-combat’’ airplanes is divided, in turn, into three parts. The largest in number, 484 thousand pieces, are 1–2 places light, sports and training airplanes. The second group consists of 342,000 general-purpose airplanes (from 3 to 11 seats, but except ones, considering here as passenger airplanes).

The remaining 170,000 are commercial airplanes. They, in turn, are divided into three large and several small groups. These are agricultural airplanes (38.8 thousand), transport (including military transport, 52.4 thousand) and passenger (65.6 thousand pieces). Another 14.1 thousand commercial airplanes belong to small groups: aerial photography, glider towing, civil patrol, mail carriers, fire fighting, ambulance and rescue, etc.

Although aviation in the public mind is associated primarily with regular passenger traffic, the share of passenger airplanes in the total output in the 20th century was only 3%.

But the calculation in pieces does not count the difference in the size of the aircraft, which means their labor and material consumption and the burden on the industry. To evaluate these indicators, it is advisable to compare the total empty mass of the constructed vehicles. This indicator has been used for almost 80 years in the reports of the US Air Force [13, P. 99. Table 61 “Airframe weight of all factory accepted military airplanes”] precisely to estimate the workload of the industry with the production of aircraft of various types.

Calculation in tons changes the role of passenger airplanes. Of the 9 million tons of 20th century airplanes total mass, commercial ones occupy 2.37 million tons, a little more than a quarter. This group is dominated by passenger airplanes: 1.5 million tons, or 1/6 of the total production per century. This share more adequately describes the role of passenger airplanes in the aviation.

In production the USSR/Russia ranks second, the same as in the total production of airplanes in the 20th century. The United States built 25854 passenger airplanes, USSR – 9715, in third place is the UK with a result of 5432 airplanes.

Graphs for the production of passenger airplanes in the world in pieces, tons and passenger seats, divided by country and by five-year periods, are given in the author’s article [14], in this article we will not repeat them.

For the first time we publish a detailed table of the production of passenger airplanes in USSR (Table 1, after 1991 in Russia, before 1923 there were no passenger airplanes built in the country).

Table 1 shows the output in pieces, tons and passenger seats, as well as the number of new models of passenger airplanes that were designed from 1923 to 2000.

Let us present these data graphically. Fig. 1 shows the lines for the output of passenger airplanes in the country year by year and the number of passenger seats on them. In our opinion, it is this indicator, which is directly related to ability to transport peoples, is most relevant for passenger aviation.

Of course, the interiors of post-war airplanes may have different layouts (before the World War, there was almost no diversity). How the “typical” arrangement was chosen and what errors in results are possible in connection with this, is explained in [14].

TABLE 1. Production and Development of Passenger Airplanes in USSR/Russia

Year	Airplanes	Tons	Passenger seats	New models
1923	5	6	20	0
1924	1	1	4	1
1925	3	4	11	3
1926	0	0	0	0
1927	4	6	16	1
1928	0	0	0	1
1929	19	32	85	2
1930	28	56	141	1
1931	59	171	511	3
1932	99	287	816	2
1933	106	272	853	4
1934	180	452	1186	4
1935	63	115	361	2
1936	65	117	400	2
1937	22	52	154	2
1938	6	30	84	0
1939	15	116	270	1
1940	61	431	1281	0
1941	102	720	2142	0
1942	0	0	0	0
1943	0	0	0	0
1944	10	71	210	0
1945	42	317	879	2
1946	28	286	739	3
1947	174	1830	4059	1
1948	102	954	2277	0
1949	230	2232	5199	1
1950	122	731	2076	0
1951	184	1013	2937	0
1952	240	1339	3870	0
1953	134	676	2004	0
1954	134	717	1776	1
1955	167	1069	2354	2
1956	540	5398	9158	0
1957	418	4828	8600	8
1958	313	5040	11804	4
1959	427	6876	17470	3
1960	378	6159	16347	2
1961	289	4275	11611	2
1962	175	3711	9920	2
1963	114	3336	9013	2
1964	118	3082	8369	1
1965	133	3105	8874	5
1966	212	4206	13174	2
1967	134	3186	9710	0
1968	219	4493	13702	2
1969	200	3589	10724	3
1970	194	3599	10750	2
1971	235	4681	13605	1
1972	254	4899	14249	0
1973	279	5216	15655	2
1974	326	7262	21460	1
1975	307	7260	21406	2
1976	272	7157	21442	2
1977	229	7088	21056	1
1978	210	7329	22548	2
1979	166	7126	22490	0
1980	172	7375	23632	2
1981	135	6312	19624	1
1982	129	5915	18248	0
1983	70	3847	11980	0
1984	57	2812	8875	1
1985	39	2327	7586	0
1986	45	2767	8968	0
1987	49	2957	9392	0
1988	58	3333	10839	2
1989	57	3382	10806	1
1990	73	4236	13496	1
1991	57	3258	10606	0
1992	80	4645	14599	3
1993	61	3430	11034	1
1994	26	1422	4452	1
1995	19	1042	3144	0
1996	6	338	1076	1
1997	8	380	1274	0
1998	9	369	1242	1
1999	8	413	1255	2
2000	10	308	1042	2
Total:	**9715**	**197871**	**573022**	**107**

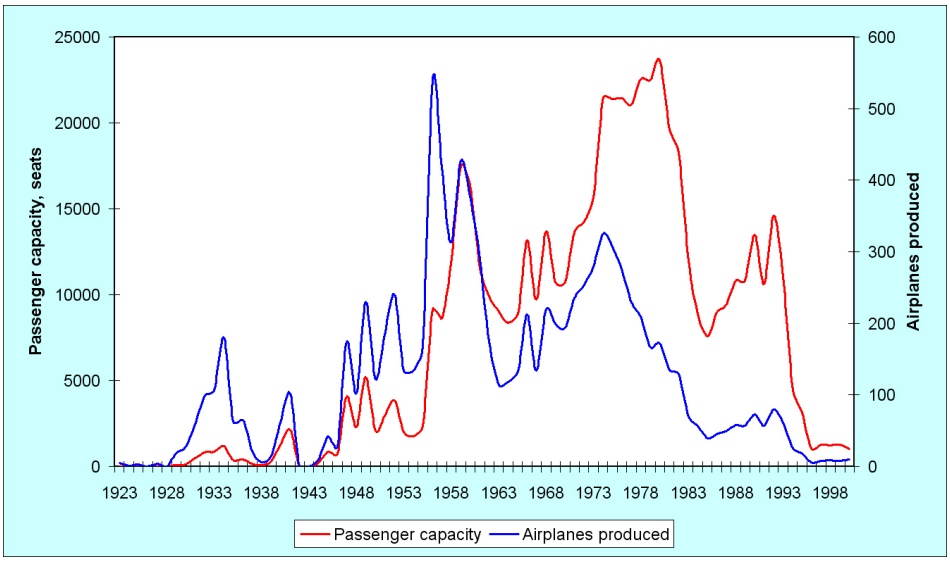

Fig. 1. Output of passenger airplanes in USSR/Russia during 20th century: number of airplanes and summary number of passenger seats of them.

The production of passenger airplanes in Russia began in 1923 at a factory in the Fili village near Moscow (now a district of Moscow city). In 1916, the “Russo-Balt” company built an automobile plant there using equipment evacuated from Riga. In 1921, it was renamed the “First State Armor and Automobile Plant”.

On January 23, 1923, the plant was transferred for 30 years to the concession of the German company ”Junkers”, but on March 1, 1927 the agreement was dissolved [15, pp. 55–56]. In the 1923, three Junkers F.13a and one float Ju-13 “Hydro;; (Russian designation) were built.

The following year, 1924, the first model of a domestic passenger airplane appeared, albeit with a French HS 8Fb engine: a biplane of state aircraft factory No. 5 (GAZ, Gosudarstvennyi Aviacionnyi Zavod), the former Moska plant in Moscow. It was designed by E. E. Gropius [16] (Fig. 2). This biplane also remained an experienced model.

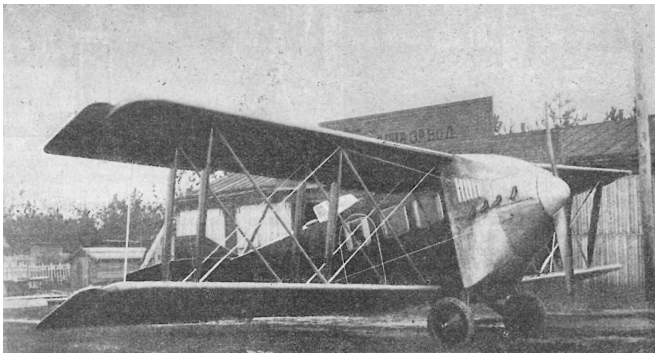

Fig. 2. Airplane GAZ No.5 took four passengers and two pilots.

The first Soviet serial passenger airplane K-4 was created in 1928 by Konstantin Alekseevich Kalinin. During 1928–1930, 39 copies were built at the Kharkov aircraft factory, mainly with German Junkers L-5 engines.

Since 1929, the rise of passenger airplanes production in the USSR began, and in 1934 the output reached its peak: 180 airplanes, including 87 Putilov “Stal-2”, 44 Kalinin K-5 and 37 Tupolev PS-9. This is more than in any other country: 137 passenger airplanes were built in 1934 in the USA, 136 in Great Britain, 125 in Germany. Yes, the depression was raging at that time. But first place is first place.

The rise did not last long, in 1938 only six passenger airplanes were produced in USSR, all of them are ZiG-1, which was due to the militarization of industry due to the feeling of an imminent war. Worldwide, the production of passenger airplanes also halved between 1934 and 1938.

The next short-term rise is associated with the manufacturing of licensed PS-84 (Douglas DC-3). In 1942 and 1943, not a single passenger airplane was built, but in 1944 in Tashkent 10 PS-84s, which by that time had received the name Li-2, were produced not in a bomber or transport, but in a civilian passenger version. In the United States that year, all efforts were still directed to supply the military forces, not a single passenger airplane was built there.

After the end of World War II, the production of passenger airplanes, both licensed Li-2 and domestic-designed An-2P and Il-12B, began to grow rapidly, although unevenly.

The Korean War, during which the production of MiG-15 fighters and Il-28 bombers was sharply increased, slowed down this process. These years, the last years of Stalin’s life, new models of passenger airplanes did not appear.

But in the Khrushchev years, civil aviation flourished. 427 passenger airplanes were manufactured in 1959. Frankly, the most produced model among them was the small An-2P (274 pieces, Fig. 3), but 60 jetliners Tu-104, 48 Il-18, 39 An-10 and An-10A and 5 giant Tu-114s also were built.

In 1959 the USSR produced the entire half of all passenger airplanes around the world (748 pieces). The results of passenger capacity were more modest, but more than one third of the worldwide output (17 thousand seats against 48 thousand).

But the production of An-2 was transferred to Poland, in 1962 their output in Kyiv was finished. This led to a new, although not catastrophic and short-timed drop of lines on the Fig. 1.

Fig. 3. Most mass-produced passenger airplane of 20th century, An-2. 4150 pieces were built in USSR, Poland and China in passenger variants. On the photo: polish-built passenger PZL An-2P.

Soon a new growth has begun, and in 1980, the total output reached an absolute maximum: 23.6 thousand passenger seats. The period from 1955 to 1980 was also a period of technical triumphs. At that time, one of the first jetliners Tu-104, the world's first supersonic passenger aircraft Tu-144, and the largest An-22 "Antaeus" cargo transport airplanes have appeared in the USSR.

The production line ''in pieces'' on Fig. 1 began to decline much earlier, from 1974. But at that time there was a transition to the construction of more complex airplanes with a larger capacity. The share of Tu-154 and Il-62 grew, therefore, in our opinion, consider 1974–80 years of recession, as it could be concluded only by the release in pieces, is wrong.

In the first half of the 1980s, the production of airplanes of all classes around the world simultaneously and sharply decreased, and later the output volume did not return to its previous level. This unexpected crisis and its possible causes were discussed in the author's article [17]. And the passenger aircraft industry of the USSR was no exception: from 1980 to 1985, production fell three times, to 7.5 thousand passenger seats.

During ''perestroika'' and a little later, in 1986–1992, output grew both in pieces (twice, from 39 in 1985 to 80 in 1992), and in thousands of passenger seats (almost doubled, from 7.6 to 14.6 thousand seats). But galloping inflation, which absorbed the savings of carriers, the rupture of production ties due to the collapse of the country, the growth of property stratification of the population and the associated decrease in demand for air travel, the inability of aircraft manufacturers to reorganize to work in new conditions, and a number of other reasons led to the collapse of the industry in the next four years. And in 1996, just six passenger airplanes were built in the country at four factories (2 Tu-204-100 at the "Aviastar" in Ulyanovsk , Il-62M and Tu-214 in Kazan, Tu-154M at "Aviakor" in Samara and Yak-42D in Saratov).

Let's compare the production and development pace of passenger airplanes. The development of passenger planes was an insignificant part of the activity of the aircraft design teams of the USSR/Russia. In the country from 1923 to 2000 inclusive, 1884 airplane models were created, of which only 107 were passenger, that is, 6%. 67 of them were built serially (60%, this share is at the "average world" level).

Fig. 4 shows the number of airplanes built in USSR/Russia over a five-year period (the first one, 1923–30, is taken longer due to the small output) and the number of passenger airplane models brought out for flight during the same time.

The two curves correlate well. At first, the ''development'' curve goes higher (taking into account the different scales along the axes), then it approaches the "production" curve and goes below it in the 1970s–1980s. This is a good sign, it means that the average the number of copies built of each model is growing, the activity of designers is bringing more and more returns.

In 1944, the only year after the end of the First World War, not a single new model of passenger airplanes appeared in the world. In the same year, the world aircraft industry worked at maximum struggle: 232.7 thousand airplanes were produced in a year, more than 10% of the century output. In the USSR in 1944, 40,268 airplanes were built, it's over 12% of a century production. But already in 1945, the USSR began testing a new passenger airplane, the Il-12 prototype.

Since 1960, the frequency of the appearance of new models of passenger airplanes in the country has been decreasing all the time. There is a temptation to explain this by the growing complexity of design, but it is unlikely that the development of the first jet Tu-104 or An-10 in the pre-computer era was four times easier than the development of the Yak-42 or Tu-204. The total number of new airplane models, including combat ones, in the USSR during this period, fluctuated greatly, but there was no such significant decrease.

The divergence of the lines at Fig.5 in the end of the century is interesting. The designers responded to the colossal decline in demand, downtime of production sites, and the severe shortage of working capital not by saving and improving the support of existing products, but by intensification of creative activity. The number of models began to increase sharply. Almost all never reached the stage of serial production, and the unprofitable expenditure on R&D (research and development) further aggravated the financial distress of the industry.

This ineffective reaction of engineers to a long-term decline in production is not a typical Russian mistake; it is observed all over the world, including in the USA and Western Europe during the Great Depression and during the recession of the 1980s. Evidence that an increase in R&D in response to a decline in customer's demand is a usual behavior, at least in the global aviation industry, is given in [18].

By the end of the 20th century, the production of aircraft in Russia dropped dramatically, and the structure of production differed sharply from the world's one. In 2000, 140 airplanes were built in the country, mostly light-engine, primarily MAI-890 in different versions. Among these 140 there were also 20 combat airplanes (prototype MiG 1.42 and 19 Sukhoi aircraft, 18 of which were built by Chinese order [19]) and only 10 passenger airplanes of eight different models belonging to six types: two An-3 and Yak-42D and one each An-38-200, T-208, Tu-154M, Tu-204-100, Tu-204-120, Tu-204-300. Two of these models appeared only in 2000 (An-38-200, T-208). The total mass of these 10 aircraft was equal to 308 tons, while the total mass of airplanes produced in 2000 in the country was 776 tons, that is, 40%. The total mass of 20 combat aircraft was equal to 353 tons or 45% of the total output.

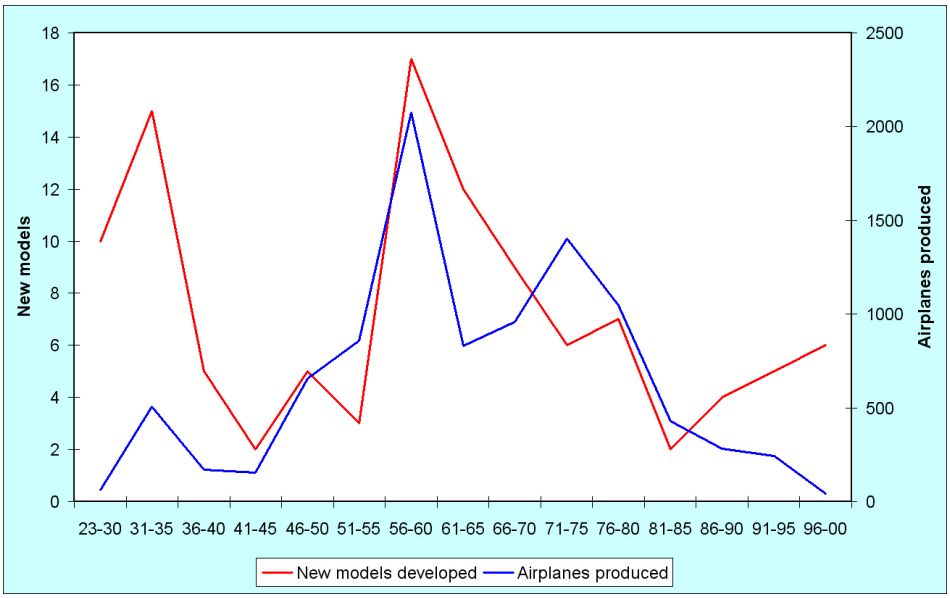

Fig. 4. Production and development of new models of passenger airplanes in USSR/Russia in 20th century.

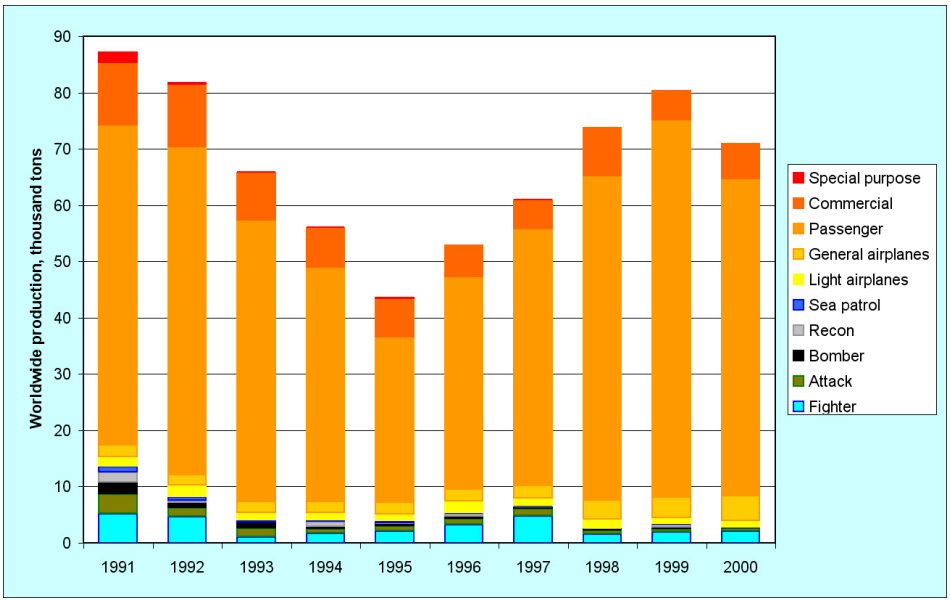

Fig. 5. Airplane production in 1990s in the world (in tons) by purpose.

But in the world, including Russia, in the same 2000 year, 70,900 tons of airplanes were built, of which only 2,770 tons were combat (4% of the total output) and 56,270 tons were passenger (79%). The growth in the share of production of passenger airplanes in the world (in tons) in the last decade of the 20th century in the world is shown in Fig. 5, it was they who, at the beginning of the 21st century, mainly loaded the capacities of aircraft factories.

Thus, in Russia in 2000, 1/8 of all combat airplanes in the world (by total airframe mass) were built, and only half a percent of passenger airplanes: over the past 15 years of the century, the civil aircraft industry has suffered much more than the military one. The Russian aircraft manufacturing infrastructure at the end of the century was (and remains) clearly disproportionate to production volumes. In this state, the Russian passenger aircraft industry entered the 21st century.

References

[1] Yu. V. Zasypkin *et al.*, *The history of homeland aircraft industry* [*Istoria otechestvennoi aviapromyshlennosti*], D. A. Sobolev, Ed. Moscow: Rusavia (in Russian), 2011.

[2] *Aircraft manufacturing market share, size, trends, industry analysis report, 2018–2021*. London: Polaris, 2022.

[3] *Jane's all the world's aircraft 1970–71*, W. R. Taylor, Ed. London: Sampson Low, Marston, 1971.

[4] P. M. Bowers, *Boeing Aircraft since 1916 (Putnam Aviation Series)*. Annapolis, Maryland, U.S.: Naval Institute Press, 1989.

[5] R. J. Francillon, *Lockheed Aircraft since 1913 (Putnam Aviation Series)*. Annapolis, Maryland, U.S.: Naval Institute Press, 1982.

[6] R. J. Francillon, *McDonnell Douglas Aircraft since 1920. Vol. 1 (Putnam Aviation Series)*. U.S.: Funk & Wagnalls, 1979.

[7] V. V. Belyaev, *Passenger airplanes of the world 97* [*Passazhirskie samolyoty mira 97*]. Moscow: Argus (in Russian), 1997.

[8] D. A. Sobolev, *History of passenger airplanes development* [*Istoria razvitija passazhirskih samolyotov*]. Moscow: Russkie Vitjazi (in Russian), 2018.

[9] J Taylor and S. Young, *Passenger aircraft and airlines*. Secausus: Chartwell Books Inc, 1977.

[10] *Aviation rules. Part 25. Airworhiness standards of transport category aircrafts* [*Aviacionnye pravila. Chast 25. Normy letnoi godnosti samolyotov transportnoy kategorii*], Part A, International Aviation Committee, Moscow, 1994.

[11] Yu. V. Kuzmin, *Bibliographical guide for 20th century airplanes* [*Bibliograficheskij spravochnik po samolyotam XX veka*]. Moscow: IIET RAN (in Russian), 2021.

[12] Yu. Kuzmin, "The numerical history of airplane manufacturing in XX century," 31 ICAS Congress reports, Rep. 2018_0705, 2018.

[13] *Army Air Forces statistical digest 1947*. Washington: Statistical Control Division, 1947.

[14] Yu. V. Kuzmin, ''Passenger airplane building in 20th century. Quantitative analysis [Passazhirskoe samolyotostroenie XX veka. Kolichestvennyi analiz]," (in Russian), *Civil Aviation High Technologies* [*Nauchnyi vestnik MTGU GA*], vol. 26, no. 3, pp. 8–24, 2023.

[15] D. A. Sobolev and D. B. Khazanov, *German track in the Soviet aviation* [*Nemeckij sled v otechestvennoi aviacii*]. Moscow: Rusavia (in Russian), 2000.

[16] "Passenger airplane syst. By Groppius [Passazhirskij samolyot sist. Groppiusa]," (in Russian), *Airplane* [*Samolyot*], 1924, no. 11, p. 37.

[17] Yu. V. Kuzmin, "The decline of airplane production in USSR in 1980th [Spad proizvodstva samolyotov v SSSr in 1980-h godah]," (In Russian), *Historical informatics* [*Istoricheskaya informatika*], no. 2. pp. 106–146, 2019, doi: 10.7256/2585-7797.2019.2.29402.

[18] Yu. V. Kuzmin, "Can engineers manage? On the example of airplane industry history [Umejut li inzhenery upravlyat? Na primere istorii samolyotostroenija]," (in Russian), *Aviation and Cosmonautics* [*Aviacija i Kosmonavtika*], no. 9, pp. 23–29, 2022.

[19] A. Fomin, "Sukhoi airplanes in Chine today and tomorrow [Sukhie v Kitae segodnya i zavtra]," (in Russian), *Takeoff* [*Vzlyot*], no. 11, pp. 20–31,2 2006.