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The Nuclear Icebreaker Fleet and Its Role in the Economic Development of the Northern Sea Route *

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Abstract. This scientific article studies the development of nuclear icebreakers, the history of their commissioning and service; the growth of nuclear icebreaker capacity is investigated. The Soviet and Russian stages of their history have been compared. A diagram of this development was constructed. Key tactical and technical data of nuclear icebreakers are compared; their proportionality and similarity are proved. The prospects of the nuclear icebreaker fleet development are investigated. The growth of cargo turnover along the Northern Sea Route in 1933–2022 is analyzed and systematized. The development of nuclear icebreakers is compared with the growth of cargo turnover along the Northern Sea Route, their interdependence is proved; the diagram of this interdependence is constructed. The reasons for the influence of both the development of the human economy and political events in and around Russia on the changes in the grouping of nuclear icebreakers are revealed. It is identified that the volumes of transportations along the Northern Sea Route in the 21st century are many times higher than in the Soviet era, largely due to the growth of the quality and quantity of the nuclear icebreaker fleet. The reasons for the reduction of the nuclear icebreaker fleet at the beginning of the 21st century under the influence of the general temporary reduction of cargo flows along the Northern Sea Route are shown. Maximum small and optimal sizes of nuclear icebreakers grouping for effective operation of the Northern Sea Route are specified.
Keywords: *nuclear, icebreaker, Arctic, Russia, economy, fleet, Northern Sea Route*

Introduction

The Russian economy has long been aware of the serious benefits of developing the Northern Sea Route (hereinafter referred to as the NSR) and its adjacent locations, and with their help — from building new logistics business models for states and large companies interested in delivering their cargoes via the NSR — to Russia itself. Without a high-quality and reliable nuclear icebreaker fleet, this is ineffective. Modern Russia demonstrates unique and large-scale achievements in this direction, both in shipbuilding and in the operation of nuclear icebreakers.

Actual history of nuclear icebreakers

During 32 years (1959–1991), 7 nuclear icebreakers of three different projects were built in the USSR: 1 of the project 92M “Lenin” (3.12.1959) [1], 4 of the project 1052.0: “Arktika” (25.04.1975) , “Sibir” (28.12.1977), “Rossiya” (21.12.1985), “Sovetskiy Soyuz” (30.12.1989) and 2 of the project 1058.0: shallow-draft “Taimyr” (30.06.1989) and “Vaygach” (25.07.1990) [2, Ushakov A.].

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These and further icebreakers are presented in the diagram in figure 1, taking into account the duration of their service (the separator in the figure shows 1991 as the border between the Soviet and Russian periods):

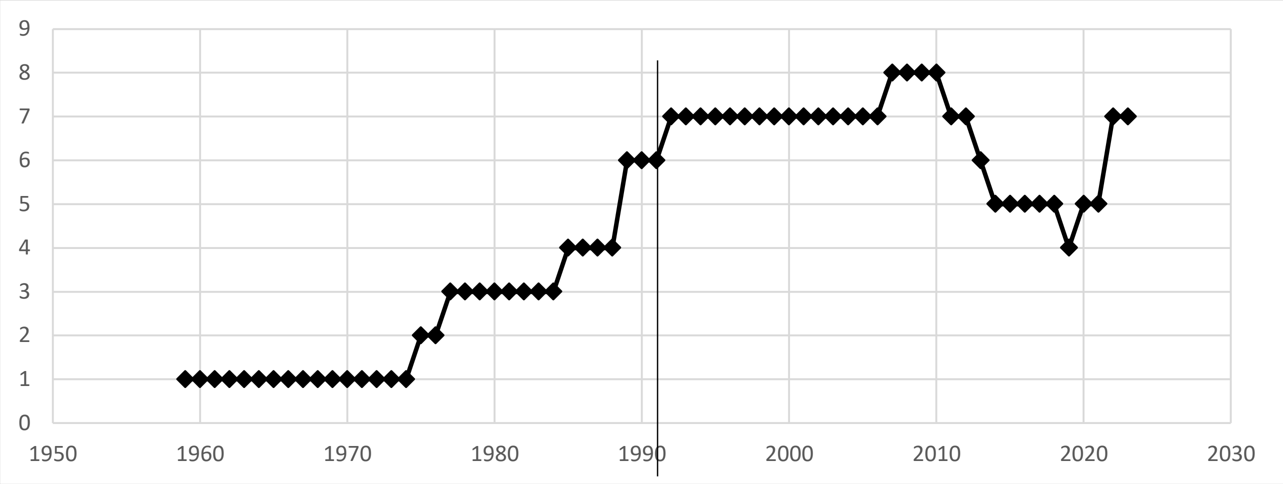

Fig. 1. Number of nuclear icebreakers in different years [1].

The dynamics of their commissioning intervals is quite interesting: 16 years — 2 years — 8 years — 4 years — 0.5 years — 1 year.

In the Russian Federation, during the same time — 32 years (1991–2023) — 5 nuclear ice-breakers of two projects were built: 2 of the project 1052.0: "Yamal" (27.10.1992) and "50 Let Pobedy" (23.03.2007) and 3 of the project 2222.0 LK-60Ya: "Arktika" (21.10.2020), "Sibir" (25.01.2022) and "Ural" (22.11.2022).

Their dynamics of commissioning intervals is also very indicative: 14 years — 13 years — 2 years — 0.5 years. There is a lot in common between the dynamics of the Soviet (16–2–8–4–0.5–1) and post-Soviet (14–13–2–0.5) periods, showing a rather long acceleration point in icebreaker construction at 13–16 years, seriality during 2–4 years and even simultaneous commissioning of several ships in one year.

Fig. 1 shows that the dynamics of nuclear icebreakers development is visually obvious: their peak of 8 units occurred in 2007–2010, after which the number began to decline, and the lowest number was in 2019 — 4 vessels. Then the number of nuclear icebreakers started to grow, and in 2022 there were 7 units, almost back to the maximum achieved.

At the moment, 3 more nuclear icebreakers of 2 projects are being built: 2 of the project 2222.0 LK-60Ya: the already launched "Yakutia" (12.2024?) and "Chukotka" (12.2026?); "Rossiya" (12.2027?) of the project 1051.0 LK-120Ya. Two more icebreakers of project 2222.0 LK-60Ya is planned in the near future: "Kamchatka" (5.2024–2028?) and "Sakhalin" (10.2025–2030?). Thus, the current grouping of 7 icebreakers is planned to be at least maintained at the current level, and at a maximum — to be increased to 8. It is possible to build 2 more icebreakers of Project 1051.0 LK-120Ya until 2034 [3, Aleksushin G.V.]. Moreover, a new shipbuilding plant — SBC Zvezda in the

[1] Compiled by the author.

Far East — is involved in this new series, and the Soviet principle of building nuclear-powered icebreakers at a single enterprise is passing into the past.

However, despite the obvious slight superiority of the USSR in the number of icebreakers built (7 versus 5+3), the combined displacement of Soviet icebreakers is actually the same (16.000 tons (Lenin), 4 by 23.460 tons and 2 by 19.600 tons = 149.040 tons) as that of the Russian ones (2 by 23.460 tons and 3 by 32.747 tons = 145.161 tons). It should be taken into account that now part of the shipbuilding capacity is occupied by 3 icebreakers under construction, and part of their total displacement has already been built.

Growth of domestic nuclear icebreaker capacity

It is obvious that designers are striving to constantly increase the capacity of nuclear icebreakers while maintaining their overall size, which can be seen in Table 1:

Table 1

Comparison of nuclear icebreakers' technical characteristics (power indicators are in bold) [2]

	project 92M "Lenin" (1)	project 1052.0: "Arktika" (6)	project 1058.0: "Taimyr" (2)	project 2222.0 LK-60Ya (3+5)	project 1051.0 LK-120Ya (+3)
					
Water displacement in tons (full/standard)	16000	23460	19600	32747/26771	71380/50398
Width, m	27.6	30.0 / 28.0	29.2 / 28.0	34.0 / 33.0	47.7 / 46.0
Power on shafts, kW	*32400*	*49000*	*32500*	*60000*	*120000*
Speed in clear water, knots	18	20.8	20.2	22	23
Ice capacity, m	*1.7*	*2.25*	*1.95*	*2.8-2.9*	*4.3*
Crew, people	243	130	89	54	127

There is a constant growth of displacement: icebreakers are gaining weight. However, the increase between the main projects 1052.0 and 2222.0 is already small — only 1.14 times, but the increase in power on the shafts is more significant — 1.22 times. Moreover, this power increase is not used to increase speed — it increased by only 1.06 times, which is significantly lower than the calculated coefficient — the increase in power was used to significantly increase icebreaking capability — by 1.24–1.29 times. This indicates not only quantitative, but also qualitative growth in the development of nuclear icebreakers, which suggests an increase in the efficiency of the technologies used. The same growth of efficiency is evidenced by a noticeable increase in the degree of mechanization and automation in management: 54 crew members on the icebreaker 2222.0, which is more than 2 times less than on the project 1052.0 with an increase in dimensions and displacement.

[2] Compiled by the author.

Judging by the known and publicly available performance characteristics, in the case of the nuclear icebreaker of the new project 1051.0, the matter is not just a new series of icebreakers (2222.0), which will be built at least until 2230, but a fundamentally new class of nuclear icebreakers — almost twice the size of the previous ones, and capable of passing through ice 4.3 m thick. The issue is the separation of two subclasses of nuclear icebreakers — conventional and heavy. It is obvious that heavy icebreakers are going to be used in cases and on routes with thick ice, significantly expanding the logistics capabilities on the NSR, and their width has been increased to guide larger-tonnage vessels. Their use will increase the range of wide-hull vessels sailing along the NSR. By the way, the unification of the internal structures of icebreakers is increasing, which reduces construction and operation costs. The new nuclear reactor “Rhythm-200” is particularly indicative in this respect.

Relationship between the dynamics of the nuclear icebreaker fleet and cargo turnover of the Northern Sea Route

Nuclear icebreakers are not a goal in themselves; their task is to ensure ice navigation of ships along the NSR, the profit from the operation of which is one of the important factors in the development of the Arctic [4, Liu M.].

The NSR began to be used in 1933[3]. An independent task in this study was to create the most complete picture of the dynamics of cargo traffic along the NSR, presented in Table 2:

Table 2

Dynamics of cargo traffic along the Northern Sea Route in 1933–2022. [4]

Year	Cargo, mln t	Year	Cargo, mln t	Year	Cargo, mln t	Year	Cargo, mln t	Year	Cargo, mln t
1933	*0.13*	1934	No data	1935	No data	1936	No data	1937	No data
1938	No data	1939	No data	1940	*0.35*	1941	*0.165*	1942	No data
1943	*0.289*	1944	No data	1945	*0.444*	1946	*0.412*	1947	No data
1948	No data	1949	No data	1950	No data	1951	No data	1952	No data
1953	*0.506*	1954	No data	1955	No data	1956	No data	1957	No data
1958	No data	1959	No data	1960	No data	1961	No data	1962	No data
1963	*1.264*	1964	*1.399*	1965	*1.455*	1966	No data	1967	No data
1968	No data	1969	No data	1970	*2.98*	1971	*3.032*	1972	No data
1973	No data	1974	No data	1975	No data	1976	No data	1977	No data
1978	No data	1979	No data	1980	No data	1981	*5.005*	1982	No data
1983	No data	1984	No data	1985	No data	1986	*6.455*	1987	*6.7*
1988	No data	1989	No data	1990	*5.5*	1991	*4.804*	1992	*3.9*
1993	No data	1994	No data	1995	*2.2*	1996	*1.8*	1997	No data
1998	*1.458*	1999	No data	2000	*1.6*	2001	*1.7*	2002	*1.5*
2003	*1.6*	2004	*1.65*	2005	*1.9*	2006	*1.956*	2007	*2.15*
2008	*2.1*	2009	*1.7*	2010	*2*	2011	*3.111*	2012	*3.6*
2013	*3.93*	2014	*3.982*	2015	*5.392*	2016	*7.47*	2017	*10.691*
2018	*19.6*	2019	*31.5*	2020	*32.97*	2021	*34.85*	2022	*34.034*

[3] Starodubtsev V. Shiroty vysokoy vazhnosti [Latitudes of high importance]. Kommersant, no. 53 (6047). March 29, 2017.

[4] Compiled by the author. Source: Severnyy morskoy put' [Northern Sea Route]. Rosatomflot. URL: http://www.rosatomflot.ru/o-predpriyatii/severnyy-morskoy-put/ (accessed 14 February 2023); Rosatom; Kalashnikov M. Sevmorput': ot deklaratsiy — k deystviyu! [Northern Sea Route: from declarations to action!]. URL: https://m-kalashnikov.livejournal.com/3443.html (accessed 14 February 2023).

Cargo traffic, which had gained momentum in the pre-war years, decreased during the Great Patriotic War. After the war, cargo traffic first slightly decreased due to economic recovery and then began to grow. But only the commissioning of the first nuclear icebreaker in 1959 significantly and rapidly increased this figure. The growing number of nuclear-powered icebreakers made it possible to significantly increase cargo turnover. The peak of transportations with a fleet of 4 nuclear icebreakers (they were assisted by 18 diesel sea icebreakers - also the peak number of diesel icebreakers, and only now this value has been restored again [5, Aleksushin G.V.]) was in 1987. Then, before the collapse of the USSR, the growth dynamics of cargo transportation along the NSR decreased, and by 1991, the traffic with 6 nuclear-powered icebreakers was already less than with 4 ones. The USSR leadership headed by M.S. Gorbachev failed to use the NSR effectively. After the collapse of the USSR in 1991, this process accelerated (although the NSR was opened to foreign ships in 1991, and a powerful increase in cargo traffic should have been observed), and it reached a record minimum by 1998, despite the fact that the fleet of nuclear icebreakers became even larger in 1992 — 7 units. This created an illusion that there was no need for a nuclear icebreaker fleet, and its replenishment was not taken care of for a long time.

In 2000–2009, there was a stabilization of the volume of cargo flows on the NSR; a slight increase in traffic occurred in 2003–2008 — from 1.6 to 2.1 million tons. But then the global economic crisis began, reducing cargo traffic to 1.7 million tons.

Most likely, the creation of FSUE Atomflot in August 2008 played an important role in the further growth of the nuclear icebreaker fleet and its provision of transportation.

Since 2009, a gradual growth began, rapidly gaining momentum. By 2011, the Russian Federation reached indicators comparable with 1971, and in 2015 — with 1981. The need to restore the nuclear icebreaker fleet to its previous volumes was realized, and in 2013 the lead nuclear icebreaker of the new series was laid down [6, Lasserre F.].

In 2016, the Russian NSR traffic exceeded the Soviet figures, but the number of nuclear icebreakers decreased to 5 vessels. In 2020 and 2021, due to the pandemic, the growth in flows decreased, but remained. Sanctions pressure on Russia in 2022 slightly reduced cargo traffic. The prospects seem much more profitable — there are plans to increase cargo flows to 80 million tons [7, Zelenkov M.Yu.].

A comparison of the dynamics of the nuclear icebreaker fleet development and the volume of cargo traffic along the NSR is presented in the diagram in Fig. 2:

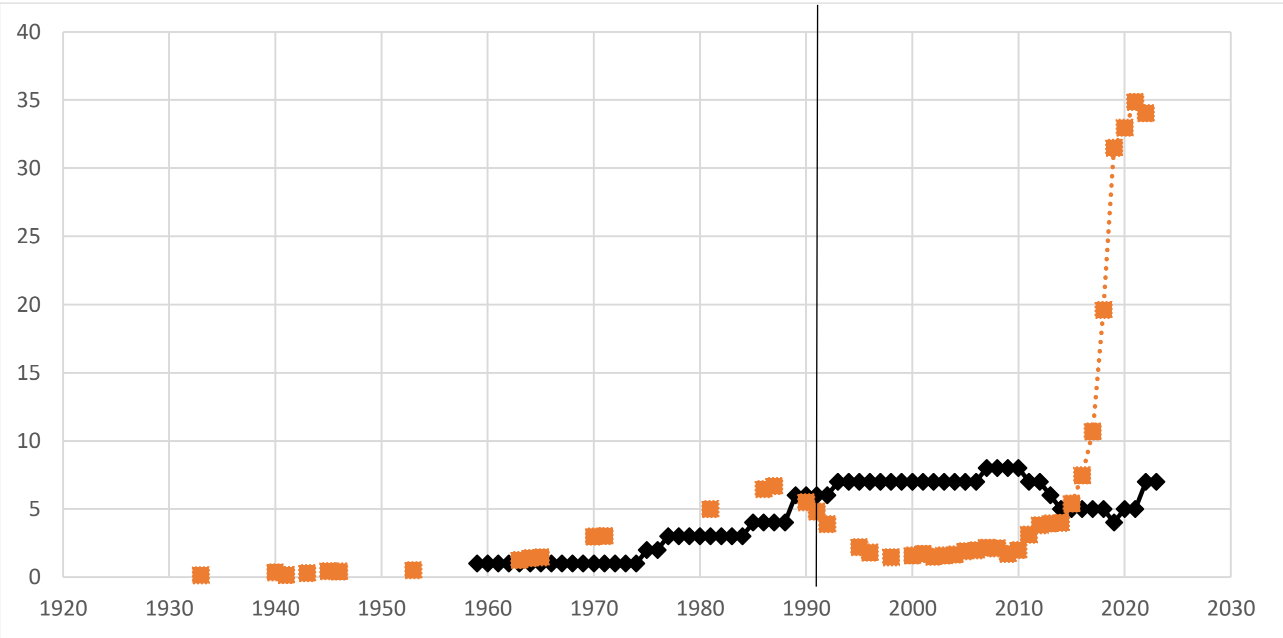

Fig. 2. Comparison of cargo traffic on the Northern Sea Route and the nuclear icebreaker fleet [5].

The diagram compiled by the author clearly shows how many opportunities were missed from the late 1980s to the early 2000s due to problems with the Russian economy. It is also obvious from the chart how poorly the NSR was exploited during the Soviet era.

Conclusion

In summary, it should be noted that due to the collapse of the USSR in 1991, the Russian Federation, in the process of building nuclear icebreakers, was forced to almost repeat the path already taken. Now it is at the point of furcation, after which, at the proper pace, we can significantly and qualitatively surpass the achievements of the USSR in the development of the Arctic and operation of the Northern Sea Route with the help of a nuclear icebreaker fleet. Unique positive trends have emerged: the development of a second shipyard for nuclear icebreakers (SBC Zvezda), the division of nuclear icebreakers into 2 different subclasses — conventional and heavy. The degree of mechanization and automation in the management of icebreakers is significantly increasing, as a result of which two icebreakers are controlled by fewer sailors than previously. The thickness of the ice to be overcome (which expands the navigation area and duration) and the power plants' capacity, their compactness and replaceability are increasing. The class of cargo ships under construction for high latitudes is growing: Arc7 ice-class ships are being built. As their number increases, it is also necessary to develop the Arc8 and Arc9 ice classes, which have not been developed by Russia. In total, 12 nuclear icebreakers have been built in the USSR and the Russian Federation from 1959 to the present day, 4 ones are under construction and 2 ones are being prepared for laying down. Domestic nuclear icebreakers indicate a very high level of technical thought and production capabilities of Russia, since only Russia builds nuclear-powered icebreakers — no other country in the world has built such vessels. Of course, it can be said that no

[5] Compiled by the author.

other country in the world has ever had the economically justified task of providing year-round navigation, but this is not true: in addition to Norway, Finland, Iceland and Great Britain, Canada, which needs these capabilities the most, has been striving for this level for a long time. The United States also has a small icebreaker fleet, which they plan to strengthen. But so far these states have not gone further than heavy diesel icebreakers. In addition, it is necessary to take into account the decrease of ice cover area around the North Pole, which strengthens the tendency to transport use of the Arctic Ocean and surrounding seas. And the rapidly growing indicators of cargo turnover of the Northern Sea Route, in which the icebreaker fleet is directly involved, are obvious. The only pity is that tourism opportunities on nuclear icebreakers are being reduced [8, Aleksushin G.V.] — "50 Let Pobedy" will be decommissioned sooner or later, and the rest of the Russian icebreakers for tourists are diesel ones.

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