CONTRADICTIONS IN THE RUSSIAN SPACE PROGRAM: CHANGING PRIORITIES DURING THE ECONOMIC CRISIS

Nikolay A. Ganichev, Igor E. Frolov

Institute of economic forecasting of the Russian academy of sciences, 117418 Moscow, Nakhimov avenue, 47, Russia

Abstract

Discussion on the financing of new Federal Space Program (FSP) of Russia on 2016-2025 revealed a number of inconsistencies in the goals and tasks of aerospace industry development. Due to the downturn in the Russian economy (devaluation of the ruble, imposing international sanctions, and so forth), the amount of finance of the FSP has been reduced by approximately 30% in relation to the original inquiry. This has been achieved by rescheduling the implementation of some high-cost projects for the period after 2020 with the intention of resuming its funding later in full volume. However, with the expected inflation rate, the actual funding gap in the FSP in 2016-2020 may amount to approximately 60% of the required funds. Furthermore, the cost of implementing the projects on hold will increase considerably after 2020 due to the necessity of recovering the scientific and technological infrastructure of the projects that will be regressing as a result of underfunding. Consequently, if the Russian Space Agency does not change the priorities of the FSP, that might lead to abandon a much larger number of promising long-term projects. This will adversely affect the long-term prospects of the Russian space industry and the retention of its leading position in the global market.

Key words: *innovation, high-technology, space, Russian Space Program, financing of innovation*

The guided missile and space industry (GM&SI) is one of the few high-tech industries where Russia has retained a number of places as the world leader, primarily due to strong demand for the services of sending payload into orbit, using relatively inexpensive and reliable Russian launch vehicles. The space industry has always been one of the most centralized in terms of management and depended on government funding. Moreover, in recent years, international cooperation has started to play a significant role in the development of the GM&SI (placing foreign satellites into orbit, delivering crews and cargo to the ISS, cooperation on the joint Russian-French project "Soyuz-Kourou", deliveries of the Russian RD-180 engines for the American missile Atlas, etc.).

However, many international projects could be jeopardized by the political conditions that have changed dramatically in 2014–2015 (Bendikov A., Ganichev N. 2015). In addition, the Russian government was compelled to significantly reduce the funding program of the GM&SI in the long term because of the general deterioration of the economic situation in Russia, while starting a large-scale institutional reform of the sector at the same time. All this creates significant risks for the development of the GM&SI, some of which will be examined in this paper.

Over the period 2000–2014 the Russian GM&SI managed to maintain a high level of competitiveness and leading position in the market for the launching of spacecraft (SC). The average annual growth rate of marketable products of the GM&SI (including the delivery of spacecraft, as well as military products) in 2000–2014 amounted to approximately 12 %, while the total production of marketable products increased by almost 4.7 times for this period (see figure 1).

Throughout this period Russia retained the leading position in the number of rocket launches (over 40 % of the total number of starts) and spacecraft placed into orbit. Russia has also been launching more and more of its own satellites but their share in the total number of satellites launched over the past few years has decreased. Summary data on the number of Russian space-launch vehicle (SLV) and the placing of spacecraft into orbit are presented in table 1.

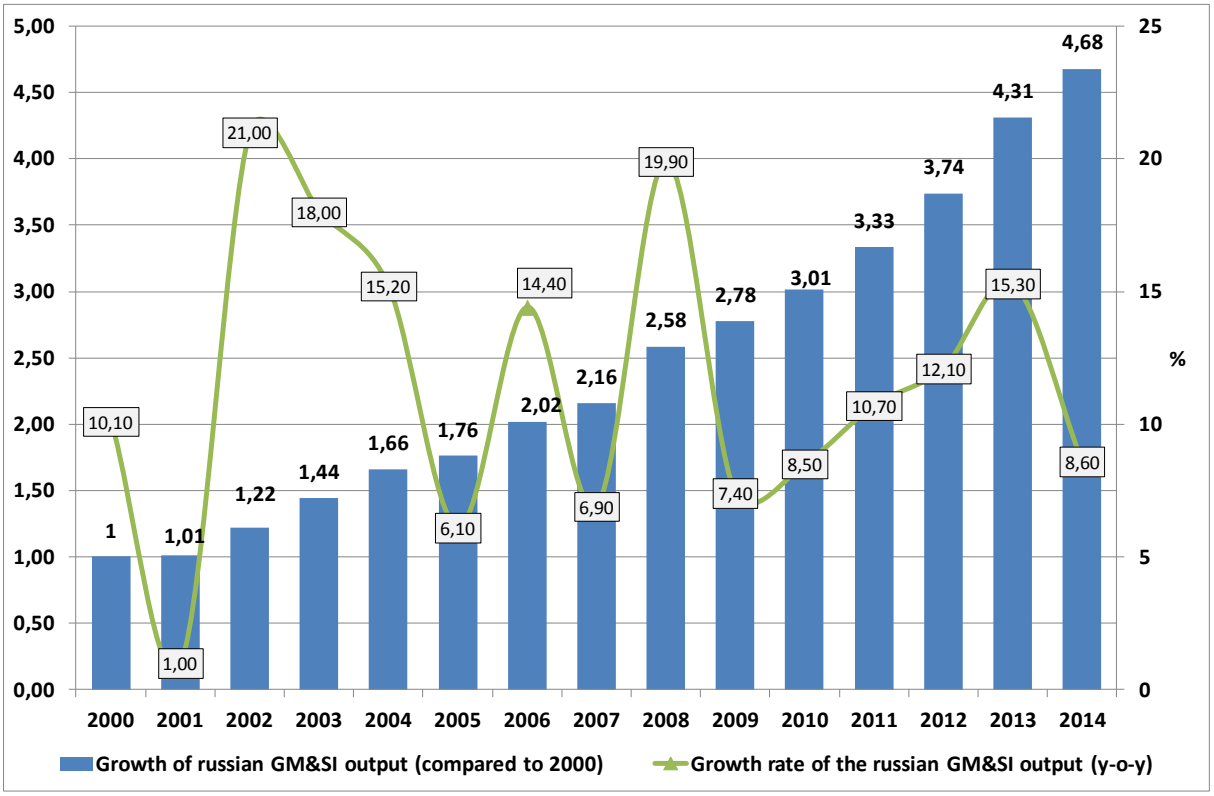

Fig 1. Dynamics of the Russian GM&SI output in 2000–2014 (Source: Ministry of Economic Development of the Russian Federation)

Table 1. Data on the number of launches and spacecrafts placed into orbit between 2005–2014.

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
The total number of SLV launches (including failed launches), PCs.	55(3)	62(3)	68(3)	69(2)	78(4)	74(4)	84(7)	76(2)	82(4)	92(2)
The total number of russian SLV launch (including failed launches), PCs.	30(3)	31(2)	27(2)	32(5)	33(1)	31	35(5)	29(1)	35 (2)	37(1)
The share of Russian SLV in the total number of launches, %	*54,5%*	*50%*	*39,7%*	*46,4%*	*42,3%*	*41,9%*	*41,6%*	*38,1%*	*42,7%*	*40,2%*
The total number of spacecraft placed into orbit (including accident losted vehicles)	72(3)	122(19)	113(3)	104(4)	123(3)	118(6)	131(7)	135(1)	212(6)	243(31)
The number of spacecraft placed into orbit by **a Russian SLV. PCs****	42(3)	48(18)	51(2)	48	50	43(3)	63(2)	40	92(4)	101(1)
Share in the total number of spacecraft placed into orbit,%	*58,3%*	*39,3%*	*45,1%*	*46,1%*	*40,6%*	*36,4%*	*48,1%*	*29,6%*	*43,4%*	*41,5%*
The number of produced in Russia spacecraft putted in the orbit,PCs.	21(1)	27(1)	17	21	30	26(3)	26(2)	22	31(3)	41(1)
Share in the total number of spacecraft placed into orbit,%	29,2%	22,1%	15,1%	20,2%	24,4%	22%	19,8%	16,3%	14,6%	16,8%

Source: Federal Space agency of the Russian Federation; TS-VPK. http://www.vpk.ru/cgi-bin/uis/w3.cgi/CMS/Item/index

* Taking into account the launch of the Russian-Ukrainian rocket "Dnepr" and "Zenith" (Sea Launch), and "Soyuz ST B", launched from Kourou.

** Including satellites placed into orbit by a Russian rocket launched by Sea Launch program and Arianespace Co. from Kourou launching area.

The achievements of the GM&SI are largely attributable to the production and technological stock built up during the Soviet period. However, there are a number of factors that have also contributed to the sustainable development of the industry. Unlike most other high-tech industries, the GM&SI has enjoyed increased support from the state. Even during the most difficult crisis years Russian Space Agency has always maintained their projects and kept the Federal space program (FSP) of Russia, federal target programs (FTPs) "GLONASS" and "Development of Russian spaceports" fully funded.

In addition, the apt organizational structure of the industry has also contributed to the successful development of the GM&SI. Unlike other high-tech engineering sectors there were already some holding type integrated structures (IS) by the mid-2000s operating in the space sector, and further reform of the industry was conducted by way of expansion and development of these existing structures. It is this property, integrated structures was able to operate independently on the domestic and foreign markets, to use the possibility of further consolidation of resources which had a positive impact on their economic sustainability.

The expansion of international cooperation was an additional factor contributing to the successful development of the GM&SI, especially in the period from 2009 to 2013. There are 16 countries (including the US) involved in the ISS program, that are actively using Russian space-launch vehicle and attracting Russian companies to cooperate. From 2012 to 2020 the United States alone were expected to allocate about USD 3.5 billion for contracts with Russian space companies (The Commercial Space Transportation: 2013).

It was expected that through the participation in the operation of the international space station RSC "Energy" and other Russian companies were about to at least double the volume of production of space technology that performed launch services for the ISS until 2020. In recent years, the Russian-French commercial project "Soyuz-Kourou" was developed and within the framework of this project launches of the upgraded rocket "Soyuz-ST" are made from the launch complex at the spaceport at Kourou in French Guiana. The project has 60 launches scheduled for the carrier rocket “Soyuz-ST” from the Kourou launching area over the next 15 years, which will increase the volume of the contracts with Russian GM&SI companies to approximately USD 2.5 billion (The Space Economy at a Glance 2014).

According to another international contract, implemented within the framework of a joint program of NPO Energomash V. P. Glushko and the American corporation Lockheed Martin, Energomash was to supply the USA with 50 RD-180 rocket engines to be installed on the upgraded Atlas launch vehicles. The deal of Energomash with Lockheed is estimated at USD 500 million. (Gruss M. 2015) There are other examples of successful cooperation between Russian space companies and foreign partners.

However, in 2014–2015, the situation for the GM&SI changed dramatically due to the imposition of sanctions against Russia; many international projects have been put in jeopardy. For example, since 2017 NASA plans to abandon the Russian services for the delivery astronauts to the ISS and used for these purposes, a manned spacecraft (Sokolov, I. Terentyev 2014).

In addition, the industry is undergoing another large-scale institutional reform, which although has good intentions will in practice only disrupt the current (though not perfect) system of the industry and inhibit the start of work on a number of promising projects. The main negative factor could be a significant reduction in funding for the GM&SI for 2016–2025, which will take place against the background of the economy crisis.

At the end of 2014 Russian Space Agency determined the volume of financing for RSP for 2016–2025 at 2.436 trillion rubles (in prices of 2014). The program entails a very ambitious and large set of activities and research projects. So, it includes the development costs and the creation of extra-heavy rockets for launches from Russia's new Vostochny cosmodrome, the development and testing of a new manned spacecraft, a new unmanned spacecraft for various purposes (communication satellites relay,

navigation, remote sensing), the commissioning of an automated system of impact on asteroids, comets and debris, the creation of prototypes of various cargo transportation and manipulation machines for a prospective landing on the Moon, and much more, up to development of a "robot astronaut" which will have to help the crew of the ISS during spacewalks (Safronov I. 2014).

The implementation of the program would allow Russia to retain a leading position in several areas of space exploration. However, by the beginning of 2015 it became clear that, given the projected rate of inflation under the changed economic conditions, the cost of many items of this program could increase and the amount demanded by Russian Space Agency would increase to up to 2,849.4 trillion rubles at 2015 values. At the same time, instead of increasing subsidies as part of budget cuts, RSP was subjected twice to strict sequestration. At the end of 2014, the Ministry of Finance of the Russian Federation approved a budget of 2,117.3 trillion rubles for the RSP. The final version of the drafted program that was adopted in the spring of 2015 saw the limits of its budget funding reduced to 2,004 trillion rubles. (Chernov A., Sidorenko M. 2015)

However, Russian Space Agency has no plans of giving on realizing the majority of their projects stated in the original version of the program. Its implementation will simply be transferred to the period 2020–2025, the reduction in funding for the program now (during the crisis) should allow them to save to more important programs, and the economic growth after 2017 is expected to help make up for lost time. However, this approach is not very realistic. The effect of the reduction of funding for many R&D programs at an early stage can consequently lead to a much stronger rise in costs, as well as a shift of the results of such research and development over time. This effect is observed both because of inflation and because of the need to restore the scientific-technological infrastructure of the projects, which will degrade. As a result, long-term total cost of RSP 2016–2025 will increase much more than the maximum amount of requested funds laid down in Russian Space Agency plans.

Based on the directions of officially conducted sequestration of RSP, one can conclude that funding will mostly be reduced in the development program of heavy launch vehicles and means of remote sensing. Moreover, a part of the funds obtained as a result of the reduction of the program funds will be directed to the creation of advanced basic products and communications.

Table 2. The structure of sequestration costs of Russian RSP (comparison amended end of 2014 and beginning of 2015), billion rub.

	First edition of the RSP (2014)	Changes in the volume of financing	Second edition of the RSP (2015)
R&D, at all	1483,4	-63,4 (-4%)	1420
Manned flight	402,9	15,4 (+3%)	418,3
SLV	398,3	-139,52 (-35%)	258,78
Programme management	42,9	-3,21(-7%)	39,69
Promising basic products	222,5	70,51 (+31%)	293,01
R&D	60,6	2,4(+4%)	63
Communication satellites	70,1	19,89(+28%)	89,99
Earth Observing satellites	153,6	-20,97(-14%)	132,63
Fundamental space research	132,5	-7,9(-6%)	124,6

Source: Federal Space agency

However, the RSP will face a much more radical reduction and withdrawal of a number of research areas. All the most expensive and long-term projects will be likely delayed or excluded from the RSP. The fact is that the valuation of the program activity costs carried out by the Russian Space Agency was initially greatly underestimated. To explain this one must consider the cost of activities of the RSP at current values taking into account the projected inflation rate of the RF Ministry of Economic Development. Given the forecasted deflators (Economy Ministry of Russia 2014) to fully satisfy all requests from Russian Space Agency , 3,804.8 trillion rubles at current values should be allocated to the RSP.

However, the analysis of the real rise in prices for the products of engineering industry showed that, for the period from 2000 to 2014 deflators predicted by the MED appeared to be lower by an average of 1.5-3 % than the actual increase in prices for the products of relevant product groups. Assuming that the trend of underestimating the actual rate of inflation will continue in the forecasted period from 2016 to 2025, it is possible that a more realistic assessment of the rate of price increases and the final cost of the activities of the RSP with the adjusted deflator measures the real value of the RSP until 2025 can be estimated more than 4.25 trillion rubles at current values. Moreover, since the limits of the budget funding for the program will be based on the official forecasts of the MED, resulting from underestimating inflation shortfall will not be covered quickly. Fig. shows a comparison of requests from the Russian Space Agency, the assessment of the real value of the RSP and limits of budget financing assigned for it at current prices, as well as the financing gap of the RSP on year-by-year basis.

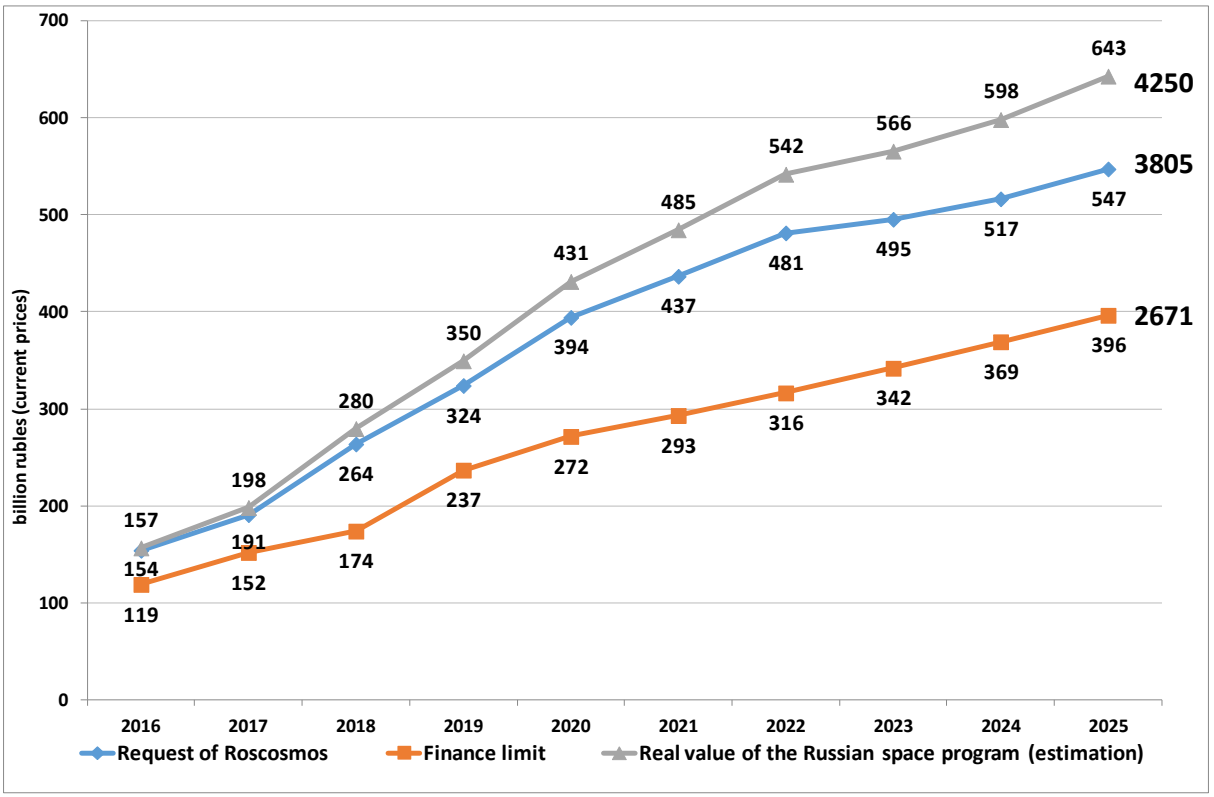

Fig. 2. Estimation of the real value of the activities of the RSP and the lack of financing on the basis of limits of funding defined by the RF Ministry of Finance.

Thus, the implementation of all the measures laid down in the RSP will require about 60 % more than the defined limits of budget financing. This means that for the execution of all the activities of the RSP, funding for the program should amount to above 3.18 trillion rubles in 2015 values. So, it is apparent that a part of program activities simply cannot be performed. Thus, instead of launching 212

spacecraft, initially scheduled in the RSP, only 181 launches can be performed with the allocated budget limits (...). But what will suffer the most from long-term under-funding will be the promising research projects. R&D for a nuclear tug will be excluded from the program list, which is one of the most promising Russian projects and could become a really exclusive development and a significant contribution of Russian specialists in global international projects for development of the moon and flights to Mars[1]. Given the shortage of 60 % of funds, all the works on the project, except the development of propulsion system and samples of power sources, required for realizing the range of parameters required for it were excluded from the RSP. In fact, the remaining R&D in the program in this area involves the creation of one-time power of applied satellites (to provide a power supply to satellites in orbit), but its use in manned flights or directing interplanetary stations in the long-term mission seems impossible.

The lunar program has significantly been shortened and simplified (the plans for the project "The moon soil" which was implemented jointly with the European Space Agency have been postponed until after 2025). In addition, funds are not sufficient for the development of the landing of the lunar module, so it was officially announced that a manned mission to the Moon would be delayed to sometime after 2030.

The timeframe on some Martian program has also "shifted to the right". The development of complex astrophysical research in millimeter, submillimeter and infrared bands of the electromagnetic spectrum has been excluded. The program of a study of the sun at close range with a series of devices "Intergelio-Probe" has been curtailed. The program to conduct biological experiments in space has been strongly curtailed. The RSP also had to abandon project financing for the creation of super-heavy launch vehicle, the forced variant SLV "Angara A5" will instead be developed (Federal Space agency 2015).

In general, due to the lack of funding of the RSP, it was necessary to exclude the majority of long-term research projects, which were scheduled to resume after 2020. Now the saved funds will be directed to a simple short-term program, where there is stock that already exists and one can get a real result by the end of the program in 2025.

The main result of the program should be creation of a Russian orbital station, based on the Russian segment of the ISS, remaining in orbit after the completion of the International Space Station. At the same time it was decided to abandon the idea of creating of a free module OKA-T, which would carry out various experiments in automatic mode, and dock to the International Space Station only to serve man, loading / unloading of samples and results.

In addition, the RSP will focus on the creation of a universal manned transport spacecraft of a new generation (MTS NG), which will have to make flights in low-Earth orbit (including transport and evacuation to the space station) and the Moon (including as a part of a possible future lunar-landing expeditionary complex). As scheduled, an unmanned launch of the PTK NP into orbit will take place in 2021, the unmanned launch to the ISS in 2023, a piloted launch to ISS by 2024 and a manned flight around the Moon in a new MTS NG is planned for 2025.

However, given the lack of funding we can already say with certainty that the terms of implementation of these plans will be postponed. In addition, all planned projects, including the SLV "Angara" and the MTS NG have unsuitable performance characteristics for commercial launches, which are now one of the main sources of income of the Russian space industry. However, the RSP is involved in phasing out of the operations of launch vehicles and spacecraft "Soyuz" and "Progress", which are well established as an inexpensive and reliable means of launching satellites into orbit. All this may lead to a reduction in income of the Russian GM&SI enterprises from commercial activities and further aggravate their situation.

In addition, the new Russian MTS NG will be a direct competitor of several similar American vessels (primarily the "Orion"), and it's not necessarily true that Russian developers will be able to provide it

[1]Nuclear tug – a system of powerful electric rocket engines (ERE), powered by a nuclear reactor. It can be used to output the payload into normal geostationary orbit, as well as transport cargo to a lunar orbit and back.

with any significant competitive advantages. In addition, the manned launch by a family LV "Angara" has not been possible so far because of security problems, and the operational development of this family of SLV to get ready for manned launches of the MTS NG may take longer than planned.

As a result, the approach associated with the abandonment of long-term R&D in favor of simpler projects, based on increased R&D funding after the end of the economic crisis, cannot justify itself. Firstly, due to the high growth rates for the basic components and materials, and underreporting of estimated deflators laid out in the RSP, the resumption of research on frozen programs for 2020–2025 may require 10–20% more funds than is forecasted by Russian Space Agency. To unfreeze projects and successfully bring them to fruition will require a lot more money than could be spent in the coming years on the creation of scientific and technological potential of R&D in these areas.

Secondly, even if we can provide additional funding in the amount needed after 2020 the loss of time at the initial stage of research can no longer be compensated. The development of a satellite takes an average of 5 to 7 years and it will be impossible to reduce this period by more funding.

In addition, if the most complex research projects are frozen, the degradation of these research teams will take place and it is impossible to estimate the time and resources required for their reconstruction even approximately.

Thus, the priorities laid down in the latest version of the Russian RSP look ambiguous. To save its position in the global market space and the further participation of Russian companies as equal partners in long-term international projects for the development of outer space, the adopted RSP is not realistic. Given the sharp reduction of budgetary financing limits it would be appropriate to retain the already well-established spacecraft and SLV family of "Soyuz" within the program of support. This will not only enable saving money, but also to continue to receive income from the exploitation for commercial purposes within the framework of international cooperation. In addition, the concentration of financial resources in long-term perspective projects related to breakthrough technologies in which Russian scientists have a unique experience and groundwork looks promising.

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