India-Russia Space Cooperation: A Way Forward

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TAKSHASHILA DISCUSSION DOCUMENT 2021 - 7

V1.0, 13 October 2021

Executive Summary

India - Russia space cooperation in the past includes the USSR launching India's first few satellites, Rakesh Sharma's inclusion in a manned Soviet mission, and Russia's sale of cryogenic engines for India's Geosynchronous Satellite Launch Vehicles. Currently, India-Russia space cooperation is largely limited to NavIC-GLONASS ground stations and Global Navigation Satellite Systems (GNSS)–Indian Regional Navigation Satellite System (IRNSS) augmentation. Glavcosmos, a subsidiary of the Russian state space company ROSCOSMOS, is also providing commercial services to India's human space flight mission Gaganyaan.

Russia is pursuing the development of a potential deep space mobility platform, a nuclear space tug called "Zeus" that can significantly shift the course of human space exploration worldwide — which could hold potential for new India-Russia collaboration in space. India has historically been able to harness much needed know-how and technology for its space industry by closely co-operating with Russia. Given the right impetus, it can continue to do so today.

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Introduction

Political and Geostrategic Context

India today is increasingly moving towards indigenisation in all strategic sectors.[1,2] However, some high-tech technologies are not easily mastered, and international cooperation is the only way forward until self-sufficiency can become a reality. India has significantly diversified its international cooperation in the field of space exploration, as indicated by the over 250 documents it has signed with 59 countries.[3] However, extensive cooperation projects seem to be limited to Russia, the United States (US), Japan, the European Space Agency, France, and Israel.[4,5,6]

India has often chosen to make purchases from both the US and Russia based on what serves its capabilities and interests better. For example, India placed orders for Russian S-400 air defence systems over analogous US systems. Similarly, India chose to lease and potentially buy US–supplied advanced MQ-9 family UAVs.[7,8]

However, such an approach can also lead to concerns about reliability. It is very plausible that despite existing cooperation, India may be denied access to some sensitive features of key technologies because sellers fear these may be compromised or leaked to adversaries that are also suppliers to India. The reliability concerns also apply to other partners like France, Israel and Japan, as they too might pragmatically prioritise their national interests over the depth of their partnership with India.

The US

Many of India's high-tech and military interests were set back significantly in the late 1990s and early 2000s because of sanctions imposed on it by the US.[9,10] In recent years, with China's rise, the US has pivoted to courting India as its "lynchpin" in the Indo-Pacific.[11] With this new elevated "lynchpin" status comes increased access to US technology, hardware, and strategic data streams. These include the Earth Observation and Space Situation Awareness data/geospatial imagery banks from the US's National Reconnaissance Office and other agencies, among others.[12]

These data streams, apart from being useful for reconnaissance, also have the potential to vastly improve the accuracy of India's missile arsenal and other long-range fires.[13] Furthermore, US–origin Signals Intelligence, Reconnaissance and Maritime Patrol platforms like the Boeing P-8i also provide superior capabilities compared to their recently-decommissioned Soviet-origin counterparts.[14]

However, even today, there is a risk that the US might impose sanctions on India under the Countering America's Adversaries Through Sanctions Act (CAATSA) for purchasing advanced Russian military hardware like the S-400 air defence system.[15]

Russia

Apart from the S-400 purchase, there are still many strategic areas where Russia has been able to retain its place as a crucial strategic partner for India by supplying irreplaceable technology, hardware and services to the military and other government departments.[16] The best example is Russia's willingness to provide nuclear-propelled attack submarines on lease to the Indian Navy. It has also provided significant help in the development of key technologies for India's indigenous nuclear submarines, especially for their onboard nuclear power plants.[17,18]

The P-800 Onix-derived cruise missile BRAHMOS is another successful joint R&D project that India and Russia have pursued together.[19] The Indian Space Research Organisation (ISRO) has also benefited from Russian cooperation. Russia has also conducted the training and certification of India's first batch of spacefarers. Their equipment, including custom space suits and life support systems for the Gaganyaan-I spacecraft is also to be supplied by Russia.[20]

China

As India's main strategic rival and a quasi-ally to Russia against their shared adversary — the US — China has emerged as a serious contender in the global high-tech space. Within the last few decades, China has undoubtedly developed the wherewithal to undertake complex scientific, military and commercial endeavours.

The most visible progress is in China's defence technology manufacturing and space industry, with milestones like the J-20 fifth generation fighter jet, the Change-5 lunar sample return mission and the Tianhe space station module.[21,22,23]

China's continued dominance in the global Rare Earth Element supply chain and its efforts to develop a substantial silicon chip manufacturing base is evidence that today, China is striving to present itself as an alternative in a largely US–dominated global order.[24,25]

The Past

The former Soviet Union aided the Indian space programme several times during the Cold War. It launched India's first few satellites, including Arybhatta-I and Bhaskara-I and II.[26,27,28] Rakesh Sharma, the first Indian spacefarer, was a part of Soyuz T-10 and T-11 missions which took and returned Cosmonauts to and from the Soviet space station Salyut 7.[29] More recent examples of bilateral cooperation are listed below.

Russian–origin Cryogenic Engines on GSLV MK-I

For many years, the existence of India's heavy-lift Geosynchronous Satellite Launch Vehicle (GSLV) rockets, which enable ISRO to fly payloads to geosynchronous orbits, was only possible because of Russian–supplied cryogenic engines.[30] However, India was unable to receive a Transfer of Technology (ToT) from Russia after the US interpreted it as a violation of the Missile Technology Control Regime (MTCR) and imposed sanctions on the Russian commercial space company Glavkosmos.[31]

The seven cryogenic functional units and one ground demonstrator unit supplied by Russia to ISRO were used for the GSLV MK-I. They became the seeds from which India developed the GSLV MK-II and III's home-grown cryogenic stage. Russia, for its part, is strongly against reshaping MTCR into a strict sanctions regime and prefers to make decisions on technology and equipment export independently at the national level.[32]

Luna-Resurs

India-Russia lunar cooperation in the Luna-Resurs project did not become a reality because of significant delays in the Russian state space agency ROSCOMOS's schedule for lunar exploration missions. These delays were in turn affected by the Phobos-Grunt mission's failure (which never reached its intended destination, Mars's moon Phobos, and failed after launch).[33] India's strategic space exploration goal was to be competitive with China, and the delay in the Luna-Resurs became untenable if ISRO was to keep up with Chinese advances in lunar exploration.

The Present

India and Russia are likely to continue their cooperation for even more ambitious follow-on projects to the Gaganyaan crewed mission. These are apparently aimed at a sustained human presence in orbit, including an Indian space station.[34,35] According to Times of India reporting, ISRO chose Russia and Glavkosmos as the vendor and service provider for crucial elements of its Human space Flight Missions for reasons of familiarity with their infrastructure and past dealings of Indian institutions like the Indian Air Force (IAF). IAF pilots will undergo cosmonaut training in the IAF-run Institute of Aerospace Medicine.[36]

Russia and India are also setting up ground stations for their satellite navigation systems, GLONASS and NavIC respectively, in each other's territory.[37] These ground stations will enable both countries to improve the accuracy of their systems for many important civilian applications: global navigation satellite systems like GLONASS, and their regional counterparts like NavIC, need augmentation and interoperability to deliver a seamless experience without signal loss or compromising on accuracy.

India has also reportedly emerged as a supplier for some GLONASS chipsets.[38] It is not clear if the production of the chipsets would be by Indian companies, by the Indian Government, or any of India's Public Sector Undertakings (PSUs). However, the Centre for Development of Advanced Computing, under the Government of India's Department of Information technology, has earlier signed a Memorandum of Understanding (MoU) with the Russian company to become part of a non-commercial partnership called the GLONASS Union.[39] The MoU notably mentions the "organization in the Republic of India of joint production of GLONASS /GPS / IRNSS chipsets for civil users" as a key highlight.[40]

Russia has inherited much of the former Soviet Union's capabilities in outer space, albeit with significantly reduced financial resources to support them. The need for funding makes Russia amenable to monetising and commercialising many of its technologies and services, especially since it is not only competing with other national space agencies but also private space enterprises today. India has historically been able to harness much needed know-how and technology for its space industry by closely co-operating with Russia. Given the right impetus, it can continue to do so today.

The Future

India's space sector is moving towards an increasingly indigenised and sustainable environment, where new space enterprise will dominate discourse. This is in line with the broader worldwide trends of a rapidly-expanding private space sector.

However, Russia's state space enterprise is developing a potential deep space mobility platform called the Zeus TEM that can significantly shift the course of human space exploration worldwide — which could hold potential for new India-Russia collaboration in space.

Zeus

From 1969 to 1988, the Soviet Union launched 32 space objects with thermoelectric nuclear-powered engines.[41,42] Most of these objects were used for radio-electronic surveillance and had a rather short active period. The recent renewal of the Russian atomic space programme has a different rationale from these Soviet attempts. The focus now is on interplanetary missions and then eventually deep space exploration — which entails spacefaring far beyond Earth orbit into interplanetary space, and ultimately beyond the solar system.[43,44]

The Russian state space company Roscosmos has ordered the completion of the NUKLON (Nucleon) space complex, which is undergoing development by the Arsenal design bureau (a subsidiary of ROSCOMOS), since 2010.[45,46] NUKLON will likely consist of several parts including a payload module, launch and technical facilities at the Vostochny spaceport, control systems, and surface and space transportation vehicles. Most crucially, it will also include a nuclear "space tug" called Zeus.

A model of Zeus was showcased during this year's MAKS-2021 airshow.[47] Zeus is a Transportation and Energy Module (TEM),[48] commonly called a "space tug" since it is a deep space propulsion platform that can carry other spacecraft (which might carry crew and cargo). This is similar to how tugs are used to transport or position other vehicles on land or sea.

As the "Energy" in TEM suggests, the Zeus TEM is not only a space mobility platform but can also serve as a power source to power the components of deep space interplanetary missions — even with multiple stops in the solar system and perhaps beyond.

Anatoly Zak, a noted expert on Russian space activities, notes that the Zeus TEM is powered by "a nuclear reactor with an electric rocket engine. The electric propulsion systems heat up and accelerate ionized gas to create a thrust-generating jet and, therefore, are alternatively known as ion or plasma engines."[49] Such "electric engines are more efficient than traditional liquid or solid-propellant rockets" but have a high power requirement, which the Zeus TEM's "Megawatt class" onboard nuclear power plant can deliver.[50]

Endurance, Secondary Capabilities and Extendibility

Both the Zeus TEM and a payload module would probably be launched separately by Angara-class rockets with a total mass of up to 55 tonnes (of which Zeus will be not more than 35 tonnes), and will mate in space before a trip or other task.[51] Roscosmos claims Zeus would be able to deliver 10 tonnes of payload to the Moon in 200 days.[52]

With existing technology, Zeus TEM can support low-thrust, long endurance missions theoretically for decades, potentially enabling deep space travel beyond the solar system in the future.[53]

Zeus will not be the first spacecraft to be nuclear-powered, but its uniqueness lies in its versatility. It needs to be launched only once and will be able to work in space for years. This makes Zeus much more effective as a cargo ship between destination points in space than traditional solid– and liquid–fuelled space vehicles.

Apart from long-endurance propulsion, it can be used to perform counter space missions like orbital and air defence with Directed Energy Weapons (DEW), or supplying “high ground”–enabled targeting data to terrestrial missile systems.[54] The coverage would depend on the power of the onboard radar and can reach a radius of 4300 km, which is enough to secure almost all the airspace above Russia.[55]

Finally, Zeus can also serve as an in-orbit high-speed information relay, and can be adapted as a power source for other spacecraft, satellites and high-tech space objects in its range.[56]

Roadmap of Development and First Mission

Zeus TEM is the latest in the lineage of the Russian nuclear space mobility programme, which began its efforts in at least the late 90s.[57] The current versatile form of the TEM programme only started taking shape around 2004, with the Arsenal design bureau’s efforts towards designing a “nuclear-powered space tug that could host a variety of payloads”.[58] These early efforts were designated “Plazma-2010” or “UKP-YaEU” — the latter a Russian acronym meaning “Universal space Platform – Nuclear Power Unit”.[59]

Almost a decade later in 2014, the then Director General of Arsenal, Dr Andrei Romanov, remarked that the TEM was “an active project and that the platform was essentially ready for production.”[60] The same year, Romanov alluded to Arsenal taking over an ambitious project aiming to develop a Megawatt class TEM from another Russian state space entity, called the Keldysh Research Center.[61]

The primary role for the TEM programme has always been space transportation, but the versatility tertiary functions of the platform, encompassing “Earth remote sensing, space studies and the relay of signals during research of deep space” were reflected in illustrations dating back to at least 2014.[62] According to Russian state media outfit RIA Novosti, Arsenal conducted research between 2018–2019 to ascertain if Zeus can also be effectively used for high ground-enabled orbital counter space activities and communication roles, alongside its primary space tug and research roles. The research found Zeus to be fit for these additional ancillary roles.[63]

Roscosmos and Arsenal finally signed an agreement for the TEM in December 2020, which puts the initial cost at around 4.2 Billion Roubles ($57.3 Million) with a completion date around July 2024.[64,65] It is believed that the power plant for the TEM is ready and will be tested with prototypes by 2025.[66] The drip cooler-emitter system for the TEM will also be tested by 2025 onboard the International Space Station (ISS)’s Nauka module.[67] According to Russian news agency TASS, the TEM will have its first flight by 2030 and a 50-month-long complex interplanetary mission will be undertaken by it in the future.[68]

This interplanetary mission will involve three stops. The first would be an approach to Earth's moon where a spacecraft will detach. Secondly, a detour to Venus where another spacecraft will detach, and a gravity assist manoeuvre will be performed. Finally, for its last leg, Zeus will head towards Jupiter and one of its moons.

In the future, Roscosmos also expects Zeus to meaningfully contribute to the search for extra-terrestrial life beyond the solar system. [69]

Interestingly, according to a TASS report, another Roscosmos official, Alexander Bloshenko, has revealed that Russia's future orbital space station will also be based around the same principles as Zeus — nuclear power and ion engines.[70] This suggests that Zeus's success will have a much wider impact on Russian space activities than just its primary and already-versatile ancillary roles and applications.

Criticism

Some extant commentaries deride the "on paper" nature of most of the successes Zeus is envisioned as heading towards, with very little demonstrated evidence to back it.[71]

The compatibility of the Zeus project (which is a dual-use technology) with international law norms is a potentially major issue. Some states may attempt to impede Russian collaboration with India or other states on Zeus. Simultaneously, the US and EU might try to compete with the Zeus project to fulfil their own commercial interests in driving potential clients away from Russia.

Zeus's Benefits for India

1. India is mulling many ambitious manned space missions following the Gaganyaan project, and this may include a prospective future Indian Space Station.[72] Any sustained human presence will only be possible with constant resupply missions delivering payloads to the prospective Indian Space Station or other spacecraft. Zeus TEM can deliver some of these payloads by tugging Indian cargo spacecraft or contracted payload missions from other vendors.

2. India's involvement in any interplanetary space missions featuring Zeus's tug capability will serve as an opportunity for observing cargo missions under low thrust–high endurance propulsion. The experience gained through observing the complexities and logistics of the mission would further ISRO's prospects of pursuing multi-legged interplanetary missions, and then deep space missions.

3. India can diversify its payload delivery capabilities, and amplify its in-orbit logistics, by contracting the space mobility and in-orbit power source capabilities of Zeus. This can range from Indian satellites and other objects being moved to another desired location, either while being decommissioned to a graveyard

orbit or when a special situation arises where power needs to be supplied to an Indian space object.

4. India can amplify its Space Situational Awareness capabilities and avoid collisions between its space objects and others by co-ordinating or integrating communications with Russian space assets, including the Zeus space tug, which may be able to supply a unique stream of SSA data.

Zeus's Potential Downsides for India

1. India's involvement with Zeus may result in complications in the trajectory of India-US space cooperation. NASA may deny India access to key space technologies and services for fear of Intellectual Property (IP) leaks and strict operational secrecy concerns. India would ideally like to keep the door open for cooperation with other countries, including the US, for commercial space activity, human space flight and a sustained presence in space, as well as Space Situational Awareness infrastructure building and data sharing. A close cooperation with Russia may dissuade the US from extending still greater cooperation in these sectors.

2. The US or other actors may impose sanctions on India for engaging with Russia on a platform which may be classified as a space weapon in the future. This is evident from past tensions owing to US sanctions, which not only distanced India from US but also arguably strengthened India's desire to strive for strategic autonomy and non-alignment in contemporary times. However, relying on unrealistic expectations of autonomy might be detrimental to India's interests as China continues to grow closer to Russia, tilting the balance of power in the international arena against India.

3. Nuclear propulsion is not completely risk-free, as evident from the saga of the Russian Kosmos 954 satellite (which re-entered the Earth's atmosphere in 1977 and scattered radioactive debris over Canadian territory). Any potential failure in the Zeus platform could have serious consequences, sparking concerns both domestically and internationally and dealing severe blows to India's image as a competent space power.[73]

International Collaboration

According to another TASS report in July 2021 that quotes a source inside the Russian space industry, Russia will be open to joint space missions involving Zeus.[74] However, from the words of an "interlocutor" at MAKS 2021, it appears that the details of international cooperation opportunities are still being worked out and may only involve "foreign payloads".[75]

Russia's primary motivation seems to be the recouping of the high development costs by offering Zeus as a commercial ferry service.[76] This is not unlike how Roscosmos and its commercial subsidiary Glavkosmos offer their Soyuz spacecraft for space tourism, space station-bound crew replacement, or cargo resupply missions to either the private sector or other space agencies like NASA.[77]

There is less clarity on the prospects of other states funding and jointly developing the Zeus TEM instead of just being clients for the commercial space services it can provide. It is doubtful that other states will be engaged in the technical aspects of the platform, as the intellectual property has a high chance of being stolen or copied. A slight exemption could be made for China because Moscow is already helping China develop an Early Warning System with orbital components, suggesting that China may have a much closer look at the extent of Russian orbital capabilities than any other partner.[78]

However, Russia and China's servicing and operation of their Early Warning complexes will likely be independent of each other, because of the tentative nature of their alliance and because Russian nuclear forces have to take into account the existence of China's nuclear forces while maintaining credible deterrence against shared adversaries.

The MTCR on Zeus

The Missile Technology Control Regime (MTCR) addresses space launch vehicles able to deploy at least 500 kg and with a range beyond 300 km. However, it does not specifically discuss space tugs or deep space mobility platforms. The MTCR is primarily focused on preventing the proliferation of Weapons of Mass Destruction, but it is not unreasonable to assume that the dual-use nature and orbital capabilities of Zeus will be a cause of much anxiety. The Annex and Guidelines Draft also cast a wider umbrella under which platforms such as unmanned aerial vehicles (anything capable of carrying 500 kg upwards of 300 km) are also covered.[79,80] Due to the MTCR forbidding the export of production capabilities of a dual-use system, and Russia's desire to keep its newest space tug technology to itself to potentially monopolise the deep space mobility market, a transfer of technology to India is unlikely.

However, the applications in the domain of Space Situational Awareness and deep space mobility are much greater and should be the focus of Zeus's civilian uses. India should express interest in Zeus as a high-tech strategic platform. Privileged access to it can provide crucial long-endurance deep space propulsion technology to ISRO missions and potentially diversify low cost–high efficiency orbital ferry services to India's private space sector.

If Roscosmos agrees to provide India with exclusive or at least privileged access to Zeus TEM in exchange for a sum of money, it will recuperate some development and operational costs spent on the project, thus providing some relief to the stressed Russian state coffers and Roscosmos budget.[81] This could give India an opportunity to reduce Russia's dependence on China, especially on space exploration matters. It is interesting to note that India's designated total yearly budget for Space in 2021 is around $1.864 Billion and ROSCOMOS's non-military projects budget for 2020 was around $2.430 Billion, while China outclasses both "with just over $10 bn in disclosed public funding" in

2020.[82,83,84] It is clear that India's space activities are backed by much less wherewithal than Russia's. However, despite this asymmetry, India can prove to be a paying partner and collaborator on novel platforms.

Russia will likely weigh any potential revenue gained by co-operating with India against revenue and strategic benefit from cooperation with China. Thus, the influence India can expect in a best-case scenario will be incremental and will not result in a dramatic de-coupling between Russia and China, with any visible resultant wedge only emerging gradually, if at all.

Although not specifically stated anywhere, it is likely that Zeus TEM will have a spill-over role in the International Lunar Research Station (ILRS) programme that Russia and China have jointly pledged to undertake.[85,86,87] Zeus's spill-over role will likely be in the third stage, dubbed "construction", of the ILRS project, which is bound to require multiple and repeated payload deliveries to the Lunar surface.

ILRS is quickly emerging as a competing bloc to the US-led Artemis Accords and Programme.[88,89] With Russia-China ties strengthening and a heightening of the rivalry between the US and China, India can benefit from keeping its options open by engaging in high-level space cooperation with Russia.

Conclusion

Russia-India space cooperation is a very sensitive subject that is impacted by the geostrategic context, historical precedent, and relevant international agreements.

Space cooperation is a key fulcrum apart from military ties for the broader Russia-India relationship. There are several convergences in Russia's interests with China, and relations between the two have improved as a result.

The same can be said about India and the US. This has caused a limited divergence of interests between India and Russia and can be a limiting factor or obstacle depending on the nature of the specific project and its scope.

The priority for New Delhi is to balance in its foreign affairs and avoiding dependence on foreign sources and increasing indigenisation. However, there are still prospective avenues, like deep space propulsion, where India and Russia can collaborate.

Appendix

International Treaties and Agreements which may apply to India–Russia space Cooperation

- **1963 Moscow Treaty or Partial Test Ban Treaty (Nuclear Test Ban Treaty in Atmosphere, Space and Underwater):** The Partial Test Ban Treaty forbids and aims to prevent nuclear tests or explosions in outer space and other domains.[90]

- **1967 Outer Space Treaty (OST):** The fundamental treatise of international law that applies to outer space. Article IV of the treaty explicitly says that the signatory parties must not place any kind of weapons of mass destruction in outer space, including nuclear weapons. The OST forbids any military activity on celestial bodies, or their use for anything except peaceful purposes.[91]

- **1972 Liability Convention:** Also called the Convention on International Liability for Damage Caused by space Objects is a UN General Assembly resolution which asserts that states are responsible for any damage that is caused to another state or entity in pursuit of their space activities or any activity supporting their space programme.[92]

- **1979 Agreement on the Moon:** This serves the function of re-emphasising the principle of peaceful use of celestial bodies, including Earth's moon. It also talks about the way in which exploration and exploitation of the lunar surface and resources should take place — as "the common heritage of mankind".[93] However, in recent times the US and its frameworks like the Artemis Accords have caused controversy because of their approach to Lunar exploration and exploitation of its resources under the principle of "safety zones", which may turn parts of the Moon into private property. [94]

- Under its **NPOK framework,** Russia has signed dozens of agreements banning deployment of any type of weapons in Outer space with countries which are unlikely to ever have counterspace capabilities.[95] These have been signed bilaterally with states such as Cambodia, Venezuela, Togo, Burundi, Sierra-Leone etc., and multilaterally with CSTO nations.[96] As commentary in the Russian press has highlighted, the primary motivation behind these agreements is the Russian desire to build a consensus on a favourable counter space and anti-counter space order in multilateral fora, including the United Nations.[97]

- **The Missile Technology and Control Regime (MTCR):** As its Annex and Guidelines Draft says, the MTCR is primarily focused on preventing the proliferation of weapons of mass destruction but it also casts a wider umbrella under which space launch vehicles and platforms such as unmanned aerial vehicles (anything capable of carrying 500 kg upwards of 300 km) are covered.

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We would like to thank Chandrashekar Srinivasan from the National Institute of Advanced Studies, Banglore for an insightful conversation around the topics in this document