QUAD-PLUS Dialogue

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Cooperation on Space Capability and Common Threats

Lieutenant General Davinder Kumar
Vivekananda International Foundation

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Outer space plays a vital role in the management of Earth's resources, economic development as also in the provision of different services to all humanity, largely through the application of space technology. The future of space as a resource, however, depends not so much on technology as on the slow and difficult struggle to create sound international institutions to manage this resource. It will depend most of all upon humanity's ability to prevent an arms race in space.

The trend lines indicate that space has the potential to become an over-contested domain, particularly in the continuing absence of integrated policy and the promotion of best practices and behavior. In this session, three issues, as follows, have been listed for discussion:

1. ***What threats do the Quad countries share that can be addressed through cooperation in space?***
2. ***What are the strengths of each Quad country's space programme and how can these be enhanced through cooperation?***
3. ***Is there existing cooperation either among two or more of the Quad countries or between individual Quad countries and programs elsewhere that can be used for best practices?***

Threats

Space Environment and Space Weather

Space is an extremely harsh and inhospitable environment with solar radiation; space radiation storms (also known as solar proton event); coronal mass ejections; solar flares; extreme temperature gradient; micro gravity and absence of external pressure; transfer of heat only by conduction; and ultraviolet radiation and meteoroids (near-Earth objects and potentially hazardous asteroids) being some of the challenges which directly impact the design, useful life, and survivability of the satellites and other space assets. The net effect is that a space system is very fragile and vulnerable.

Man-made Threats

Debris

"The greatest risk to space missions comes from non-trackable debris."

Space debris pose a significant, constant, and indiscriminate threat to all space assets. Despite debris mitigation guidelines, such as those of the Committee on the Peaceful Uses of Outer Space, the problem remains overwhelming and a great threat to space assets.

Orbital Crowding

There is ever-accelerating demand for orbital slots and radio frequency spectrum, both of which are finite and hence the likely areas of conflict on the issue of "demand and supply." The situation is going to aggravate further due to the drive to launch satellite constellations.

Traffic Management

With 57 countries operating in space currently and many more to follow, including the private operators, the problem of orbital crowding and debris is going to grow exponentially necessitating international collaborations and partnerships to conceive and develop innovative solutions and strategies as part of a worldwide space traffic management architecture.

Weaponising of Outer Space

The use of outer space has all along been driven by forces from two directions: one is the impetus of outer space weaponisation, and the other is the efforts toward the prevention of an arms race in outer space (PAROS). The threat of weapons likely to be placed in space and weapons designed to attack space systems both in space and on ground like counter space and anti-satellite weapons (ASATs) is very real. Avoidance of an arms race in outer space is the biggest challenge.

Lack of transparency particularly in military/strategic/ dual-use space programmes. Besides reluctance to share orbital and technical information as part of space situational awareness (SSA), there is hardly any information on both the testing of space weapons and space combat doctrines by different nations. This information could be termed as necessary to "minimize the possibility of harmful interference" and engaging in "actions that damage or destroy space objects or the supporting systems on the ground."

Reluctance to share information. This is more relevant to cyber interventions, orbital maneuvers for intelligence, sensors on board and their capabilities, launch of military satellites, and so on. The sensitive nature of some information and the small number of space actors with advanced tools for surveillance have traditionally kept significant data on space activities shrouded in secrecy.

Military and Cyber Threats

Outer space is being considered as another domain of warfare which might trigger a major transformation of space. The trend lines indicate that space is fast becoming an over-contested domain particularly in the continuing absence of integrated policy and the promotion of best practices and behavior. Likely introduction of weapons in space for missile defence, ASAT operations, and even for extended force projection from "earth orbits" to achieve "full spectrum dominance" is a major and perhaps an imminent threat.

Cyber interventions in all facets of space systems have raised the threat to an entirely a new level with state-backed lone-wolf attacks posing a lethal threat.

Exploitation of "dual-use" assets for military application. The dual-use nature of space assets presents another threat as a satellite not specifically designed to be an offensive weapon can be used as one. This aspect has become a point of contention in the applicability of traditional arms control measures with the very adequacy, feasibility, and applicability of arms control in outer space being questioned. It is felt, however, that al-use technologies in the space domain constitute an obvious consideration for multilateral arms control efforts. This issue is a major obstacle to advance on PAROS.

Challenges

Space Sustainability

"Long-term sustainability of space activities" presents a major challenge. Issues like space debris, space weather, near-earth objects, nuclear-power sources in space, and others closely related to space sustainability have been on the agenda of the United Nations Committee for Peaceful Use of Outer Space for many years. It seeks the adoption of a comprehensive approach to the multifaceted challenges of preserving space for the generations to come.

Space Security

There is a new sensitivity and urgency emerging about the security of outer space. It has become a major challenge, particularly after the testing of an ASAT weapon by China in 2007 and subsequent momentum by many other nations to develop and test counter-space capabilities. The challenge is to have an internationally accepted Code of Conduct which can assist in achieving enhanced safety and security in space, comprehensive transparency and confidence-building measures (TCBMs) to strengthen adherence, and an authority which can effectively enforce the agreed rules and procedures.

Space Weather

Space weather is a term that over the past few years has come to refer to a collection of physical processes, beginning at the Sun and ultimately affecting human activities on Earth and in space**.** Though there is increasing awareness of threats from space weather, there are challenges of greater coordination of activities, technology and infrastructure related to space weather, real-time sharing of information, and availability of finance.

Transparency and Confidence-Building Measures (TCBMs)

TCBMs are already present in existing, legally binding space agreements. TCBMs have also been introduced through the draft International Code of Conduct for Outer Space Activities proposed by the U.S. However, there are issues of verification, compliance, and the authority to ensure their implementation. Carefully crafted TCBMs that take into account operational characteristics of space can go a long way to bolster space sustainability, prove to be an indispensable tool for space security, and promote trust and confidence.

Space Situational Awareness (SSA)

Sharing of SSA data with all stake holders would help to increase the transparency and confidence of space activities, which would, in turn, reinforce the overall stability of the outer space regime. As the importance of space situational awareness is acknowledged, more states are pursuing national space surveillance systems. There are no plans, however, to have a global system or data-sharing agreement. SSA infrastructure and sharing of data thus remain major challenges.

Increased Space Pollution

Space pollution is a product of negligence. The detrimental effects of space junk grow worse each year, putting the international space infrastructures increasingly at risk. With a very large number of satellites planned to be launched in the coming decade, the challenge is to limit space pollution through innovative strategies, international collaborations, partnerships, and legally bound stringent measures.

Space Governance

The core for "Space Governance" is embodied in five space treaties (i.e., the Outer Space Treaty of 1967, the Rescue Agreement of 1968, the Liability Convention of 1975, the Registry Convention of 1975, and the Moon Agreement of 1979) and five sets of principles adopted by the UN General Assembly. There are likewise a number of resolutions relating to outer space and various bilateral and multilateral practices and agreements. The impression, however, is that implementation of these provisions are rather weak. In view of an ever-increasing number of nations using space assets and developing threats as outlined above, the challenge is to urgently have a comprehensive and effective space governance framework and an organization with requisite authority to monitor and ensure compliance.

Private Sector in Space

Entry of the private sector in outer space systems has given a new perspective to both exploitation of space and its security. The challenge is to address the implications and facilitation of more active involvement of private actors, whose role is increasingly relevant for deliberations on space activities.

The China Factor

Countries that may either have their own power ambitions or feel threatened are most likely to develop counter-space technologies and weapons to gain advantage through asymmetry. In this context, China is likely to be considered a possible adversary in the future, and may be one of the countries that could threaten U.S. dominance in space, even though it has constantly opposed the use of space for military purposes. The counter-space technologies being developed by China and demonstrated at times are of serious concern. The common belief is that China was slowly flexing its muscles and that an arms race may be underway. China's behavior smacks of hypocrisy for wanting a global treaty to ban weapons in space on the one hand and then developing and testing full-spectrum counter-space capabilities. Continuing increase in China's capabilities both in outer space and counter space present strategic challenges.

The Indian Scene

India's space program, in spite of sanctions and comparatively low budget, has been impressive. From building and launching commercial satellites to sending lunar probes and Mars Orbiter Mission, the Indian space program spans the full spectrum of civilian space activities in various fronts of national development: commercial, strategic, societal, and economic.

India has indigenously developed capabilities in space, launch, and ground systems on the upstream and specific civilian programs (resource monitoring, earth observation, education, broadcast services, communications, meteorology, and disaster management) on the downstream. It has created a vibrant, innovative, and focused eco-system of small and medium-size entrepreneurs numbering over 3,500 involved both in manufacturing and R&D. Some of the major achievements of India in space are given in the succeeding paragraphs.

Remote Sensing and National Natural Resource Management System

The Indian Remote Sensing Satellites (IRS) System, with currently 13 satellites in orbit, is one of the largest constellations of remote-sensing satellites in operation in the world today. New capabilities in Earth observations are planned with the development of the geo-imaging satellite (GISAT).

Indian Regional Navigation Satellite System (IRNSS)-NAVIC

IRNSS is an ingeniously built constellation of seven satellites which has now been given an operational name of NAVIC (*Navigation with Indian Constellation*). The satellites can provide accurate real-time positioning and timing services and extend its service to regions 1,500 kilometers around India. A network of 21 ranging stations located across the country provides data for the orbital determination of the satellites and monitoring of the navigation signal.

GPS Aided Geo Augmented Navigation (GAGAN)

The Indian Space Research Organization (ISRO) and Airports Authority of India have jointly commissioned a GPS Aided Geo Augmented Navigation (GAGAN) system as a forerunner for the operational Satellite Based Augmentation System (SBAS) over the Indian airspace.

Multiple Satellite Launch by Single Rocket

- PSLV C28 successfully launched five UK satellites weighing over 1,440kg to the orbit carrying five British satellites on board.
- India displayed unique capability in its space exploration programme on 26 September 2016, when it successfully launched eight satellites from one rocket into two different orbits.
- The launch of 104 satellites by single rocket on 15 February 2007 was a world record.

These were essentially commercial ventures contracted by ANTRIX, the commercial arm of ISRO. But these have also put India in the forefront of Large Scale Integrators. The challenge of interoperability with satellites of different nations, varied categories, and different configurations have been met successfully.

Mars Orbiter Mission (MOM)

MOM, dubbed as “Mangalyaan,” successfully entered the Martian orbit in September 2014 in its maiden attempt. India became the first country to successfully complete the maiden Mars mission and also the fourth country to successfully venture to Mars. It is the most cost-effective mission launched in just 18 months. ISRO also developed a deep space network to monitor the mission.

Education

A vital application of the INSAT system in the last decade has been in the field of education with the launch of thematic satellite EDUSAT in 2004. EDUSAT was specially designed to spread education (formal and informal) at all levels and regions of the country with more than 55,000 EDUSAT classrooms.

Launch Systems

Recently, ISRO tested the crew module aboard the GSLV MK3 and its cryogenic engine, which will, by 2020, put India in a special group of space cruising nations capable of taking humans to space. Adding to this, ISRO is also working on a Reusable Launch Vehicle (RLV) to reduce satellite launch costs. Also, ISRO is working on taking GSLV to the next level with the GSLV MK4, which will be able to lift 6.5 tons instead of only 4 tons with the GSLV MK3.

Space Science and Planetary Exploration

The following missions in space science and planetary exploration have been planned in the near future:

- Chandrayaan is India’s Lunar Exploration Programme. The first mission Chandrayaan-1 was launched in October 2008 on board the PSLV XL rocket and made the stunning discovery of water on the Moon.
- Chandrayaan-2, with a lander and a rover intended for in-situ investigations of the lunar surface is expected to be launched in 2017 aboard the heavy-duty GSLV Mk II rocket.
- Multi-wavelength astronomy observatory satellite ASTROSAT-1 for observation of celestial objects covering optical, UV, and X-ray bands.
- India’s first space-borne solar coronagraph mission ADITYA-1 for studies on coronal mass ejections.

These achievements are remarkable considering the frugal budget of the ISRO, which has made a name for itself for low-cost, high-return space missions.

Research & Development

Research and development activities under the space programme are carried out in various centers/units of the Department of Space and ISRO. The major centers are:

- Vikram Sarabhai Space Centre (VSSC), Thiruvananthapuram;
- ISRO Satellite Centre (ISAC), Bangalore;
- SHAR Centre at Sriharikota (Andhra Pradesh);
- Space Applications Centre (SAC), Ahmedabad;
- Liquid Propulsion Systems Centre (LPSC) with its facilities at Bangalore, Thiruvananthapuram, and Mahendragiri;
- ISRO Telemetry Tracking and Command Network (ISTRAC) with its network of ground stations; and
- Development and Educational Communication Unit (DECU), Ahmedabad.

Research and development under way on critical technologies related to the semi-cryogenic engine, re-usable launch vehicles, air-breathing propulsion, and human space flight will pave the way for realisation of advanced launch vehicles.

An important achievement of the last decade is realising two high powered communication satellites, W2M and HYLAS, for European customers.

International Co-operation

- India's maiden mission to the moon, Chandrayaan-1, carried six scientific instruments from the U.S. and Europe.
- Two satellite missions (Megha-Tropiques and SARAL (Satellite with ARgos and ALtica)) were realized through India-France cooperation.
- YOUTHSAT, a satellite for space weather studies has been realized by young scientists of India and Russia.
- During the recent past, India has signed 10 new cooperative instruments with various countries and space agencies.

India has bilateral agreements on space with:

- U.S.
- Russia
- France
- Japan
- Israel
- United Arab Emirates

The Indian Space Research Organisation (ISRO) of the Department of Space, Government of India has signed memoranda of understanding/ cooperative agreements for exploration and use of outer space with 37 countries: Argentina, Australia, Brazil, Brunei Darussalam, Bulgaria, Canada, Chile, China, Egypt, France, Germany, Hungary, Indonesia, Israel, Italy, Japan, Kazakhstan, Kuwait, Mauritius, Mexico, Mongolia, Myanmar, The Netherlands, Norway, Peru, Republic of Korea, Russian Federation, Saudi Arabia, Spain, Sweden, Syria, Thailand, Ukraine, United Arab Emirates, United Kingdom, United States of America, and Venezuela.

International Collaboration and Activities

Major Activities

India is intimately involved in international efforts in the following activities:

- Space debris mitigation;
- Collision avoidance studies for launch vehicle lift-off clearance;
- Space object proximity analysis;
- Space debris modeling;
- Long-term evolution of space debris scenario;
- Establishment of multi-object tracking radar;
- Joint activities with the Inter-Agency Space Debris Co-ordination Committee (IADC); and
- Outreach programmes.

International collaboration

• Member of the IADC since 1997;

• Hosted IADC annual meetings in 2003 and 2010;

• Significant contributions in framing IADC space debris mitigation guidelines;

• Study team member in "Space Traffic Management" Project Report in 2007 by International Space University;

• Current representation in the IADC;

- Member Steering Group
- Deputy Chair: Working Group 4.

Recommended Approach for Quad Nations Cooperation

Quad countries must work together to spell out strategy for the safeguarding of outer space, its long-term sustainability; and more inclusive use by new actors. A six-point approach as given below is recommended for consideration:

1) A comprehensive and proactive implementation strategy is needed for addressing space debris, including improvements in the resolution of debris-tracking systems and sharing of information.

2) Active and collaborative participation to formulate, disseminate, and ensure implementation of traffic management rules in space as a logical consequence of an increase in the numbers of satellites, in order to avoid collisions and to guarantee safe access.

3) Adopt and propagate measures to narrow the gap of "Technological Asymmetry" and ensuring equitable exploitation of space for development and disaster management.

4) Render collaborative support for empowerment of relevant UN organizations and work aggressively for

    a. Quick finalization of common and consistent rules and procedures for operating in outer space (International Code of Conduct?) and
    b. More integrated approach and accountability towards "space governance," including introduction of property rights envisaged in Moon Treaty 1984, to prevent conflict.

5) A way must be found to prevent conflict in space and to prohibit ASAT tests and counter-space technologies.

6) Cooperate and promote space situational awareness. Sharing of information on launch and location of space assets must be made mandatory.