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Specifics of Space Cooperation Potential Between Japan and India

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Abstract

Space activities in the Asia Pacific region have been increasingly developing and diversifying. Many nations have sought to acquire indigenous space capabilities for a wide variety of reasons. Active commercial and security space activities can also be seen in this region. Asian nations also dream to explore the unknown in outer space by promoting space science and exploration. International space cooperation has also been considered as a key element in developing space activities in this region. In this context, the University of Tokyo (UoT) and National Institute of Advanced Studies (NIAS) have conducted a joint research on regional space policy and programs, especially focusing on policy analysis on space policies in Japan and India as a first step. A recent study by UoT and NIAS has explored lot of commonalities and uniqueness in space policies of the two nations. These commonalities and uniqueness in space policies offer potential opportunities for future space collaboration between the two. As leading spacefaring nations, Japan and India have been playing a key role in developing space activities in the Asia Pacific region. By cooperating together, Japan and India will be able to identify and advance regional common interests in space activities in the region. In particular, recent space policies in Japan and India have placed emphasis on space applications for societal needs such as communication, remote sensing, positioning, and so on. Japan-Indian cooperation in this area will contribute to social development in the Asia Pacific region by complementing and supplementing regional space capabilities. On the other hand, Japan and India have also had substantial experiences in space science and exploration. In this regard, Japan-India joint space mission will also be a potential item for future cooperation and will be a great boost to space science and exploration activities at a regional and global level. A third pillar of collaboration is for industry-to-industry tie-ups and development of commons in space industry in the two nations. Space industrial capabilities in both nations can jointly be involved to develop and offer unique space services in applications of earth observation, satellite communications, disaster management, and security, and undertake joint manufacturing activities. Based on the analysis of the commonalities and uniqueness in space program of Japan and India, this paper examines and explores in detail potential ”mission" opportunities for space cooperation between the two nations. Hopefully, these identifications will help Japan-India space cooperation in the future.

1. Introduction

Space activities in the Asia Pacific region have been increasingly developing and diversifying in recent years. Many nations have sought to acquire indigenous space capabilities for a wide variety of reasons. Outer space is a source of curiosity and inspiration for the Asian people. Space has also become a part of daily life for a majority of citizens in the Asia Pacific region. Today an increasing number of nations are using a variety of space applications such as satellite communication, broadcasting, earth observation, satellite navigation, and so on. Security is also a major driver of space activities in this region. Commercial space activities can also be seen in the Asia Pacific region in recent years. Moreover, international cooperation is considered as an important element in the development of space activities in many Asian countries.

Against this backdrop, it is highly helpful to study space activities and policy perspectives in the Asia Pacific region in promoting regional space cooperation and bringing societal benefits to the region. Regional space policy research will foster mutual understanding among nations and help them to identify potential opportunities for future space cooperation.

In particular, space cooperation between Japan and India has significant potentials for bringing not only mutual benefits but also benefits to the Asia Pacific region. Japan and India has a lot of commonalities in space policies. Both nations are great space powers with independent space access capabilities and have many operational space assets. Promoting the use of space applications domestically and regionally is a common objective of space policies in both nations. Although the two nations have focused on civil and scientific space activities for several decades, there is an increasing interaction between space activities and security in recent years. Privatization of space activities is also a common space policy goal. On the other hand, space science and planetary exploration are also shared interests of space activities in Japan and India[1].

In this context, this paper examines specific potential opportunities for space cooperation between Japan and India. Based on the analysis of space programs and policy perspectives in the two nations, it identifies several areas of potentials for the future space cooperation between Japan and India. Lastly, this paper discusses how the potential opportunities can be stepped into a concrete cooperative mechanism.

2. Analysis of space program in Japan and India

2.1 Japan's space program and policy

2.1.1 Historical overview of Japan's space activities

Japan started space activities in 1950s with the development of a very small "pencil" rocket by Professor Hideo Itokawa. After successfully launching K-6 sounding rocket by his rocket team, the Institute of Space and Aeronautical Science (ISAS) was established at the University of Tokyo in 1964 and later placed directly under the Ministry of Education in 1981. In 1970, ISAS successfully launched the Japan's first satellite *Osumi* with L-4S rocket. Since then, ISAS has developed solid-propellant rocket and undertaken scientific space missions. Today ISAS is credited with various achievements in space science and exploration missions.

In parallel, Japanese government organized for space activities during 1960s. As early as in 1960, the National Space Activities Council was established in Prime Minister's Office as an advisory body for space policy making, and replaced by Space Activities Commission (SAC) in 1968. In addition to ISAS, Japanese government also set up another space agency, National Space Development Agency (NASDA), under the Science and Technology Agency (STA) in 1969.

Responding to emerging social needs for space applications, NASDA had made efforts to develop satellites for communication, broadcasting, and meteorology in collaboration with user organizations and industry during 1970-180s. With the technological assistance from the United States, NASDA also developed and advanced space access capabilities to launch a large satellite into orbit. In 1984, NASDA decided to develop H-II rocket without the assistance from the United States, which was successfully launched in 1994. At about the same time, Japan also decided to participate in U.S. space station program, which eventually became International Space Station (ISS) after the end of cold war.

During the 1990-2000s, Japan experienced several changes in the situation surrounding space activities and its policy perspectives. First, as U.S.-Japan trade conflict had risen, Japan had faced criticism from the United States that Japanese government protected domestic space industry by unfair satellite procurement protocols. In 1990, Japanese government agreed with the United States to procure satellites being used for the purposes other than R&D and security from international market. In consequence, it became difficult for Japan's space industry to develop an application satellite for the government because the international competitiveness was insufficient to compete internationally. Since then, Japan's space activities have placed greater emphasis on the development of new technology and scientific missions, rather than the use of such technologies for society.

Second, policy perspectives concerning space and security has gradually changed since the end of cold war. Although Japan's space policy had long refrained from using space for any security purposes during the cold war, Japanese government realized the importance of space for national security in face of a changing security environment in 1990s. In particular, responding to the launch of North Korea's *Taepodong* missile in 1998, Japanese government decided to introduce Information Gathering Satellite (IGS) in order to enhance Japan's surveillance capabilities. The first two IGS satellites were launched in 2003.

Third, there were major organizational changes concerning space activities in the early 2000s. As part of the administrative reforms, the Ministry of Education and the Science and Technology Agency were merged into the Ministry of Education, Culture, Sports, Science and Technology (MEXT) in 2001. In consequence, Japan's two space organizations, NASDA and ISAS, were also consolidated into Japan Aerospace Exploration Agency (JAXA) together with National Aerospace Laboratory (NAL) in 2003.

2.1.2 Japan's space policy in recent years

These changes in the situation surrounding Japan's space activities during 1990s-2000s eventually led to the establishment of the Basic Space Law in 2008 for the first time[2]. It defined several policy orientations of Japan's space activities: improving the daily lives of citizen, strengthening national and international security, encouraging Japan's space industry, promoting international cooperation and diplomacy, advancing science and technology, and so on. Under the Basic Space Law, Japanese government have formulated the Basic Plan on Space Policy. The latest plan was decided by Strategic Headquarters for Space Policy in January 2015[3].

The 2015 Basic Plan on Space Policy sets forth three fundamental goals of space activities in Japan. First, it seeks to strengthen space security. The Basic Space Law in 2008 opened the way to use space for security and defence purposes. The 2013 National Security Strategy of Japan also identifies space systems as an important instrument for national and international security. Against this backdrop, the 2015 Basic Plan seeks to further promote the use of space for national and international security. On the other hand, as outer space has been increasingly congested and contested, it also recognizes the needs to ensure stability and sustainability of outer space for a long term. Therefore, Japan has made multiple efforts to enhance security in outer space, which include space situational awareness, improvement of critical space systems, diplomatic effort to create norms of behaviours in space, and so on. International cooperation is also an important element in Japan's space security efforts. In particular, as stated in the 2015 Guidelines for U.S.-Japan Defense Cooperation, space security is positioned as an integral part of U.S-Japan alliance cooperation.

Second, the 2015 Basic Plan also emphasizes the promotion of space applications for the benefit of society. JAXA has developed a wide variety of operational space systems (communication, remote sensing, positioning and meteorology) as important social infrastructures. Since the establishment of the Basic Space Law in 2008, Japanese government seeks to promote the active use of these space assets in a wide variety of areas, such as disaster management, environmental monitoring, climate change, land and ocean observation, diplomacy and international cooperation, and to contribute to resolving global issues. Furthermore, these space assets have also potentials in creating new services in private sector. For example, agriculture and fishery are potential areas in which space applications would create new values and new services on a commercial basis. Japanese government has made an effort to support private industry in developing such new space application services.

Third, it is also an important goal of the current Japan's space policy to improve international competitiveness of Japanese space industry, as well as to advance scientific and technological capabilities. In this regard, Japan is now in the process of legislation for commercial space activities. In March 2016, the Cabinet decided the bills concerning Space Activities Act and Satellite Remote Sensing Act, and submitted them to the Diet. They will help private sector in launching and running space business by clarifying rules for commercial space activities, while ensuring public safety and compliance with space treaties and other international agreements. The 2015 Basic Plan also states that Japan continues to invest in scientific missions and planetary exploration. Japan has accomplished many of world-class space missions, especially in the fields of lunar and asteroid exploration. Japan also has long experienced in X-ray astronomy. Japan has also been an important partner in International Space Station (ISS) program and recently agreed with the United States in extending its operation through 2024. On the other hand, it is fair to say that space science mission and planetary exploration come to be required to consider an appropriate balance with other objectives in overall space policy making.

2.2 India's space program

Indian space activities owe much to the vision given by Dr. Vikram Sarabhai - "……to be second to none in the application of advanced technologies to the real problems of man and society." This extraordinary vision founded the Indian Space Research Organization (ISRO) and was first led by Prof Satish Dhawan way back in 1970s.

Indian space activities is directly under the Prime Minister of India – thereby giving space activities the high-level authority and over-arching governing umbrella of the whole Indian government in support. An apex Space Commission, comprising of the Chairman of ISRO and top administrative officers of Indian government and technical experts, has been given programmatic and financial autonomy to plan, oversee and implement India's space programme.

ISRO is organised into various competence centres that address specific areas of space technology, including satellite design and manufacture, rocket development, mission operations, launch complex, space applications, remote sensing applications, education and training, space science etc. Antrix

Corporation is a wholly-owned commercial and marketing arm of ISRO. About 17,000 people are employed by ISRO and its sub-units.

Various industries collaborate with ISRO mainly as sub-contractors. Universities and research institutions also undertake R&D in space, and ministries and state governments have space cells to address specific needs.

2.2.1 Indian Space Achievements

As of 2016, some of the major achievements of Indian Space include:

- Present annual budget of 2016-17 FY for Indian Space through ISRO is INR 75.09 billion. Over the past 40 years, as against a cumulative budget of about INR 930 billion allocated, the actual spend/utilisation has been INR 612 billion.

- India has realised 137 missions (80 spacecraft, 54 LV, 1 SRE, 1 CARE, and 1 RLV-TD). India has presently successful missions in space exploration (MOM & ASTROSAT), satellite navigation (IRNSS & GAGAN), satellite communication (13 satellites and 240 transponders), earth observation (11 LEO and 3 GEO) in orbit.

- Independent access to space is realised through a reliable and operational PSLV launch vehicle and a proven operational indigenous geostationary launch vehicle, GSLV, incorporating an indigenously developed cryogenic upper stage.

- World class satellite capability that cover a wide variety of applications satellites – INSAT, IRS and IRNSS for telecommunications, broadcasting, weather observations, remote sensing, and navigation, and scientific spacecraft including orbiters to the Moon and Mars and astronomy studies.

- Wide use of INSAT communication systems has resulted in the wide outreach of TV signals to almost whole of the country, and contributed to the growth of large-scale DTH and VSAT data communication business.

- IRS images have provided a great thrust to use of images and geographical information techniques into many governance and national building activities by way of inventory and maps of natural resources, critical support to disaster management activities, and environmental monitoring.

- Weather and ocean services have derived a great boost from the availability of INSAT and Oceansat images/data on a variety of ocean and atmospheric data.

- Forays in planetary missions have been made through Chandrayaan-1 and MOM-1 for advanced scientific studies.

Global commercial operations of Indian space have been made through 83 commercial/foreign satellites on its PSLV and sale of IRS images and value-addition services. More lucratively, transponder lease business in India are estimated to have resulted in revenue earnings of about INR 100 billion over the past 20 years, although only a part of the capacity created was available to the commercial activity.

2.2.2 Satcom Policy[4]

India adopted a formal Satcom Policy in 1999 and the main goals were as follows:

- Build national capabilities in satellite communications by way of a healthy and thriving communications satellite, ground equipment and satellite communications service industry, AND sustained utilisation of Indian space capabilities - satellites, launch vehicles, and ground equipment design
- Make available INSAT systems for social-applications development and ensuring that INSAT system benefits a larger segment of the economy and population
- Encourage and promote privatisation of satellite communications in India by way of encouraging private sector investment in space industry and also attracting foreign investments

The corner stone of the Satcom Policy was the preference to be given to Indian Satellite Systems (ISS) while giving service licenses – thereby ensuring "protective cover" for INSAT and other Indian registered private sector satellites for Indian services against any "market on-slaught" from global commercial systems. However, the pragmatism of the Satcom Policy is that it does not in any way prohibit the use of foreign satellite systems – which, after a due process, can be treated on par with ISS for service licensing in India. This has not happened mainly due to deficiencies of appropriate procedures in implementation.

2.2.3 Remote Sensing Data Policy[5]

The Remote Sensing Data Policy (RSDP) defines the Indian regulations for acquisition, dissemination of satellite images in India. Earlier RSDP-2001 and now RSDP-2011[6] govern how satellite images are to be acquired and distributed – allowing up to 1m images to be openly disseminated to users.

RSDP-2001 recognised earth observation images as "public good" and the concept of national commitment to a continued imaging programme through IRS has been outlined. The RSDP is based on the concept of "one-window" access to any image (Indian or foreign satellite) and "regulatory use-determination" whereby images up to 5.8m would be "available on non-discriminatory basis" but images better than 5.8m would be "regulated" for private sector users on case-by-case basis. The RSDP-2001 outlines that images would be screened to obliterate some geographic regions. The RSDP requires foreign satellite images TO BE routed through the national agency – National Remote Sensing Centre (NRSC).

RSDP-2001 crafted the concept of "licensing" remote sensing satellites and their data acquisition/distribution in India – creating that "window-opening" for future Indian private remote sensing satellites and Indian private agencies to acquire and distribute any satellite images in India. However, till 2016 no such licensing application has been provided and NRSC has continued to be the single "monopolistic" data provider.

By 2005-06, India also launched 2.5m and 1m imaging satellites, but by then the larger proliferation of 1m images from US commercial satellites had also happened. Thus, the 5.8m threshold of RSDP-2001 as "regime for non-discriminatory access" was found detrimental to Indian cause/users and was soon rendered irrelevant. Therefore, in RSDP-2011 a lower bar for "non-discriminatory access" to 1m was promulgated, but then fully retaining all other aspects of RSDP-2001.

2.2.4 Looking Ahead

Looking ahead, ISROs direction is to undertake the missions that have been approved and planned in 12th Five Year Plan and meet the national needs. At various times, ISRO has also publicly acknowledged to develop industrial capability and involve Indian industries for its national and global programmes. The shortage of communication transponders and easy availability of remote sensing images have triggered many industries to look at private-sector space activities – but these are yet to take off in a major way mainly due to lack of policies that can enable a national space eco-system with industry and commercial activities.

Indian space challenge is also in future activities of human spaceflight programme from not just technologically but also investment and sustenance point of view. Public acceptance of such programmes can be forth-coming but the technological aspects along with organizational structures are yet to be defined and fructified, though study level activities have been just funded.

2.3 Identifying commonalities in space policy in Japan and India

Japan and India have a lot of commonalities in space policy. Both nations are major spacefaring nations in the Asia Pacific region and have independent capabilities to access to space. They also have developed and operated a wide variety of space systems for applications, such as communication, remote sensing, navigation and positioning, meteorology, and so on.

More importantly, Japan and India are also similar in space policy orientations. The emphasis on the promotion of space application for the benefit of society can be seen in space policies in the two countries. Under the fundamental space policy tenet set forth by Dr. Vikram Sarabhai, India has long focused on the use of space for national development. In Japan, the Basic Space Law in 2008 laid out new space policy orientation emphasizing the use of space in a variety of fields. Moreover, both nations share a very unique history that space activities have developed in entirely civil and scientific areas, rather than in military fields of efforts.

On the other hand, India' space activities has recently come to be more comprehensive, incluidng scientific mission and planetary exploration such as Chandrayaan-1 and MOM-1. India is also interested in human spaceflight in the future. Japan has a wealth of experience in the fields of scientific mission and planetary exploration since the launch of the first satellite, *Ohsumi*. Lunar observation by *Kaguya* and sample return mission by *Hayabusa* are Japan's major accomplishments in these areas. Japan has also actively participated in ISS program. Japanese Experimental Module known as *Kibo*, as well as cargo transportation by H-IIB and HTV are Japan's major contributions to this international program.

It is also similar in that Japan and India seek to privatize space activities by promoting space industry. Although its international competitiveness is not yet sufficient, Japan's space industry has mature

capabilities to manufacture a whole of space systems including launch vehicle and satellites. Although this cannot be seen in India, major space industry plays an important role in national space activities through ISRO. The both nations have shared the interest in promoting and privatizing space industry though governmental supports.

Moreover, it can also be pointed out that there is a growing interaction between space and security in both nations in recent years. In Japan, the Basic Space Law in 2008 opened the way to use of space for national and international security. The 2015 Basic Plan places a greater emphasis on security aspect of space activities than ever before. Similarly, India's space activities have been expanded to include security aspects. ISRO has launched several space assets potentially contributing to national security in India, which include RISAT-2, GSAT-7, CARTOSAT-series, and IRNSS. Security is an emerging space policy objective in both Japan and India

3. Specific potentials for Japan-India space collaboration

India and Japan have deepened their cooperation in recent times. In the Joint Statement on India and Japan Vision 2025: Special Strategic and Global Partnership Working Together for Peace and Prosperity of the Indo-Pacific Region and the World, which was issued on December 12, 2015[7], Prime Minister Narendra Modi and Prime Minister Shinzo Abe shared the view that imperatives of a stronger bilateral strategic partnership require deep and broad-based cooperation and concrete actions in defence, security, economic and cultural fields. Our future-oriented partnership raises our collaboration to a new level in areas of infrastructure, manufacturing, and high technology, including advanced transportation systems, civil nuclear energy, solar power generation, space, biotechnology, rare earths, and advanced materials.

In the 3rd SPLANAP Space Policy Roundtable organised by NIAS and UoT in Bangalore on August 16, 2016, where 22 experts from India, Japan and Malaysia participated, a host of areas were discussed and identified as possible areas of cooperation in space. This virtually provides inputs for extension of specific of cooperation that have been stated by the two prime ministers in December 2015.

This section details the areas that emerged from the roundtable meeting[8].

3.1 Policy and law

Space policy and legal regimes would be an area that is necessary for national, regional, and global cooperation. Both India and Japan recognise this importance and have been working at the government or national space agency levels (Track-1).

Unique collaborations, like the UoT-NIAS joint space policy research, need to be encouraged as Track-2 cooperative initiatives – they can not only bring researchers from India and Japan together but can also enable networking of experts in China, Malaysia, Indonesia, Vietnam, Philippines and many others in the Asia Pacific region. This initiative is offering both India and Japan to share experience in space policy and law research, Remote Sensing Policy, Geographic Information Policy – at academia/researcher level, as well as at space agency level. Such policy research cooperation between India and Japan could also help in promoting regional policy and legal regimes standardisation and sharing the outcomes and benefits through Asia Pacific Regional Space Agency Forum (APRSAF).

Track-1 and Track-2 cooperation would help long-term space policy and law definition, ensuring that no untoward 'unfair' competition or restriction for space technology and applications, and positioning efficient space governance system to address voluntary codes of conduct. The threats of space militarization also will impact policy definition even as use of space for human security will increase in a cooperative manner.

Thus, a collaborative framework between India and Japan in space policy and law will go a long way for both nations to emerge at the forefront of regional and global policies and to make a sound national justification at national levels. Such a policy-analysis collaboration could include documenting models of implementation and utilization of space programmes in the Asia Pacific region, identifying the shared opportunities in utilizing capabilities and futures space technology in the region, and assessing common applications and shared perspectives of utilization so as to identify a common ground for space application cooperation. The initiative could also help identify issues that will have an impact on space activity in the region, including the role of non-state actors, economic cooperation, climate change programmes and cooperation, potential constraints from international regimes or codes of conduct, industrialization of space, risks of space, the threat of possible weaponisation of space and so on. Ultimately, this kind of cooperation could help build the case for a comprehensive "Asia Pacific Regional Space Policy," which addresses the

long-term cooperation strategy and policy development. Some of the key areas for the policy research would be to address regional cooperation and applications, especially in the context of maritime security, space governance, industry collaboration, earth observation applications, satellite communications for education and health, disaster management, manned space exploration, and assessment of role of space in improving quality of life etc.

Building upon the Modi-Abe Joint Statement directives, India and Japan collaboration must not only be at space agency level, but must fortify Track-2 initiatives like UoT-NIAS research collaboration, and jointly expanding this effort through the APRSAF framework could be some methods that can build this cooperation element.

3.2 India-Japan joint space missions

India and Japan have tremendous capabilities for satellite building and for launching of satellites. While space is utilised to meet respective national needs, in areas like space science and planetary explorations there is possibility for joint missions in the areas of space science instruments, satellite bus, launch systems, human spaceflight technology, and many other areas. Of specific interest to both nations could be joint mission for weather and climate change observations, positioning and navigation, disaster management constellations, space science systems for astronomy, planetary studies, sensor systems in hyper-spectral domain, synthetic aperture radars, etc. India and Japan could explore these possibilities for joint mission and utilise the mutual capabilities for respective goods.

3.3 Satellite navigation

India and Japan are best placed to collaborate in the area of satellite positioning and navigation systems. Both nations have developed regional satellite positioning systems through IRNSS and Quasi-Zenith Satellite System (QZSS). The foundation for technological development of positioning systems is available but both nations currently have just a regional outreach covering their geographies.

Both India and Japan recognize the need to expand the coverage areas of their regional positioning systems. This could be an area of collaboration by which India and Japan can plan, develop and operate a joint regional positioning system that not only meets the national needs in both countries but also offers operational positioning services to countries in the Asia Pacific region.

Collaboration in satellite positioning will also bring the two nation's industries and space agencies together, apart from bringing a commonality of applications in maritime and terrestrial navigation and even among security applications.

3.4 ISS utilization and space exploration

Japan has been playing an active role in the ISS program, while India has not yet participated in this program. However, it can be easily presumes that India will soon take an opportunity for ISS participation. It could be through an opportunity in initially collaborating with Japan. Japan has been making an effort to promote ISS utilization though the Kibo-ABC (Asian Beneficial Collaboration through "Kibo" Utilization) initiative under the framework of APRSAF. This is a cooperative initiative aiming at the promotion of the use of ISS and Japanese Experimental Module among researchers and industries in the Asia Pacific region. Such collaboration would help India universities and academia in sharing the outcome of ISS utilization and in carrying out joint research projects and scientific experimentation in a unique zero gravity environment.

In addition to ISS utilization, planetary exploration is also an area in which Japan and India share the interest and can potentially strengthen their cooperation in the near future. Japan has achieved a lot of world-class planetary exploration missions such as *Kagurya* (lunar exploration) and *Hayabusa* (asteroid sample return mission). Although India's space activities has long focused space application for the benefits of society, planetary exploration and scientific missions comes to be an emerging emphasis in India's space policy in recent years. ISRO launched the first lunar probe, Chandrayaan-1, in 2008. India also successfully achieved MOM-1 and became the first Asian nation in sending a spacecraft to Mars orbit. Japan-India collaboration will bring significant benefits from not only the cost sharing perspective but also from the diplomatic and political point of view, because this kind of collaboration between the two will foster a regional collaboration in these areas.

3.5 Space application for disaster management and climate change

Space utilization for disaster management is a highly possible area in which the both nations can cooperate in the near future. In fact, the Memorandum of Understanding between JAXA and ISRO, which was agreed in 2005 for the first time, identified space for disaster management as one of the focused areas in Japan-India space cooperation.

The Asia Pacific region is the most natural disaster prone region in the world. There were more than 1,600 disaster events in this region over the past decade and approximately 500,000 people lost their lives[9]. Japan also experienced the Great East Japan Earthquake in 2011, as well as another big earthquake in Kumamoto in 2016.

The experience in the Great East Japan Earthquake in 2011 demonstrated values of space technology in disaster response. Emergency satellite observation by remote sensing satellites helped the government and local authorities in swiftly understanding the damage situation of the affected areas. High-resolution satellite imagery also played an important role in supporting rescue and relief operation. Furthermore, satellite imagery taken before the earthquake also enabled to clearly understand damage situation by comparing with post-disaster satellite information. Put another way, satellite information is highly useful to disaster management in all phases of efforts ranging from response and recovery to mitigation and preparedness.

More importantly, the experience in the Great Earthquake in 2011 also highlighted the significance of international space cooperation for disaster management. In face of the Great Earthquake in 2011, Japan requested for emergency satellite observation of the affected areas through Sentinel Asia and International Disasters Charter. Through these cooperative frameworks, Japan received more than 5000 scenes of satellite imagery from 14 countries/region and 27 foreign space agencies, including ISRO[10]. International cooperation can help supplement satellite capabilities of each nation in case of emergency. In this regard, major spacefaring nations like Japan and India are significant contributors to the Asia Pacific region.

In this context, Japan and India can expand the scope of international space cooperation for disaster management by including a pre-disaster phase of efforts. The existing frameworks of international cooperation mainly focus on "disaster response," namely the post-disaster phase of efforts such as emergency satellite observation. The expansion of this scope to include pre-disaster phase will enable nations to create and update disaster prevention map, monitor crustal movement and volcanic activity on a regular basis, understand climate change, and so on. These efforts will help in mitigating the future risks of natural disasters. As leading spacefaring nations, Japan and India can also contribute to the capacity building in the Asia Pacific region for the use of space technology in disaster management.

3.6 Space robotics

Both Japan and India have programmes for space science and planetary exploration. Future missions in these areas will require mastery of robotic technology and high-end technology automation, as well as precision of remote operations. Space robotics can be an area of interest. For orbital robotics, potential areas include electromechanical design of controls, micro-gravity motion, machine vision for inspection and integration in space, etc. In the area of planetary rovers, it is likely to collaborate in the fields of sensing and perception for planetary exploration; precision position estimation; above-surface, surface, and sub-surface planetary mobility; command and control with optimal bandwidth for terrain navigation and manipulation; rovers systems engineering, testing and qualification; human-robot system design and development; and robotic spacecraft design and development.

Orbital robotics would be of interest to explore development of manipulation and mobility capabilities on orbit for future satellite servicing or even possible space station projects. Planetary rovers would be of most interest to Japan and India for roving systems on the Moon and Mars or even on other planetary objects. India and Japan also need to explore robotic spacecraft as an unmanned spacecraft with tele-robotic control for various space science missions.

Japan and India could embark on a cooperative programme for space robotics through the active collaboration of universities/academia and also at space agency level. The collaboration must aim for joint missions that create a roadmap for India-Japan space robotics missions and promote collaboration for future missions to the Moon, Mars, and other planetary systems.

3.7 Maritime domain awareness and space situational awareness

Japan and India also have a potential opportunity in promoting cooperation in the field of space and security. In particular, space-based maritime domain awareness (MDA) and space situational awareness (SSA) are specific areas in which Japan and India can share the interest and can promote their cooperation through information sharing.

As seafaring nations, as well as spacefaring nations, Japan and India shares the interest in securing critical sea lanes of communication from the Middle East though the Indian Ocean and the Straits of Malacca to the South China Sea and the East China Sea. On the other hand, the two nations are facing a wide variety of

similar maritime security challenges, including not only traditional security threats posed by nation states but also diverse non-traditional challenges such as piracy, armed robbery, terrorism, trafficking, smuggling, WMD proliferation risks, illegal fishing, pollution of ocean environment, natural disaster, and other unlawful acts at sea.

In this context, Japan and India have similarly made an effort to increase "effective understanding" of maritime domain, namely MDA, as a key element to maritime security. In particular, as spacefaring nations, the both nations seek to integrate satellite information into the efforts of MDA. In fact, both nations have several space assets potentially contributing to this effort. In addition to optical and radar earth observation satellites, both nations are also operating the experimental space-AIS satellites, ALOS-2 and Resourcesat-2, which can observe vessel's movement at sea with a wide coverage.

Due to the vastness of ocean and its global nature, no single nation/organization cannot achieve the effective understanding of maritime situation alone. It therefore requires international cooperation and interagency collaboration for information sharing, including satellite information. In fact, Japan has been strengthening the cooperation with the United States for space-based MDA and information sharing. Japan-India cooperation in sharing space-AIS data, as well as other space-based information, will potentially expand the network of international cooperation in creating a shared understanding of maritime domain across the region and eventually improve MDA in the Indo-Pacific region.

Likewise, SSA is also an area in which Japan and India should promote cooperation to ensure security in outer space. While space systems orbiting the earth are crucial as critical infrastructure in the both nations, they are facing a diverse threats and risks in outer space. In particular, outer space has been congested with an enormous number of man-made objects, including space debris, which brings potential risks to safe operation of space systems. SSA is "the ability to detect, track, identify and catalogue objects in outer space such as space debris and active or defunct satellite [11] ." International cooperation for SSA information sharing will improve such ability in each nation and contribute to making space environment safer and more sustainable.

Both Japan and India have several space surveillance capabilities. In Japan, Kamisaibara Space Guard Center (KSGC) and Bisei Space Guard Center (BSGC), both in Okayama prefecture, are monitoring space objects with optical telescope and radar respectively. In May 2014, Japan made an agreement with the United States for SSA information sharing between JAXA and JSpOC. India also develops the Multi-Object Tracking Radar (MOTR) at Satish Dhawan Space Centre, which is potentially capable of tracking space debris. More importantly, India also seeks to promote SSA information sharing with United States[12]. In this context, SSA data sharing, as well as collision avoidance and space debris removal, would be potential items for Japan-India cooperation in the near future.

3.8 Regional contribution in the Asia Pacific region

India and Japan are best placed to emerge as leading partnerships in the Asia Pacific region. Both need to expand collaboration to jointly offer expertise and knowledge in support of other nations in the Asia-Pacific region. For example, remote sensing and GIS applications, communications experimentation, space systems management, and policy and legal research are potentials. A possible mechanism for regional cooperation could be jointly established by a bilateral cooperation in a multilayer framework.

In particular, India could join with Japan and considerably expand its role and participation in APRSAF. In 2017, when India will host APRSAF, a bilateral collaboration thrust in APRSAF could be led jointly. Initiatives like UoT-NIAS collaboration are a great opportunity in the academic and institutional domains. These opportunities could potentially be formalized as a Track-2 collaboration for space policy research.

3.9 Industrial partnership

Privatisation of space is yet to develop in both nations in terms of investment, development, and ownership of space assets in private sector. The eco-system for such a development is yet to evolve. However, major industries in both nations are involved in national space activities through ISRO and JAXA, respectively. In Japan, industries have matured capacities to develop a whole systems of satellite and launch vehicle. This is yet to be seen in India where industries are still in a sub-system mode.

Both countries have considerable industrial capability and this can be one major area for industrial collaboration between the two nations. The potential for Japan of using Indian space capability platform through industry involvement and at space agency level to leverage costs is tremendous.

4. Modality of building cooperation

In the modern context of developments and spread in the space activities globally, one can see a clear dichotomy arising from conflicts between cooperation and competition. This polar division is also complicated by the existence of multi-objective drivers for space activities in diverse nations. The foregoing discussion has demonstrated that in the comparison of space program and policy perspectives in India and Japan there are several commonalities in goals and objectives, and there is an expression of political will at the highest level that augurs well for higher level of collaboration. This is notwithstanding the autonomy goals for space capabilities in both the nations. Wherever space investments are of a higher order either through public investments or private investments, cooperation will be driven by considerations of strategic advantages to those parties. Hence identification of common strategic goals will be a prerequisite to expand India-Japan cooperation in the field of space. Joint bilateral missions such as resource exploration from space, asteroid/interplanetary missions, cooperation for certain elements of human spaceflight could possibly fit into such mutually complementary but strategically important activities. The second model of cooperation could be based on evolving an existing bilateral cooperation into multilateral mode on the basis of commonness of goals across a wider range of countries in the regional context. Disaster management research or climate change-related applications can fit into this. However operational information services in support of disaster management need both the government and the industry to work together. Even as the commercial use of space is expanding globally and is being threatened by some disruptive trends, building confidence and resilience for long-term investments in space remains to be a challenge. As 'ideas' involving convergence of diverse fields of modern knowledge are the main drivers of economic growth, there is need for growing an environment which incentivises the innovative behaviour and an ambience of trust among diverse stakeholders. The changing landscape of stakeholders is to be recognised. Dynamism has to be built into policy framing process and conflicts are to be managed systemically. This opportunity space for collaboration needs a different model that harmonises multi-tracks in engagement for cooperation that can meaningfully involve governments, industry and academia both severally and collectively. Multi-track dialogue is most beneficial for India-Japan collaboration as it can boost the confidence of different stakeholders in the government, academia and industry.

5. Conclusion

Japan and India have robust space programme spawning more than 50 years of development. With vision and determination, both programmes have matured into success at various levels.

Bilateral cooperation has been outlined in Joint Statement by the Prime Minister Modi and Prime Minister Abe in 2015, where space cooperation has been emphasised and highlighted. Japan and India are major nations in the Asia Pacific region and together can play a major role in regional space activities in terms of complementing and supplementing capabilities for the societal and commercial development of space in the region. There are tremendous capability to "pool" and cooperate to not just mutually benefit within Japan-India cooperation but also reach space products to many nations in the region through bilateral and multilateral cooperative frameworks.

NIAS and UoT have initiated a sound research collaboration between India and Japan AND also established a SPLANAP network, which is involving experts from both nations and outlining a Track-2 initiative for space cooperation.

Key areas for cooperation have been identified. The extremely high-level technological capabilities in the areas of earth observation, space science, planetary missions, positioning, space robotics indicate that a India-Japan joint space mission is of high potential. This will be a great boost to space activities at the regional and global level.

Both countries also have considerable industrial capability and this can be one of major areas for industrial collaboration between the two nations. The potential for Japan of using Indian space capability platform through industry involvement and at space agency level to leverage costs is tremendous.

Significant similarities among the objectives of the policy, the policy drivers, and paradigms are pushing renewal of policy environment for outer space in Japan and India. This creates tremendous opportunities and potentials for cooperation in policy discourse on contemporary concerns like space security, space science, human spaceflight operation, and space industry cooperation for strengthening space infrastructure needs in both countries and even in the region, joint missions that address humanitarian concerns as well as technological advances that promise 'New Space' developments. Policy studies can be one great opportunity for collaboration between like-minded

institutions in India and Japan, especially extending the University of Tokyo and NIAS collaboration.

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[1] Yuichiro Nagai, Mukund Rao, Hideaki Shiroyama, K.R. Sridhara Murthi, Motoko Uchitomi, and Baldev Raj, "Policy Analysis: Space Programs of Japan and India," conference paper prepared for IAC-2015 E3.1.9, October 2015.

[2] Uchu Kihon Ho (Basic Space Law), May 27, 2008. Available at (http://www8.cao.go.jp/space/pdf/keikaku/hou24.pdf), in Japnaese.

[3] Uchu Kaihatsu Senryaku Honbu (Strategic Headquarters for Space Policy), *Uchu Kihon Keikaku* (*Basic Plan on Space Policy*), January 2015. Available at (http://www8.cao.go.jp/space/plan/plan3/plan3.pdf), in Japanese.

[4] Satellite Communications (SATCOM) Policy, 1999. Available at (http://www.isro.org/news/pdf/satcom-policy.pdf)

[5] Mukund Rao and K R Sridhara Murthi, Perspectives for a National GI Policy, (Report R 11 -2012) National Institute of Advanced Studies, Bangalore, September, 2012. Report No: R11-2012. Available at (www.nias.res.in/docs/R11-2012-GI-Policy.pdf)

[6] RSDP (2011), Remote Sensing Data Policy, 2011. Available at (http://www.isro.org/news/pdf/RSDP-2011.pdf)

[7] Joint Statement on India and Japan Vision 2025: Special Strategic and Global Partnership Working Together for Peace and Prosperity of the Indo-Pacific Region and the World, December 12, 2015. Available at (http://www.mea.gov.in/bilateral-documents.htm?dtl/26176/Joint_Statement_on_India_and_Japan_Vision_2025_Special_Strategic_and_Global_Partnership_Working_Together_for_Peace_and_Prosperity_of_the_IndoPacific_R)

[8] Record of 3rd SPLANAP Space Policy Roundtable organised by NIAS-UoT Collaboration at at Bangalore on August 16, 2015.

[9] UNESCAP, *Asia Pacific Disaster Report 2015*. Bangkok: United Nations, 2016. Available at (http://reliefweb.int/sites/reliefweb.int/files/resources/Asia%20Pacific%20Disaster%20Report%202015.pdf)

[10] Japan Aerospace Exploration Agency, *Higashi-Nihon Daishinsai Taiou Hokokusho* (*Report of the JAXA's Response to the Great East Japan Earthquake*), November 2011. Available at (http://www.sapc.jaxa.jp/antidisaster/20110311report/311JAXA_report_s.pdf), in Japanese.

[11] Spacesecurity.org. *Space Security Index 2014*, October 2014. Available at (http://spacesecurityindex.org/wp-content/uploads/2014/11/Space-Security-Index-2014.pdf)

[12] U.S.-India Joint Statement, September 30, 2014. Available at (https://www.whitehouse.gov/the-press-office/2014/09/30/us-india-joint-statement)