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Assessment of Space Programs and Policies for Regional Cooperation in the Asia Pacific Region

Yuichiro Nagai[a]*, Mukund Kadursrinivas Rao[b], Hideaki Shiroyama[c], K.R. Sridhara Murthi[d], Motoko Uchitomi[e], Tunku Intan Mainura[f], Rogel Mari Sese[g], Tan Cheng Hai[h]

[a] *Nihon University, 2-31-145 Bunkyo-cho, Mishima-shi, Shizuoka, Japan,411-8555*, nagai.yuuichirou@nihon-u.ac.jp
[b] *National Institute of Advanced Studies, Indian Institute of Science Campus, Bangalore 560012, India,* mukund.k.rao@gmail.com
[c] *The University of Tokyo, 7-3-1, Hongo, Bunkyo-ku, Tokyo 113-0033 Japan,* siroyama@j.u-tokyo.ac.jp
[d] *Jain University and National Institute of Advanced Studies, Indian Institute of Science Campus, Bangalore 560012, India,* krsmurthy09@gmail.com
[e] *The University of Tokyo, 7-3-1, Hongo, Bunkyo-ku, Tokyo 113-0033 Japan,* uchitomi.motoko@jaxa.jp
[f] *Universiti Teknologi MARA,* tunkuintan@yahoo.co.uk
[g] *National Space Development Program,* rmdsese@gmail.com
[h] *Singapore Space and Technology Association,* chenghai.tan@space.org.sg
* Corresponding Author

Abstract

International space cooperation in the Asia Pacific region have entered a new stage. Today a lot of nations in this region have actively developed space capabilities, and have come to use them for a variety of purposes. In addition to the long-experienced spacefaring nations such as Japan, India, and China, many emerging nations like Malaysia, Philippine, Singapore, Indonesia, Vietnam, Thailand, South Korea, etc., have made active efforts to develop space technology and applications and to undertake their space programs. Such space applications as earth observation, satellite communication, and positioning emerged in this region have tremendous potentials as a driving force for peaceful development and prosperity of the Asia Pacific region in many facets: disaster management, climate change study, national and regional security, environment management, agriculture, urban planning, geospatial program, land management, as well as the advancement of science and technology. Against this backdrop, many nations also seek to establish national space policy with an aim to set out the vision and goals of nation's space programs.

The University of Tokyo and National Institute of Advanced Studies have created a research network, Space Policy and Law Network in Asia Pacific (SPLANAP), among researchers and experts in the Asia Pacific region and started a research project to examine space policy and program directions in the region. In particular, as the first step of this research project, a comparative analysis of space programs and policy perspectives in Japan and India has been taken up to examine commonalities and uniqueness in space policies of both nations and to identify potential opportunities for the future cooperation between the two nations. Based on the previous work in this research project, this study aims to move to the next phase of the research and to extend the scope of the analysis by including several other nations, such as Malaysia, Philippine, and Singapore. While updating information on the recent developments in space programs and policy in Japan and India, as well as adding new analyses from the perspectives of the above-mentioned three nations, this study will examine common interests and potential opportunities for regional space cooperation from a wider point of view.

Keywords: space policy, space program, international cooperation, Asia Pacific region

1. Introduction

International space cooperation in the Asia Pacific region have entered a new stage. Today a lot of nations in this region have actively developed space capabilities, and have come to use them for a variety of purposes. In addition to the long-experienced spacefaring nations such as Japan, India, and China, many emerging nations like Malaysia, Philippine, Singapore, Indonesia, Vietnam, Thailand, South Korea, etc., have made active efforts to develop space technology and applications and to undertake their space programs. Such space applications as earth observation, satellite communication, and positioning emerged in this region have tremendous potentials as a driving force for peaceful development and prosperity of the Asia Pacific region in many facets: disaster management, climate change study, national and regional security, environment management, agriculture, urban planning, geospatial program, land management, as well as the advancement of science and technology. Against this backdrop, many nations also seek to establish national space policy with an aim to set out the vision and goals of nation's space programs.

The University of Tokyo (UoT) and National Institute of Advanced Studies (NIAS) have created a research network, Space Policy and Law Network in Asia Pacific (SPLANAP), among researchers in the Asia Pacific region and started a research project to examine space policy and program directions in the region. In particular, as the first step of this research project, a comparative analysis of space programs and policy perspectives in Japan and India has been taken up to examine commonalities and uniqueness in space policies of both nations and to identify potential opportunities for the future cooperation between the two[1].

Based on the previous works in the research project, this study aims to move to the next phase of the research and to extend the scope of the analysis by including several other regional nations, such as Malaysia, Philippine, and Singapore. While updating information on the recent developments in space programs and policy in Japan and India, as well as adding new analyses from the perspectives of the above-mentioned three nations, this study will examine common interests and potential opportunities for regional space cooperation from a wider point of view.

2. Analysis of Space Programs and Policies in Asia

2.1 Overview of Japan's space program and policy

Although Japan has a long history of space activities since the development and launch of a very small "pencil" rocket in 1950s[2], it was not until 2008 that the nation established the Basic Space Law for the first time[3]. It defined new objectives and 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.

Aiming to carry out Japan's space activities strategically and comprehensively, the Basic Space Law also established the Strategic Headquarters for Space Policy as a top-level, whole of government space policy decision making body[4]. Japanese government also set up the Office of National Space Policy within the Cabinet Office to effectively coordinate policies and programs among various ministries and to make plans for space program and budget from a comprehensive perspective. In line with the principles of the Basic Space Law, the role of Japan Aerospace Exploration Agency (JAXA) was expanded in 2012 to work as a core implementation agency, not only carrying out research and development but also providing necessary technical support to achieve overall Japan's space policy objectives[5]. Under the Basic Space Law, Japan's space activities became comprehensive and all ministries and related agencies have potentially become involved in space activities.

In conformity with the Article 24 of the Basic Space Law, Japanese government has formulated the Basic Plan on Space Policy. This is a fundamental space policy document in Japan and provides basic policy orientations concerning space activities. The latest plan was decided by the Strategic Headquarters for Space Policy in January 2015 and approved by the Cabinet in April 2016[6].

The 2015 Basic Plan on Space Policy sets forth three fundamental goals of space activities in Japan. First, it seeks to strengthen space security. Historically, Japan had long refrained from using space for military and security purposes by strictly interpreting its peaceful constitution. Against the backdrop of the changes in security environments, however, the Basic Space Law opened the way to use space to strengthen national and international security in a manner consistent with the peaceful spirit shown in the Constitution[7]. Today space systems come to be considered as a critical element in Japan's national security policy. The 2013 National Security Strategy of Japan identifies space systems as an important instrument for national and international security[8]. The 2015 Basic Plan seeks to support national and international security efforts by further promoting use of space for the enhancement of information gathering capabilities and defense communication capability.

In this situation, Japan launched in January 2017 a X-band defense communication satellite, known as *Kirameki*-2. This is the first satellite that the Ministry of Defense of Japan owns and operates as its dedicated satellite. The ministry also schedules to launch two more X-band defense communication satellites in the future. Japanese government also launched a new IGS satellite in March 2017 and is now operating seven IGS satellites. Japanese government plans to eventually create ten IGS satellite constellation in the near future.

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 as important social infrastructures. In particular, Japanese government has been building a regional positioning satellite system known as Quasi-Zenith Satellite System (QZSS). Aiming to start operating the four-satellites QZSS constellation, Japanese government launched the second and third QZS (*Michibiki-2 and 3*) satellites respectively in June and August 2017. The forth satellite will be also launched soon. Besides, JAXA has also operated various remote sensing satellite, including ALOS-2 (also known as *Daichi*-2), which contains an upgraded high resolution synthetic-aperture radar (SAR) sensor, PALSAR-2. It is potentially used for various purposes, including disaster management and ocean monitoring, etc. Also, Japan has now developed advanced remote sensing satellites with high resolution optical and SAR sensor, which will be launched in 2020.

Japan's space policy has sought to promote the active use of these advanced 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. To this end, Japanese government is also willing to promote and expand international space cooperation, especially in the Asia Pacific region[9].

Furthermore, the use of space systems has also potentials in creating new businesses and application services in private sector. For example, being used in combination with various other information & communication technology (ICT) such as Big Data, IoT, geospatial information, artificial intelligence, and so on, space-based information is expected to produce new values in society and to create new businesses in a wide variety of fields, as well as to offer innovative ways to provide effective solutions to various societal problems. In November 2016, Japanese government set up Space and ICT working group to examine innovative ways to promote the use of space-based information in the context of rapidly growing ICT society. The working group drafted in June 2017 a comprehensive strategy toward maximizing synergy between space technology and ICT, which aims to generate new values and new businesses[10].

Third, it is also an important goal of the current Japan's space policy to improve international competitiveness of Japanese space industry [11]. In November 2016, Space Activities Act and Satellite Remote Sensing Act were passed into law. Clarifying rules for commercial space activities, as well as ensuring public safety and compliance with space treaties and other international agreements, such legal frameworks will help private sector in starting and running space business. In addition, Japanese government set forth Space Industry Vision 2030, which aims to strengthen international competitiveness of Japan's space manufacturing industry and to help start-up companies in paving the way for new space-based businesses[12]

Although Japan's space policy in recent years has placed a greater emphasis on the promotion of use of space for society, including for security purposes, it also recognizes the importance of scientific missions and planetary exploration. Japan has accomplished many of world-class space missions, especially in the fields of lunar exploration (*Kaguya*) and asteroid sample return mission (*Hayabusa*). *Hayabusa*-2 spacecraft was also launched in 2014. JAXA plans to launch a lunar lander, SLIM, in 2019. In addition, JAXA intends to conduct Martian Moons Exploration (MMX) in collaboration with French Space Agency (CNES), aiming to send spacecraft in early 2020s for sample return from Mar's moons (Phobos/Deimos)[13].

Japan has also been an important partner in International Space Station (ISS) program and agreed in December 2015 with the United States in extending its operation through 2024. In this situation, Japan also started the development of next generation's ISS cargo transport vehicle, HTV-X. Besides, Japan will host the second meeting of International Space Exploration Forum (ISEF- 2) in Tokyo at the beginning of next year. Japan is willing to play a key role in this important meeting to promote international discussion toward the future international space exploration in the post-ISS period.

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 April, 2017, 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. A unique milestone was created when India placed into orbits 104 satellites from 1 PSLV launch mission in November, 2016 – this is a world record.
- 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[14]

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 cornerstone 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[15]

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 [16] 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 Space Program in Singapore[17]

Singapore has started space activities in the mid 1990s and early 2000 to develop space sub-systems and an experimental micro-satellite (X-Sat) respectively at Nanyang Technological University (NTU), Singapore. X-Sat was launched in 2011 and this know-how was commercialised by a newly formed joint-venture company ST Electronics (Satellite Systems). Singapore's first locally designed and built near-equatorial orbit commercial remote sensing satellite TeLEOS-1 went into commercial service in July 2016[18]. In the same year, a local start-up company Gilmour Space Technologies based in Singapore University of Technology and Design (SUTD) successfully launched a self-made rocket in Australia using 3D printing technologies [19] . This year Gilmour Space has successfully raise S$5million in Series A funding to further develop the rocket technology[20]. Singapore has focussed on space industry as an economic driver and aims to develop a thriving space industry, undertake new R&D in space technologies and grow a pool of human capital for space industry. To boost this vision, Singapore established a Office for Space Technology and Industry (OSTIn) in 2013 – adding a goal of forging partnerships with international space industry.

Within Singapore, space industry is active in satellite technology development where satellite systems are developed; in remote sensing applications development and providing satellite communications services. The aim of Singapore is also to address, in future, sub-orbital spaceplane programme [21] related technologies. As of early 2017, Singapore has 10 satellites in orbit and these have been launched through procured launches; second commercial remote sensing satellite -TeLEOS-2 [22] and research cube satellites by National University of Singapore (NUS) [23] are under development.

A Singapore Space and Technology Association (SSTA) was established in 2007 - focused on developing Singapore's space and related high technology industries. SSTA serves as a neutral platform to facilitate information and communication for industry, government and academia; spearheads initiatives that advances Singapore's space ecosystem and drives educational and outreach programs to encourage careers in space and high technology engineering fields. SSTA organises the annual Global Space and Technology Convention (GSTC) to support the growing Singapore space program, and allow policy makers to have a neutral sharing platform[24]. The GSTC has grown into Asia Pacific's most comprehensive commercial space event. Unique initiatives have also been launched by SSTA in the education arena for students, youth and young researchers – in unmanned systems technologies and space systems; space medical systems research and new technology satellites for air traffic navigation.

Looking ahead, SSTA in collaboration with JAXA will facilitate more cubesat launches, micro-gravity experiments and also developing concepts of research on exposure of materials in-orbit using the International Space Station Japanese Experiment Module (*Kibo*). Singapore has not yet developed a Space Policy, moving forward it is opportune to establish some form of domestic regulatory framework under the management of a National Space Organisation/Agency to further mature the local space industry.

In summary, Singapore's space development is at nascent stage but activity in recent years has been vibrant - in addition to commercial satellite launch, universities and research institutes have planned experimental and research micro and cubesat launches. SSTA aims to continue to focus on enhancing Singapore space education programs and technology development; working with other nations in international cooperation to provide affordable launch of micro and cubesat and exposing materials in actual space environment; space eco-system will continue to morph to better support and facilitate the increasing vibrant space academia and commercial activities across the world. SSTA will continue to facilitate and support OSTIn and space eco-system to grow Singapore's space technology and industry and will also play an active role to support the establishment of space policy and National Space Organisation/Agency.

2.4 Space Policy of Philippines[25]

As a developing country, the Philippines is a recent entrant to the Space Age. Similar to most developing countries, space was viewed in the past as a very challenging endeavour and is usually cast aside for more immediate concerns such as poverty alleviation and economic growth. Being an archipelago of 7,600 islands in the Pacific edge of Southeast Asia, the Philippines is situated in the Pacific Ring of Fire and is battered by an average of 20 typhoons annually. The most devastating of which was Typhoon Haiyan which struck Central Philippines in November 2013, causing thousands of casualties and large-scale damages. Given these numbers, it became clear to the Philippines that the use of space is vital in addressing issues such as disaster risk reduction, national security, food production and climate change.

The Philippines' first space development activity was the missile and sounding rocket program in the 1970s. However, this program was terminated and no significant development was done in the next decade. In 1997, the country launched its first satellite - AGILA-2 Telecommunications Satellite, mainly funded by the private sector. Subsequently, the Philippine Space Science Education Program (PSSEP) was facilitated by the Science Education Institute of the Department of Science and Technology (DOST) since 2005 to spark interest in space among young students in the country. It has conducted the annual celebration of the World Space Week which coincides with the National Water Bottle Rocket Competition. Since 2015, it has also conducted the Can Satellite Competition for High Schools. The CanSat Competition provides training for high school students on the basic principles of satellite development and systems engineering.

More recent developments include the creation of the Philippine Earth Data Resources Observatory which serves as the primary ground receiving station for satellite images in the country. During late 2000s, the PHIL-LIDAR Program was conducted to provide high-resolution 3D digital elevation maps and flood vulnerability predictions in various river basins that will help meet the country's information needs for hazard assessment and other applications such as water resources management, land-use planning, forest and agricultural monitoring.

2.4.1 *Philippines Space Development Policy and Program*

In 2013, the Philippines began establishing a long-term and sustainable space program through a series of studies initially aimed at understanding the national status of space development. The 10-Year Baseline Research Study in 2013 and Cost-Benefit Analysis of a National Space Program in 2015 highlighted the need for a clear strategy and policy for sustainable space development. In addition, it also stated the need for a centralized space agency in order to coordinate all space activities within the country. This led to the proposal in 2014 for the creation of the Philippine Space Development and Utilization Policy (PSDUP) and the Philippine Space Agency (PhilSA). The PSDUP serves as the primary strategic roadmap for national space development in the next decade focusing on areas of space science and technology applications and addressed national issues and concerns. The policy focuses on six (6) Key Development Areas (KDA) – namely, National Security and Development; Hazard Management & Climate Studies; Space Research and Development; Space Industry Capacity Building; Space Education and Awareness and International Cooperation. On the other hand, the organizational structure of PhilSA was drafted based on consultations with various stakeholders and agencies.

The Philippine Microsatellite Program (PHL-MICROSAT) commenced in 2014 with the aim to develop and launch two (2) microsatellites by the year 2018. The microsatellites will be developed by scientists and engineers from the University of the Philippines together with Japanese collaborators from Hokkaido and Tohoku University as part of the Asian Microsatellite Symposium. In April 27, 2016, the 50-kg DIWATA-1 microsatellite was deployed from the Japanese Kibo Module of the International Space Station. The DIWATA-1 carries four optical payloads namely the High Precision Telescope, Spaceborne Multi-Spectral Imager, Middle-Field Camera and Wide-Field Camera. To date, it has obtained images of various parts of the Philippines and is expected to be operational until late 2018 or after the launch of DIWATA-2.

In 2015, the Department of Science and Technology (DOST) created the National Space Development Program (NSDP) to serve as an interim program to lay the groundwork and necessary infrastructure for space development prior to the creation of PhilSA. As part of its mandate, the NSDP drafted several roadmaps for space development in the next decade and spearheaded the lobbying for the formal legislation of PSDUP and PhilSA. The four critical roadmaps created were the following:

- National Space Research and Development Agenda – identified five (5) research priorities: Earth Observation, Safety and Security, Space Systems and Facilities, Space Education and Space Science Innovation;
- Satellite Development Roadmap – addresses the satellite requirements of the Philippines for the next 15 years which includes a geostationary telecommunications satellite, an optical infrared EO satellite, a synthetic aperture radar satellite and a precipitation radar satellite;
- Space Industry Development Roadmap – noted four (4) competitive niche areas for the Philippines namely space sub-system production, assembly, integration and testing, space applications and services, and launch services; and
- Satellite Data Sharing Policy – outlined the mechanism for acquisition, utilization, archiving and distribution of satellite images from Philippine satellites and ground receiving stations.

In 2016, House Bill 3637 and Senate Bill 1211, collectively known as The Philippine Space Act of 2016, was submitted for legislation to the Philippine Congress and Senate, respectively. Three other House Bills and one Senate Bill of similar content was also filed by the end of 2016. In addition, the 10-Year Space Development Program was presented to the Cabinet and President Rodrigo Duterte in January 2017 and was approved in principle. This included a civilian budget allocation of PHP 24.4 Billion (approx. $500 million) over the next ten years.

As part of its aim to be a responsible member of the international space community, the Philippines hosted the 23rd Asia-Pacific Regional Space Agency Forum in November 2016. The APRSAF was attended by more than 500 participants from several Asia-Pacific countries and discussed various issues related to space development in the region. Furthermore, the Philippines is considering the ratification of the Outer Space Treaty, the Liability Convention, the Registration Convention and becoming party to the Missile Technology Control Regime. The Philippines is also an active participant to the SETINEL Program for image-based applications in flood mapping and landslides.

Despite being a late-entrant, it provided the Philippines with the unique opportunity to study the various policies, programs and experiences of other emerging space nations. This has enabled the country to leapfrog and progress rapidly in a very short period of time and with minimal resources. It is hoped that the current programs will further the rate of development in space science and technology that will enable the Philippines to conduct have a sustainable space program that is beneficial not only to Filipinos, but also to the global space community at large.

2.5 *Space Programme in Malaysia*[26]

Malaysia has many space-related programmes in the fields of space science and technology programme, the astronaut programme and space education programme. The two main activities include - building of space infrastructures: national observatory and remote sensing centres. Their purposes include the supervising and monitoring of space network frequencies and coordinating space networking, providing a platform for Malaysian scientists and international astronomers to do research on space science, and controlling and maintaining the satellite operations and satellite activities. 7 satellites have been launched, the latest is MEASAT 3B in 2014. These satellites are used for communications services and applications, remote sensing, earth observations and space science.

Malaysia's Astronaut Programme has been launched to inspire all Malaysians to strive for excellence and a unity of purpose and instill a sense of identity that will promote national resolve and enrich their lives. The programme aims to instill the interest of young Malaysians to explore new areas of science and technology which are crucial to sustaining a long-term national competitiveness in a globalization era. In 2007, Malaysia sent its astronaut, Datuk Sheikh Muszaphar to the International Space Station to conduct scientific experiment.

Space Education Programme is actively taken up in Malaysia, Major activities include the National Planetarium which is equipped with theatre, display gallery and observatory tower; Astronomical workshops for school teachers; space camps, poster contest and workshops for school children and Model Rocket launching contest for public.

All these space activities in Malaysia are organised under the Malaysian National Space Agency (ANGKASA)[27] – which is responsible for leading and observing the development of space science in Malaysia through - providing leadership in the educational aspect and the research of space science; assisting the government in formulating and executing the National Space Fundamentals and providing quality service to customers to help achieve the above- mentioned goals. ANGKASA has a vision of "harnessing space as a platform for knowledge generation, wealth creation and societal well-being" and set Mission goals to "develop the country's potential in the space sector to support the development of the new economy, generate knowledge and strengthen the national security infrastructure".

On 26th September 2000, Malaysia's first satellite, TiungSAT-1 was launched from Baikonur. This micro-satellite is for Earth observations; scientific Cosmic-Ray Energy Deposition Experiment (CEDEX) as well as for simple communication application. TiungSAT-1 is equipped with a Multi Spectral Earth Imaging Camera system and Meteorological Earth Imaging camera system which has a resolution of 72 m and 1.2 km respectively.

The MEASAT group is a premium supplier of satellite services to leading broadcasters, Direct-To-Home (DTH) platforms and telecom operators in the world. With capacity across six (6) communication satellites, MEASAT provides services to over 150 countries representing 80% of the world's population across Asia, Middle East, Africa, Europe and Australia. Working with a selected group of world-class partners, MEASAT also provides a complete range of broadcast and telecommunications solutions. Services include UHD/HD and SD video play-out, video turnaround, co-location, up-linking, broadband and IP termination services.

Malaysia uses space technologies for a huge number of applications through three enabling tools, namely communication, navigation and positioning, and remote sensing.

2.5.1 Space Policy in Malaysia

ANGKASA has developed the "Malaysian Space Policy". The Policy is to inter alia - set out the vision and goals of Malaysian space activities for the new century; provide strategic context for investments in space exploration and exploitation by the Government and industry in order that they contribute effectively towards the socio-economic well-being of the nation; mobilize and organize the resources (financial, manpower & institutional) to make such investments work for the nation in term of enhancing the productivity and skill-levels of the key economic sectors as well as the generation of high value added products, processes and services and establish the framework for the effective performance of the various actors involved in the exploration and exploitation of space including the engagement with external parties; to ensure that Malaysia space activities moves forward, to progress further according to the space policy – because Malaysia desires to be a developed nation by the year 2020.

Researchers in Malaysia have recommended for strong financial support from government for space related projects, industry player incubation, research development and commercialization and human capital development and international cooperation goals.

3. Identifying Commonalities and Uniqueness

Japan and India have a long history of space programme – from 1960s onwards. They 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 activity has recently come to be more comprehensive, including 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*. *Kaguya* and *Hayabusa* are Japan's major accomplishments in these areas. Japan has also actively participated in ISS 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.

Philippines is the unique nation that has legislated a Space Act and brought space activities under legislator framework. The Act has provided a strong foundation for a Philippine Space Agency and for planning and coordinating of various space programme. Thus, Philippines has laid a strong foundation for future space activities and the framework provides a systematic approach to developing space. Philippines has a strong space applications and education segment – with intense earth observation applications. 3D DEM programme (using Lidar), disaster management applications like flood, typhoons etc. The space industry in Philippines is still at nascent stage – though contours of space industry development is clearly defined in the Space Act. Philippines has development capability for small-satellites but depends upon cooperation and collaboration or operational satellites and for launch services. Philippines has a strong component of regional space cooperation and much of its advanced activities of satellite building, launch etc are based on international cooperation.

Singapore is a developed economy and has a strong industrial and academic base for advanced space technology development. SSTA, ST Electronics (Satellite Systems), NTU, NUS, Center for Remote Imaging Sensing and Processing - NUS (CRISP), SUTD are major institutions that develop commercial remote sensing satellite, technology research and new products in space applications. Singapore's space development is at nascent stage but activity in recent years has been vibrant - in addition to commercial satellite launch, universities and research institutes have planned experimental and research micro and cubesat launches. SSTA aims to continue to focus on enhancing Singapore space education programs and technology development; working with other nations in international cooperation to provide affordable launch of micro and cubesat and exposing materials in actual space environment; space eco-system will continue to morph to better support and facilitate the increasing vibrant space academia and commercial activities across the world. SSTA will continue to facilitate and support OSTIn and space eco-system to grow Singapore's space technology and industry and will also play an active role to support the establishment of Space Policy and National Space Organisation/Agency. Singapore is yet to develop a Space Policy but has established an administrative structure for space activities under OSTIn and SSTA. Singapore is one nation that aims for suborbital spaceplane programme technology development – which is unique in the Asia Pacific region.

Malaysia has developed its Space Policy. Malaysia has established a national Space Agency known as 'ANGKASA', which focusses on technology development, space science and education and development of space applications. Malaysia's space policy contains issues related to vision and goals, context for investments in space exploration and exploitation, mobilize and organize the resources required. Malaysia has small-satellite development capability and a declared Astronaut programme. There is also a private company known as MEASAT, which is actively providing space related services to the public.

4. Potentials for Space Cooperation in the Region

The previous works in this research[28], which examined potential opportunities for Japan-India bilateral space cooperation, identified a lot of potential areas for future space cooperation between the two nations: (1) policy and law, (2) joint space mission, (3) satellite navigation, (4) ISS utilization and space exploration, (5) space application for disaster management and climate change, (6) space robotics, space security, (7) regional contribution in the Asia Pacific region, (8) industrial partnership. Many of these areas can also be potentially viewed from a wider perspective as regional agendas for future space cooperation in the Asia Pacific region. Based on the analysis discussed above, this section will review potential opportunities for future space cooperation from a regional perspective.

4.1 Policy and law

Space policy and legal regimes would be a potential area that will bring regional benefits. Today many nations in the region, including emerging spacefaring nations like Malaysia, Singapore, and Philippines, have been starting to develop national space policy and to establish laws concerning space activities. The importance and opportunity of regional space policy cooperation have been increasing in recent years.
In this situation, regional space policy cooperation mechanisms should be developed. A cooperative framework for regional space policy dialogues at the government level has remained insufficient in the Asia Pacific region. Although the Asia Pacific Regional Space Agency Forum (APRSAF) has long been a good platform for regional space cooperation, it has so far emphasized largely on the cooperation in the fields of space technology and applications at the space agency level, rather than space policy cooperation at the government level. It would be worth consideration to set up a new cooperative framework for regional space policy discussion at the government level under APRSAF. ASEAN also has the Sub-Committee on Space Technology and Applications (ASEAN SCOSA),

which aims to formulate for enhancing collaboration in space activities among the ASEAN nations[29]. It would potentially offer a door to encourage the participation of ASEAN countries in regional space policy discussion. ASEAN Regional Forum (ARF) has also been working on space security issues and has functioned as a good forum for inter-governmental dialogue in this region, which would help in formulating a common understanding about the safety and sustainability of space activities. The promotion of the government-level space policy cooperation would help in finding common interests and common challenges in space activities, as well as identifying potential areas for regional space cooperation in the future.

In addition to the so-called Track-1 government-level cooperation discussed above, other unique collaborations, like academic space policy research collaboration among researchers and experts in this region, should also be encouraged as Track-2 cooperative initiatives[30]. For example, UoT and NIAS have conducted joint space policy research since 2013. It has organized the Annual Space Policy Round-Table Meetings in Bangalore, as well as many workshops as a side event of APRSAF, in order to promote regional space policy discussion. The round-table meetings and workshops have been participated by many researchers and experts not only from Japan and India but also from China, Malaysia, Indonesia, Vietnam, Philippines, Singapore, and so on. This kind of cooperative initiative can not only bring researchers and experts from many Asian countries together but can also enable networking of them to share experiences in space policy and law research, as well as to share information concerning remote sensing policy and geographic information policy.

Specifically, such space policy research 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 interests in space utilization so as to identify a common ground for space application cooperation. This kind of research cooperation could also help identify issues that will have an impact on space activity in the region, including the role of non-state actors such as private company and universities, economic cooperation, climate change programmes, disaster management, regional security environment, potential constraints from international regimes or codes of conduct, industrialization of space, denial of access to space by others, activities that poses threats to others, and so on. 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.

Track-1 and Track-2 regional space policy cooperation will go a long way for the countries in this region to create a common understanding of space programs and policy perspectives and to make a sound justification at national levels. It would also help space developing countries to develop long-term space policy and law definition, ensuring that domestic regulatory framework encourages innovation on cost effective satellite services and applications, and sustainable and safe practises, as well as fostering regional and global sharing and collaboration. The latter offers the bedrock for without-bounder products and services for environment monitoring, disaster mitigation and effective response, counter-terrorism, and improving the livelihood of populations/communities at risk. Ultimately, space policy cooperation could also help build the case for a comprehensive "Asia Pacific Regional Space Policy," which addresses the long-term cooperation strategy and policy development in this region.

4.2 Joint space mission

India and Japan have tremendous capabilities for satellite building and for launching of satellites. It would create new possibilities for joint space missions. For example, in the areas of space science and planetary explorations, Japan and India have potentials for joint missions in developing space science instruments for astronomy and planetary studies and, as well as human spaceflight technology. Sharing the outcome and scientific information for space science research would also be possible. Both nations can also consider joint missions in mutually using technological capabilities such as satellite bus and sensor systems for hyper-spectral remote sensing and synthetic aperture radars, etc. Joint missions for weather and climate change observations, as well as disaster management constellations, would also be worth serious consideration.

From a wider perspective, joint space missions can also be a good opportunity for emerging spacefaring nations in the Asia Pacific region to leverage the programs for their experiments and researches based on common interest and goal. Such collaborations would help them to develop their space technology and capabilities, as well as to advance their scientific research.

4.3 Satellite navigation

India and Japan are best placed to collaborate in the area of satellite positioning and navigation systems. India has developed regional satellite positioning system known as IRNSS and has already launched 7 satellites necessary for the system. Japan has also been developing QZSS. The construction of the four-satellite QZSS constellation will be completed soon and its operation will start in 2018. Japan also intends to eventually build 7-satellite constellation by 2023.

The foundation for technological development of positioning systems is available in this region. Unlike US Global Positioning System (GPS) and other global systems, however, IRNSS and QZSS have just a regional outreach covering their geographies. In this situation, India and Japan can consider the possibility of expanding the coverage areas of their regional positioning systems by working together. 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 the countries in the Asia Pacific region. The combination use of IRNSS and QZSS together with other global system like GPS could also offer more accurate and valuable positioning services in the entire region. The use of operational information derived from such multiple positioning satellite systems would also potentially create new applications and businesses in a wide variety of fields.

While emerging spacefaring nations have currently no any specific plans to develop their own satellite positioning system, they are potential users of these systems in this region. In this regard, a regional collaboration would also be possible in examining the potential ways to use such multiple satellite navigation systems available in this region and creating new applications and services which meet national and regional needs. As the providers of satellite positioning services, Japan and India can also play a leading role in promoting the use of their satellite positioning system in this region.

4.4 ISS utilization and space exploration

Japan is the only nation in Asia to have participated in the ISS program and has been playing the important role as Asian gateway to the ISS program. In particular, Japan has made an active effort to promote ISS utilization though the Kibo-ABC (Asian Beneficial Collaboration through "Kibo" Utilization) program under the framework of APRSAF. This program aims at offering opportunities for researchers and industries in the Asia Pacific region to use of ISS and Japanese Experimental Module, *Kibo*. Through this program, many nations in the region, including emerging spacefaring nations, will be easily able to take the opportunity for ISS utilization. It would help them in carrying out scientific research projects and experimentation in a unique zero gravity environment and in sharing the outcome of ISS utilization.

Kibo also has a very unique capability known as JEM Small Satellite Orbital Deployer (J-SSOD), which is a mechanism for deploying cubesats in orbit[31]. Because many developing countries in the Asia Pacific region has been working on the development of satellite technology, the unique capability of J-SSOD would provide a significant opportunity for them to deploy their cubesats in orbit and conduct technological experiment. It would also contribute to capacity building for the development and operation of small satellite. In fact, Philippines took this opportunity and deployed the nation's first satellite DIWATA-1 from ISS/Kibo in 2016, which was developed in the collaboration between several universities in Japan and Philippine.

In addition, planetary exploration would also be a potential area in which regional space cooperation can take place 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). *Hayabusa-2* was also launched in 2014 with an aim to achieve sample return from a near earth asteroid. Planetary exploration and scientific missions are also emphasized in India's space policy in recent years. ISRO launched the first lunar probe Chandrayaan-1 in 2008. India also successfully achieved Mars Orbiter Mission (MOM-1), which made India the first nation in Asia to successfully send a spacecraft to Mars orbit. By using these advanced capabilities, Japan and India can jointly play a significant role in leading and promoting regional cooperation in the field of planetary exploration. 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 will foster a regional collaboration in this area.

The future space exploration in the post-ISS period requires a wider international cooperation. Japan will host the second meeting of International Space Exploration Forum (ISEF) in Tokyo at the beginning of 2018. This will be a tremendous opportunity to solicit the participation and cooperation from emerging spacefaring nations in the Asia Pacific region and to discuss future vision and common goals of international space exploration, including human spaceflight.

4.5 Space application for disaster management and climate change study

Space utilization for disaster management, as well as climate change study, is a highly possible area in which all nations in this region can share the interest for 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[32]. Safeguarding the lives and safety of citizens from natural disasters such as earthquake, tsunami, typhoon, heavy rain, flood, landslide, volcanic eruption, and so on, is a common challenge for all nations in this region. Japan experienced the Great East Japan Earthquake in 2011, as well as another big earthquake in Kumamoto in 2016. Likewise, Philippines was severely damaged by a super typhoon in 2013. As climate change progresses, it is also expected to increase extreme weather events and its adverse consequences.

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 imagery.

More importantly, the experience 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 cooperative frameworks such as 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[33]. International cooperation can help supplement satellite capabilities of each nation in case of emergency.

As leading spacefaring nations, Japan and India can be major suppliers of satellite imagery in the framework of Sentinel Asia. Moreover, given the fact that many emerging spacefaring nations in this region have made active efforts to develop satellite technology for earth observation, the opportunity for regional space cooperation for disaster management will increase in the near future. To this end, Japan and India can also contribute to the capacity building in the Asia Pacific region for the use of space technology in disaster management.

Besides, regional space cooperation for disaster management should be expanded to include a pre-disaster phase of efforts. The existing frameworks of space cooperation for disaster management mainly focus on the provision of satellite imagery for "disaster response," namely the post-disaster phase of efforts such as emergency satellite observation. The expansion of this scope to include pre-disaster phase of efforts (preparedness and mitigation) will enable nations to create and update disaster prevention map and to monitor crustal movement and volcanic activity on a regular basis. It will contribute to disaster risk reduction. Also, the use of satellite information for climate change study in a cooperative manner will help in mitigating the future risks of natural disasters.

4.6 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.

Apart from space science and planetary exploration, space debris removal technology would also be a potential interest for future cooperation. Space agencies and research institutes in major spacefaring nations, including Japan, have started research and development of space debris removal technology. A Japanese private company, Astroscale, was also setup in 2013 to address the threats of space debris. Space debris removal requires advanced robotics technologies rendezvousing and approaching to non-cooperative objects, as well as capturing and removing them from orbit. International research and development program, which involves participations from universities and research institutes, would be desirable from not only technical but also political standpoints. It can help in encouraging an international shared interest in space debris issues and also increasing transparency in developing such technology.

4.7 ***Space cooperation for security***

Space cooperation for security can also be regarded as an area of regional common interest. As discussed above, Japan' s space policy in recent years have placed a greater emphasis on the use of space for security than ever before. India have also launched several space assets dedicated to, or potentially used for, security purposes. Besides, space for security is an important driver for space activities in emerging spacefaring countries in the Asia Pacific region. In Philippines, national security is identified as one of the priorities in Space Research and Development Agenda. Although Malaysia space activities has largely focused on scientific and technological aspects, the government recognized the importance in enhancing national security interests through space.

One of the possible commons interests to the nations in the region would be a cooperation for the use of space for maritime security, namely space-based maritime domain awareness (MDA). All nations addressed in this paper are seafaring nation and have a shared 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. The nations are also 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.

Japan and India have similarly made an effort to increase "effective understanding" of the situation in maritime domain, namely MDA, as a key element to maritime security and sought to integrate satellite information into the efforts. Both nations have several space assets potentially contributing to MDA. 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/regional cooperation, as well as interagency collaboration, for information sharing, including space-based information.

Such information sharing would potentially bring tremendous benefits in this region, not only increasing a shared understanding of the situation in the maritime domain across the region and helping each nation to address a wide variety of maritime security challenges in a cooperative manner but also potentially contributing to making regional security environment more stable. To this end, a possible cooperative framework for space-based maritime security information sharing should be considered from the perspective of regional security cooperation.

4.8 Social Development in the Asia Pacific region

Regional space cooperation not only promote space activities in the region but also potentially contribute to making more advanced society in Asia. The promotion of regional space cooperation will help to address common challenges such as natural disaster and climate change. It would also contribute to the improvement of security environment in the Asia Pacific region. Space technology such as remote sensing can also be used to help agriculture and fishery. It also contributes to making a precise map of entire country, which is essential for urban planning and land management. Satellite communication has a potential to mitigate digital divide in a remote area. It would also make it possible to introduce tele-education and tele-medicine. Positioning satellite and GIS application will help improving traffic problems in developing countries. Space can also foster economic and industrial development in the region.

As leading spacefaring nations in this region, India and Japan are best placed to expand collaboration to jointly offer expertise and knowledge in support of other nations in the Asia-Pacific region, including remote sensing, GIS information, satellite communications, positioning application, and so on. India and Japan should also cooperate with other nations in considering possible mechanisms for regional cooperation in a manner that their expertise and knowledge in the field of space application would encourage social development in the Asia Pacific region. In doing so, it would be essential to involve multiple stakeholders in this region, not only from space community but also from various non-space user community.

4.9 Industrial partnership

Privatisation of space is yet to enough develop in many nations in the Asia Pacific region 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 Japan and India are involved in national space activities through national space agency, respectively. In Japan, industries have matured capacities to develop a whole system of satellite and launch vehicle. Also, several start-up companies have been emerged in Japan and started space business in recent years. This is yet to be seen in India where industries are still in a sub-system mode. Singapore's space industries on the other hand is led by commercial company ST Electronics (Satellite Systems). The approach to work with local companies and collaborate with global partners has enabled the company to launch the first locally design and built commercial near-equatorial orbit satellite that went into commercial service in mid-2016. As space activities develops further in this region, privatization of space will make significant growth in the future.

Against this backdrop, industrial collaboration can be one of major areas in regional cooperation in the future. Leveraging strengths in industrial capabilities with each other would have greater advantages from the perspectives of cost reduction. Industrial collaboration would also create new business and application services. For private companies in developing countries, it would be a tremendous opportunity not only to help them in starting their business but to learn technical know-how and to develop their capability.

5. Building Regional 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 there are several commonalities in goals and objectives, and there can be an expression of political will at the highest level, as forthcoming between India and Japan, that augurs well for higher level of collaboration. This is notwithstanding the autonomy goals for space capabilities in all 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.

Thus, for example identification of common strategic goals will be a prerequisite to expand 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 regional collaboration as it can boost the confidence of different stakeholders in the government, academia, and industry.

60 years of space endeavours have demonstrated that applications of space technology are vital inputs for equitable developments that hold key for Sustainable Development Goals (SDG). An overarching international legal and policy framework, though necessary, is inadequate to bring about the quantum jump in the international cooperation that is warranted by the challenges of SDG recognising the economic, political, and social and security drivers and imperatives of cooperation. The key is to accept and sustain the diversity of approaches and mechanisms that can address the needs of a renewed Space Governance – (i) strengthening bilateral cooperation which forms the base for the pyramid of international cooperation where the broader regional as well as global cooperative initiatives form the middle and apex levels. Broder the base of this pyramid, greater will be the scope for regional and global cooperation (ii) reinforcing of mechanisms to strike harmony in areas that create conflicts and unhealthy competition, through more equitable access to any limited natural resources (iii) growth in cooperative institutions to extend support in humanitarian tasks, in capacity building and so on; and,(iv) global system of systems to monitor issues of common concern such as monitoring environment, space debris and regulating their impacts. The present article brings further dimensions of seeking expansion of cooperation through systematic analysis by experts and stakeholders from different countries and creation of awareness of potentials, opportunities and risks and also possible solutions. Such systematic evaluation and exploration of thought leaders and engagement of forums beyond the formal for a purely represented by the governments will add value to the endeavours towards accomplishment of objectives of SDG.

6. Conclusion

Space programme in the Asia Pacific region is spawning more than 50 years of development. With vision and determination, programmes in many nations have matured into success at various levels. Japan and India have advanced and progressive space programmes – they have many commonalities and high potentials in new areas of cooperation. Malaysia and Philippines have strong applications programmes and are developing satellite building capability in a significant manner. Seeking space services from other nations under cooperation is a major element of space development. Singapore is having strong industrial capability and seeks partnerships in global space industry and also has vision for suborbital programme technologies.

This study identified several key areas for regional cooperation in the future. The high-level technological capabilities in the areas of earth observation, positioning, space science, planetary exploration, space robotics indicate that India-Japan joint space mission is of high potential. This will also be a great boost to space activities at the regional and global level. The opportunity and importance of regional space cooperation will be more and more increasing with the advent of newly emerging spacefaring nations in the region. In this context, the regional common goals and possible framework for space cooperation should be formulated and developed. Japan and India can play a leading role in regional cooperation for the societal and commercial development of space in the region.

The promotion of regional space cooperation can be considered at multiple levels. Space policy cooperation and dialogue at the government level will foster the mutual understanding of space programs/ policies in the region and identification of possible agendas for future space cooperation. Based on this, regional space cooperation at the national space agency level can be further promoted within the framework of APRSAF. Regional space cooperation will also be able to involve more participation from private sectors in the future.

Moreover, this study also demonstrated that space policy research collaboration among researchers and experts in the Asia Pacific region can be a great potential for future cooperation. This study involved many researchers and experts not only from Japan and India but also from many other emerging spacefaring nations in this region and enabled a cooperative analysis to examine potential opportunities for future regional space cooperation from a wider perspective. Such space policy research collaboration should be further encouraged and extended to cover many other nations in this region. Though informal and academic-centric, such cooperative studies point out clearly the strengths and gaps – which are potentials for cooperation.

Significant similarities among the objectives of the policy, the policy drivers, and paradigms are pushing renewal of policy environment for outer space in the Asia Pacific region. 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 the region, joint missions that address humanitarian concerns as well as technological advances that promise 'New Space' developments.

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[30] While Track 1 refers to "all official, governmental diplomacy," Track 2 diplomacy generally refers to "interactions among individuals or groups that take place outside an official negotiation process." See, Dalia Dassa Kaye, *Talking to the Enemy: Track Two Diplomacy in the Middle East and South East*, RAND Corporation, 2007, 5.

[31] http://iss.jaxa.jp/en/kiboexp/jssod/

[32] 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>

[33] 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.