M.A. (Space and Telecommunication Law)

SPACE TECHNOLOGY - FROM NATIONAL DEVELOPMENT TO INTERNATIONAL COOPERATION: AN ANALYSIS

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DECLARATION

I declare that the present Dissertation titled **"Space Technology: From National Development to International Cooperation- An Analysis"** has been prepared and submitted by me to the NALSAR University of Law, Hyderabad in partial fulfilment of the requirement for the award of Master Degree in **Space and Telecommunication Law** under the guidance and supervision of Prof. (Dr.) V. Balakista Reddy, Registrar, is an original, bonafide and legitimate work of the undersigned, and has been pursued purely for an academic interest. This dissertation shall not be used for any political purposes or connotations or as a testimony against any person or communities or regime. The views and idea expressed in this Dissertation are exclusively of the research and do not represent any person, organization, or community.

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Table of Abbreviations

ABAE: Bolivarian Agency of Space Activities

ABM: Anti-Ballistic Missile

AECA: Arms Export Control Act

APRSAF: Asia Pacific Regional Space Agency Forum

APSCO: Asia Pacific Space Cooperation Organisation

ASAT: Anti-Satellite

ASTP: Apollo-Soyuz Test Project

ATS: Advanced Technology Satellite

CAPE: Crop Acreage and Production Estimation

CBRN: Chemical, Biological, Radiological and Nuclear

CEO: Chief Executive Officer

CEOS: Committee on Earth Observing Satellites

COCOM: Coordniating Committee for Multilateral Export Control

COPUOS: Committee for Peaceful Use of Outer Space

CTS: Communications Technology Satellite

EAA: Export Administration Act

EAR: Export Administration Regulations

EC: European Commission

ECMWF: European Centre for Medium Range Weather Forecasts

EO: Earth Observation

ESA: European Space Agency

EU: European Union

EUMETSAT: European Organisation for the Exploitation of Meteorological Satellites

FASAL: Forecasting Agricultural Output using Space-borne Agrometeorology and Land-based observations

GDP: Gross Domestic Product

GEO: Geosynchronous / Geostationary Orbit

GIS: Geographic Information System

GNSS: Global Navigation Satellite Systems

GPS: Global Positioning System

GSLV: Geosynchronous Satellite Launch Vehicle

HCoC: Hague Code of Conduct

IGA: Intergovernmental Agreement

INCOSPAR: Indian National Committee for Space Research

IN-SPACe: Indian National Space Promotion and Authorisation Centre

INTELSAT: International Telecommunication Satellite Organisation

ISRO: Indian Space Research Organisation

ISS: International Space Station

IT: Information Technology

ITAR: International Traffic in Arms Regulation

ITU: International Telecommunication Union

JAXA: Japanese Aerospace Exploration Agency

KARI: Korean Aerospace Agency

LEO: Low Earth Orbit

LTBT: Limited Test Ban Treaty

MDG: Millennium Development Goals

MoU: Memorandum of Understanding

MTCR: Missile Technology Control Regime

NACA: National Advisory Committee for Aeronautics

NASA: National Aeronautics and Space Administration

NATO: North Atlantic Treaty Organisation

NCD: Non-Communicable Diseases

NDMA: National Disaster Management Authority

NISAR: NASA ISRO Synthetic Aperture Radar

NNRMS: National Natural Resources Management System

NSIL: New Space India Limited

OECD: Organisation for Economic Co-operation and Development

OST: Outer Space Treaty

PSLV: Polar Satellite Launch Vehicle

R&D: Research & Development

RASCOM: Regional Satellite Communications Organisation

SDG: Sustainable Development Goals

SITE: Satellite Instructional Television Experiment

SOHO: Solar and Heliospheric Observatory

STDA: Storm Thurmond Defence Act

TERLS: Thumba Equatorial Rocket Launching Station

TRL: Technology Readiness Level

UN: United Nations

USD: United States Dollar

USML: United States Munition List

WMO: World Meteorological Organisation

CHAPTER 1

1.1. Introduction

"The sky's danger offers the eagle more opportunities than the nest's comfort" - Matshona Dhilwayo

Space has always been a fascination for the human. The stars, the planets and the celestial bodies fueled curiosity in him. With the same curiosity, his intuitions conveyed to him that, if he could send an object high up in the sky, like an eagle who soars high, he can see and feel the ground from much above without any interruptions. As said by the Canadian philosopher Matshona Dhilwayo, with the danger it poses up in the sky, it offered more opportunities.

When Sputnik 1 pulsed its signals back to Moscow in 1957, it was opening a new domain in the scientific domain- the space technology. Space technology refers to the utilization of space based systems such as satellites and space stations to achieve remote sensing, weather forecasting, navigation and position information, observing outer space for scientific data collection, interplanetary missions under the aegis of astronomy and earth sciences, satellite television and global communication. All these contributions are very essential to achieve the sustainable development goals.[1]

The full range of activities which creates value and benefits to human beings in the course of this explorations constitute the Space Economy. According to Morgan Stanley think tank, the $380bn USD global space industry could surge over to $ 1 trillion USD by the year 2040.[2] Once belonging only to a handful of technologically advanced super powers, more and more States and private actors are now keen on investing in this rewarding galactic business. Driven by the economic incentives associated with this sector, more private participation is expected resulting in competition for exploitation.

During the origin of the space technology, the situation was governed by a bilateral paradigm dictated by the then super powers. As time progressed, due to the multiplicity of space actors and due to the focus shift to military, civil and commercial aspects, the domain of international cooperation has also changed its outlook. The inherent dual use nature of the civil space technologies raises concern of unauthorized access and utilization in technology transfers. This has aided the unilateral paradigm of State involvement as a pertinent issue in the field of export controls limiting the synergetic cooperation for a

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[1] *United Nations Office for Outer Space Affairs Annual Report 2018* 82.
[2] *A New Space Economy on the Edge of Liftoff*, MORGAN STANLEY, https://www.morganstanley.com/Themes/global-space-economy (last visited Apr. 6, 2022).

peaceful use and exploration of outer space. The full potential of technologies is confined to the developer and as envisaged in the Space Law treaties, there doesn't happen any equitable sharing of the technical outcomes. It seems that there exists a clear nexus between the legal, political and technical domains which impact the transfer of technologies. With the proliferation of the commercial space actors as well as the impactful entry of the new space entrants, the international cooperation in space will definitely benefit and help to reduce the costs incurred by the traditional space actors.

International cooperation is much needed to achieve mankind's continued exploration of the space in a peaceful way. International cooperation in this sophisticated field will result in improved technologies and applications which can be leveraged to maximize the benefits accrued from the exploration of outer space. Due to variety of reasons, the access to space technology is denied to many developing countries the main reasons being; technological gaps, geographical constraints, lack of financial resources to fund the high cost involved in the space research and in fact mere lack of understanding about the potentials. The role of regional and international cooperation are much needed to address these bottlenecks. Space technology is considered as one of the major tools for attaining the 17 sustainable development goals put forward by the United Nations. The data from the space is expected to provide real time key information which can be utilized to arrive at strategic policy making decisions and they are considered essential in wake of the monitoring the progress of the SDGs[3]. When the world was fighting the Covid-19 pandemic, we have seen in what all areas the communication could be improved making use of the space technologies. Same is the case when it comes to population at risk from the rising seas or advancing desertification.[4]

1.2. Objective of Study

The present study tries to bring out the relationship between the national development by virtue of a nation's hold on the space technology and the extent to which the developments in one country can be extended to the dependent countries through various international cooperation mechanisms. The researcher proposes to throw light on the effects of trade regulations on the space cooperation when one nation tries to extent its technological development to another. The study will also focus on the ill effects

[3] *United Nations Office for Outer Space Affairs Annual Report 2018*, *supra* note 1.
[4] *UNOOSA Annual Report 2020*, http://www.unoosa.org/documents/pdf/annualreport/UNOOSA_Annual_Report_2020.pdf. (last visited Apr. 6, 2022).

on the proliferation of the space technology-based commerce though in an angle it will be giving a huge thrust to the development of a nation's development. It is proposed to bring out concern about the national security when sophisticated technology transfers are attempted.

1.3. Statement of Problem

Space technology has always been a backbone for the national development. There always exists an element of national security dilemma when thinking about the technology transfers involved in the space domain as a result of the international cooperation. In addition to this, the restrictions imposed by the multilateral trade regulation always stands as stumbling blocks when transfer of technology or equipment of dual nature is involved, which are quite common when it comes to space domain. Also, the growing militarization and securitization of the space poses serious questions when it comes to an accommodating approach demanded in the domain of space. Sustainable development goals put forward by the United Nations calls for a much clearer mandate on the regional and international cooperation in the space domain to achieve its goals. Thus, it is obvious that space technology, though a sharper tool for national development, faces various dilemmas when it comes to the foray of international cooperation.

1.4. Hypothesis

It is hypothesized that there exist certain stumbling blocks preventing nations from making greater strides in this domain due to various restrictive practices when it comes to the sharing of space technology.

1.5. Research Questions

The researcher proposes to analyze the following questions to get a better understanding of the subject matter.

1. What is the need for international cooperation in space technology?
2. Were there major international and regional cooperation in space technology?
3. How does the national security dilemma prop up when technology transfer in space technology comes into picture?
4. What are the restrictions faced in space technology when it comes to international cooperation?

1.6. Research Methodology

The present research work is based on a combined approach on doctrinal and empirical research. Descriptive and analytical methods are used as tools for achieving the proper outcome of research. Primary sources, namely existing conventions and laws are analysed to collect data along with the data from secondary sources such as journals, articles, reports, conference papers, text books, newspaper *et cetera* to support the analysis.

1.7. Scope of Research

The interdependence of nations needs greater cooperation in the civil space domain to ensure an equitable sharing of the resources from the space. But the story always strikes a balance between the haves and the have not. The study will limit its scope within the ambit of technology transfers resulting in global civil space cooperation, effects of various trade regulatory practices as well the ill effects of the proliferation of the commerce in the outer space regime.

1.8. Research Plan

The researcher will be achieving the objectives of the research by giving emphasis to the following major chapters.

1. Introduction

   This chapter introduces the topic and gives a brief outline on the aim, scope and purpose of research.

2. Space technology and national development

   This chapter focuses on the role of space technology in national development.

3. Space Economy trends and need for international cooperation

   The space economy is growing and today it stands at $400b. This chapter discusses the trends in the space economy and growing need for international cooperation in the space domain.

4. Major International cooperation in space domain

   This chapter discusses about the major international and regional cooperation in the space domain.

5. Determinants and Challenges in Space Technology Transfers

Variety of factors play critical role in a successful technology transfer. The factors which determines a successful technology transfer and the existing challenges in this domain is discussed in this chapter.

6. Technology transfer and national security dilemma in space

   This chapter intends to discuss about the technology transfers between nations in the space domain and the associated restriction in view of the national security concerns.

7. Conclusion

   This chapter will provide the suggestions and conclusions and discusses about future directions of the space activities and need for cooperation to ensure an equitable utilization of the common resources.

CHAPTER 2

SPACE TECHNOLOGY AND NATIONAL DEVELOPMENT

Seven and a half decades from the first space mission, the space technology has achieved tremendous progress touching every aspect of the human life. Nations depend immensely on the services offered by this eye in the space. Economic and technological prosperity is considered as one of the major goals to be achieved in a global society. However, at the same time, the challenges faced by the planet are umpteen which are expected to become upsetting in the years to come. Pertinent among them are the issues related to global warming, desertification, global pollution, loss of rain forests, digital divide, lack of land resource management in less developed countries etc. A closer look at any of these issues faced by the planet turns us to Space technology as a promising candidate to offer better solutions. In this chapter, the contributions of space technology to various nations' development are addressed.

For a space program to be successful, there needs to be tangible benefits for the country and its people who money is being spent in realisation of the systems. When the progress of a developing nation is considered, the progress of India over the past 50 years in developing and operating a space program offers considerable lessons. This model can be applied to majority of nations who are now exploring the space. Countries choose space programme for multiple reason. The prime among them being the tangible benefits accruable from the technology and the other being countries broader development of a strong science and technology base.

Neoclassical economic theory urges for creation of strong science and technology investment for a country's economic prosperity. This stands against the classical theory which upheld capital investment for economic competitive positions as an increase in production of a country in minerals, agriculture, natural resources which are ought to create a market by themselves. This shift in the economic theory proposed by the neoclassical economics ties national development to investment in science and technology through major endeavors like national space program.

Over the last one decade, the space industry has witnessed tremendous growth and today there are 82 countries who has at least one satellite in the orbit.[5] It is clear that venturing into this technical domain is done by countries who possess only limited technical capabilities to access, benefit and operate from

[5] Sara Hadley, *Emerging Spacefaring Nations* 16.

the space segment. The success and the penetration of the space technology need not alone be attached to the deep space missions, lunar rovers and interplanetary missions. The clear fact is that most of the satellite look down to the earth and they are positioned there to upbring the life of human on earth by providing various services. Over the years, earth observation from the space has been providing essential information on various natural resources in different spatial and temporal scales which are quite not possible from other source of monitoring.

Space science is identified as one of the technologies to provide solutions to achieve the sustainable development goals including the better use of natural resources, reducing poverty, preventing humanitarian crisis and as well as improving the communication technologies to reach all parts of the world. The developing countries who are increasingly depending on the national space programs consider it as a valuable investment along the road to development. The assets and infrastructure created provides vital information to the knowledge driven economy. Rockets, satellites, ground station s and other high technological strength required in this domain calls for significant investment in the advanced manufacturing and education sector. This results in the creation of an overall industrial-academic ecosystem in the country which proves beneficial to the overall development of the nation. Satellite communication over the other hand provides connectivity to the unconnected areas as well as boost the information and communication technology covering large geographical areas, reducing the cost of establishing communication channels through the terrestrial lines.

In addition to the benefits towards national development, some of the drivers which enabled the creation of the space race still holds good- international prestige and indication of national power as clearly linked when one establishes an upper hand in the space technology. Direct benefits to the citizens of a nation can also be directly counted when it comes to space technology. The pursuit of these benefits can be expressed in the advancement of scientific and technical skills, boost towards economic growth and improvements in the standard of living. The idea is to apply the Space Information Systems to coordinate the complex demands managing the planet and the human. This chapter analysis the methods by which application of space technology could accelerate the sustainable development.

2.1. Applications in food security and agriculture

A typical example of the successful integration of space technology in agriculture dates back to 1980s when the Indian Earth Observation Programme under the aegis of National Natural Resources

Management System (NNRMS) employed remote sensing for a national wide programme of pre-harvest Crop Acreage and Production Estimation (CAPE) covering major cereals, pulses and oil seeds.[6] CAPE provided accuracy in the range of 90% and later it was extended to multiple crop forecasting system which could provide advanced information about the possible shortfalls aiding decision making on timely import and export of food grains depending on the demand. Later the program was further scaled up resulting in Forecasting Agricultural Output using Space-borne Agrometeorology and Land-based observations (FASAL) which was powerful enough to estimate the impacts of unusual temperature variations on the harvest aiding the forecast thus helping the Ministry of Agriculture in taking appropriate decisions on import and export of food grains.

As depicted through the typical application adopted by India, Space technology provides vital resources for agriculture. Adopting these contributions were limited only to the developed nations due to the high cost involved. Due to easy access to the geospatial information and lower cost of geo data technologies, many countries are now stimulated to plug this capability to various applications.

Another major example of utilizing the space technology is the agricultural meteorology products developed by World Meteorological Organisation (WMO) which provides weather and drought forecasting services to farmers, herders ensuring agricultural development and food security.[7] S. Lamba et al suggests nine major applications where space technology could be successfully integrated to agriculture.[8] Based on the change in the spectral reflectance of the vegetation, remote sensing can be effectively utilized for monitoring of diseases and insect-pest infestation. Another application is on the assessment of soil texture and mineralogy. Spectral signature in the infra red spectrum can be effectively implemented to assess the mineral composition. Similarly based on the specific absorption features, soil texture could also be assessed. By making use of various imaging EO products soil problems as well as an assessment of topography, land use and land cover could also be determined.

Yet another noteworthy application is that of Statistics Canada becoming the first national statistical office to replace a farm survey with a remote sensing model for crop estimation.[9]

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[6] SPACE TECHNOLOGIES FOR THE BENEFIT OF HUMAN SOCIETY AND EARTH (Phillip Olla ed., Springer Netherlands 2009).

[7] *Exploring Space Technologies for Sustainable Development and the Benefits of International Research Collaboration in this Context* 16.

[8] Shubham Lamba et al., *Application of Innovative Space Technology Approaches to the Sustainability of Agricultural Systems in the Developing World*, 12 REMOTE SENS. LETT. 315 (Apr. 2021).

[9] *Exploring Space Technologies for Sustainable Development and the Benefits of International Research Collaboration in this Context*, *supra* note 7.

Earth observation through space technology can be a great problem solver to achieve targets of sustainability related issue in the agricultural productions systems ensuring food security. More and more nations need to be urged to espouse the implementation of space technology products for establishing sustainability in agricultural production systems. It is true that there exist technology gaps in many of the developing nations, which can be tacked with the support of international cooperative efforts.

2.2. Applications in Health Sector

Health sector is another important area where Space technology has crucial roles to play. The outcomes of the technology can be effectively utilized to support decision making, improved care, education in the sector and early warning measures. Discussed below are few domains where different streams of space technology has made significant contributions.

2.2.1. *Remote Sensing*

Satellite based remote sensing tools were effectively used for creating an intelligent alert system wherein the satellite observations were used for monitoring diseases and identifying their association with multiple sensed parameters. These models were used to determine forecasting of the spatio-temporal evolution of diseases thus aiding better decisions in public health strategy. In certain cases, direct monitoring of certain microorganisms was also reported[10]. Malaria evolution prediction models were implemented by Midekisa et all by identifying relations between rainfall, vegetation indices and temperature utilizing the remotely sensed parameters.[11]

2.2.2. *Global Navigation Satellite Systems*

GNSS was used often with GIS and remote sensing for epidemiological studies indicating a synergy between remote sensing, GIS and GNSS. Proximity to environmental contaminants, exact location of subjects etc were identified effectively by clubbing different technologies. GNSS were also used to track communicable disease and many of its applications were profound while tracking the Covid 19 pandemic. Person to person transmissible varieties, vector-borne diseases etc were subjects of study. Sites of vector breeding could be identified making use of the technology. Geolocations were used in

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[10] Damien Dietrich et al., *Applications of Space Technologies to Global Health: Scoping Review*, 20 J. MED. INTERNET RES. e230 (Jun. 2018).
[11] Alemayehu Midekisa et al., *Remote Sensing-Based Time Series Models for Malaria Early Warning in the Highlands of Ethiopia*, 11 MALAR. J. 165 (May 2012).

many cases to improve the delivery of health services and thereby improving the health policy. [12] GNSS and GIS were also combined in many cases of epidemiological studies for activity tracking, population studies and randomization. There were also instances when GNSS helped to improve the disaster response and autonomy improvement in disables patients. For the success of systems using GNSS, there needs to easy access to satellite signals and well connected power systems with back up. Combining GNSS with ground and cyber data could augments its potential and with the of AI and machine learning techniques, further applications can be well derived. Creating a platform warranting availability, interoperability, and quality of data issued from different sources is a requirement to go further in this direction.

2.2.3. *Satellite Communications*

Satellite communications finds tremendous applications in the event of failure to access conventional communication channels using landlines and terrestrial antennas for mobile communication in the event of any natural disasters. By making use of satellite communication technology, tele-health education, telemedicine etc can be ensured. In addition to information exchanges, telemedicine encompasses laboratory exams and medical procedures at distance and sometimes in real time. Examples include tele-echography, tele-electrocardiogram, tele-dermatoscopy, and tele-surgery.

2.2.4. *Human Space Flight*

Space associated studies helps in microgravity related studies and its human interactions. It is known that physical inactivity is one of the major causes of the non communicable diseases like cardio vascular diseases and osteoporosis. In space, since the astronauts are exposed to microgravity, the space research has helped to augment the understanding of human physiological interactions. An typical example of technology transfer from space in this domain is the bone quality measurement tool

Physical inactivity is a major determinant of NCDs such as cardiovascular diseases and osteoporosis. It is thus of particular interest to global health. Despite this fact, studies on the physiological effects of physical inactivity are lacking. In space, astronauts are exposed to microgravity, and accordingly, the space research and development area has been very active in studyingthe physiological effects of microgravity, notably by using ground-basedbed rest analog.As microgravity partly mimics physical inactivity and aging, space-associated study results may help us to understand the deleterious

[12] Dietrich et al., *supra* note 10.

physiological effects behind those processes. Future joint research programs should thus be encouraged. As another example of space technology transfer, bone quality measurement tools were initially developed by the space industry. A NASA review of spin-offs of space researchcan be found on their website. Long-term missions will require the development of "integrated countermeasures" to prevent the adverse effects of the space environment, including radiation. These countermeasures may find applications on earth, such as in radiation medicine.

2.2.5. *Telemedicine project of ISRO*

Implementation of telemedicine network in India by ISRO has been one of the key indicators of the contribution of space technology to national development. In association with state governments, NGOs and private/trust hospitals, ISRO has established about 400 nodes connecting 350 remote hospital locations. The network also had access to 45 super speciality hospitals and 15 mobile systems. Diverse medical departments were covered using the telemedicine network. This included departments such as ophthalmology, community health, diabetology, oncology, etc. About 400,000 tele-consultations have taken place all over the country in this network, including some remarkable lifesaving instances. A notable disaster management activity renedered by ISRO telemedicine network was during the period of tsunami and Koshi river flood in the state of Bihar in 2008. Later telemedicine has become part of the general health services and it was very evident during the covid pandemic time. Initially the whole project was run on a pilot scale by ISRO as a total solution encompassing connectivity, hardware, medical equipment etc in association with the various hospitals connected to the project. This has resulted in enhancing the awareness about this facility among the user community as well as the medical community. Later suitable guidelines and standards were issued by the ministry of IT for practice of telemedicine in India.[13]

Based on the successful completion of pilot projects, it has been possible to take the system into an operational mode. The program was subsequently scaled up with the participation of various state governments. They have come up with plans to enhance their networks and organizing their own infrastructure making use of the satellite connectivity from ISRO. Workshops and seminars were organised by ISRO at the same time to keep the momentum running aimed at spreading the message of benefits and for making the people aware to have an improved use of the systems.

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[13] A. Bhaskaranarayana et al., *Indian Space Research Organization and Telemedicine in India*, 15 TELEMED. E-HEALTH 586 (Jul. 2009).

Public health is an area of concern as far a nations development is concerned. It is shown here how satellite technology could be used effectively to improve the policy makers role in this area. The technology could be very well utilized to improve the overall health information infrastructure. Beyond monitoring infectious diseases or providing access to medical care in remote locations, space technologies can enable medical research that would otherwise be difficult to conduct in a terrestrial environment.

2.3. Applications in Disaster Management

Integration of data from earth observation and meteorological satellites with ground based terrestrial information along with data from communication and navigation satellites are used in the effective management of a disaster support. Data from meteorological satellites are used for cyclone track, intensity and landfall prediction in the event of extreme weather conditions. Whereas data from earth observation satellites are used for monitoring the impact of the disasters and for assessing the damages. Communication satellites at the same time helps to establish emergency communication backups in the disaster struck area with the aiding from navigation satellites to provide locations.

India is an example of developing nations who has effectively utilized satellites networks for the effective management of disasters. The country is one of the most disaster-prone countries across the globe as it is having ocean on 2/3rd of its boundaries, which often results in the creation of severe natural calamities like flood, cyclone, earth quakes etc. According to National Disaster Management Authority (NDMA), 58% of landmass in India is prone to earthquakes over 40 million hectares (12%) of its land is prone to floods and river erosion; close to 5700 km, out of the 7516 km long coastline is prone to cyclones and tsunamis; 68% of its cultivable area is vulnerable to droughts; and, its hilly areas are at risk from landslides and avalanches. Moreover, India is also vulnerable to Chemical, Biological, Radiological and Nuclear (CBRN) emergencies and other man-made disasters. The vulnerability profile as depicted by NDMA further states that disaster risks in India are further compounded by increasing vulnerabilities related to changing demographics and socio-economic conditions, increasing urbanization, development within high-risk zones, environmental degradation, climate change, geological hazards, epidemics and pandemics. All these situations clearly contribute to a situation which could seriously threaten the country's economy, its population and sustainable development.

Government of India has brought out a typical architecture for the disaster management. Balanced approach encompassing all phases of the disaster management cycle is considered. Investments in mitigation of disaster is given prime importance than the relief and rehabilitation process. Efficient disaster management practice is now being followed with the support of various ministries. All this schemes are worked with the clear backing of inputs from remote sensing, communication and navigation satellite based technologies. Under the Disaster Management Support programme developed by ISRO, data from earth observation, remote sensing and communication satellites are used for providing support for disaster management. The program also offers support for real time mapping of floods, cyclones and forest fires, hazard zone identification and tracking of forest fires.[14]

2.4. Application in Natural resources and environment management

Natural resource and environment management are directly linked to the progress of a nation's economy. Earth observation plan significant role in managing as well are the monitoring the goals set forward for these activities. Data from earth observation satellites can be made use to monitor agricultural production, fisheries and forest management and can also help to monitor the harmful effects on the environment due to pollution. Precipitation prediction models from JAXA offers global rainfall maps using satellite data. Brazil monitors forests using satellite images collected by the National Institute of Space Research, although the size of the area to be observed represents a challenge. The Biomesat project is an initiative for monitoring forest health in the Amazon using nanosatellite technologies. Earth observation is also a tool for monitoring illegal mining activities. Remote sensing can be used to monitor natural variations in sand flux in rivers and, thereby, illegal sand mining. Finally, Earth observation data can also be used to analyse various physical and environmental challenges applicable for a country like snow, ice and glaciers. can be used to monitor country-specific environmental conditions and challenges, such as with regard to snow, ice and glaciers.

Space technology can be efficiently utilized to manage the water resource management. Remote sensing is a primary tool for water management. Water levels in the water bodies can be tracked using satellites.. Synthetic aperture radars can be used to augment this data for pre can be used to augment this, by showing water obscured by vegetation, and the use of interferometry to measure water levels, which Sentinel-1 is capable of [42]. Furthermore, systems such as NASA's MODIS can do calculations in blue bandwidths to determine levels of chlorophyll-a [43], which shows how nutrient-rich water may be. Sat ellites can also identifyharmful algal blooms which endanger marine life as well as allow for estimation

[14] Dhruvi Bharwad, *Space Technology Based Disaster Management and Its Societal Implications*, *in* PROC. INT. CONF. REMOTE SENS. DISASTER MANAG. 493 (Peddada Jagadeeswara Rao et al. eds., Springer International Publishing 2019).

of the water consumption of invasive plant species [44]. These services are mostly very accessible, however African governments do need more widespread adoption of such technologies with relevant training to ensure successful water management. [15]

2.5. Penetration of communication technology

Access to terrestrial networks is limited or non-existent in many parts of the world, particularly in sparsely populated remote or mountainous areas. Satellite technologies are well-placed for the delivery of broadband services in such areas either on their own or in combination with other technologies and existing infrastructure. Instead of the traditional network infrastructure used for broadband connectivity (i.e. blanket coverage with many adjacent cells each supported by a base station), a new set of network technologies can often reduce infrastructure requirements and offer more cost-effective service delivery options. For example, Bangladesh has recently launched a telecommunications satellite that is also broadcasting television and radio programmes and will soon provide Internet, telemedicine and distance-learning facilities for people in remote areas. 20. New and emerging technologies may shape the evolution of telecommunications access, including low and medium-altitude satellites, other aerial devices and the innovative use of unused portions of the radio frequency spectrum.24 For example, the development and future deployment of non-geostationary orbit satellite fixed-satellite service systems has the potential to increase access to broadband infrastructure and bridge the digital divide, particularly for populations in rural areas. In addition, private sector companies can provide global Internet access through nanosatellite constellations and high-altitude balloons.

2.6. Space for sustainable development

Goals envisaged in the sustainable development of the world looks for a ambitious transformation. Nations strive to aim to achieve a world free of poverty, hunger, diseases and where all live could thrive. A world with universal literacy where one could live without the fear and is free of violence. Sustainable development thrives for a world with universal and equitable access to quality education and access to health and social care at all levels ensuring social, physical and mental wellbeing at all levels. It looks for a commitment towards ensuring human right for safe drinking water, and sanitation and everyone has access to improved hygiene, safe nutritious and enough food for all. The goals also aim at ensuring

[15] Annette Froehlich et al., *How Space Can Support African Civil Societies: Security, Peace, and Development through Efficient Governance Supported by Space Applications*, ACTA ASTRONAUT. S0094576521003039 (Jun. 2021).

safe, resilient and sustainable habitats where there is access to affordable, reliable and sustainable energy.[16]

The General Assembly of the United Nations took a strong vision to implement the 2030 Agenda for Sustainable Development on September 25, 2015. The agenda, holistic in nature, aims at a plan of action for the people, planet, prosperity and peace to be achieved in unison leaving behind no one. The 2030 agenda revolves around the economic, social and environmental development. Based on 17 universal Sustainable Development Goals (SDG), the agenda put forward by the UN covers a wide range of global issues of the present and the future.

The UN resolution A/RES/70/1 speaks immensely about the challenges of the present towards achieving a sustainable development goal. Billions among out humanity are still devoid of proper food and they are denied a life of dignity. Rising economic inequalities are seen among the and within the countries. There exists a huge disproportion of wealth, education, opportunity and power. Another key challenge is the gender equality. Frequent natural disaster, youth unemployment, conflict among nations, terrorism, extremism, forced displacement of war on account of war, social crisis are engines which try to reverse the development process and the progress achieved over the years. Along with this another major concern is the increase in pollution and the fast depletion of the natural resource which could adversely affect the steps taken by various nations to achieve sustainable development. Many least developed countries and island nations are seriously getting affected by the rise in sea level and ocean acidification and other climate change impacts. These pictures cast a griming shadow on the sustainable development and survival of many societies and life on the planet.[17]

As the sustainable development goals looks for a long-term transformation, it need to be based on a technology driven sustainable development trajectory. The new agenda as defined in the 2030 SDG is as follows

> *"We are announcing today 17 Sustainable Development Goals with 169 associated targets which are integrated and indivisible. Never before have world leaders pledged common action and endeavour across such a broad and universal policy agenda. We are setting out together on the path towards sustainable development, devoting*

[16] A/RES/70/1

[17] *Transforming Our World: The 2030 Agenda for Sustainable Development | Department of Economic and Social Affairs*, https://sdgs.un.org/2030agenda.

ourselves collectively to the pursuit of global development and of "win-win" cooperation which can bring huge gains to all countries and all parts of the world. We reaffirm that every State has, and shall freely exercise, full permanent sovereignty over all its wealth, natural resources and economic activity. We will implement the Agenda for the full benefit of all, for today's generation and for future generations. In doing so, we reaffirm our commitment to international law and emphasize that the Agenda is to be implemented in a manner that is consistent with the rights and obligations of states under international law."[18]

A clear analysis of the sustainable development goals indicates that for a successful implementation of the 2030 agenda, space technology needs to play a decisive role. The role which the space agencies can plan is well articulated by major space faring nations. ICT clubbed with the space technology can bring tremendous results in fruitfully achieving the SDGs. Space technology can support the 2030 Agenda implementation in the following two ways : (i) by supplying information and data that can directly or indirectly support in the achieving a particular SDG , (ii) by providing concise information about the SDG indicators, which allows to assess the status and maturity of progress of an SDG. The Millenium Development Goals which were tried to be implemented by UN saw serious issues due to the lack of reliable data. This fallacy is clearly addressed by the 2030 agenda with an aim to mobilize the data revolution to enable success in sustainable development.

As seen from many of the applications listed, a national space program when applied judiciously could drive power to an economy. Space program especially remote sensing enable identification and proper management of a nation's resources thereby enabling a nation's productivity and wealth. Also, space being technically intensive, the capability achieved could be easily adopted to other high technology fields. In essence by investing in a high technology program like space, a nation could build capacity towards a technically driven economy.

Indian space program is an open book of excellence indicating how developing countries could thrive in high technology fields like the space program. From its inception in the 1960s, the country and its national agency has taken bold steps in achieving targets aimed at the national and societal development. Capabilities which were available within the country was boosted. ISRO has funded many facilities in industries to augment the captive capabilities available within the Indian industries. These kinds of

[18] *Id.*

investments were majorly done in public sector establishments, but private sectors were also not left behind. ISRO program always looks towards building a space ecosystem in the country. Along with this, through judicious use of technology transfers, India joined hands with the major space powers of US, Europe and Russia. The rocket to launch communication satellites from the Indian soil, GSLV MkII was developed using the Russian supplied Cryogenic engine and stage. Viking engine technology acquired from France helped in the development of the Vikas engine for the second stage of PSLV. In its initial days, NASA has helped India with the sounding rockets and later with the ATS6 satellites for the Satellite Instructional Television Experiment (SITE) and the cooperation continues smoothly today also. India also built on its capability to build and operate world class remote sensing satellites which helped tremendously in bringing up the earth observation capabilities of the country. Driven by a quest in the regional and national development, the efforts taken by the then political leadership in investing in high technology areas is noteworthy. The strength brought forward in the earth observation capability has helped to really boost the country's developmental requirements.

India has taken judicious steps in engaging technology transfers, foreign direct investment and technical assistance to augment its indigenous capabilities. Possession of these high end capabilities and technologies gave a platform for the nation to share shoulder with space faring nations in many areas. This has helped the country to achieve an industrial base in the county capable of delivering quality space products as well as improving the technical strength in various domains. India stands as a testimony to prove that for a developing nation, technical inputs and foreign aid are indispensable for the technical and economic growth of a country to get into developing complex programs like the space technology.

CHAPTER 3

SPACE TECHNOLOGY TRENDS AND NEED FOR INTERNATIONAL COOPERATION

Significant levels of cooperation have been demonstrated in the outer space affairs by the international community over the years which has surpassed the limits of nation, culture or geography. However, the current space age suggests a situation which Hardin would describe as the "tragedy of the commons".

Competition to achieve a successful global economy marks the signature of the current state of affair of the world. In order to achieve economic growth and improve quality of life, innovation and the desire to compete is identified as the key ingredients. Over the years, space technologies has been part of the economy builder as it was providing key pillars in the socio economic and military strengths of a space faring nation. Contribution towards the natural and environmental disaster, natural resource management, telemedicine, agriculture, earth observation, banking and climate monitoring are some of the areas in which the technology has proven its mettle. Other sector includes defence and national security backbones. There were also instances when the spin offs from the space technology could create wonders in various domains. Studies indicate that investment in space domain has created revenue flow in various streams outside the space sector. Figure 1 indicates socio economic benefits in various sector due to the investment in space sector.

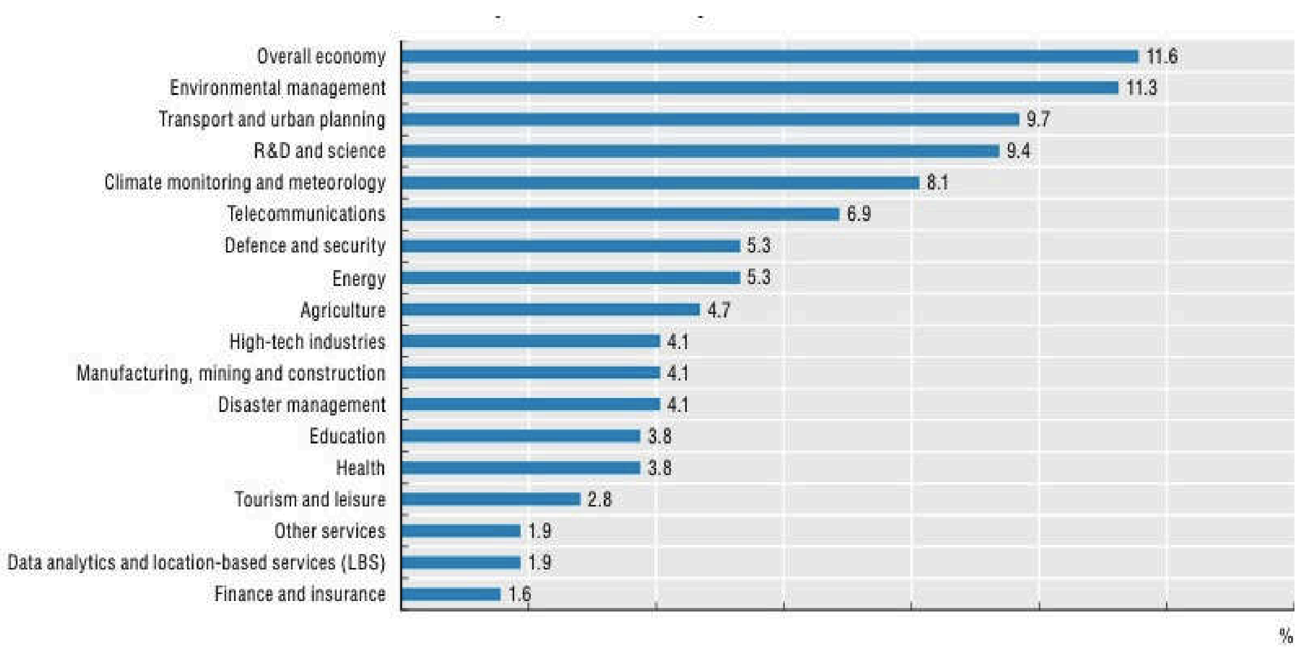

Figure 1: Socio economic benefits from Space sector, over the years 1972 to 2019

[19] OECD, *The Space Economy in Figures: How Space Contributes to the Global Economy* (OECD Jul. 2019).

The benefits of space are not limited to actor in the space sector alone as indicated above. The contributions are spread to non-space actors also with significant cost saving and cost avoidance. OECD study in 2019 indicates 57% cost savings and more than 75% of cost avoidance realised in sectors lying outside the space domain. Quality of information provided by the earth observation satellites makes is possible for better forecasting and decision making thereby saving considerable public money. These are quite evident in the fields such as environmental management, meteorology and disaster management[20]. The impact of such cost savings is very vital in developing countries whose public wealth is limited.

Space technology and the associated industrial sectors include all kinds of actors who are involved in the space exploration and the application of the various disciplines of science and engineering like propulsion, aerodynamics, chemical systems, electrical and electronic systems, control and guidance, mechanism, materials and fabrication etc. Name any field of science, an application related to that domain finds application in the space technology. When we look at the global space sector, it is an amalgamation of various services and sectors such as space institutions, research labs, production centers, testing centers, data handling and broadcasting services, earth observation and telecommunication, ground stations, etc.

Space economy refers to all kind of resources capable of adding value and efficacy to human lives while exploring, understanding, managing and exploiting space. Hence it accounts for all kinds of public and general public who utilizes the space infrastructure and also makes it possible to derive benefits out of the sector and pass it on to the society and the economy. Space technology and it services goes well beyond the space sector and it is quite pertinent to note that the sector is able to deliver its impact on the society and the economy.[21]

It is quite heartening to observe the act from the global community in defining the sustainable development goals to achieve global prosperity and development. Space technology plays a significant role in achieving and shaping this technology. Satellite technologies play an integral role in navigation, in providing early warning of natural disasters, such as floods, heavy rains, cyclones tsunami and hurricane, as well as in enabling rural mobile and prompt communications and broadcasting across the world. Space data is now being used by multiple industries to maximize their service. Delivering the

[20] *Id.* at 43.
[21] *Id.* at 30.

food to our door steps, guiding us on the road or even guiding a driver less car on the road have all become possible only with technological support offered by the satellite navigation systems. This is also true for the guidance systems used in rockets as well as missiles. It is clear that the satellite communication plays a noteworthy role in today's global socio-economic prospects for the developed as well as the emerging economies.

3.1. Space Business and its Evolution

Like any other public sector investments of the major scale like the telecom, ships, trains etc, national governments were the first interested parties and investors in the space business as well. This is mainly due to the security related applications which were very imminent from the space technology. Many of the applications in the initial time period were aimed at national building and societal developments. Gradually, as in any other public investments, there started a transition towards the commercial applications and investments.

Walter et al identifies three specific developmental milestone in the space economy evolution:[22]

1. National government driven phase
2. Commercial oriented industry driven
3. Equity funding based entrepreneurial phase.

3.1.1. *National government driven phase*

Most often the initial phase in many of the space business were pushed with an attire of national pride and prestige, to establish a technological overpowering in the then political situation. When the first artificial satellite Sputnik was launched in the year 1957, the National Advisory Committee for Aeronautics (NACA) director Hugh Dryden paved way for the formation of an exclusion research program for the space technology by publishing in 1958 "A National Research Program for Space Technology" which stated

> *"It is of great urgency and importance to our country both from consideration of our prestige as a nation as well as military necessity that this challenge [referring to Sputnik] be met by an energetic program of research and development for the conquest of space . . . It is accordingly proposed that the scientific research be the responsibility of a national civilian agency working in close cooperation with the applied research and development groups for weapon systems*

[22] Walter Peeters, *Evolution of the Space Economy: Government Space to Commercial Space and New Space*, 19 ASTROPOLITICS 206 (Sep. 2021).

development by the military . . . NACA is capable, by rapid extension and expansion of its effort, of providing leadership in space technology."[23]

It can be seen from the history that during the Space Race, US congress have funded the space program as it was considered as a national priority. This funding process began immediately with the Sputnik launch and later got intensified when the Russia was able to send a human to space by 1961. This technological advancement from the Russia intensifies the technological rival and prompted the US president John F Kennedy to announce the Apollo program on May 25, 1961. It is interesting to note that the official budget of NASA increased by 550% between 1961 and 1965. It is quite evident that such an increase in spending of the government exchequer is possible only with the support of the private space industries which was there to support NASA in achieving its objectives. This is also points to the fact that there were considerable technology transfers between the private space industries and the government in this period.

The intensification of the space race is also propelled by another factor which being the military interest sponsored by the satellite technology. As an eagle in the sky, the high ground aided the observation of the enemies post the World War II. This led to considerable amount of reconnaissance satellites being deployed. Russian zenith satellite and the US Corona satellites are typical examples of this development. Though the space race was a culmination of the national prestige dimension which resulted in the cold war, astronauts who were part of the elite missions in the early days believed in the same aspirations and desired to be the envoys of humanity and they worked beyond the political considerations.[24] Yet, one cannot overlook that the Space Race was a substance of supreme national prestige, which was acknowledged by all political parties.

Considering the role of the space technology in the nation building and especially the contributions to national security, the investment in the development of space activities are likely to continue from the government department irrespective of the spurring up of the commercial space activities. There could be sharing of loads between both the sectors. In many of the economies, government plays a major role in the space economy as investors, developers, owners, regulators and customers. In the recent years, government started offering a level playing field to the private entrepreneurs involved in the space activities. Joint development is also initiated to achieve many of the objectives. Government agencies

[23] *Creation of NASA - Wikiwand*, https://www.wikiwand.com/en/Creation_of_NASA (last visited Apr. 24, 2022).
[24] Peeters, *supra* note 22, at 4.

are more focused toward funding the basic and applied science research, the onus of the commercial establishment of resources are shared with the private sectors. In many of the economies, the industries were playing a supportive role in filling up the supply chain rather than being core development agencies. This is truer in developing countries like India where the private sector industries were only engaged in built to print role in most cases. Designing and specification finalization was always the role of the research lab of the space organisation.

According to a study by the OECD research group, in the year 2020, "the median value of space budgets as a share of gross domestic product (GDP) amounted to 0.05% for G20 economies, as a whole, with the United States and the Russian Federation investing more than 0.2% of GDP and France more than 0.1%."[25] These comparison have been standing for a quite long time and the only exception to this is from Saudi Arabia which has done a series of launches in the recent years and had become a major space investor. The figure below shows the G20 space budget for the year 2020, including contributions from the European Space Agency and the Eumetsat program. These calculations are based on the government budget sources.

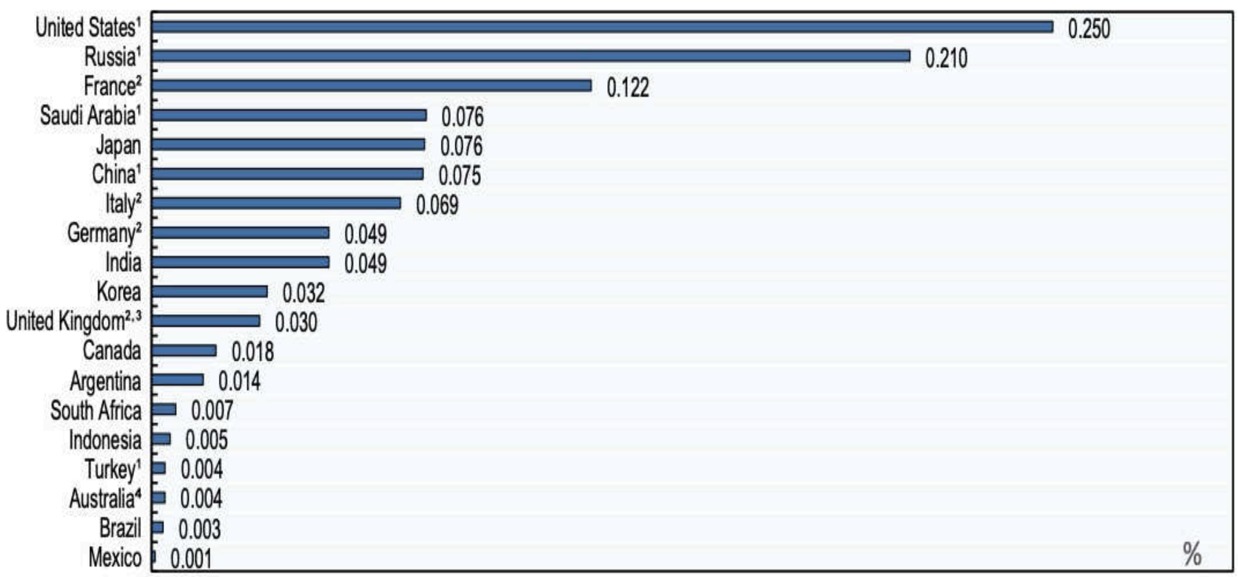

Figure 2: Space budget of G20 nations for the year 2020[26]

COVID-19 has severely affected majority of the space faring nations. Main effects were found in the delivery schedules from the industries who play supportive role in the space sector. The future impacts

[25] OECD, *supra* note 19.
[26] UNDSETH Marit, *Space Economy for People, Planet and Prosperity* 27 (2021).

of the pandemic are still early to estimate. Based on the available information, it is estimated the back-to-back lockdown has resulted in a loss of 1.6billion for NASA in the year 2020 due to the disruptions in the deliveries and launch. Further, the pandemic has also affected the launch schedules of many space faring nations. This was mainly due to the restrictions in the movement of people within the country due the lockdowns imposed. These disruptions have also affected the funding on the R&D program in many of the countries especially India. However, there were positive impacts too. The Covid-19 pandemic has highlighted how the space technologies could be effectively utilized to manage the crisis and support the economy and the society in such difficult times. In India, the educational backbone created for the tele-education was put to use at its maximum to run the schools to reach the home as the kids were stuck at home. Many countries invested in strengthening their communication infrastructure as was seen in the Space Infrastructure hub in South Africa. As the pandemic started losing its grip as is seen today in wake of the weak strains of the virus and its benign effects, the co-investment trend of the public private partnership is expected to pick momentum. Many governments have taken specific steps to regulate the space sector as well as to push the technology transfer to the private sector through the creation of specific agencies for the space. India has brought in two separate agencies under the Department of Space to manage these activities. New Space India Ltd (NSIL), a central public sector enterprise under the department of space will act as the nodal agency for the technology transfer and commercialization of the space sector activities. Whereas, IN-SPACE a regulatory body under Department of Space will act as a regulator between the private entrepreneurs and the government lab for ensuring a level playing field as envisaged by the Indian government. Korea is also learned to transfer to technology and know-how in satellite and launch vehicle manufacturing to the private sector. NASA is formulating plans to engage private sector to buy scientific mission modules for its various application (e.g. lunar payload service contracts) and the People's Republic of China is encouraging private financing and initiatives in the sector.[27]

3.1.2. *Commercial space phase*

Even though the idea of a communication satellite was brought to the fore by Arthur C Clarke in 1945, it took another 15 years for the technology to experienced. Extra-terrestrial radio relays were proposed by Clarke way back in 1945 and the first communication satellites being commercial exploration of the space was launched in 1960. Later in 1965, satellites to geosynchronous orbits were also launched and

[27] *Id.* at 7.

placed in orbit opening up the commercial space telecommunication. INTELSAT, Inmarsat, SES Astra were the initial players in the domain and soon the private space actors started entering the earth observation and the space transportation. In the case of commercial space sector, the private firms arrange to fund themselves risking their capital or using debt funding to manage service to the private sector. Through the United States National Space Policy of 2010, President Barack Obama defined the term "commercial" space as " *space goods, services, or activities provided by private sector enterprises that bear a reasonable portion of the investment risk and responsibility for the activity, operate in accordance with typical market-based incentives for controlling cost and optimizing return on investment, and have the legal capacity to offer these goods or services to existing or potential nongovernmental customers*".[28]

Commercial space rather refers to activities which are subject to free-market forces as on the contrary there exists strong support of the government for the national space program and which happens in a legitimized market place to achieve goals which are independent of the government sponsored program.[29]

Subsequent to the moon landing, the space race has more or less come to a conclusion and the national governments started off loading the launch vehicle and the remote sensing responsibilities to the commercial sector in the developed nations. This brought an end to the government monopoly in those sectors by 1970s. Aerospace companies were confronted with strong declining markets which led to the agglomeration of various companies through mergers and acquisitions to cope with a more volatile and open market. For example, Lockheed-Martin was formed through the merger and acquisition of Lockheed, GD Aircraft, Martin-Marietta and later Loral, Boeing acquired De Havilland, Rockwell, McDonnel-Douglas and later Hughes Space. The idea behing these acts were mainly to form larger consortia which has both end to end capacity and financial resources to enter the open market and respond to the requirements.

In developing country like India, this sort of a movement was recently witnessed when the Hindustan Aeronautical Limited and L&T consortia won the bid to manufacture the PSLV rocket which is the first time such a manufacturing is happening outside the national space organisation ISRO. The selected

[28] *Commercial Space Activities*, https://spacepolicyonline.com/topics/commercial-space-activities/ (last visited Apr. 25, 2022).
[29] Peeters, *supra* note 22, at 211.

consortia can make use of the ISRO facility and there involves considerable technology tranfers in this process to the private sector to meet the requirements of the production.[30]

The space economy shares in the year 2019 and the expectations for 2040 clearly indicates the shift of sharing from the government to the commercial sector. Initially the government to commercial sector was 100 to 0 and in the year 2019 it became 25 to 73 with a $360 billion U.S. dollars space economy. The trend is expected to improve and reach a Pareto equilibrium of 80 to 20 in the coming years with strong support from the commercial space sector.[31]

3.1.3. *New Space economy*

A new competition for the space race is now on the anvil which is backed not by the national governments, but driven on a corporate scale. This trending phenomenon, termed the "New Space" which are recognized worldwide as another revolution in the industrial sector as it is expected bring with it new employment opportunities. The name is fixed so as against the traditional space sector backed by the government where the policy and the goals are also set by the government. Traditional force mainly focused on activities with less risks, primarily on public financing, competence enhancing and was bound by the social forces. However, the new space populations are based on nongovernmental market goals controlled by market forces which are exposed to multiple sources of risk and operate initially with the support of the government. Often these entrepreneurs are run with the support of angel investors making use of disruptive innovations or competence destroying innovations and relies strongly on innovations sourced from other industries. It is seen that due to use of the commercially off the shelf products and innovations, the time to reach market is considerably low and thus often results in reduced cost and hence expanding the customer portfolio. Thus, it can be seen that due to this competitive advantage, the space industry provides a conducive ecosystem for the similar industries to bring down the average cost.

The thrust seen in this business progress is expected to sustain for quite a long period and studies indicates that the space economy will touch 1 trillion USD$ by 2040. Due to the innovations, new products as well as space based services are expected to decrease cost and increase the customer base. This trend will also make it possible to undertake resource mining from extra terrestrial locations.

[30] *L1 Bidder HAL-L&T Combine to Deliver PSLV Rocket in 2024 | Business Standard News*, https://www.business-standard.com/article/companies/l1-bidder-hal-l-t-combine-to-deliver-pslv-rocket-in-2024-122040900618_1.html (last visited Apr. 25, 2022).
[31] Peeters, *supra* note 22, at 211.

Increase in space tourism is also expected in the near future which is quite evident from recent space tourist missions from the Virgin Galactic, Blue Origin and SpaceX where thrust was given to the tourist mission in the year 2021.Meanwhile the Russian space agency also brought two space tourists into space with focus on Space adventures.

Financial estimates indicate that the global space economy rose to $447 billion in the year 2020.[32] The estimated growth is 55% more than the size of the economy a decade ago. The space report 2021 Q2 report finds that the commercial space industry grew by 6.6% in the year 2019 and is nearly $357B in 2020, representing 80% of the global space economy. When the commercial space sector grew considerably, there has been a reduction in the government spending and it fell by 1.2% in 2020 reaching $90.2B. Out of this, 58% comes from the United States.[33]

On the occasion of the release of the Q2 report by the Space Foundation, its CEO Tom Zelibor states

> *"The global space ecosystem is an emerging force for continued growth and expanded opportunity worldwide. The Space Report's Q2 findings verify that the global space economy not only weathered but actually emerged stronger from the worldwide pandemic that spanned three quarters of the year. It also validates the strength and resilience of the space ecosystem and illustrates why it's well positioned for growing investment, market development, and employment opportunities across multiple sectors."*[34]

The Space Report indicates that the top three investors remained the same in the year of the study, US being the top followed by China and European Space Agency. Collective spending from the top three agencies comprises 81% of the global government spending in 2020. Shifts in the space economy is also seen as Japan became the fourth highest contributor to the global space economy surpassing Russia. The study indicates that military spending by the US increased by 6.1% in the year 2020 pegging a new mark of $26.6B indicating a growing concern of threat from the space.

Data from existing satellites combine with efficient algorithms are applied in niche areas to reduce the cost. When new satellites are required to be launched, the New Space firms try to achieve it by developing satellites with limited redundancy and are often launched as secondary payloads along with

[32] UNOOSA, *Space Economy Initiative*, https://www.unoosa.org/documents/pdf/Space%20Economy/2021_Space_Economy_Report_-_Africa_In_Focus.pdf (last visited Apr. 25, 2022).
[33] *Global Space Economy Rose to $447B in 2020, Continuing Five-Year Growth*, SPACE FOUND. (Jul. 15, 2021), https://www.spacefoundation.org/2021/07/15/global-space-economy-rose-to-447b-in-2020-continuing-five-year-growth/.
[34] *Id.*

primary missions from the space faring nations. This has helped the new firms to achieve a higher growth rate in the recent years. Another important revolution is the transition from large satellites to small satellites in large numbers. This aids low capital expenditure. In order to ensure a global coverage, constellations of small satellites are employed now resulting in several disruptive technologies.

Mega-constellations are announced by different firms. Starlink internet project from SpaceX envisages 42000 satellites in the final configuration. However currently the US Federal Communication Commission has given permission to launch only 12000 satellites. As on April 21, 2022, 2388 satellites are already launched by Starlink.[35] Another major constellation are projected from OneWeb with 7000 satellites[36], Kupier project from Amazon with 3276 satellites and Boeing gets approval for a constellation with 147 satellites. Due to very high number and the mass production involved, the cost is expected to fall considerably. Global coverage is also possible as multiple inclinations and multiple height orbits are planned. Combination of the small satellites along with the terrestrial communication network will help attain cover the underserved areas and extend service to every nook and corner of the world. With the advent of the commercial satellite communication utilizing commercial off the shelf computer processors, every cellular mobile handset can get communicated to the satellites in LEO. Every mega-constellation promises to offer very high-speed data transmission capability.

When the entrepreneurs look forwards to mega constellations, it is expected that the bright orbiting objects orbiting the earth would interfere the observations of the universe as well as pose collision hazard in the Earth's orbit. Along with that due to the burning up of the metals during the re-entry could severely affect the climate of the planet. As of April 4, 2022, the SSA network of the European Space Agency confirms that 12,980 satellites were launched in all of the history with only 5400 functioning. Total mass of man made space objects in the sky amounts to 9900 tonnes with a catalogued count of 36500 space debris objects greater than 10 cm, 1000000 space debris objects from greater than 1 cm to 10 cm and 130 million space debris objects from greater than 1 mm to 1 cm.[37]

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[35] Adam Mann et al., *Starlink: SpaceX's Satellite Internet Project*, SPACE.COM, https://www.space.com/spacex-starlink-satellites.html (last visited Apr. 25, 2022).

[36] *OneWeb Adjusts Target Constellation Size Down to 7,000 Satellites - Via Satellite* -, SATELL., https://www.satellitetoday.com/broadband/2021/01/14/oneweb-adjusts-target-constellation-size-down-to-7000-satellites/ (last visited Apr. 25, 2022).

[37] *Space Debris by the Numbers*, https://www.esa.int/Safety_Security/Space_Debris/Space_debris_by_the_numbers (last visited Apr. 25, 2022).

The addition of a plethora of satellites are going to bring about a congestion in the outer space. There is no addition of resources in the outer space. As depicted by Hardin in the tragedy of common, the resources available are limited. There needs to be judicious usage of the available resources so that the benefits reach all in an equitable fashion. This clearly indicates the need for cooperation in attaining the results and enjoying the benefits for a sustainable future in this sector.

3.2. The Need for Cooperation in Space Sector

International cooperation in outer space has a greater role to provide significant benefits to all participants if it is properly managed. Monetary advantages, political and programmatic stability combined with stability of work force can also be achieved if the activities in the exploration of outer space is carried out in a harmonized way. Sharing of resources and establishment of standardization practices can ensure strategic use of redundancy through interoperability.

Nations cooperate in space to achieve certain needs particular to them. Prominent among them is the lack of budgetary provisions to undertake these high-tech missions. There are other few reasons which prompts the nation to commit international cooperation which are explained by D. A. Broniatowski and et al.

3.3.1. *International cooperation and diplomacy*

International cooperation in space carries with it an element of diplomatic control. It offers an advantage of diplomatic utility derived from the cooperation. Value of each country depends on the world politics and the utility increases when the number of countries engaged in cooperation increases. Cooperation of Russia with US in the ISS signifies an increased level of significance subsequent to the fall of the Soviet Union. India-US participation in the Chandrayaan mission and the forth coming NISAR mission sends a strong signal to the world about the good relation existing between the two nations. Space exploration and cooperation could be used a diplomatic tools to extract utility to meet policy makers agenda.

3.3.2. *Political Sustainability*

Engaging in international cooperation will ensure political sustainability for a nations space project. Support of the congress for maintaining the ISS was meagre. But since Russia become a partner in the project, it is would not be prudent for US to cancel the international agreement. Once an international agreement is concluded and cooperation is formally commenced, cancelling the agreement will result in political inconsistency. This is because the utility cost associated with the loss of the diplomatic benefits will outrun the utility cost required to maintain the system in place. Withdrawal from international agreement is seen as a damage to the reputation to the nation who withdrew. There exists long term benefits in maintaining cooperation even though the immediate costs might seem high.

3.3.3. *Sustainability Perspective*

The other reasons to cooperate emerge from a global perspective of sustainability. Sustainability of space is a growing concern in the wake of the new space progress. This could more be related to the "tragedy of commons" as expressed by Hardin. The natural resources in the outer space such as the orbital slots, the frequency allocation is subjected to congestion, competition and is severely contested. For an efficient and equitable usage of the limited resources, clear planning and coordination is required. Unlike the general perception that the space signifies infinite resources, the situation is not as conceived. When we see significant progress in the outer space business, it is a hard truth that the resources required for many in the outer space is not increasing. The orbital slots and the frequency allocation require clear planning, international cooperation and co-ordination to ensure its sustainable use. When significant steps are taken by the global forum towards combating the growing concern of the climate change and environmental conservation, similar efforts towards conservation and sustainable use of the outer space resources is not noticed. It is often neglected at the international forum. The recent trails of the mega-constellations posing threat to the astronomy is not given sufficient importance by the space community as more and more clearance are given for the launch of these mega constellations. Congestion in the major orbits such as LEO and GEO are facing a deteriorating situation and it is posing a big worry on the practitioners and policy makers of the space sector. Similar is the worry about the on-orbit collisions threat from the debris as well as the mega constellation elements. Collision avoidance studies are really becoming important and it quite natural these days to see the postponement of launch schedules or extra vehicular activities from ISS by few minutes to avert possible collision threats.[38]

When we talk about the need for internal cooperation in outer space, we must also say that this field has already shown significant levels of cooperation in various fields successfully without any limit on the culture, nation or geographical boundaries. The international treaties which came into force by the 1960s have played significant contributions towards achieving these levels of cooperation. But there are areas where significant international cooperative efforts are not seen in resolving some of the global challenges. Threat posed by space debris is one which will not only undermine the sustainable

[38] *NASA Reschedules Spacewalk for Thursday after Delay Due to Debris Threat*, https://www.cbsnews.com/news/nasa-spacewalk-called-off-possible-risk-space-debris-notification/ (last visited Apr. 25, 2022).

development efforts but will also act as a stumbling block in undermining the global information and communication technology systems.

3.3.4. *Growing pressure from the technology burst*

Geostationary orbits are considered to be prime and scare real estate.[39] With an eye to disrupt the communication, earth observation and remote sensing domains, the New Space entrepreneurs are determined services based on mega constellations. The international community had agreed to regulate the occupancy in the GEO belt through coordination efforts of International Telecommunication Union (ITU) by assigning slots of orbit. Any satellite operator need to apply to ITU to obtain an orbital slot over the GEO and it known that the slots over North America, Europe and Eastern Asia have become so congested that very few or no slots are left to any new entrant. With focus on the GEO belt regulation, the orbital assignments for low earth orbit, medium earth highly eccentric orbit have been unregulated. Due to the congestion satellites in the GEO belt and due to the accumulation of space debris in the major orbits, there is a growing concern and worry in the management of the spectrum. Number of navigation and communication satellites are located in these orbits. It was a tremendous jump in the population of the communication and navigation satellites over the last two decades. Starting with the GPS system from the US NAVSTAR in 2011, GLONASS from Russia, BeiDou from China, Quasi-Zenith from Japan, IRNSS from India, Galilio from Europe are all occupying various positions in the orbit to offer navigational solutions. This trend if left unchecked could pose serious concern toward the navigation and communication infrastructures. The global policy makers need to act to achieve a sustainable resource management in the outer space by acting judiciously in the present regime. The international space community needs to contribute in a considerable way to ensure socio-economic development and to promote the goals envisages in the UN SDGs to meet the results in 2030. Sustainable development is one which ensures development of the present without affecting the ability of the future generations to meet their requirements. The space community needs to act and establish generous practices to ensure that such goals are achieved. Space resource needs to be considered as a global common and there needs to be a special attention from the international community to ensure a promising future.

[39] Joseph W Gangested, *ORBITAL SLOTS FOR EVERYONE?*, https://aerospace.org/sites/default/files/2018-05/OrbitalSlots_0.pdf (last visited Apr. 25, 2022).

3.3.5. *Earth and its resources*

A concrete framework outlines in the sustainable development goals indicates a consensus among the global community in addressing a severe issue which was there around the corner for many years. The planet earth, an undisputed global common needs better management to ensure an equitable access to its resources by the all its inhabitant today and in the future by peaceful arrangements among the global community. Being an immaterial resource, space and its resources are not properly reflected in the sustainable development goals put forward by the UN. But space and its resource need to be considered as a common pool of resource as consumption of large scale nature of the orbit and its resource indicates that the future users are left with only negligible resources. Reduction in availability of resources is aggravated with the concerns of the space debris and the collision probabilities. With the initiation of a collision, it could lead to multiple collision are termed by the phenomenon Kessler Syndrome triggering a chain reaction and populating the space with an ocean of debris. This could seriously impair the life of the operational satellites, the life of astronauts onboard ISS and the launch of new satellites as well. Removal of space debris still poses a problem which has not find a reliable solution. Many attempts towards on-orbit servicing are now in the advanced stage of development. The RemoveDEBRIS programe from the EU was an attempt towards the orbit servicing for debris removal using harpoon, net and a sail. This was attempted in the year 2018. For the September 2018 demonstration, a cubesat target representing an element of space debris was launched from the RemoveDEBRIS spacecraft and was successfully caught by the net and it later got deorbited to burn upon its atmospheric re-entry phase. It took around 6 years for the partners to develop this technology using various parabolic flights, drop towers as well as thermal vacuum chambers.[40] All these efforts indicate actions from various stake holders to tackle the burgeoning issue of the space debris and dedicated efforts taken in advancing the research in handling the debris accumulation. The need for international cooperation was evident when we see the RemoveDEBRIS project in detail. When the outerspace had considerable amount of debris, the project to test and prove its objectives, it had to carry its on debris. This was necessitated due to the legal challenge associated with the under development in the space law and the associated liability threats posed. Hence it is disheartening to note that there exists considerable technical and non-technical challenges in front of the debris removal program. Effective and strong global governance is required to

[40] *RemoveDEBRIS | Airbus*, https://www.airbus.com/en/products-services/space/in-space-infrastructure/removedebris (last visited Apr. 25, 2022).

ensure that the major orbits are attended to prevent the tragedy of commons, a scenarios where there are more herds in the meadow and there is nothing left to graze upon.

Considering the characteristics of the space resources as that of a common pool of resources, there is a concrete requirement for the international cooperation for ensuring a sustainable access and utilization. Space law treaties are administered by the United Nations which doesn't have a international jurisprudence to control the activities of the State. The State themselves are required to adhere to the best practices mentioned in various treaties. In the event of a discord or non-alignment towards the international set practices by a State, other States could impose measures taken on an international understanding. But that may not prove deterrent in many cases. While ITU takes steps to preserve the limited natural resources of orbital slots and the frequency of operation, the activities are more of less nullified while States as well as the commercial actors register these resources in the name of paper satellites. Similar are the situations in the handling of the space debris. Even when clear guidelines are in place for the mitigation of the space debris, many countries still resort to ASAT test operations which could result in creation of further debris. It is required as per the guideline to ensure that sufficient fuel is left over in the satellites towards its end of life to push it toward the graveyard orbits. However, the satellite operators consume every last drop of the fuel which result in the spacecraft occupying the slot at the end of its life and continue to stay there as a junk for thousand of years. This is quite evident from the space situational awareness statistics which indicates that only 6% of the 9900 tonnes of the material is operational in the outer space.

James D. Redleman et al states that *"cooperation allows a nation to leverage resources and reduce risk; improve global engagement; and enhance diplomatic prestige of engaged states, political sustainability and workforce stability"*.[41] International cooperation in space technology will allow even the poorest nation to enjoy the benefits of space. Investments in space is high and it is risky. Under developed and developing nations need the support of space faring nations to achieve the benefits of space. Thus cost motivation becomes a major drive for international cooperation. Another notable advantage is that international cooperation will help to reduce the risk of failure and allow space faring nations to draw in resources from other fellow States. It is seen that all the space faring nations engage in international cooperation. ESA has engaged USA and Japan in its science missions as a way to rescue its missions

[41] James D. Rendleman & J. Walter Faulconer, *Improving International Space Cooperation: Considerations for the USA*, 26 SPACE POLICY 143 (Aug. 2010).

from cost overrun. Great levels of international cooperation was visible in the Chandrayaan-1 launch from India in the year 2008 which carried two important payloads from the US. International cooperation can deliver a robust and vital advantage by offering programmatic redundancy, as was clear from the Russian Soyuz craft which provided transportation to the ISS following the loss of the Shuttle Challenger.

3.3.6. *Disaggregation, Distribution and Diversification*

Disaggregation, distribution and diversification of space assets is another aspect which is possible through international cooperation. This is because it allows the States to share the responsibility, costs ad capability in building space systems.

The concept of disaggregation is similar to divide and rule concept. The space technology regime witnesses a rapidly improving technology and developing reliable space systems coping up the technical standards are time consuming. By the time a system gets developed, with the effort of a single country, there is all possibility for the system component to get obsolete. Therefore attempting to build system of less complex nature at a faster time would be the best choice. Rather than developing technologies from the scratch, the States can engage in cooperation, so that significant amount of time and resources would be saved. States can make use of the capability available with other nations can get free ride. For example, the Skynet satellite developed by the United Kingdom is resistant to jamming and the same system is being utilised by the United States.

Another area of importance is the distribution and diversification. In case of a conflict, it would be difficult for the adversaries to target a distributed system or degrade the capability of a distributed system when compared to a single system. Position, navigation and timing satellites are good example of distributed system. In this system, the adversaries must exert significant effort to degrade the whole satellite systems involved in the PNT. If the systems are realised and made stronger with the help of similar systems from other nations, even in the case of a conflict, the capability of the system could be maintained with the support of similar system from other nations.

A much closer participation towards cooperation is possible if the nations choose to standardize the hardware, software and procedures among the partners. Originators of standardizing systems and procedures often become the de facto leaders of collaborative efforts. This has to be followed by ensuring interoperability of systems engaged in the exploration. Space programs can use the significant competences delivered by rationalization, standardization and interoperability to effectively synchronize and share resources among the partners which could significantly improve the efficiency of systems. Systems like space situational awareness (SSA) can be grown to a greater extent if the international cooperation in the space domain is taken to greater heights. Cooperation in space also create a sense of sharing and dependencies among States which could obviate the reason for any conflict.

CHAPTER 4

MAJOR INTERNATIONAL SPACE COOPERATIONS

International cooperation in space capacity building is a good practice towards ensuring equitable sharing among all spacefaring nations and between non-space faring nations as it helps in bridging the technical gap. Increase in the complexity and extended exploration of the outer space indicates that utilization of the outer space should not and cannot be conducted by individual nations having space faring capability, rather than as a collective international effort. Article 1 para 3 of the U.N. charter exhorts to achieve international cooperation among States and it is one of the major goals in establishing the United Nations by the international community. The UN charter also envisages international cooperation to solve international issues concerning economic, social, cultural or humanitarian character. The Outer Space Treaty encourages States to undertake international cooperation in Outer Space in scientific investigations and the States should be guided by the principle of cooperation and mutual assistance in such explorations. This chapter analysis the major international cooperation in the space domain from major space faring nations.

4.1. NASA and international cooperation

The National Aeronautics and Space Act which created the national policy of NASA pushes for international cooperation with the international community. The policy declaration provides that:

> *"The Administration, under the foreign policy guidance of the president, may engage in a program of international cooperation in work done pursuant to this Act, and in the peaceful application of the results thereof, pursuant to agreements made by the President with the advice and consent of the Senate (sec. 205)."*[42]

Nearly two thirds of the flight missions in which NASA leads or participates involve international cooperation. Several ground based activities also rely on international cooperation, whether because of unique knowhow, geography, or the need for a global response. NASA has over 3000 international agreements with more than 100 nations of which 500 are still active. More than half of the agreement are with France, Germany, ESA, Japan, UK, Italy, Canada and Russia.

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[42] US Congress, *International Cooperation and Competition in Civilian Space Activities*, No. OTA-ISC-239, 34 (Office of Technology Assessment Jul. 1985).

Cooperation in space is not limited to launching foreign built satellites alone, NSA also undertakes ground based studies, analysis of data and information exchanges. They also include joint development of hardware, sharing of data and sample returned, training, visits and joint publication of research papers.

The International Space Station (ISS) Program's greatest accomplishment is as much a human achievement as it is a technological one—how best to plan, coordinate, and monitor the varied activities of the Program's many organizations.

Management of the International Space Station is an excellent example of an international partnership of space agencies. The principals are the space agencies of the United States, Russia, Europe, Japan, and Canada. The ISS has been the most politically complex space exploration program ever undertaken. At every formative step in the realisation of the ISS, the partner nations were part of the process. The high and the detailed level of legal agreement of ISS now serves as a basis for several other space stations. It is the largest of the spacecraft ever built and weighed 420,200kg at the time of completion which took more than 40 assembly flights. The civil agreement for the sharing of resources in ISS was signed by various parties in the year 1998 and it is worthwhile to note that the agreement is not signed in the name of any particular nation. Rather, each partner owns registration of that specific module which they have contributed and enjoys ownership of jurisdiction of the that component part.

ISS brings together international crew and launches, operations, training, engineering, communication networks and global scientific community to a global platform. Every partner State has the responsibility to manage and run its hardware and systems. Construction and realisation of the ISS needs support from many facilities on Earth managed by international partner agencies and these include construction facilities, launch and mission support centres and communication facilities. [43] Launched in the year 1998, it had participation from Russia, Japan, Canada and the US and many participating countries from the ESA. The space station is being continuously built and it has visits of astronauts from 18 countries till date.

Another major international cooperation effort was in the launch of Cassini probe. The probe was launched in October 1997 with ESA's Huygens probe. The primary mission of Cassini was to study Titan, the largest moon of Saturn. It is worth to note that 17 countries were involved in the design and realisation of Cassini probe. Solar and Heliospheric Observatory (SOHO) is a collaboration between the

[43] Mark Garcia, Text, *International Cooperation*, NASA, http://www.nasa.gov/mission_pages/station/cooperation/index.html (last visited Apr. 27, 2022).

European Space Agency and NASA and was launched in December 1995. Its objective was to study the internal structure of eh Sun, its outer environment and the expulsions from the Sun.

Swift is another spacecraft which was launched in the year 2004 and it is used for studying the gamma-ray burst science in gamma ray, X-ray, optical and UV bands. Goddard Space Flight Center is the prime institution with international hardware partners from many universities.

International Laser ranging service was offered by NASA to measure ranges from ground stations to satellite borne retro reflectors to offer resolution in the millimeter level. It helps to develop models with improves reference frames to support earth quake protection, and measuring global sea surface height. Laser ranging stations are distributed all over the world including the US and the Mediterranean countries.

In the year 2020, NASA and the United Nations pledged to cooperate in areas of science and technology to support the peaceful use of outer space. This agreement envisages combining the expertise of NASA with the UN's global reach to leverage the benefits of space. This also assures access to space for the countries without space programs.

United States and other nations cooperate on multiple domains in the space. These include operation of communication satellites, remote sensing satellites, scientific and interplanetary missions. The cooperation between NASA and other countries traces back to 1960s. US has offered Nike Apache sounding rockets and telemetry station to support India in establishing the sounding rocket facility in Thumba. Further in 1976, NASA has supported Canada to launch a Communications Technology Satellite (CTS). Here NASA offered Canada the required hardware and enabled Canada to assemble the satellite. Subsequently NASA helped to launch the satellite. Another cooperation arrangement was held with Japanese National Research Institute of Metals in 1973 for the investigation of composite material processing in space aboard the U.S. Skylab. Cooperation was also established with other European countries as early as 1970 for exploration of the upper atmosphere including cosmic ray electrons.[44]
International geophysical year in 1962 was really a push to international cooperation in space activities. This has particularly helped the sounding rocket projects across many nations for upper atmospheric studies. Sounding rockets generally climb to an altitude up to 100km and follow a sub-orbital trajectory. As discussed earlier NASA has supplied its sounding rockets to many nations to conduct the experiment

[44] Congress, *supra* note 42, at 38.

from their land. In 1980, sounding rockets were supplied to Germany and Norway for studying the electrojet process in the upper atmosphere. NASA has also established ground station in multiple countries for remote sensing applications. Landsat programme of NASA offered earth observation data to many nations. This has resulted in the research on oceans, winds, snow cover, water management etc.

Utilizing the ATS 6 satellite from NASA, collaboration was established with India for conducting the Satellite Instructional Television Experiment (SITE) in the year 1975. For a country like India, this programme was an eye opening in understanding the long standing benefits of the satellite communication. SITE focused on disseminating programs on agriculture and family planning to more than 2400 Indian villages. NASA leveraged the program and had aired discussions on remote sensing and films related to technology development to 27 participating developing nations using the ATS-6 satellite through their Agency for International Development (AID).

4.1.1. *Cooperation of NASA with USSR*

International cooperation with USSR was also established on the backdrop of the geophysical year. NASA and the USSR Academy of Science has cooperated on meteorological studies, telecommunication and geomagnetic mapping. Later in the year 1972, a format agreement between the two nations was inked and this has resulted in the Apollo-Soyuz Test Project (ASTP), which made way for the only joint manned mission involving two nations. This agreement has also resulted in exchanging cooperation in the field of natural environment studies, meteorology, Moon and planet, space biology and medicine. The success of this cooperation has helped to further extent the agreement by President Carter in 1977. However based on the political instability which resulted in the worsening of East-West relation, the agreement got expired in the year 1982. After two years, renewed interests were kindled and in the year 1984 President Reagan re-established cooperation with the Soviet Union and has resulted in the cooperation in several scientific disciplines related to space. Joint cooperation with USSR, France and Canada was seen in the COSPAS/SARSAT search and rescue program.

4.1.2. *Cooperation in Artemis*

Named after the twin sister of the Goddess of Moon, Apollo, NASA has named its next mission to Moon as the Artemis. Through this renewed interest in the lunar exploration, NASA is trying to push the limits of the science and technology.[45] It is planned to send the first woman and the next man to the Moon.

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[45] Zack Hester, *After the International Space Station: National Aeronautics and Space Administration, Industry, and the Future of Commercial Spaceflight in Low-Earth Orbit*, 5 NEW SPACE 33 (Mar. 2017).

The doors for cooperation are kept open by NASA and it is planned to collaborate with industry, academia and other nations to reap the benefits in a sustainable and quicker way. Cooperation with the private space industry has also given a timely push for the completion of the programme. NASA has go very strong and committed plans in the Artemis mission. Schedules are being worked out to sent robotic mission to the Moon initially followed by manned mission in the next four year and establish presence on the surface of moon by the end of this decade.

Artemis mission has another objective also on the anvil. Lessons learned from this mission will be used to lead the scientist to take up the exploration of the Mars. Manned mission to Mars is a complex program in itself and NASA wished to source in support from all its partners across the globe. The thrust for the Artemis programme from the US is again to prove the leadership of the agency in the space domain by sending the first man to Mars.

Based on the lunar landings are the lessons learned from the feast, the NASA envisaged platform for the international partners and the U.S. companies to benefit from the outcome of their learning. Many nations have already joined with NASA for the Artemis programme. Canadian Space Agency will be providing the advanced robotics for the Gateway, ESA has plans to provide an International Habitat, a module to deliver additional communication capabilities and a science airlock to deploy the science payloads and Cubesats. Japan has agreed to contribute components and logistics resupply[46].

Towards these, eight partner nations, Australia, Canada, Italy, Japan, Luxembourg, the United Arab Emirates, the United Kingdom and the United States have signed the Artemis Accord. Subsequently Ukraine also joined the cooperation as a ninth signatory. The Artemis Accord, set of nonbinding principles aims to establish a framework to maintain peace and a governing system in place.[47]

4.1.3. *ISRO and NASA*

ISRO and NASA has long standing in the cooperation in space. NASA's Moon Mineralogy Mapper has flown aboard Chandrayaan 1 Moon mission of India which led the way to the discovery of water ice on the lunar surface. Later in 2014, ISRO Mangalyaan mission and NASA's Maven mission arrived in Mars orbit within a gap of two days. Support for navigation as well as communication was provided to ISRO by the Jet Propulsion Lab of NASA. Subsequently a joint working group was established by both the

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[46] *Id.*

[47] *Artemis Accords: A Step Toward International Cooperation or Further Competition?*, LAWFARE, https://www.lawfareblog.com/artemis-accords-step-toward-international-cooperation-or-further-competition (last visited Apr. 27, 2022).

agencies to share learning of Mars exploration and coordinate for the observation and analysis of data from Maven and Mangalyaan.[48]

4.2. ESA and international cooperation

European Space Agency (ESA) was created to pool the expertise available in the European continent to place the European space industries at a competing position with the US industries. Eleven states of the European union are members of the space agency. With a limited budget at its inception, it was necessary for ESA to cooperate with other nations to broaden their basic agenda of the missions. ESA cooperates with NASA in many areas, it is to be noted that the US Space Shuttle has orbited the ESA-built Spacelab for many science missions. Cooperation with NASA was also seen for the building up of the Space telescope which was launched in 1985 by the Space Shuttle.[49] Policy establishing ESA encourages cooperation with non-ESA member states as well as other international partners to achieve progress in science missions. ESA policy is based on a programmatic approach. The policy upholds programmatic needs and rationale rather than a more general foreign policy requirement. ESA enjoys strategic partnership with USA, Russia and China and has got a long-standing cooperation with Japan, India, Argentina, Brazil, Israel, Australia and many more countries. ESA also has cooperation with EU member states who are not ESA members. Space cooperation from ESA is governed by multiple objectives. Prime among them are engaging in large and major international space programmes like ISS, moon and mars mission etc. and leveraging ESAs resources making use of the international cooperation from participating agencies. ESA also focuses on dissemination of ESA mission data across the world.

4.2.1. ESA and Russia

Framework agreement exists between ESA and the government of Russia for cooperation in space for peaceful purpose. Significant cooperative efforts were seen both in the launcher side as well the satellite operations. Russian Soyuz launch vehicle utilised Europe's spaceport in French Guiana for this launch operations as its launch base. This was being managed through a framework agreement between ESA and Russian Federal Space Agency. More than 1700 successful launch of Soyuz is made from the French Guiana to carry men and women from different nations into space. This cooperation is typical example of win-win situation. Europe meets its access to space for medium-size mission though Soyuz whereas

[48] Namrata Goswami & Peter A. Garretson, *The Rising Salience of "NewSpace" in India: Prospects for U.S.-India Space Cooperation*, 10 NEW SPACE 87 (Mar. 2022).
[49] Congress, *supra* note 42.

Russia utilises this for improved access to the commercial market. First mission of Soyuz was in the year 2011.

However, the cooperation between the nations is now affected due to the ongoing war in Ukraine. Russia has decided to pull out its workforce from the launch site and ESA has taken stance to stick to the sanctions imposed by the member states against Russia. A statement from ESA says they are aligned to the decisions taken by industrial and international partners.[50]

ESA has also taken significant steps in upholding international cooperation for earth observation requirements leveraging the effectiveness of ESA Earth observation activities.[51]

ESA has spearheaded the formation of Committee on Earth Observing Satellites (CEOS), an international agency for coordinating missions to study and observe planet Earth. CEOS has today grown in strength and today it has 23 members who are mostly space agencies and 21 associate members. CEOS exhibits tremendous coordination for ensuring cooperation between member states for developing data products, services and policies.

In order to assist Africa in managing its water resources, ESA has initiated another international programme called TIGER, which provides Earth observation data for this activity. This has a major societal impact in the sense that the project is driven by focusing on the needs of the local population in order to ensure sustainable development in the water resource development.

ESA takes effort to ensure that the relevant technology and the satellite data is transferred to the participating countries in need to ensure a satellite data gets integrated into long term planning for the nation's development.

ESA has also joined with China for carrying out joint research in the areas of agriculture, forest monitoring, water resource management, atmospheric chemistry and climate change.

4.2.2. ESA and India

India and Europe have inked agreements to establish cooperation in education, cultural exchange, joint research in science & technologies, and law enforcement. The first agreement between ESA and ISRO was formally concluded in 1978 and it is renewed until 2022. The cooperation of ISRO and ESA started with the launch of India's first geostationary satellite Apple in Ariane -1 in 1981 with Meteosat-2. Since then India has turned to ESA multiple times and ISRO is one of the best Arianespace's customer. ISRO

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[50] *ExoMars Suspended*, https://www.esa.int/Newsroom/Press_Releases/ExoMars_suspended (last visited Apr. 30, 2022).

[51] *International Cooperation*, https://www.esa.int/Applications/Observing_the_Earth/International_cooperation (last visited Apr. 27, 2022).

and ESA has already established cooperation in areas of space science, human spaceflight, exploration, earth observation, launchers, navigation, etc[52].

ESA and National Remote Sensing Centre of ISRO signed agreement in 1991 for direct reception, processing, archiving and distribution of ERS-1 SAR data at Shadnagar ground station 50 km away from Hyderabad. It was further extended for ERS-2 in 1995. In the prestigious Chandrayaan-1 mission of ISRO, ESA has joined hands with India and provided technical expertise on flight dynamics and mission analysis. Three payloads from ESA were also flown in the mission. This mission was a major milestone in the cooperation between the two nations and it has fostered increased collaboration between the scientific community from both the nations. Payloads from ESA were also flown in Astrosat mission and one is scheduled in the Aditya L1 mission. Many of the European universities has made use of the PSLV, the work horse launch vehicle of ISRO for the launch of miniaturised cubesats. Other major cooperation are France-CNES for Megha-Tropique on atmospheric monitoring, Altika/Saral on ocean altimetry, with Italy-ASI for AGILE launch by PSLV, with Germany-DLR for the IRS earth observation data acquisition and distribution in Europe, EO sensors development and EUMETSAT cooperation agreement with ISRO on the access and exchange of meteorological information. [53]

Recently, ESA and ISRO have signed agreement for establishing future cooperations in space. ESA has agreed to offer support from its ground stations for the upcoming Gaganyaan, Chandryaan-3 and Aditya-L1 missions of ISRO. In return, ESA will be getting ground segment support from ISRO's tracking stations.[54]

4.3. Indian Space Research Organisation

The Indian space agency ISRO has attributed significant importance to cooperation in space. ISRO has engaged with other nations in missions of planetary exploration, climate change studies and space science studies. The birth of the Indian Space agency is itself a result of international cooperation. NASA had agreed to cooperate with the INCOSPAR (Indian National Committee for Space Research) to undertake research of mutual interest for peaceful scientific purposes through an MoU signed in 1962.

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[52] *India – Europe Cooperation*, https://www.esa.int/Science_Exploration/Space_Science/India_Europe_cooperation (last visited Apr. 30, 2022).

[53] *40 Years of Cooperation between ESA and ISRO*, https://espi.or.at/files/news/documents/40_years_of_cooperation_between_ESA_and_ISRO_-_Jean-Charles_Bigot.pdf (last visited Apr. 26, 2022).

[54] *ESA and Indian Space Agency ISRO Agree on Future Cooperation*, https://www.esa.int/Enabling_Support/Operations/ESA_Ground_Stations/ESA_and_Indian_space_agency_ISRO_agree_on_future_cooperation (last visited Apr. 30, 2022).

Under this agreement, it has led to the formation of a sounding rocket facility near the geomagnetic equator. The agreement had also provisions for extending payloads for the sounding rocket missions, supply of launching device (launcher) on loan basis, training for Indian personnel at NASA facilities and technical support from NASA for the launch operations. To enhance the cooperation with other nations, India has expressed at the UN regarding its interest to become a host for an international sounding rocket facility and as an effect UN has approved the sponsorship for the facility established India. The Thumba Equatorial Rocket Launching Station (TERLS), an international sounding rocket facility is thus a master example of how international cooperation could help nations achieve significant strides. The 20th session of the United Nations General Assembly accorded approval for sponsoring the TERLS facility in 1965 and continuing its operations.[55]

As discussed earlier, ISRO also had several cooperative agreements with ESA, NASA, ROSCOSMOS and many more space agencies. The initial stepping stones of the Indian space programme like the Satellite Instructional Television Experiment (SITE), launch of Aryabhatta, Bhaskara, APPLE, IRS-1A, INSAT series of satellites were all achieved with the support of other international space agencies. [56]

ISRO is viewed in the international domain as an emerging space power who provides low cost access to space. Hence the developing countries look to India for its assistance in building up their capabilities to derive benefits out of the technology. Today, India has executed formal cooperative agreements with 59 countries either in the form of Agreements or MoU or Framework Agreements. Similarly, cooperative agreements are also executed with international multilateral bodies like European Centre for Medium Range Weather Forecasts (ECMWF), EC, European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT), ESA and SAARC.

ISRO has achieved success in executing several significant missions utilizing international cooperation. Chandrayaan-1, the maiden moon mission from ISRO earned several national and international laurels in achieving its missions objectives, especially the discovery of water molecule on the moon's surface. Megha-Tropiques, an ESA-ISRO joint mission was launched in 2011 and the data products related to tropical atmospheric study and climate are made available to the international scientific community. SARAL is another success story with France, which got launched in 2013 for studying ocean from the space.

For the upcoming mission of human space flight, ISRO has joined hands with other space agencies for

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[55] 1 CS HARISH & VP BALAGANGADHARAN, VSSC PAST PRESENT FUTURE 11 (VSSC/ISRO 1st ed.).

[56] *International Cooperation - ISRO*, https://www.isro.gov.in/international-cooperation (last visited Apr. 30, 2022).

astronauts training, life support systems development etc. NISAR (NASA ISRO Synthetic Aperture Radar) is another hallmark cooperative project on the anvil.

ISRO also hosts another major capacity building programme for international participants wherein training is offered to international students in assembly and building of nano satellite development. This programme is brought as an initiative of UNISPACE+50 and is named as UNNATI (UNispace Nanosatellite Assembly & Training by ISRO).

4.4. China

The Chinese space agency supports international space cooperation and aims to promote and strengthen the cooperative efforts on the basis of equality and mutual benefit. China has long term cooperative agreements with many countries. China gives significant importance to space cooperation in the Asia-Pacific region by establishing cooperation with countries like Iran, Korea, Mangolia, Pakistan and Thailand.[57]

4.5. Regional Cooperation in Space

4.5.1. *Role of Venezuela*

The Bolivarian Agency of Space Activities (ABAE) was established in 2007 and they have focussed on regional cooperation for the development of Latin American nations. Venezuela launched its first telecommunication satellite in 2008 which was built with the support of China. The spectrum was utilised such that the Ku band was used for covering the Latin American countries of Bolivia, Cuba, Dominican Republic, Haiti, Paraguay, Uruguay, Venezuela. Another remote sensing satellite was launched in 2012 and it has provided help to these countries as well as helped Venezuela to enter into many international agreements related to education, scientific application, environmental protection, disaster monitoring etc. It is pertinent to note that international technology transfer has helped the economic development of these developing nations in the Latin American region. Pena and Yumin[58] argue that developing countries need to depend on cross border acquisition of technology to foster country's growth. The space technology offered by Venezuela has helped the Latin American nations to improve their telecom capabilities, education and environmental monitoring. Technology transfer through regional cooperation in Venezuela is a testimony to the development and technological independence which can be achieved.

[57] *China's Space Activities*, https://www.fmprc.gov.cn/ce/celt/eng/zt/zfbps/t125258.htm (last visited Apr. 27, 2022).
[58] J Peña & T Yumin, *The Role of Venezuelan Space Technology in Promoting Development in Latin America* 6.

4.5.2. *Cooperation of Space faring nations of Africa*

Space technology and its benefits are known in the African continent through few of its active players like Africa, Algeria, Morocco, Nigeria and Egypt who have committed themselves to the development of space science and technology. They have cooperated with other nations to imbibe the capability to at least build one satellite or other. Most of the other nations in Africa have their activities limited to the use of space data for their socio-economic developmental projects.[59] RASCOM (Regional Satellite Communications Organisation), established in 1993 is an intergovernmental organisation which works to provide the satellite capacity required for the African nations, by pooling and optimising space resources from the INTELSAT. RASCOM services provided telecom, direct TV broadcast services and internet access in rural areas of Africa. RascomStar-QAF is a private company has concluded an agreement with RASCOM and is planning to implement 14 communication satellite project for Africa.[60]

Another major cooperative arrangement is ARMC (African Resource Management Constellation), which works on a collaborative arrangement involving Nigeria, South Africa, Kenya and Algeria. ARMC works on a three pronged strategy to provide Africa with technology and resources, development of African human resource and providing Africa access to satellite data to ensure effective management of its resources. Another major cooperative agreement is the establishment of the Disaster Monitoring Constellation (DMC) which aims at imaging any part of the world from a constellation of five satellite from the nations of Algeria, Nigeria, Turkey, United Kingdom and China. Though each country owns and maintains the satellite, the consortium ensures that the daily worldwide imaging is possible.[61]

4.6. International Committees Promoting Cooperation in Space

There exists a number of international organisations fostering cooperation in Space. Importance and activities of few among them are discussed below:

4.6.1. *UN-COPUOS*

The UN Committee on the Peaceful Use of Outer Space was set up by the UN general assembly in the year 1959 and it aims to bring benefit of space to the whole human mankind. The committee was instrumental in bring five treaties and five principles related to the outer space. Starting with 24 members

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[59] Olusoji Nester John et al., *International Cooperation among Space-Faring Countries of Africa*, Proc. 5th Int. Conf. Recent Adv. Space Technol. - RAST2011 843 (IEEE Jun. 2011).
[60] Wikipedia: Regional African Satellite Communication Organization (Nov. 2021).
[61] John et al., *supra* note 59.

in the year 1959, today the committee has 95 permanent State members. In addition, many national and international organisations have observer status in the COPUOS. The mandate of the committee and its two sub-committees is to ensure the expansion of international cooperation in the peaceful use of the outer space. The committee aims to foster coherence and synergy in the international cooperation in space activities at all levels.[62]

4.6.2. *International Telecommunication Union*

ITU, founded in 1865, is a specialized committee coming under the United Nations facilitating global allocation of radio spectrum and satellite orbits and define standards for ensuring interoperability of networks and technologies. Today ITU has 193 States and about 900 companies, universities, international and regional organisations as its members.[63] Much of the standards that ITU brings forth are decided in study groups which are expert representatives from its member States thus representing a forum of international cooperation.

4.6.3. *Group on Earth Observation (GEO)*

Group on Earth Observation is a intergovernmental partnership working towards improvement of earth observation methods for the benefit of the society. They bring in earth observation projects and initiatives focusing on addressing environmental and social challenges. With a participation of 113 member countries and 140 participating organisations, it aims to improve the interoperability between the various earth observation systems and implement project and initiatives to solve global programs.[64]

4.6.4. *APRSAF (Asia Pacific Regional Space Agency Forum)*

APRSAF aims to utilize space technology for the socio-economic development of the Asia and the Pacific. This largest space related conference is being generally attended by representatives from over 40 countries and regions. APRSAF currently engages four working groups to share the information and plan for future activities in each country and the regions. APRSAF also supports projects such as disaster management and environmental protection, to enable mutual cooperation among participating nations.[65]

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[62] *COPUOS: Committee and Subcommittees*, https://www.unoosa.org/oosa/en/ourwork/copuos/comm-subcomms.html (last visited May 1, 2022).
[63] *About ITU*, ITU, https://www.itu.int:443/en/about/Pages/default.aspx (last visited May 1, 2022).
[64] *GEO*, https://earthobservations.org/index.php (last visited May 2, 2022).
[65] *About APRSAF | Asia-Padific Regional Space Agency Forum*, https://www.aprsaf.org/about/ (last visited May 2, 2022).

4.6.5. *APSCO (Asia Pacific Space Cooperation Organization)*

APSCO is another inter-governmental organization working in the Asia Pacific and is headquartered in Beijing. It acts as a cooperative mechanism for the developing countries in the region by sharing resourced in space science, space technology and its application. APSCO today has nine member states. Cooperative sharing networks established by APSCO for the benefit of their member states are note-worthy. Data sharing network for remote sensing data sharing and management, sharing of ground stations in member countries, ground-based space object observation networks are some among them.

It is clear from the above discussions that the majority of nations engaging in space technology do not have the captive capability to reap the benefits. However, success in achieved through cooperative efforts. Cooperative space ventures could help the developing countries to achieve a quick step in achieving the development in various domains of the economy buildup with the application of space technology which would otherwise takes years of time. This will help them to bypass intermediate steps and help them to become independent of the technologically advanced nations.

Satellite instructional television experiment (SITE) implemented in India with the support of NASA had demonstrated how effectively a developing nation could share shoulder with technologically advanced nations to leapfrog in the developmental steps. This had proved to the government how the technology could be utilized to build a strong educational and communication network. Office of the technology assessment has submitted a report to the US congress in which four major factors are identified as impediments to any nations joining the space club: ": *1) lack of capital; 2) few technically skilled personnel; 3) small scientific support base (computers, facilities, etc.); and 4) the need for stable government and policymaking apparatus committed to the long-term political and financial support of space".*[66] Reliance on foreign nations for its assistance often comes with a cost. The recipient countries often become overly dependent on them or will be heavily influenced by the policy shifts of the donor country. India is often quoted as example for judiciously employing the assistance from the East and the West bloc at the same time works towards developing an independent space capability. Even at this time when the West has made severe sanctions against the Russian on account of the war in Ukraine, India is maintaining a measured step in maintaining its association with the East as well as Russia as India depends on Russia for meeting its requirements of the space as well as defence.

[66] Congress, *supra* note 42, at 58.

The international space station stands a testimony of the largest cooperative technological project. It has provided a platform for a number of developing countries who ordinarily may not have the capability to engage in space exploration. It has also shown how cooperation in space technology could bring cost advantages to the participating nations. It also allows for the peaceful coexistence of the nations involved in the project as well as encourages transfer of technical know-how and idea among the cooperating nations. Cooperation in international space projects helps to maintain a symbiotic relationship among the participating nations and enables a capacity building in competence as it takes into account the ideas and technical resources from all the participating nations. With all these advantages in front, a close analysis of the cooperative efforts indicate that a complete transfer of technology or its development doesn't happen often and thus the international community is yet not fully capable of synergizing the their capabilities in the peaceful exploration of the outer space.

CHAPTER 5

DETERMINANTS AND CHALLENGES IN SPACE TECHNOLOGY TRANSFERS

Cooperative agreements is a norm of the human civilization. Starting from the early nomads, agreements have resulted in partnerships and relationship to foster one another's wellbeing. When time progressed and nations advanced in their civilizations, cooperation in all its realms need to be seen as a platform for the nations to develop dependencies thus avoiding any need for conflicts. Sharing of resources, know-how, technical support could all help developing nations achieve leap frogging the intermediate steps involved in technology readiness level. This could prove beneficial to countries with less resources. Most of this technology sharing is achieved through technology transfer agreements/MoUs between the nations involved. This chapter focuses on the determinants of a successful technology transfers and the challenges in international space technology transfers.

5.1. Defining Technology Transfer

The process by which knowledge, technical information, skills, methods, procedures developed in one organizational setting finds application in another organizational setting is termed as technology transfer. Technology transfer is source of innovation, industrial growth and job creation and thus aids in the national development. The socio-economic benefits of space technology are such that the program most often results in a multiplier effect than those which can be directly obtained from the publicly funded space technology programmes. This has led the government of the space faring nations to actively encourage technology transfers. Though the benefits of TT are well documented and known to the public, due to the lack of clarity in the policies, the desired benefits are not often reaped. This deficiency ranges from insufficiency of support mechanism to encourage TT and an absence of regular evaluation of the effectiveness of the transfer program.

Technology transfers involves a complex process that often depend on a range of factors "*including the technology itself, the R&D programme, the nature of recipient actors, as well as the institutional and regulatory frameworks in place*"[67]. They stimulate innovation by means of industry science collaboration. Technology transfers happen between the public funded space agencies and the industries in the country, to other publicly funded research labs, to universities, between countries as part of international technology transfers or as part of foreign direct investments.

[67] *Space Technology Transfers and Their Commercialisation*, No. 116, 14 (Jul. 2021).

5.2. Factors determining technology transfers in space

Space technology always work on the cutting edge technology and so the technology transfers and commercialization schemes are wider and innovative and competing. Transfers from space agencies are always bounded by policy frameworks. They provide a regulatory framework defining the legality involved in the transfer of rights between the transferee and the transferor with clear definitions of the commercial terms involved. The policy will be aimed at wider absorption of the technology in the market so as to make maximum returns from the publicly funded space programs. In some case the policy defines situations where the technologies are co-created with the support of industry and/or academia ensuring a long term relationship with the industry and the academia.

Being a complex program, the technology transfer process involves several concurrent factors and decisions involving strategic dimensions as there will be many actors involved especially when the technology is created by a publicly funded mechanism. Technology readiness level, application and market involved, level of interaction between the transferor and the transferee will all become determining factors in a successful technology transfer. Policy report from OECD on space technology transfer and commercialisation[68] identified the following main factors which could act a crucial determining factors in the technology transfers:

a) Market consideration

   Technologies developed which has an element of the requirements of market demand will have a thrust for successful commercialisation. This market pull will enable transfer of the technology easy and will result in a successful commercialisation of the technology. The closer the demands match the design and specification of the technology, the higher will be probability of interaction and the success of the transfer.

b) Technological content

   Maturity of a technology plays a major and critical role in the success of technology transfer. Technologies which are space qualified will be adopted with lesser push from the agencies side. It provides a higher level of confidence to the takers as it is said to be 'flight qualified'. A versatile and higher TRL level encourages faster adoption of the technology.

c) Nature of the licensee

   Technology diffusion can depend upon the nature of the developers and their interaction with

[68] *Id.* at 18.

the network of the recipient licensees of the technology. The reciprocal trust from the recipient will surely depend on the quality of the information exchange and the availability of the knowledge from the developers side.

d) Internal structure of the recipient industry

Flexibility and adaptability of the recipient industry will play a key role in the success of the technology transfer. Technology in the space domain are often created for a specific mission. The application of the technology in another domain often requires certain tailoring and customisation to make it adaptable to the recipients technical network. The adaptability of the recipient organisational structure will surely play a key role in the success of the technology transfer.

5.3. Accomplishing technology transfers

Technology transfer in space sector occurs through different formal and informal channels. Formal channels are traceable including the signed contracts, MoUs and agreements whereas informal transfers occurs in the form of tacit transfers.

Formal technology transfer happens with due diligence on the technology content involved and will often be concluded through formal technology transfer agreements. Large space agencies such as NASA, ESA, ISRO, JAXA etc have dedicated technology transfer offices who take care of the management of the technology transfer business. The potential industry is assessed before the transfer of the technology to understand its capability in assimilating the technology and understanding its potential for taking it to market. For NASA, individual centres have their own technology transfer offices. Whereas in the case of ESA, a network of technology brokers are employed for diffusion of the technology and identifying potential licensees. For ISRO, individual centres have technology transfer offices. The offices work in a centralised manner and the technology transfer is currently accomplished through a commercial arm of ISRO, New Space India Ltd who is authorised to enter into technology transfer agreements with other agencies. For JAXA, promotion and development of the R&D activities, introduction of the technology to non-aerospace firms and promoting its use in non-aerospace industries are accomplished through Business Development and Industrial relations Department of JAXA. Korea and Germany, for example, have got provision of business development services such as KARI’s STAR Exploration programme and DLR’s Technology Marketing Office.[69]

[69] *Id.* at 21.

Patenting and licensing of technologies are often followed by Space agencies for the commercialisation of their technologies. As part of the technology transfers, the technology is licensed to the licensee for a specific duration and they will be allowed to commercialise the technology meeting certain terms and conditions of the licensing agreement. In most cases, the agency hold the IP right for the technology. NASA presently holds more than 1200 patents which are available for exclusive as well as non-exclusive licenses. ESA also hold more than 530 patents to its credit and it provides non-exclusive licenses to the prospective industries for commercialisation of the technology. ISRO hold more than 500 patents to its credit and they can be licensed through the commercial arm of ISRO, New Space India Ltd for a non-exclusive license agreement by making the required technology transfer fee and applicable royalty.

Sharing of facilities and resources owned by public space sector agencies for use by other space agencies as well as private and non-space actors act as another channel for triggering the knowledge transfer. In the case of academic institutions, these facilities will be shared on favourable terms for fostering collaboration and attracting spin-ins of technologies.

Another track for the technology transfer followed by some of the space agencies is through the establishment of clusters, incubators and collaborative platforms for the commercialisation of the technologies. Space agencies support the industries incubated and helps in the commercialisation of the technology.

5.4. Drivers of Technology Transfer

International technology transfers and cooperation do exists and a whole host of scientific endeavourers exits which reflects the true spirit envisaged in the Outer Space Treaty which calls for a peaceful use and exploration of the space. With the decline of the Cold War, new strategic alliances started cropping up and nations looking for a leap frogging in the technological advancements ushered into international space alliance and partnership with plurality of nations leveraging their expertise. The United States took constructive steps in this direction by reaching out to nuclear global powers like India and China.

Political decisions drive a nation’s desire to engage in space cooperation. The choice of nation and the modality of the engagement are all calculated steps truly determined by the political positions and the utility involved in the international space. Similarly private investments in the strategic sectors are controlled by domestic regulations. Thus there ought to be clear guidelines on which a nation enter into agreements with international partners on the domain of strategic technology and there will be clear national directions and guidelines. Cooperation in space, which has a military dimension to it is always concluded only when the security and the intelligence requirements provides clean chit to proceed with such arrangements. Cooperation emanates internationally when it is driven by "*national diplomatic prestige, provides for political sustainability and enables stability of workforce*."[70]

5.4.1. *National Prestige*

International cooperation especially in the field of complex technologies indicate a nation's leadership and technical prowess. India presently has cooperative agreements executed with more than 60 countries. Also, payloads from many international partners are being launched aboard the Indian launch vehicles. Similarly Russia and China also attract lot of international customers. The channels for collaboration and cooperation in other domain increases once the perceived utility and prestige from the cooperative missions increases.

5.4.2. *Political Sustainability*

Engaging in international cooperation, one nation will be forced to maintain the political will required to sustain the agreement in place. Even when the program faces severe cost over-runs, the nation will see to it that the programs are sustained. This is because, withdrawal from international agreements is not viewed politically correct and it creates a sense of disbelief about the political instability of the nation. Any unilateral decision to pull out of the agreement will signal that the other party is unpredictable and possibly a disrespectful partner. It is often quoted that the engagement of Russia in the manned mission of ISS has kept for saving the mission.

5.4.3. *Enabling stability of work force*

It is well understood that the foundations laid for the manned mission to Moon, Apollo has far reaching effects on the scientific research, ,engineering and innovation that lies in the heart of the US workforce. It has created a push to be on the innovation front lines. The systems developed for the Apollo such as the communication backbone, weather, PNT and surveillance all have far reaching benefits and has revolutionised and connects USA to the rest of the world. Indigenous capability is being generated within the nation that can be well utilised for the military and the national pride. Spending on cooperative projects could create large pool of work force and thus can ensure job to a large pool of local communities and engage the educational institutions in engaging in the technological front.

5.5. Challenges in transfer of technology

The benefits of international civil space cooperation are many but the space program managers confront

[70] Rendleman & Faulconer, *supra* note 41, at 146.

difficult situation when efforts are actually brought up for implementation. Competing interests and the looming budgetary loads expected to follow the bigger cooperative missions pull back the real sense of cooperation. These kind of behaviors are quite evident and can be read from the recent lunar and interplanetary attempts from space faring nations. Better results could have been achieved if nations were to cooperate and run a single mission pooling in all the resources from the participating nations. The mask of national pride over rules the sense of cooperation when this wealthy and sophisticated missions are considered. There are also restrictions when one firm in a country approaches a cost effective launcher from another nation. USA prohibits launch of its civil and commercial spacecrafts from Chinese launchers. ESA prefers to launch European satellites to be launched on the Ariane launcher. Thus, there are boundaries defined by the national and regional interests.

Added to this, there are export control from the USA which complicates utilization of interoperable platform and cooperative operations of the satellites which are tagged as sensitive technologies and their release to other nations are controlled. This is applicable even to allies and close partners, and the government decides the releasable from the non-releasable. Many nations have restrictions put in place which clamps down the efforts of cross border technology transfers. Release of sensitive articles, which are defence related are regulated by policy arising out of Arms Export Control Act (AECA) and it governs the release of technical data to other nations. The severity of export control regimes in the US is such that it is driving the small firms out of business as they are unable to cope up with the regulatory demands. Even the international customers find the AECA rules wary and burdensome. Chosen controlled articles, technologies and services are listed in the U. S. Munitions List (USML), which is contained within the ITAR. Many nations take advantage of this situation and claim their products to be "ITAR free".

5.5.1. *Volatility in International Politics*

Stability of international politics play a critical role in cajoling partners to enter into technology transfer cooperation. These are governed by the vision of government running driving the politics. In the case of USA, the process of biennial and quadrennial election bring with it uncertainty in the international engagements. The change in plan from a Vision to embrace space exploration by returning human to the moon and later abandoning the plan and switching to a flexible path to undertake manned space exploration have caused confusions and message of unreliable cooperation to ESA, one of the active partner to NASA.

Recent wars in Ukraine by the Russia, has resulted in severely affecting the civil space cooperation which existed between Russian space agency with ESA, NASA and other western blocs. The western bloc stands together and are standing by the sanctions imposed on the Russians. A series of long standing cooperation in the space have come to a firing line with the Russians threatening the operations of the International Space Stations and the cooperation planned with the UK space company OneWeb to launch its mega constellation. The economic sanctions imposed by the EU and US have halted the movement of semiconductor devices and critical electronic components required for the aviation and space sector and thus has made space business difficult in the Russia. ROSCOSMOS in a retaliation has taken steps to cancel all the planned launch of OneWeb mission. The ExoMars mission from ESA, and eRosita telescope mission from Germany too stands affected because of the political turmoil and the war. Russians have called of its workers from the French Guiana Space Centre where they were employed for the Soyuz mission on an intergovernmental agreement. Following the war and the sanctions, the Russians had cancelled the CSO-3 and Galileo missions on French space agency CNES.[71] ESA has announced its decision to cancel the collaborations planned for the Lunar missions with Russia. ESA has announced its plan to collaborate on Russia's Lunar 26 lander and Lunar 27 rover, which were expected to fly with ESA supplied navigation and sub-surface drill mechanisms.[72]

5.5.2. *Exceptionalism*

Nations hold a perception of being exceptional, or being superior in their actions and nature. Many nations in the history have claimed exceptionalism which forces or makes it their choice to remain separate from others. This idea enables one to claim to be a leader in the world, to show the strength and prowess of one's self. This claim of being exceptional, explains actions taken by different nations in exploration of space though it is a redundant or duplicate one of the already exercised one. The plan of South Korea to have a moon mission utilizing their own rocket, to show that they are at par with their erstwhile enemies China and Japan, can be tagged to the exceptionalism claim defined above. The desire of China to have their own moon mission can also be termed as a behavior of exceptionalism. The desire of many nations to have their own moon missions and on-orbit capabilities can be associated with the national pride and self esteem requirement poised by the exceptionalism.

Exceptionalism brings with it a lot of inefficiency, duplication of efforts and unnecessary overlap of research happening across the space agencies. Exceptionalism always leads to mistrust as nations are

[71] *Ukraine War Disrupting East-West Cooperation in Space*, SCIENCE|BUSINESS, https://sciencebusiness.net/news/ukraine-war-disrupting-east-west-cooperation-space (last visited May 3, 2022).

[72] *Ukraine Invasion's Impacts on Space Exploration: Live Updates | Space*, https://www.space.com/news/live/russia-ukraine-invasion-space-impacts-updates (last visited May 3, 2022).

always in a competing mood to do better or far off than their counterparts. China has generated mistrust Among the international community as they always try to have secrecy in achieving their military overpower in the space. Added to the that the ASAT test carried out in 2017 has been alarming to the space community when it created thousands of space debris when nations look forward to create reduction of debris in space.

5.6. Dual Use Nature of Space Technology

5.6.1. *Space technology in terms of export control*

Space technology can be defined as any technology that are designed, intended or used in a space environment or in a system which is planned to be used in a space environment or its support system. When it comes to export control regulation, because of the typical nature of the space technology, the yardsticks differ. In realms of export control, the term "technology" has a specialized meaning and it is not defined to the items that are exported but will also refer to the know-how that gets transferred or which could be inferred when an item is transferred. Export control puts strict checks on the item being exported as well the specific information required to realise, produce or use an item. This specific know associated with an item is termed as the technical data or technical assistance which are tagged by the export control regulations. This information could take physical form or can be shared as know-how.

Physical goods could also be brought under the terms of technology as an item transferred could be reverse engineered and experts skilled in the art would be able to decipher the underlying technology. Hence the technical knowledge transfers are more or less linked to the item being transferred. Thus, a physical item transferred could also come under the ambit of export control. Typically, in export control, space items are divided into launch vehicle, satellites and ground support equipment.

5.6.2. *Defining Dual Use*

Dual-use items are goods, technology, skill or software that can be employed for both military and non-military applications. The technology associated with the realisation and application of the dual use good constitute the dual use technology. Dual use technology thus has the potential for both civil and military applications. Export control definitions of the United States, elaborated the term "dual use" refers "to distinguish Export Administration Regulations [Commerce Department] controlled items that can be used both in military and other strategic uses and in civil applications from those that are weapons and military related use or design and subject to the controls of the Department of State or subject to the nuclear related controls of the Department of Energy or the Nuclear Regulatory Commission."[73]

Typical space systems such as launch vehicle, satellites and the technology associated with their development have dual use nature because of the historical reasons for its development. Most of the rockets in the initial stage were converted machines from the missile used in the World War II. The outcome of the satellites or the results derived from the satellites are sensitive and could be strategically used. Space and its assets form a backbone of a country in this technological growth and hence they possess strategic importance.

Since the Expendable launch vehicles finds their roots in the ballistic missile, the power to carry war heads is still not far away. Hence the international community attributes the same technological category for both the launch vehicles and the missiles which are capable of carrying weapons of mass destruction. Though the export control regime views the launch vehicles and ballistic missiles in the same category, there exists quite a lot technical distinction between both the domains. The difference mainly in the booster stages in the rockets and the missiles. Generally, launch vehicle carry liquid fuel powered boosters considering their ISP, whereas the missile employs solid boosters considering their ease of assembly and short readiness time required to realise the systems. The payload fairing engaged in a launch vehicle and a missile serves two different purposed. In the case of launch vehicle, the fairing protects the spacecraft while climbing to the space and is dislodged once its function is over. However, in the case of ballistic missile, the payload needs to be protected at the time of its reentry and the payload need to hit the target accurately. Even when there exists considerable technical difference between the launch vehicles and the satellites, the export control regime views both the technology through the same lens. There are reports in the US which alleges that the payload fairing related information passed to Chinese government would have been to reutilized in the improved of a Chinese sub marine.[74] Satellites are considered dual use because of the end use could result in civil or commercial application. An earth observation satellite disguised as natural resource monitoring could easily be used to movement across the borders when it has very high resolutions of imaging. Typically, satellites could be classified into three categories based on its end user application: civil, commercial and military. Michael Mineiro depicts through the figure 3 that most of the satellites are dual use in nature.

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[73] *Code of Federal Regulations*, https://www.govinfo.gov/content/pkg/CFR-2020-title15-vol2/xml/CFR-2020-title15-vol2-part730.xml (last visited May 3, 2022).

[74] MICHAEL MINEIRO, SPACE TECHNOLOGY EXPORT CONTROLS AND INTERNATIONAL COOPERATION IN OUTER SPACE 6 (Springer Netherlands 2012).

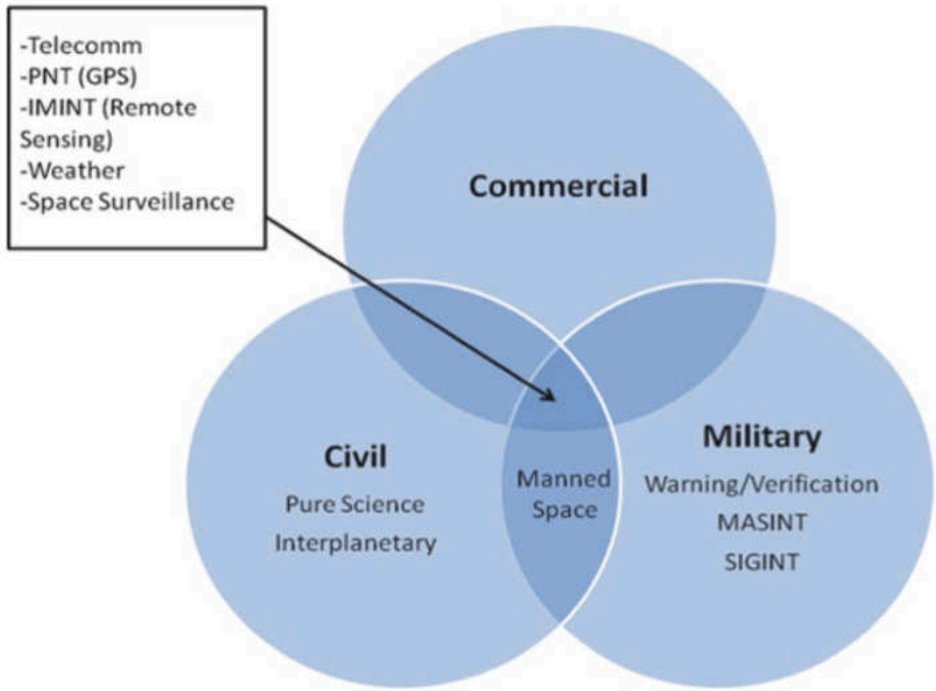

Figure 3: Dual use application of satellites (Source: MICHAEL MINEIRO, SPACE TECHNOLOGY EXPORT CONTROLS AND INTERNATIONAL COOPERATION IN OUTER SPACE, PAGE 6)

Figure 3 indicates that depending upon the intended use, the payloads could be modified and the class of the satellite could be changed. Export control machinery will have a difficult time in determining the class of the application of the intended satellites.

A satellite in space is like an eagle in the sky. The strategic importance attached to an object looking from high above, stealthily, is of greater strategic importance. It can give invaluable information about the neighbour or enemy to the military and the intelligence operations. Satellites ensures that the men in the field are always connected and their movement are well measured and watched with precision. Recent surgical strikes adopted by India when attached the militant base in Pakistan is an excellent example of how a satellite based moved could fetch grand results. EMISAT was a recently launched satellite from the Indian ground, which can sense presence of electronic signals on the ground especially enemy radars and can scan through any strong weather conditions of ice, rain, coastal zone, land masses, forests and wave heights.[75] This kind of military satellites could bolster the capability of India in

[75] *EMISAT Can Bolster India's Surgical Strike Capability*, ECON. TIMES (Apr. 1, 2019), https://economictimes.indiatimes.com/news/defence/emisat-can-bolster-indias-surgical-strike-capability/articleshow/68670153.cms?from=mdr.

achieving precise surgical strike operations.

For any satellite launch to occur, bare minimum details need to be shared with the launch vehicle team. When a satellite from one country is moved to another country for launch operation, there will be certain exchange of information. This could be mainly to ensure successful separation commands, signal frequency used to undertake interference studies, mass and C.G. measurements for vehicle stability analysis, interface details for ensure compatibility of electrical signals etc. Thus when, where, how and by whom a launch takes places will all be scrutinized by an export control office.

5.7. Making the distinction

Since the decline of the cold war, there has been a flow of technologies from the military to the civil society applications. However, recently a reversal of flow of technology transfer from civil to military is observed. The military is offered a host of technology from the dual nature civil commercial satellite application. In most cases, a gently fine tuning of the technology will aptly provide and meet the requirements of the military needs. This evolution of technology is creating a technical bewilderment in classifying the nature of technology into civil, commercial or military. Due to the strategic nature of the assets placed in space, the technology employed in space is inherently dual use. Hence the definition of the regulation required while transferring the technology always poses serious concerns. The definition ultimately resides in the choice of the policy and the law guarding the national and political interest of the exporting nation. The choice of the definition will eventually decide the nature and characteristic of the cooperation involved.

CHAPTER 6

TECHNOLOGY TRANSFER AND NATIONAL SECURITY DILEMMA IN SPACE

Space today has become really import to the commerce and national security. Defining a clear line dividing the two sectors have now become blurred. Considering the national interests, the States have now shaped and retuned the international rules governing the access to and use the space to meet their national requirements by defining appropriate national space policies. Erstwhile leaders in space tends to establish and retain their upper hand in the space by instilling control regimes prohibiting the proliferation of new players. The information revolution aided by the space communication and assets is so powerful that it has vital bonds between the commerce and national security. Any glitch in the operation of a space asset could adversely affect the military, economic and societal life of nation who is having considerable space assets. Thus, only who is wealthy in space, tries to control the entry of others adversaries to establish such capabilities.

Moreover, for a greater part of the space age since its inception, the space civilization has been defined and controlled by the United Nations and the Soviet Union. Being sole players in the domain, the rules of road were written in place by them. Both these nations established an asset base in the space and ensured an unfettered access to the space. However, the situation changed with the entry of more space faring nations, resulting in political and economic challenge to the freedom enjoyed by the then super powers. The growth of space technology and the proliferation of commerce thus became a threat to the assets of the super power. The super powers in space, started growing concern about the adversary's assessment about the importance of space assets to them and thus could become a probable target. This heavy dependence on space could enable the adversaries to hold asymmetric strategies to inflict the assets in space without having to take on with the might military forces. This could also enable them to develop counterspace weapons against space assets. In overcome these threat perception, international and domestic export control regulations were brought in place by the United States so as to put a check to what is being shared outside the sovereign national boundaries. Many followed this, ultimately resulting in a dilemma restricting the movement of technology across the border.

6.1. Sovereignty and Export Control

A sovereign state has got the right to establish domestic and international export control as per the definitions of the international legal concept. The current international legal system enables sovereign States to establish unilateral space technology export control to coordinate their domestic regulations.

This is being done in the absence of a supranational jurisdiction to regulate and enforce the regulations. This is because only the recognized sovereign states have the authority to exercise its control over the territory, persons, natural resources and other objects which are typically being controlled in an export control context. On the other hand, when non-space actors do a coercive control of the export control, it stands illegal and it is often categorized by legal authorities as pirates, thieves, terrorists, or rebels.[76] Thus export is a legal concept associated with a sovereign State and territorial sovereignty is legal requirement to exercise export control.

States need to enter into bilateral or multilateral technology transfer agreements to overcome these obstacles and obtain a cross border transfer of export of the technology. Sovereignty is associated with controlling the territorial boundaries and infusing the national jurisdiction. It provides the public authorities to control and check the movement of goods/technology across the borders. The Montevideo convention on the rights and duties of States, define State as "*a person of international law should possess the following qualifications:*

a. a permanent population;

b. a defined territory;

c. government; and

d. capacity to enter into relations with the other states."[77]

A sovereign state can initiate export control on the basis of legitimate and permissible jurisdiction. This exercise is carried out on the basis of territorial jurisdiction of national concept principle. Along with this, for effective control of export, two specific forms of territorial jurisdictions are required as per the Public International Law. These are referred to as prescriptive and enforcement jurisdiction. *"Prescriptive jurisdiction concerns a State's power to regulate or prescribe conduct, usually through the passage of law or regulation and the interpretation of such rules by domestic courts or tribunals." "whereas, enforcement jurisdiction concerns the power to take action consequent upon those rules, usually by way of executive or administrative action, and includes all measures of constraint aimed at securing compliance with such rule."*[78] Thus for a proper control on the export, a State is supposed to have an effective regulatory mechanism to prescribe the law and an enforcement mechanism for proper implementation in case of any misconduct of the law.

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[76] MINEIRO, *supra* note 74, at 14.
[77] *Montevideo Convention on the Rights and Duties of States - The Faculty of Law*, https://www.jus.uio.no/english/services/library/treaties/01/1-02/rights-duties-states.xml (last visited May 5, 2022).
[78] MINEIRO, *supra* note 74, at 18.

It may also be noted that, for proper enforcement of the export control on a foreign national in a foreign country, there needs to have prior arrangement between both nations. Through these agreements only scope of regulation and post inspection in case of any export control is possible. Multinational export control arrangement works in close coordination with strategic trade control agreements. These kinds of arrangements will be adaptable to the existing domestic regulations with respect to specific exports.

6.2. International Legal Obligations in export of launch vehicle and satellite technology

Sovereign states could impose control on exports in accordance to the requirements of international law. Theoretically, international law could even direct the Sates to follow certain export control directions. States could even be imposed to allow an item for export. There are four instruments in international law, that could instill such an imposition. They being: "*U.N. Security Council resolutions, binding international agreements (e.g. treaties), customary international law, and peremptory norms of international law (jus cogens). In addition, States enter non-binding agreements that impose political (but not legal) obligation"*[79]

6.2.1. *Security Council Resolutions*

In case an exportation of satellite technology is perceived to have a threat to peace, the U.N. Security Council has got the authority to control such export. Satellite are designed to orbit the earth, generally for observation purposes in different domain and using different technologies. The same satellite could also be customized to become an instrument of mass destruction inflicting the nearby satellites. Since such a threat is not yet posed by any of the States, the U.N. Security Council has not yet acted to impose such restriction on the exportation of satellite.

6.2.2. *Agreements and Treaties*

Existence of any multilateral treaties control satellite export control is not known publicly. However, Treaty on Non-Proliferation of Nuclear Weapons and Treaty on Limitation on Anti-Ballistic Missile, consider that space technology has a potential to deliver weapon. The Outer Space Treat as well as the Moon Treaty prohibits placement of weapons in the outer space or other celestial bodies. There are cases in which bilateral agreements are made operation for export control of space systems.

There exist three non-binding agreements which are of importance to the launch vehicle and satellite export control: The Wassenaar Arrangement, MTCR and the Hague Code of Conduct.

[79] *Id.* at 22.

6.3. The Wassenaar Arrangement

Wassenaar Arrangement is a post cold war mechanism which "contribute to regional and international security, by promoting transparency and greater responsibility in transfers of conventional arms and dual-use goods and technologies, thus preventing destabilising accumulations"[80] Each participating state can decide on the transfer or denial of transfer of exports and they do not require the consent of any fellow members to the arrangement. Wassenaar arrangement looks for ensuring transparent transfer of items and to ensure that such items do not contribute to the enhancement of military capabilities which undermine such peaceful efforts. The arrangement is applicable to conventional arms and dual use items and the items listed under "List of Dual-Use Goods and Technologies and in its Munitions List" under the scope of Wassenaar Arrangement. Thus, this agreement ensures a transparent export control regime. Satellite technology is listed as a dual use item in the scope of this agreement.

6.4. MTCR and Hague Code of Conduct

Missile Technology Control Regime is an informal political understanding which looks forward to limit the proliferation of missiles and missile technology. MTCR urges its members to ensure vigil over the transfer of missile equipment, materials and technology which are capable of delivering weapons of mass destruction. Category I of the annex defines rocket systems, sounding rockers and launch vehicles. MTCR decisions are backed by consensus among its members.

Hague Code of Conduct or the International Code of Conduct against Ballistic Missiles Proliferation consists of a set of principles, commitments and measures towards confidence building. HCOC is designed to supplement the MTCR guidelines.

From the above discussion, it is clear that the concepts of export control are built on the concepts of sovereign jurisdiction of the geography and territory. These territorial jurisdiction and sovereignty are built from the legislative structures of the nation and thus the legislative structures define the export control jurisdictions applicable for a State.

6.5. Commercial Communication Satellite Export Controls of U.S.

Export of commercial communications satellites (Comsats) and associated equipment are controlled through provisions available under Arms Export Control Act (AECA) or Export Administration Act (EAA). The AECA established a regulatory regime names International Traffic in Arms Regulation

[80] *Home - The Wassenaar Arrangement*, https://www.wassenaar.org/ (last visited May 6, 2022).

(ITAR) and EAA establishes a regulatory regime named Export Administration Regulations (EAR). ITAR exerts control on goods, services and technologies categorized as munitions, while EAR control the export of goods, services and technologies categorized as commercial dual use. M C Mineiro states that "*The most important difference between the AECA's International Trafficking in Arms Regulations (ITAR) and the EAA's Export Administration Regulations (EAR) is that EAR controls goods and technologies generally, with special consideration given to the domestic economic impact of export controls, while ITAR controls defense articles and services. These differences are reflected in the respective licensing regulatory mechanisms including inherent presumptions regarding an applicant's right to export, license application requirements, interagency review and Congressional notification processes, de-minims context, foreign availability and other licensing exceptions, costs associated with licensing and compliance, and the severity of civil and criminal penalties in the event of a violation.*"[81]

The United States has seen three different phases of the export control centered around the cold war regime. The first era lasted until 1990s which sustained during the cold war period. Subsequently, liberalization of the export control were initiated by the U.S. The third era began with the Strom Thurmond Defense Appropriations Act of 1999 which is actually a revision of the ITAR policy which existed in the cold war period.

The definition of a commercial communication satellite arose only with the launch of Early Bird Communication Satellite in the year 1965. During the cold war, satellites were built and operated only for the national security purposes and there was no commercial market and hence no commercial export control requirement. The commerce in the satellite industry became live with the launch of Early Bird. This led to the sprawling growth of commercial telecommunication satellite industry and the US satellite manufactures dominated the market. The US government defined stringent export controls to be in place to prevent the proliferation of technology to other hands. The US satellite communication technology was listed under munitions to make this control much stringent. The requirement of the western allies was met by the launch of their satellites from the US soil which practically prevented the transfer of any satellite across the US territorial border.

The shift in the scenario happened with the rise of commercial space sector in the Western Europe with the establishment of Arianespace by France in 1980s. This economic competition from the Europe weakened the monopoly of the US dominated international satellite market. The Western bloc used to control the export under the aegis of COCOM (Coordinating Committee for Multilateral Export

[81] MINEIRO, *supra* note 74, at 47.

Control). However, with the diverging interest of Europe with the arrival of Arianespace, the policy coordination within the COCOM on satellite export became a hurdle for the U.S.

The international commercial space market began to grow with more States party to the business and their became a shift in the government sponsored launch to private commercial launch in the U.S. which got thrusted after the Challenger disaster. With the fall of Soviet Union in the 1990s, the COCOM got replaced with the Wassenaar agreement which looked for transparency on the export market. Both China and Russia inked bilateral technology safeguards agreements with the U.S. which allowed U.S. made satellites to utilize Russian and Chinese launchers. This was making the items controlled under the munitions list to the more commercial dual-use standards list. This trajectory of growth lasted until 1999, when the Cox Committee Report led way to the Strom Thurmond Defense Act of 1999 resulting in a reset, with the commercial communication satellites getting pushed back to the munitions list.

6.6. Cox Commission Report and the STDA

The evolution of policy space in the export control regulations of the United States stands incomplete without the role played by the Chinese space market. China offers a huge market for the satellite manufactures in the United States, which gets attractive with the low cost of launch operations. This economic incentive, led to the establishment of bilateral agreements with China aiding way for technology safeguards in satellite technology and the other for launch trade. The agreements were primarily aimed at unauthorized technology export to China. But the growth in this bilateral relation got strained when U.S. established a Congressional Committee to investigate concerns over Chinese acquisition of US missile and space technology while the launch service of U.S. satellite in China takes place. The Committee released its report in 1999, which led to the amendments in the export control regime included in the Strom Thurmond Defense Act (STDA) of 1999, which recommended corrections in the security deficiencies.

The committee report found that technology transfer had happened from the private U.S. satellite manufactures who assisted the Chinese during failure analysis of rockets which carried U.S. commercial satellites onboard. The committee suspected that the technical assistance provided by the satellite manufacturers from U.S. would have helped the Chinese rocket engineers to improve their commercial launch vehicles as well as in improving their ballistic missiles, an in particular the fairing on the submarine based ballistic missiles.

The amendments suggested in the STDA had severe implications on the export control regime of U.S. The major amendment was such that the commercial communication satellites which were earlier placed under the EAR regulations were then brought to the United States Munitions List (USML), thus bringing it under the ITAR. The effect of this amendment is such that all exports of satellites, regardless of the sensitiveness of the technology, need to be regulated as export as munitions by the Department of State. Along with these controls, the amendment also stipulated specific control on the satellite export considering the national security. These control include: “(1) mandatory technology control plans, (2) mandatory monitors and reimbursement, (3) mandatory licenses for crash-investigations, (4) mandatory advance notification of meetings with any foreign person or entity providing launch services, (5) mandatory intelligence community review, and (6) mandatory notification to Congress.”[82] All these restrictions are in addition to the controls defined under the Arms Export Control Act for ITAR items. NATO and other major non-NATO allies of USA are granted exemption under these additional controls.

6.7. Commercial Communication Satellite Export Controls of Europe

The export control prevalent in Europe is based on the classification of item as either conventional armament or dual-use goods. Regulations regarding conventional arms are defined by individual Member States and sets their own policy for export and trade. Dual use items fall within the ambit of E.U. and they define the regulations as well as the penalties in case of violations, ensuring a harmony within the European Union.

E.U. defined the regulatory control on the dual-use goods as per the Council Regulation (EC) No. 428/2009. This regulation provides for a Community General Export License, National General Export Authorisations, Global Authorisations, and Individual Export authorisations. Dual-use items are listed in the Annex I to IV of the Council Regulations. Communication satellites and their components are defined as dual-use items are brought under Annex I of the EU regulation 428/2009. Authorisations required for the export of the satellite outside the European Union is issued by the concerned Member State where the exported is located. The authorization is based on the successful establishment of its end use in the country of import. In case the item is not categorized under the council regulation, the ultimate decision is the discretion of the Member State.

6.8. Summary of EU-US Export Regulations of Comsats

Major difference between the regulations stems from the fact that, the U.S. categorizes Communication

[82] Floyd Spence, legislation, *H.R.3616 - 105th Congress (1997-1998): Strom Thurmond National Defense Authorization Act for Fiscal Year 1999*, https://www.congress.gov/bill/105th-congress/house-bill/3616 (last visited May 7, 2022).

satellites are munitions, whereas the E.U. categorizes as dual use item. This shows a significant divergence in the policy adopted by the two national systems. This stems from the fact that the modern U.S. export control system controlling the Comsat export is derived from a historic legislative process. Foreign policy dealing with the China is different for the U.S. It is evident that U.S. follows a strict control on the export of Comsats and associated elements significantly impeding the technology transfer and inflicting a global civil space cooperation.

6.9. Export Controls and their implications on Global Civil Space Cooperation

In the absence of a supranational space technology trade and proliferation control regime, States exercise a unilateral trade and proliferation control regime, defined mostly at the national level, giving priority to the national security considerations. United States, as a representative of the leading space technology power, imposes strict regulations on the export control upholding its national security concerns. This national centric paradigm is reflected in the absence of a supranational legally binding export control regime.

6.9.1. *Outer Space Treaty*

The Outer Space Treaty establishes the foundational principles for the exploration of space by the States and their national entities. With the launch of the first artificial satellite in 1957, the nations were seriously concerned about the nuclear and the conventional arms race potential of the Outer Space, especially in the Cold War era. The Outer space treaty was primarily brought as an arms control and disarmament agreement. Article I of the OST, mainly uphold four clauses: "*the Benefits and Interests Clause, Province of Mankind clause, Non-discrimination Clause and the International Cooperation Clause.*"[83] The OST thus requires the States to ensure international cooperation and peace and security in the exploration of outer space.

In reality, space faring nations with launch capability only does possess the capability to access the outer space. This indicates that, access to the space for other nations will be decided by the nations who have the launch capability. In the absence of an international agency or organisation carry out such a launch service activity, the launching states are not under any obligation to provide launch service to other States. As a result, in legal principle outer space is free for access by all States, however in practice, States will launch capability can choose whether or not to provide launch service to others or to prevent them from accessing the outer space.

[83] MINEIRO, *supra* note 74, at 157.

Article II of the OST speaks about the prohibition of national appropriation of the outer space or celestial bodies. It remains to watched how this principle will be put to use when nations really engage in exploration and resource extraction from the outer space. Any such action needs to be done maintaining international peace and security promoting international cooperation. Article IV prevents positioning of nuclear weapons or weapons of mass destruction in outer space and defines the outer space and other celestial bodies as areas of disarmament. However, the treaty doesn't mandate to sell, share or transfer any technology associated with the exploration.

6.10. Impact of Export Controls on space cooperation

The international regimes existing to control the unauthorized proliferation of space technology is minimal. As discussed *supra*, non-binding agreements such as the Wassenaar Agreement are used to regulate the space technologies not directly related to ballistic missiles, and international level regulation is limited to ballistic missiles, nuclear systems or weapons of mass destruction. Thus, the lack of an international system, urges States to bring in unilateral responsibility of export control of civil and commercial space related items. The close link between the launch vehicle technology and the missile technology creates technology proliferation and additional security concerns for the States. This leads way to the creation of non-harmonized fractures systems controlling the trade and proliferation controls. This concern about the un-authorized technology transfers in the absence of an international regulatory mechanism restricts the international civil and commercial space cooperation endeavours to protect the national security interests.

6.10.1. *Restrictions in civil space cooperation*

Outer space cooperation seen today are governed by bilateral or multilateral treaty regimes as there is no international organization having any supranational jurisdiction to oversee the operations. This sort of coordination does not offer any sort of coordination among the space faring nations, nor does it guarantee any access to the space for nations without that capability. This absence of an international cooperation is indicative of the current concerns of the international space security environment. However there exists many international organisations like the International Telecommunications Union (ITU), World Metrological Organisation (WMO), International Maritime Organisation (IMO) etc. who coordinates various aspects of space activity. These organisations work in narrow corridors over terrestrial matters which fin critical application in the space technology. For example, the frequency and orbit allocation and management is governed by the ITU. But beyond this area, ITU does not offer their service. In general, these international organisations do not facilitate any international civil space mission coordination or operation.

As discussed supra, there exists various national inter-agency cooperative agreements to facilitate international civil space cooperation. But most of these cooperation are limits to launch services or sharing of data for typical applications like disaster management, weather monitoring or local resource management. Thus the success of these arrangements to overcome the security concerns are based on the fact that the cooperation is limited to sharing of insensitive data/information of a particular area and the possibility of utilizing this data for military application is does not exist. Most importantly, there no sharing of technology and all operations are governed by the jurisdiction and control of the country engaged in the bilateral engagements.

Bilateral and multilateral engagements are also invoked for civil space mission developments like small satellite development, scientific payload development, manned mission technology development and most notably in the operation of ISS. These kind of arrangements raises several questions on the security risks that could arise because of the unauthorized technology transfer possibilities. This kind of inter-agency operations mandates sharing of certain information to ensure success of the system engineering operations.

As discussed supra, the cooperation in management of ISS stands as a testimony towards how a complex international space venture is structured in the absence of an international space organisation. The ISS is governed by the ISS Intergovernmental Agreement (IGA) and through other implementing arrangements between NASA and other agencies as a subset of the IGA. The partners in the ISS, develop their own elements and technical information necessary to ensure proper system integration is shared.

Article 7 of the ISS Intergovernmental agreement speaks of the management of the ISS as follows:

> *"1. Management of the Space Station will be established on a multilateral basis and the Partners, acting through their Cooperating Agencies, will participate and discharge responsibilities in management bodies established in accordance with the MOUs and implementing arrangements as provided below. These management bodies shall plan and coordinate activities affecting the design and development of the Space Station and its safe, efficient, and effective operation and utilization, as provided in this Agreement and the MOUs. In these management bodies, decision-making by consensus shall be the goal. Mechanisms for decision-making within these management bodies where it is not possible for the Cooperating Agencies to reach consensus are specified in the MOUs.*

Decision-making responsibilities which the Partners and their Cooperating Agencies have with respect to the elements they provide are specified in this Agreement and the MOUs.

2. The United States, acting through NASA, and in accordance with the MOUs and implementing arrangements, shall be responsible for management of its own program, including its utilization activities. The United States, acting through NASA, and in accordance with the MOUs and implementing arrangements, shall also be responsible for: overall program management and coordination of the Space Station, except as otherwise provided in this Article and in the MOUs; overall system engineering and integration; establishment of overall safety requirements and plans; and overall planning for and coordination of the execution of the overall integrated operation of the Space Station."[84]

The ISS is a multi national project with eight participating States. India and China, two major space faring nations are not part of the ISS and hence the definition of international community usage for the ISS is questionable. Nor does the ISS have participation from any Space Agency Partners. Hence the existing missions of multinational cooperation are examples of politically linked cooperation. Intra-agency missions of the present day are coloured by the interest of the partners and does not truly represent a global community.

Similar or less restrictions are seen in the international launch service providers. Space faring nations with launcher capabilities offers launches of satellites of other nations on cost basis. These launch firms operate as either private launch firms or government backed launch firms. Based on the capability of the launcher and its adaptations, vehicles are allowed for launch. As the launch vehicles come under the definition on the ballistic missiles, the launch vehicles are not traded on the international marker. Rather, the vehicles are used to launch satellites which reaches the launch pad of the serving nation. Differences exists in the case of Russian Soyuz launch vehicles, which used to be launched from the Arianespace launch pad in the French Guiana.

However, not all States permit foreign launch of satellites and thus they are controlled at the boundaries. This is based on the concern of unauthorised technology transfer while utilising a commercial launch service provider. Some States overcome this problem through bi-lateral treaties. However, as we

[84] Legislative Services Branch, *Consolidated Federal Laws of Canada, Civil International Space Station Agreement Implementation Act*, https://laws.justice.gc.ca/eng/acts/C-31.3/page-2.html (last visited May 8, 2022).

discussed earlier, the STDA and China launch boycott are examples of such security concerns. Thus, States in the absence of an international mechanism to ensure protection of un-authorised technology transfer, rely on unilateral trade protection mechanism and its enforcement to prevent the proliferation of classified information.

6.11. Impact of Arms Control, Disarmament and Proliferation on space cooperation

International civil space cooperation is closely linked to the arms control, disarmament and proliferation regimes. This is because of the fact that for ensuring cooperation, there needs to be sharing and co-development of certain systems and technologies and this effort will be review under the above defined control regimes. Before committing international cooperation in space, the States needs to rectify and clear the dilemmas pertaining to the arms control and disarmament policy of the counter-part, reason being absence of arms control, disarmament and proliferation regimes enhances the risk of unauthorised technology leakage. States will not engage into cooperation with strategic military competitors. The absence of an international space technology control regime enhances the security risks in the event of sharing and joint development post international cooperation.

The modern international space security regime is concerned about the proliferation of anti-satellites weapons development, ballistic missile development on the cue of launch vehicle, unauthorised technology transfer, space based ballistic missile and weapons aimed at space targets. To target these concerns, the international community have devised different arms control, disarmament and proliferation agreements like the Outer Space Treaty, Limited Test Ban Treaty, MTCR, Wassenaar Agreement etc.

Through the Article IV of the Outer Space treaty, the Member States signatory to the Treaty vows to prohibit the deployment of nuclear weapons or weapons of mass destruction in the outer space and other celestial bodies. Through the various clauses of the OST, the nations are urged to inform the Secretary of the United States regarding launch of any nature and the results of the space activities. The nations are also required to register the basic information regarding the object being launched and inform the Secretary General regarding the frequency of the operation, general functionality, orbital parameters, geographic details of the launch pad etc. On a reciprocal basis, the States are also allowed to inspect all stations, installations, etc on the moon or other celestial bodies. However, the OST does not speak about any measures to verify the objectives. Thus, the States themselves are required to implement appropriate measures to verify the facts in case of any requirement.

Signed at Moscow in the year 1963, the preamble of the LTBT or the “Treaty Banning Nuclear Weapon

Tests in the Atmosphere, in Outer Space, and Under Water" proclaims "

as their principal aim the speediest possible achievement of an agreement on general and complete disarmament under strict international control in accordance with the objectives of the United Nations which would put an end to the armaments race and eliminate the incentive to the production and testing of all kinds of weapons, including nuclear weapons, seeking to achieve the discontinuance of all test explosions of nuclear weapons for all time, determined to continue negotiations to this end, and desiring to put an end to the contamination of mans environment by radioactive substances,"[85].

The LTBT partners undertake

"to prohibit, to prevent, and not to carry out any nuclear weapon test explosion, or any other nuclear explosion, at any place under its jurisdiction or control:

(a) in the atmosphere; beyond its limits, including outer space; or under water, including territorial waters or high seas; or

(b) in any other environment if such explosion causes radioactive debris to be present outside the territorial limits of the State under whose jurisdiction or control such explosion is conducted. It is understood in this connection that the provisions of this subparagraph are without prejudice to the conclusion of a Treaty resulting in the permanent banning of all nuclear test explosions, including all such explosions underground, the conclusion of which, as the Parties have stated in the Preamble to this Treaty, they seek to achieve."[86]

Thus the LTBT serves as an arms control agreement prohibiting the proliferation of nuclear weapons in the outer space. It is to be noted that the LTBT does not per say bans any tests, but does prohibit tests which could create debris outside the territorial limits of the responsible State. Verification of compliance to the LTBT is a point of concern. Towards this the Soviet Union has proposed to bring a system to extent the control to all environment to put a check on the suspicious and clandestine operations carried out by the United States during the cold war. But the US vehemently opposed the implementation of this comprehensive test ban treaty to be brought as an amendment.[87]

As discussed *supra,* MTCR aims at controlling the movement of technology and goods amongst the

[85] *Limited Test Ban Treaty (LTBT)*, US DEP. STATE, //2009-2017.state.gov/t/avc/trty/199116.htm (last visited May 9, 2022).
[86] *Id.*
[87] *Limited Test Ban Treaty (LTBT) | Arms Control Association*, https://www.armscontrol.org/treaties/limited-test-ban-treaty (last visited May 9, 2022).

main suppliers or holders of the technology that could help in the development of weapons of mass destruction. The list includes the space launch vehicle and sounding rockets. Decided on a consensus, the MTCR partners regularly update the list of items being controlled. It is to be noted that the MTCR does not provide any transparency in the activities being undertaken by a member state as the states are free to decide on the transfer and export control mechanisms.

As we discussed earlier, the Wassenaar Agreement is a export transparency control mechanism in which the transfer or denial of listed items must be notified by the State. Some of the satellite and launch vehicle related space technologies are listed as dual use items and are thus listed sensitive. The measures are adopted according the national jurisdiction and the state policy. Though there exist several mechanism for the space security control, there are also certain gaps which makes the settings not conducive for a civil space cooperation. Since there are gaps which could be channelised to enjoy an un-authorised transfer of sensitive technology, the States are unwilling to engage in international ventures aimed at civil space cooperation. The lacunas needs to be strengthened to encourage the states to enter into international cooperation resulting in global civil space cooperation. This was quite evident from the recent ASAT tests from China and Russia creating huge lot of debris. There does not exist any international control mechanism to prevent the launch or development of space based weapon systems as we do not have any international regulatory mechanism with an independent verification mechanism. Even when the OST prevents the militarisation of the space, States are actively engaged in using satellites to increase and improve the military strength of the nations. While there exists legal limitations to the deployment of weapons in the outer space, a clear definition of such deployment is still absent. This lack of clarity in the definition of weapons could lead to disputes among the international community when one tries to engage in weaponization.

As evident from the previous discussions, it is clear that the current technology and trade control regimes are not amenable for encouragement of global technology sharing, joint development, exchange or transfer. This is because of the fact that these regimes are fundamentally defined on the national control regimes and aims at protecting the national security interests of individual States. In addition, an absence of an international organisation to regulate the movement of technology or goods across the border protecting the interest of the States as well as maintaining a collective action to maintain international peace and security bolsters the reluctance among the key players to delve in such cooperative efforts. Rooted in the traditional model of a public funded state space activity, the current international trade control regimes need a revitalisation and redesign to encourage active international space cooperation.

CHAPTER 7

CONCLUSION

Formidable advances in the space technology has been seen over the past six decades and it has touched every aspect of the human life. Though most people attach the success of the space science and exploration to deep space missions and interplanetary achievements, the technology has been utilized mainly to fill the technical gaps in the society and fulfill the needs of the people on the ground. Building a national space science foundation has been one of the driving factors for the nations to engage in the space technology investments. The other major factors being addressing the national needs of the country on a broader scale and to share tables among the technically advanced peers.

Space opened up limitless avenues in front of the man due to his relentless quest to decipher the unknown. But the diverse use of the space has posed significant amount of challenge to the global community. Though the space program is envisaged to be applied in the civil and peaceful development, nations with the space faring capability have aimed to deploy satellites with dual use capability. The resolution of the imaging system is so powerful, that even face detection is possible in the present days which have been exercised by the Ukrainians in identifying war criminals from Russia.[88]

Ever since the space exploration has begun with the launch of Sputnik 1, the international community is predominantly concerned to keep the outer space free of military activities in the same way as that Antarctica has been kept under the Antarctic Treaty of 1959, which unambiguously mandates that Antarctica should be used only for peaceful purposes.

The resentment towards the space powers and the third world countries or in fact the developing nations has been because of the increasing mutual distrust and the struggle for global hegemony by the former borne out by the ever-growing technical gaps which exists between the haves and the have-nots. When the Sputnik rose to the space, the developing nations expected that achievement would fillip to man's technological prowess and open up new vistas to improve the quality of life. But the expectation were soon doomed, when the President Reagan announced the Star Wars programme, as a pure defensive mechanism to strengthen and extend deterrence to the outer space.[89]

The USA and the erstwhile USSR, the leaders of the exploration of space, considered the space

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[88] Pittsburgh Post-Gazette Editorial Board, *Opinion: Tech Allows Ukraine to Identify War Criminals*, YAKIMA HER.-REPUB., https://www.yakimaherald.com/opinion/opinion-tech-allows-ukraine-to-identify-war-criminals/article_504b6562-d8c2-5875-bd3b-2a3aaee5067b.html (last visited May 10, 2022).

[89] S BHATT MANI VS & V BALA REDDY, RECENT TRENDS IN INTERNATIONAL SPACE AND LAW AND POLICY 527 (Asia Law House Hyderabad 2d ed. 2016).

technology as an evidence of national power, efficacy of national government systems and scientific prowess. It also needs to noted that the space technology was initiated with a military support like the nuclear energy. This was form of arrangement was carried out by the US, Russia, China, France, Britiana and Canada. From the very inception of the Space Age, the leading space powers the USA and the USSR, began to maintain consistent and diligently applied national policies to contain the international transfer of critical space technologies. The objective of these policies was to discourage the proliferation of missile capabilities and, in the case of the USA, to retain its lead and dominance in the commercial space applications and launch services. The European Space Agency, a consortium of 11 major European nations which sought to promote competitive independence from the US in advanced technologies, emerged as a major competitor to the US in the satellite and launch services market in the 1980s with the establishment of the Arianespace. With Japan, China and India set started entering this market, the civilian space sector became a highly competitive and polycentric complex of commercial, political and industrial interests. It was at this moment, that the growing space technology capability of the third world countries became a concern to the 'key suppliers' of the technology.[90]

The establishment of restrictive oligopolistic regime like the Missile Technology Control Regime has been a outcome of the realisation of the breathtaking potential of the nuclear energy and the rising national interests in the development of advanced and complex technologies like the space technology. Many nations outside the nuclear weapon states, i.e. US, Russia, United Kingdom, France and China, found the prospects of nuclear energy and found it possible to benefit them. The access to the nuclear energy by these developing nations made the nuclear-weapon states suspicious about their activities. Indeed, even the Chinese elevation to a nuclear possessor in 1964 raised concerns in the original nuclear club. They suspected a horizontal proliferation of the nuclear weapon, which lead to the establishment of the International Atomic Energy Agency in 1958 and Non-Proliferation of Nuclear Weapons (NPT) in 1968. In a further attempt to crack down the proliferation of the nuclear weapon delivery systems, the MTCR came into existence in 1987, christened as the "Agreement on Guidelines for the Transfer of Equipment and Technology Related to Missiles". [91]

However the key conceptual building blocks which permeates the current system of space technology control regime is that the trade and proliferation control should originate at a national level giving priority towards the national security concerns. This is augmented because of the absence of a

[90] *Id.* at 536.
[91] *Id.* at 555.

supranational legal entity to control and implement the space technology trade and proliferation.

The present research work was aimed at identifying the role of space technology in national development and how the nations cooperate to share the technological benefits through various international cooperative mechanisms. The chapters were focused on identifying the intricacies posed by the trade regulations when one nation tries to extent its technology across the border. In wake of this objective, four major research questions were identified to throw light on the area of research.

7.1. Key takeaways

7.1.1. *Space has immensely contributed to the national development and there exists a strong need for international cooperation*

The first and the foremost question addressed in this study is to establish the need for international cooperation in outer space. The role of space technology needs to be properly defined to address the question of the need for international cooperation in outer space. Accordingly, the role of space technology in national development especially in the case of developing countries was addressed in detail in the second chapter of this thesis. A closer look at the pertinent issues of today like the issues related to global warming, desertification, global pollution, loss of rain forests, digital divide, lack of land resource management in less developed countries etc turns us to Space technology as a promising candidate to offer better solutions. Nations turn to investments in space to reap better prospects in the economic progress according to the neoclassical economists. Such trends are seen among the developing nations, as it is quite evident when we note that today we have more than 82 countries who owns at least one satellite in the orbit. International prestige and dominance are also considerations when one nation invests in these types of high technology investments. Gist of methods by which space technology is applied in different domains of the society as well as to meet various needs of a nations indicates the growing dependence on this high technology regime. Application range from the military support to agricultural sector, health, resource management, sustainable development, wild life and biodiversity protection, disaster management etc. The role of space technology in achieving the 17 sustainable development goals put forward by the United Nation is also analysed in detail. Over the years, space technologies have been part of the economy builder as it was providing key pillars in the socio economic and military strengths of a space faring nation.

The need for international cooperation in space technology is further enumerated in the third chapter where the economic trends are brought in to have a broader picture of the current regime. The chapter dealt in detail about the evolution of a space economy and further evaluated the current trends in the space business. The need for cooperation considering the recent trends were analysed and it is found that sharing of resources and establishment of standardization practices can ensure strategic use of redundancy through interoperability. Also, nations cooperate in space to achieve certain specific targets and lack of budgetary positions tops as one of the major reasons for getting into international cooperation. The other reasons being the privilege of diplomatic utility derived from the international cooperation, ensuring a political sustainability when nations enter into cooperative agreements and the need to ensure that nations are abreast with the changing technology trends. International cooperation in outer space has a greater role to provide significant benefits to all participants if it is properly managed. Monetary advantages, political and programmatic stability combined with stability of work force can also be achieved if the activities in the exploration of outer space is carried out in a harmonized way. It is made clear that space programs can use the significant competences delivered by rationalization, standardization and interoperability to effectively synchronize and share resources among the partners which could significantly improve the efficiency of systems. Cooperation in space also create a sense of sharing and dependencies among States which could obviate the reason for any conflict.

7.1.2. *Amidst all technology transfer control there exists fruitful international cooperation in the space domain*

With the stringent technology transfer controls in place, the execution of technology sharing was assumed to be meagre. Thus, as part of this research, an assessment was carried out to trace the implementation of major technology transfers and cooperative efforts in the space domain. It is found that, amidst all the technology transfer and proliferation control, the developing nations have depended on the key suppliers or the advanced technology players for the transfer of technology as well as for development of various technological elements through different channels of international cooperation. The Outer Space Treaty encourages States to undertake international cooperation in Outer Space in scientific investigations and the States should be guided by the principle of cooperation and mutual assistance in such explorations. Along with that, The 1970 Declaration on Friendly Relations recognizes international cooperation to be one of the "Basic Principles" of international law: "*States have a duty to co-operate with one another irrespective of the differences in their political, economic and social systems in the various spheres of international relations, in order to maintain international peace and security and to promote international economic stability and progress, the general welfare of nations* *and international co-operation free from discrimination based on such differences*". [92]

Developing nations understood the requirement of international cooperation and they have strived to enter into bilateral or multilateral agreements to take the cooperation forward. The research throwed light on the international cooperation efforts from the major space faring nations viz. NASA, ESA, JAXA, ISRO, Glovkosmos etc. Along with that, the study also focused on the regional cooperation in space technology as well as the major contributions from the International committees promoting cooperation in space. It was pertinent to note that how the technical advantage of space technology helped Venezuela to share the benefits with the Latin American nations through the exchange of technology which ultimately helped these nations to improve the basic communication and education sectors.

From the inception of the space regime, the developing nations understood the potential of this technology and tried to grab the share of pie by engaging into international cooperation with the space faring nations. It has shown how international cooperation in the space domain could bring cost advantages to the participating nations. It is also brought out that cooperation in this domain will help peaceful coexistence of the nations involved in the project as well as encourages transfer of technical know-how and idea among the cooperating nations. Cooperation in international space projects helps to maintain a symbiotic relationship among the participating nations and enables a capacity building in competence as it takes into account the ideas and technical resources from all the participating nations. With all these advantages in front, a close analysis of the cooperative efforts from these agencies indicate that a complete transfer of technology or its development doesn't happen in most of these cooperative efforts. The key suppliers of the technology always try to keep the technical secrets with them and only allows the end product or the outcome of the benefits only is shared with the needy.

7.1.3. *Concept of national security hinders the technology transfer process*

The role of national security dilemma in the smooth transfer of technology was one of the questions tries to be addressed in this research. In order to drive home the point and make a fruitful analysis, the technology transfer process in space domain was analyzed to determine the factors which controls this process. Through this process, the factors contributing to the successful technology transfer process was revisited. It is found that cooperation in space, which has a military dimension to it is always concluded only when the security and the intelligence requirements provides clean chit to proceed with such

[92] UN General Assembly (25th Sess.: 1970), *Declaration on Principles of International Law Concerning Friendly Relations and Cooperation among States in Accordance with the Charter of the United Nations.* (1971).

arrangements. National diplomatic prestige and political sustainability are found to be two major drivers of the technology transfer process. Subsequently, the challenges in the space technology transfer was analysed. In the export control parlance, the definition of space technology takes a different yard stick. It is not only limited to the knowledge that is transferred but also reflects any item or know-how that gets inferred when an item is transferred. This specific know how which gets associated with a system gets tagged as the technology in an export control regime. Technology associated with space is termed as dual use technology due to its applicability to civil as well as military domain applications. Since an expendable launch vehicle has the same potential to carry a war head over a border, the international community attributes the same technological category for both the launch vehicles and the missiles which are capable of carrying weapons of mass destruction. Even when there exists considerable technical difference between the launch vehicles and the satellites, the export control regime views both the technology through the same lens.

In most cases, a gentle fine tuning of the launch technology will help to meet the requirements of the military needs of a ballistic missile. This evolution of technology is creating a technical bewilderment in classifying the nature of technology into civil, commercial or military. Due to the strategic nature of the assets placed in space, the technology employed in space is inherently dual use. Hence the definition of the regulation required while transferring the technology always poses serious concerns. The definition ultimately resides in the choice of the policy and the law guarding the national and political interest of the exporting nation.

The space technology were guarded in its intial days and its was known only to the super powers. Over the years, the technology began to grow and more efforts of commercialization started taking shape. The growth of space technology and the proliferation of commerce became a threat to the assets of the super power. The addition of strength in the adversaries pocket always created apprehension among the super powers as they considered that holding similar potential could pose a threat to the assets already in place. The super powers apprehended that this asymmetric hold on to the technology would enable the new space entrants to develop counterspace weapons against space assets. To overcome these threat perception, international and domestic export control regulations were brought in place by the United States so as to put a check to what is being shared outside the sovereign national boundaries. Many counties adopted this strategy, ultimately resulting in a dilemma restricting the movement of technology across the border. In the absence of a supra national space technology control regime, States started imposing unilateral trade control regimes, defined mostly at the national level, giving utmost importance to the national security perspective. The concerns about the un-authorized technology transfers in the absence of an international regulatory mechanism restricts the international civil and commercial space cooperation endeavours in the wake of a dilemma created around the national security interests.

7.1.4. *Export control regulations restrict the civil space cooperation to a greater extent.*

The concept of national security is complemented with a strategic consideration to maximise the export regulations. This strategic concept rules the voluntary agreements put in place to control the international system of space technology export mechanisms. Each State has got the jurisdiction to define the international law applicable to the production and trade of the space technology. The United States, being a leader of the space technology has imposed strict export control regulations and keeps pressure on its allies to follow the same stand in the export controls. The necessity of this strict export control stems from the fact that there does not exist an internationally harmonised export control mechanism. This absence has resulted in the States defining export controls which are not internationally harmonised nor transnational compliant. The current national centric paradigm does not provide an effective export control.

Missile Technology Control Regime is an informal political understanding which looks forward to limit the proliferation of missiles and missile technology. Missile Technology Control Regime (MTCR) aims at controlling the movement of technology and goods amongst the main suppliers or holders of the technology that could help in the development of weapons of mass destruction. The list includes the space launch vehicle and sounding rockets. The US established a national level control system for munition and arms control Arms Export Control Act and the Export Administration Act. The AECA established a regulatory regime names International Traffic in Arms Regulation (ITAR) and EAA establishes a regulatory regime named Export Administration Regulations (EAR). ITAR exerts control on goods, services and technologies categorized as munitions, while EAR control the export of goods, services and technologies categorised as commercial dual use. The Europe follows a simpler mechanism wherein it is based on the classification of item as either conventional armament or dual-use goods. Another mechanism existing in place is the Wassenaar arrangement which looks for ensuring transparent transfer of items and ensures that such items do not contribute to the enhancement of military capabilities which undermine such peaceful efforts. The arrangement is applicable to conventional arms and dual use items and the items listed under “List of Dual-Use Goods and Technologies and in its Munitions List” under the scope of Wassenaar Arrangement.

Though there exist several mechanisms for the space security control, there are also certain gaps which makes the settings not so conducive for a civil space cooperation. The multiple control were initially brought to prevent the growth of the developing nations and the space powers ensured to see that the developing nations does not get hold of the advanced technology. The Indo-Russian cryogenic engine transfer and its further ramifications with the involvement of US is an exemplary example towards this argument. Even when it was very clear that the Cryogenic engines are seldom used in the ballistic missile technology, the MTCR provisions were invoked to ensure that the Soveit Union does not transfer the technology to India. The US ultimately imposed sanctions on both nations, and prevented the progress of the nation in achieving self reliance in the technology. States are unwilling to engage in international ventures aimed at civil space cooperation fearing gaps in the control regimes which could foster transfer of technology to wrong hands. The lacunas needs to be strengthened to encourage the states to enter into international cooperation resulting in global civil space cooperation.

7.2. The way forward

Dr. Vikram A Sarbhai in his address to the First Un Conference on the Exploration and Peaceful Use of Outer Space said:

> "*Restrictions on the transfer of technology which are involved in the peaceful use of the outer space merely jeopardize the security of the world through retarding the progress of the nation*".

He continued to tell that against the raising technological iron curtain by the then super powers, when he told

> *".. it is important to note a fundamental aspect of human development that knowledge cannot for long be contained within the artificial boundaries and one has to learn to share and to control rather than control harmful effects through withholding transfer of technology or knowledge".*[93]

From this study, we note that the States prioritize national security interest over the cooperative arrangement, which has resulted in forcing in of a unilateral mechanism to control trade which ultimately has resulted in retarding the collective effort of the human in the peaceful exploration of space. This fractured system is acting as a hindrance to the international civil space cooperation and the blooming commercial space ventures. It only helps to increase the gap between the haves and the have-nots. Due to the absence of a centralised international organisation, the interest of global community is not

[93] MANI VS & V BALA REDDY, *supra* note 89, at 549.

represented, nor the requirements of the broader international community is addressed in the space activities.

To sum up, the States need to engage in dialogues and bring in new approached towards space technology trade and proliferation strategies aimed at improving the global civil space cooperation.

Due to the inherent gaps in the current methods of technology transfer, the States hesitate to share technology as they fear that technology could reach wrong hands and one day it could be applied against the true holder of the technology. The need for World Space Organisation which has got the jurisdiction to overview the activities of the State is a must for ensuring a global civil space cooperation. It could act as an umbrella organisation through which the civil space cooperation efforts could be coordinated. A global space technology proliferation regime could be defined with a complementary outer space disarmament agreement. Such a world space organisation could monitor the Member States programmes in space technology development and production.

The space can provide limitless opportunities once the humanity decides to move hand in hand.

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