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# DEVELOPMENT OF PAKISTAN'S SPACE PROGRAM

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# DEVELOPMENT OF PAKISTAN'S SPACE PROGRAM

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# Abstract

With space applications and activities growing at an unprecedented pace in recent times, Space has emerged as a critical element of national power. Space applications in science and technology have proven their usefulness in making vital contributions to the socioeconomic development and national security of states. Realizing its importance in national development and security, states around the world are investing heavily in their national space programs for civil, commercial, security and scientific purposes.

Pakistan commenced its space program in 1961, and the Space & Upper Atmosphere Research Commission (SUPARCO) was entrusted with the responsibility of overseeing the development of Pakistan's space program. Since then, SUPARCO has remained involved in various space activities, including the design, development, and launch of multipurpose satellites, satellite data applications, and establishment of required ground infrastructure.

However, despite venturing into space in the early 60s, Pakistan has not been able to showcase any worthwhile progress in the sector. The reasons for this below par performance are many. Space has not been given its due importance by successive governments. This has resulted in failure to formulate domestic space laws, a modern space regulatory framework, and a National Space Policy to control and monitor national space-related activities.

This paper analyzes Pakistan's existing space capabilities, highlights its international obligations in outer space, provides a broad outline for a National Space Policy framework, and recommends a way forward. The objective here is to identify existing gaps in national space outlook and suggest policy guidelines as well as the most significant measures that could facilitate the realization of a viable, sustainable and effective space program – fulfilling the national socioeconomic, scientific, and security requirements.

# INTRODUCTION

# Introduction

Ever since the launch of the first satellite, space has emerged as a critical resource for developed nations. Tenacious competition between the United States (US) and the Soviet Union during the Cold War primarily set the pace of space development.[1] This era witnessed rapid evolution of technological advancements in all facets of space technology, i.e., launch vehicles, spacecraft, artificial satellites, manned / unmanned space flights, robotic exploration missions, telemetry & tele-command systems, sensing instruments, propulsion, microwave systems, and computational power etc.

Integrated employment of these diverse technologies, coupled with human imagination, has enabled development of space-based systems that have revolutionized the spectrum and outlook of human civilization.

*Until now, more than 8,000 satellites have been launched for various purposes. Today almost 4,994 satellites of many space-faring nations are orbiting the Earth.[2] These artificial satellites are continuously providing important services impacting every aspect of human life.*

Tele-communication satellites have revolutionized the field of communication by facilitating instantaneous transfer of voice, data and images globally.[3] The meteorological satellites provide timely information about the weather, storms, ocean currents, environmental parameters as well as other related phenomena.[4] Remote sensing satellites gather data which help in improving the management of Earth's resources, precision agriculture, understanding climate change and disaster management.[5]

Navigation satellites provide precision navigation, positioning and timing information that has become essential in many diverse applications.[6]

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[1] "The Space Race," History.com, February 22, 2010, https://www.history.com/topics/cold-war/space-race.
[2] Jim Baumann, "Mineral Exploration from Space," Esri (blog), December 11, 2019, https://www.esri.com/about/newsroom/arcwatch/mineral-exploration-in-the-hyperspectral-zone/.
[3] Virgil Labrador, "Satellite Communication," Encyclopedia Britannica, Accessed November 23, 2019, https://www.britannica.com/technology/satellite-communication.
[4] Richard H. Waring and Steven W. Running, "Spatial Scaling Methods for Landscape and Regional Ecosystem Analysis," in Forest Ecosystems (San Diego: Academic Press, 2007), Third Edition, 225-V, https://doi.org/10.1016/B978-012370605-8.50014-1.
[5] Justin Sheffield et al., "Satellite Remote Sensing for Water Resources Management: Potential for Supporting Sustainable Development in Data-Poor Regions," Water Resources Research 54, no. 12 (December 2018): 9724–58, https://doi.org/10.1029/2017WR022437.
[6] Scott Madry, "Global Navigation Satellite Systems and their Applications," Springer Briefs in Space Development (New York, NY: Springer, 2015), https://doi.org/10.1007/978-1-4939-2608-4.

*Military satellites provide vital security-related data which helps national and military leadership to take prudent and timely decisions related to national security, military operations, border control and homeland security. In today's world, access to space technology and its mastery is seen as a nation's contemporary and future war potential.*[7]

Space activities since the end of World War II predominantly remained under government control and served as indicators of national prestige and power, enhanced national security and military strength. However, due to the growing benefits of space technologies in the civil domain, most governments are investing heavily in their national space programs for civil, commercial, and scientific purposes, which has resulted in an unprecedented increase in space activities.[8]

This increase in international space activities and the inherent dual application of space technology for civilian as well as military proposes, underscored the need for international treaties and legal frameworks to regulate activities in space and to deal with issues like arms control, exploration, liability safety, rescue of astronauts and settlement of disputes among nations.[9] Consequently, several treaties as well as sets of principles were signed. Along with these treaties, the UN Office for Outer Space Affairs (UNOOSA) works to develop and enhance cooperation among countries for space exploration and employment of space technology for peaceful uses to promote sustainable social and economic development. It also helps United Nations (UN) member states to formulate their regulatory and legal frameworks to govern space activities and enhance capacity to use space technology.[10]

Space laws, policies and legislation are not only required at the international level, but due the growing scope of space technology and the increasing role of non-governmental commercial entities, they have become essential to control and regulate space activities at the national level also.[11]

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[7] Keith Kruse et al., "US Space Management and Organization: Evaluating Organizational Options," Accessed February 8, 2021, https://fas.org/spp/eprint/article04/article04.html.
[8] "A Brief History of Space Exploration," Aerospace Corporation, Accessed February 8, 2021, https://aerospace.org/article/brief-history-space-exploration.
[9] Yun Zhao, "Space Commercialization and the Development of Space Law," Oxford Research Encyclopedia of Planetary Science, July 30, 2018, https://doi.org/10.1093/acrefore/9780190647926.013.42.
[10] UN-SPIDER Knowledge Portal, "About UNOOSA," Accessed February 8, 2021, https://www.un-spider.org/about/about-unoosa.
[11] United Nations Office for Outer Space Affairs, "United Nations Treaties on Outer Space: Actions at the National Level," United Nations/Republic of Korea Workshop on Space Law, ST/SPACE/22 (Vienna: Vienna International Centre, March 2004), http://www.unoosa.org/pdf/publications/st_space_22E.pdf.

*Almost all space-faring nations have enacted laws, acts, legal frameworks and policies suiting their specific national requirements and ambitions. These policies lay down the vision, principles and the objectives of a country's space program, besides outlining the basis of developing national space laws. Further, these instruments provide policy guidelines to the national, civil and military leadership in the space domain; as well as conduct of commercial and R&D activities.*[12]

Unlike many space-faring nations, Pakistan has not exploited the full potential of space-related technologies and services for its socioeconomic growth as well as military needs. Despite an early start, Pakistan's progress in space has been slow due to numerous reasons.

This paper analyzes Pakistan's existing space capabilities, highlights its international obligations in outer space, provides a broad outline for a National Space Policy framework, and recommends a way forward. The objective here is to identify existing gaps in national space outlook and suggest policy guidelines as well as the most significant measures that could facilitate the realization of a viable, sustainable, and effective space program – fulfilling the national socioeconomic, scientific, and security requirements.

[12] UNOOSA, "Space Law: National Space Law Database," United Nations Office for Outer Space Affairs, Accessed June 20, 2020, https://www.unoosa.org/oosa/en/ourwork/spacelaw/nationalspacelaw/index.html.

# APPLICATIONS OF SPACE TECHNOLOGY

## Applications of Space Technology

In today's world, space technology has attained a significant critical mass, whereby, major paradigm shifts in terms of capabilities is inevitable. Novel discoveries will continue to open new avenues and take mankind to unprecedented horizons in conceptual, theoretical, and physical domains. It is quite likely that by the next century, there may be an inter-planetary village, at least in terms of access to the moon and nearby planets.

With the passage of time, there have also been more civil applications of space technology than military usage. In fact, the focus now is more towards development of dual use space technologies, and these technologies are playing a central role in every facet of human activities. Applications of space technology can be divided in two major categories:

1. Civil / Commercial
2. Military

These are discussed in the following sections, including a review of Pakistan's space footprint in each in comparison with India to identify existing capabilities and gaps in order to pinpoint various areas for improvement.

## Civil / Commercial Applications

Progress in space technology has proven to be highly worthwhile, especially in the civil and commercial domains. The full range of space activities that are adding value to human life are growing at a rapid pace, and can be grouped into four categories:

1. **Communication** (telephony, TV/Radio broadcast, mobile technology, broadband, tele-medicine and education, transport),
2. **Meteorology** (weather forecasting),
3. **Navigation** (civil navigation, commercial/personal travel), and
4. **Earth Observation** (agriculture, geology, urban planning, natural resources exploration, and disaster management).

## Satellite Communication (SATCOM)

Satellites act as relays to communicate across the globe without line-of-sight limitations experienced with conventional wireless links. A joint network of Geosynchronous Equatorial Orbit (GEO), Low Earth Orbit (LEO), and inter-satellite

links enables satellites to provide reliable, continuous, and robust communication across the globe. Communication satellites have become the backbone for telephony to facilitate long haul and mobile communication. SATCOM also enables worldwide subscription of satellite radio, and television broadcasting, including Direct To Home (DTH) services and live telecast of news and entertainment events, such as sports. In coming days, satellite internet will play a key role in high-capacity throughput and Internet of Things (IoT) concepts. Due to all these applications, SATCOM is a major source of revenue generation at the global level.

*India has about 28 communication satellites[13] and is earning huge revenue through them in South Asia, Far East, and parts of Africa. In comparison, Pakistan has only two communication satellites[14] whose bandwidth utilization is not enough to generate significant revenues. It is imperative for Pakistan to devise a strategy to effectively market and commercialize its SATCOM services for revenue generation.*

## Satellite Meteorology

Nowadays, weather and environmental monitoring is conducted through GEO and LEO satellites. These satellites perform weather forecasting along with tracking of storms and hurricanes. In fact, modern satellites see much more than just cloud systems. Other environmental parameters, such as effects of pollution, sand & dust storms, temperatures and ocean currents are also monitored through weather satellites.[15]

*It is a matter of concern that Pakistan does not own meteorological satellites and is dependent upon foreign satellites' data for weather monitoring and forecasting. In comparison, India has developed and operates, at least, two dedicated meteorological satellites.[16]*

## Satellite Navigation

Satellite navigation provides absolute location, navigation, and timing as well as synchronization functions.[17] These services have numerous applications in travel, astronomy, fleet management, geo-tagging, cellular telephony, and robotics.

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[13] ISRO, "Communication Satellites," Department of Space, Indian Space Research Organisation, Accessed May 5, 2020, https://www.isro.gov.in/spacecraft/communication-satellites.
[14] SUPARCO, "Communication Satellite," Space & Upper Atmosphere Research Commission, Accessed May 5, 2020, http://www.suparco.gov.pk/pages/comm-satellite.asp?commlinksid=2.
[15] Martin Medina, "How Things Work: Environmental Satellites," Our World, November 8, 2010, https://ourworld.unu.edu/en/how-things-work-environmental-satellites.
[16] ISRO, "Meteorology," Department of Space, Indian Space Research Organisation, https://www.isro.gov.in/applications/meteorology.
[17] ESA, "How Satellite Navigation Works," The European Space Agency, Accessed July 2, 2020, https://www.esa.int/Applications/Navigation/How_satellite_navigation_works.

*In this domain also, Pakistan is dependent on foreign satellites for fulfilling its needs.[18] In comparison, India has established its own navigation constellation called NavIC; besides operationalization of a Space-Based Augmentation System called GAGAN.[19]*

## Remote Sensing Satellites

Earth observations conducted through Remote Sensing (RS) satellites are extremely helpful in boosting the socioeconomic conditions of any country. These satellites provide high-resolution images that are of tremendous significance in diverse fields such as land monitoring and mapping. Information about land surface, structure and composition could be vital for urban planning and development. In precision agriculture and farming, satellites are employed to monitor crop conditions, soil properties, irrigation, and as a tool to predict crop yields. Satellites also facilitate sustainable management of forest resources that are important for balancing the Earth's ecosystem.[20]

*India possesses a large fleet of Remote Sensing Satellites (operating in optical, SAR, multi-spectral, and hyper-spectral domains). These satellites are playing a significant role in various socioeconomic sectors of the Indian economy.[21] In comparison, Pakistan possesses only two Remote Sensing Satellites (one of which is experimental).[22] Utilization of imagery data from these satellites in Pakistan is minimal and needs to be enhanced.*

## Sustainable Development

Sustainable development encompasses economic, social, and environmental development and is undertaken without wasteful depletion of natural resources. Realizing the importance of 'Sustainable Development', the UN has chalked out an agenda for 2030 and identified 17 Sustainable Development Goals (SDGs) to address the challenges that confront human development globally.[23] These goals are often referred to as a global call to end poverty, protect the environment, and

[18] Sabena Siddiqui, "Pakistan Benefits from China's Sat-Nav System," China.org.cn, May 23, 2017, http://www.china.org.cn/business/2017-05/23/content_40873203.htm.
[19] ISRO, "Satellite Navigation," Department of Space, Indian Space Research Organisation, Accessed May 5, 2020, https://www.isro.gov.in/spacecraft/satellite-navigation.
[20] S.Unninayar and L.M.Olsen, "Monitoring, Observations, and Remote Sensing – Global Dimensions," Reference Model in Earth Systems and Environmental Sciences (2015), https://doi.org/10.1016/B978-0-12-409548-9.09572-5.
[21] ISRO, "Earth Observation Satellites," Department of Space, Indian Space Research Organisation, Accessed July 2, 2020, https://www.isro.gov.in/spacecraft/earth-observation-satellites.
[22] SUPARCO, "Pakistan Remote Sensing Satellite (PRSS-1)," Space & Upper Atmosphere Research Commission, Accessed May 5, 2020, http://www.suparco.gov.pk/pages/rsss.asp?rssslinksid=2.
[23] UN, "The 17 Goals - Sustainable Development," United Nations, Accessed May 5, 2020, https://sdgs.un.org/goals.

ensure all people enjoy peace and security.

*Space applications can play a key role in natural resource management, hydrology, and human settlements.*

Space-derived data and its analysis can provide policymakers reliable and accurate information to determine trends, evaluate needs, develop programs and formulate policies.[24] Pakistan, a developing country faced with multiple problems and struggling to improve its performance in various areas related to SDGs, must make use of available space technology and its applications to achieve its desired national objectives. At present, employment of space technologies in strategic decision-making, planning and execution in various social sector domains of Pakistan is minimal.

## Health Sector

Space-related technology applications hold enormous potential for the health sector. Worldwide, space technology is being used for studying disease epidemiology, disease patterns and providing telemedicine to inaccessible areas. It is also being used to identify environmental triggers for the spread of disease in the regions that require attention. Spin-offs and services provided by space technologies are emerging as important tools in the fight against the prevailing pandemic, COVID-19. These technologies have not only enabled mankind to effectively monitor, but also control the outbreak of infectious diseases.

*Pakistan, faced with a number of healthcare issues, especially the spread of COVID-19 and other vector-borne diseases, needs to utilize space technology for overcoming these issues.*

## Disaster Management

Pakistan is a disaster-prone country. It has a long history of earthquakes, floods, droughts, landslides, and other natural calamities. The 'Fiscal Disaster Risk Assessment' (FDRA) of 2015, highlighted that on average, approximately three million people are affected by natural calamities every year and the fiscal impact on the national economy is 3-4 per cent of the annual budget.[25] At the global and regional level, space-based disaster alert and management systems are employed

[24] UNOOSA, "Benefits of Space: Sustainable Development," United Nations Office for Outer Space Affairs, Accessed May 5, 2020, https://www.unoosa.org/oosa/en/benefits-of-space/sustainable-development.html.
[25] World Bank, "Fiscal Disaster Risk Assessment Options for Consideration: Pakistan," (Washington, D.C: The World Bank., March 2015), http://documents1.worldbank.org/curated/en/829791468070733917/pdf/944740WP0P13260ter0Risk0Assessment.pdf.

for timely warning of emerging disasters as well as monitoring and management functions. In Pakistan's case, there is a dire need to integrate space technology into Disaster Risk Reduction (DRR) strategies for early warning, improving response, damage assessment, reconstruction, and rehabilitation.

## Resource Management

Space capabilities can also be used as a catalyst in the economic development of Pakistan. As the country's economy is agrarian, therefore, it can be negatively affected by poor water management, climate change, and extreme weather conditions.

*A water-stressed country, like Pakistan, can manage its limited water resources by using space technology. Moreover, earth observation satellites can forecast extreme weather conditions.*

Resultantly, timely warnings can be issued that would result in lesser damage. Similarly, well analyzed space-based data can assist landowners and policymakers to predict and forecast agricultural outputs more accurately and farmers can enhance their yield and reduce losses. This data can also be used to understand climate change and its effects on agriculture. Furthermore, space capability can also play a vital role in mineral exploration, urban planning, food security, and land management.

## Economy

The last few decades have witnessed the commercial aerospace industry flourish at an unprecedented pace, mainly because of gradual loosening of military control over the space domain. Consequently, the dual-use space-related technologies, which were initially dominated by the military and controlled by governments, have become preponderant in all aspects of human activities with a greater impact on the economy.

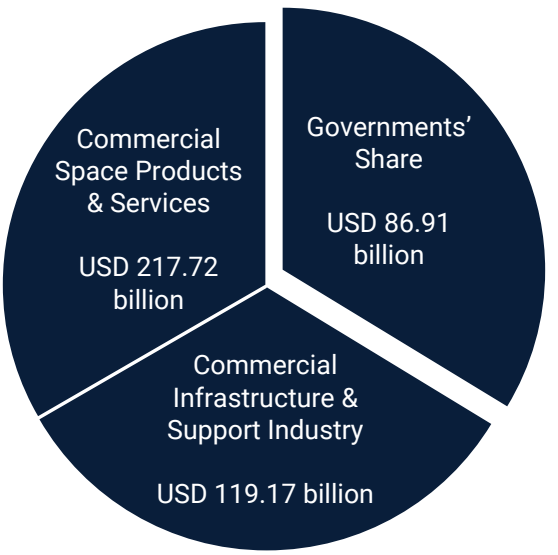
*In the modern era, space technologies like remote sensing (including weather), navigation, and communication have become the main drivers of economic growth worldwide.*[26]

More public as well as private entities are investing in space programs. This is evident from the fact that the number of countries venturing into space increased

[26] OECD, "The Space Economy in Figures: How Space Contributes to the Global Economy," Organisation for Economic Co-operation and Development, Accessed October 5, 2020, https://www.oecd.org/innovation/the-space-economy-in-figures-c5996201-en.htm.

from 50 in 2008 to 80 in 2018.[27] Similarly, the world has witnessed a rapid increase in the launch of small satellites - 900 launches from 2014 to 2018. According to the Union of Concerned Scientists database, currently, around 2,666 satellites with distinct roles are operational in outer space,[28] and the number of global commercial satellites also jumped from 170 in 2018 to 251 in 2019, registering an increase of 48 per cent in a single year.[29] This increase in activities by both government and the commercial sector contributed USD 423.8 billion in 2019 to the global space economy (an increase of more than USD 9 billion over the previous year), with the breakdown as given in Figure 1:

Figure 1: Public and Commercial Sector Breakdown of Space Economy




Source: Doug Messier, "Global Space Economy Grows in 2019 to $423.8 Billion, The Space Report 2020 Q2 Analysis Shows," Parabolic Arc, August 1, 2020, http://www.parabolicarc.com/2020/08/01/global-space-economy-grows-in-2019-to-423-8-billion-the-space-report-2020-q2-analysis-shows/.

This multi-billion dollar economy created more than one million employment opportunities worldwide. According to a report by the Morgan Stanley Institute, at the current pace, the global space economy will grow by USD 1.1 trillion by

[27] Morgan Stanley, "Space: Investing in the Final Frontier," Accessed October 5, 2020, https://www.morganstanley.com/ideas/investing-in-space.
[28] UCS, "Satellite Database," Union of Concerned Scientists, Accessed October 5, 2020, https://www.ucsusa.org/resources/satellite-database.
[29] Doug Messier, "Global Space Economy Grows in 2019 to $423.8 Billion, The Space Report 2020 Q2 Analysis Shows," Parabolic Arc, August 1, 2020, http://www.parabolicarc.com/2020/08/01/global-space-economy-grows-in-2019-to-423-8-billion-the-space-report-2020-q2-analysis-shows/.

2040.[30] Another report projects global space market growth up to USD 2.7 trillion within the same timeframe.[31] The major portion of this revenue is coming from the telecommunications sector. With the increase in demand for fixed and mobile data sharing services for broadband, television and radio broadcasting, Internet of Things (IoT), live video streaming, autonomous vehicles, virtual reality, and 5G technologies, satellite broadband is expected to generate more than 50 per cent of total space revenue by 2040.[32]

Surge in demand of data services and increasing activities in the space sector have made this industry more competitive, resulting in cost reduction in every segment. With the introduction of reusable rockets, the cost of launching a satellite is expected to come down to USD 60 million from USD 200 million, and is likely to drop to as low as USD 5 million. Similarly, with mass production, the cost of a satellite could decrease from USD 500 million to USD 500,000. This increase in space activities at economical cost is creating lucrative investment opportunities for the public as well as private sectors.[33]

For exploiting its full potential, most governments are not only investing heavily, but also facilitating private actors to participate, which is bolstering Public-Private Partnerships (PPPs). The US tops the list of countries investing the most in the space sector (see Table 1):

Table 1: Country-wise Expenditure in Space Sector (2017)

| Country | Expenditure (USD Billion) |
|---|---|
| USA | 41 |
| China | 5.83 |
| Russia | 4.17 |
| France | 3.06 |
| India | 1.45 |
| Pakistan | 36 million (FY 2019-20) |

Source: OECD, "The Space Economy in Figures: How Space Contributes to the Global Economy," Organisation for Economic Co-operation and Development, July 5, 2019, https://www.oecd.org/innovation/the-space-economy-in-figures-c5996201-en.htm.

[30] Morgan Stanley, "Space: Investing in the Final Frontier," July 24, 2020, https://www.morganstanley.com/ideas/investing-in-space.
[31] Michael Sheetz, "The Space Industry Will Be Worth Nearly $3 Trillion in 30 Years, Bank of America Predicts," CNBC, October 31, 2017, https://www.cnbc.com/2017/10/31/the-space-industry-will-be-worth-nearly-3-trillion-in-30-years-bank-of-america-predicts.html.
[32] Morgan Stanley, "Space: Investing in the Final Frontier."
[33] Morgan Stanley, "Space: Investing in the Final Frontier."

Countries identified in Table 1 are also helping the private sector in space by using commercial data for government-sponsored projects and making policies to incentivize private entities, as well as catering to human resource needs. This has resulted in the gradual expansion of investment by private entities in the space sector. In China, for instance, the introduction of new policies to boost commercialization of the space sector, has resulted in initiation of around 100 ventures by private entities, since 2015.[34]

Considering the potential offered by the booming global space economy, 14 global technology giants like Microsoft, Tesla, Google, Virgin Group, and Amazon have made considerable investments. These private companies are not only providing data, satellite launch support, and resource mining services to governments, they have also ventured into human space flights, and exclusive space ventures like SpaceX, Virgin Galactica, and Blue Origin.[35]

The most prominent amongst these is Elon Musk's SpaceX, and more recently Jeff Bezos' Blue Origin. In 2020, SpaceX successfully transported two astronauts to the International Space Station in collaboration with NASA - a major milestone in the commercial space age, and set a precedent for the future of PPPs in space. It successfully used the first-ever reusable orbital-class rocket Falcon-9, and after this mission, the value of SpaceX climbed to USD 26 billion.[36] In July 2021, Bezos made a short journey into space, in the first crewed flight of his rocket ship, New Shepard.[37]

In Pakistan, the utilization of space technologies for commercial purposes is negligible, and the participation of the private sector non-existent. The demands for space-based services far exceed what Pakistan's present space setup can provide. The budget allocation of USD36 million for FY 2019-20 is too meager to ensure successful implementation of the national space program and to meet the growing demands for downstream services.[38] This is primarily due to the absence of government policies on the use of space technologies for economic growth, for attracting private investment, and a viable organizational space setup geared towards meeting the growing demands of this sector.

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[34] OECD, "The Space Economy in Figures: How Space Contributes to the Global Economy," Organisation for Economic Co-operation and Development, July 5, 2019, https://www.oecd.org/innovation/the-space-economy-in-figures-c5996201-en.htm.
[35] OECD, "The Space Economy in Figures: How Space Contributes to the Global Economy."
[36] Trefis Team, "Revisiting SpaceX's $36-Billion Valuation After Its First Manned Mission," Forbes, June 2, 2020, https://www.forbes.com/sites/greatspeculations/2020/06/02/revisiting-spacexs-36-billion-valuation-after-its-first-manned-mission/.
[37] Paul Rincon, "Jeff Bezos launches to Space Aboard New Shepard Rocket Ship," BBC News, July 20, 2021, https://www.bbc.com/news/science-environment-57849364.
[38] Naveed Butt, "PSDP 2019-20: Rs 133 Billion Released against Budgeted Rs 701 Billion," Business Recorder, October 11, 2019, http://www.brecorder.com/news/529629.

## Military Applications

*Key determinants of national strength that influence the war potential of a nation and the nature of warfare are undergoing a significant transformation. Traditional elements of national strength, such as a country's military might and population, demographic trends, industrial base, communication network, natural resources, and leadership are being rapidly surpassed by emerging technologies. Some of which were considered the stuff of science fiction a few decades ago.*[39]

In modern warfare, innovative technology applications and doctrines, rather than traditional military hardware and strategies are now influencing battlefield outcomes.[40]

Dominion over space is one such capability that has become vital in determining national strength, and space-related technologies and their application have had a profound impact in shaping contemporary and future warfare.[41] The US National Security Strategy recognizes sustained access to space and maintaining dominance in this field crucial to the interests of the US and its allies.[42]

In fact, space is often referred to as the fourth medium like land, sea, and air within which military activities shall be conducted. Space is also being analogized with air and sea power and some of the key concepts in military strategies, i.e., command of the sea, air, sea lines of communication, parallel attacks, and sea power strategies are being applied to emerging space theory.[43]

*However, since no combat has taken place in space and no space combat force has yet been fielded, it has also been contended that it could be premature to apply these elements in crafting a theory of space battle operations. Nonetheless, this situation is not likely to remain the same, and the ability to exploit and dominate this new medium alongside land, sea, and air will shape the future battlefield, and would be at the center of future grand strategies.*[44]

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[39] James J. Wirtz, "Space and Grand Strategy," In *Space and Defense Policy*, eds. Damon Coletta and Frances T. Pilch, (Oxford: Routledge, 2009), 13-26 (14).
[40] Wirtz, "Space and Grand Strategy."
[41] Wirtz, "Space and Grand Strategy."
[42] US DoD, "Space Operations," Joint Publication 3-14, US Department of Defense, April 10, 2018, https://www.jcs.mil/Portals/36/Documents/Doctrine/pubs/jp3_14ch1.pdf?ver=qmkgYPyKBvsIZyrnswSMCg%3D%3D.
[43] Peter L. Hays, "Space and Military," In *Space and Defense Policy*, eds. Damon Coletta and Frances T. Pilch, (Oxford: Routledge, 2009), 151.
[44] Michael J. Lutton, "Oriented Toward Superiority: Counterspace Operations and the Counterterrorism Fight," In Space Power Integration (Maxwell Air Force Base, Alabama: Air University Press, 2006), 29.

Currently, space operations are being used to support and expedite observations, decisions, and actions at all levels of war - strategic, operational, and tactical.[45]

Figure 2: Military Applications of Space Technology


## Communications

The first and most important military application of space technology is satellite communication; and can be illustrated by the emerging military concept of network-centric warfare. It relies profoundly on the use of swift communication systems, which allow military leadership and different branches of the military to view the battlefield in real-time.

*Real-time information, provided by space technology, enhances situational awareness of a military's assets and commanders in each theatre and facilitates timely decision-making. This high-speed communication is enabled by a separate internet created by the military for the military. Communication satellites hold this system together by creating an informational grid over the given theatre of operation.*[46]

[45] Tylor M. Evans, "Space Coordinating Authority: Information Services from Space," In *Space Power Integration* (Maxwell Air Force Base, Alabama: Air University Press, 2006), 2.
[46] Kenneth D. Slaght, "CHIPS Articles: Network Centric Warfare from PowerPoint to Reality," Department of the Navy's Information Technology Magazine, (September, 2002), https://www.doncio.navy.mil/chips/ArticleDetails.aspx?ID=3532.

In the regional scenario, as already highlighted, India possesses 28 communication satellites, including two communication satellites dedicated for the Indian Military (namely GSAT 7 & GSAT 7A).[47]

*India is in the process of networking all its battlefield assets in an NCW environment and most of its war assets, including radars, C2 centers, transport fleet, AWACS aircraft and UAVs are connected through SATCOM. In comparison, Pakistan does not have a dedicated satellite in the military domain and its military assets' integration in the SATCOM domain needs major improvement.*

## Navigation

Satellite navigation systems are used for determining precise location and providing a highly accurate time reference almost anywhere on Earth. It uses an Intermediate Circular Orbit (ICO) satellite constellation of at least 24 satellites. The GPS system was designed by and is controlled by the US Department of Defense (DoD) and can be used by anyone, free of charge. The cost of maintaining the system is approximately USD 2 million per day,[48] including replacement of aging satellites.

The first of 24 satellites that form the current GPS constellation (Block II) was placed into orbit on 14 February 1989.[49] Its primary military objectives are to strengthen command and control of armed forces through better 'situational awareness' and to streamline 'precise targeting of smart bombs, cruise missiles, and other munitions.' The satellites are also equipped with nuclear detonation detectors, forming a vital element of the US Nuclear Detonation Detection System.

The European's concern, about this level of control over the GPS network and commercial issues by the US, materialised in the form of a planned Galileo positioning system. An independent system called GLONASS (global navigation system) is already being operated by Russia. The system operates with the help of 24 satellites that are deployed in three orbital planes as opposed to the four in which GPS is deployed.[50] China has similar navigation capability in the form of its BeiDou system.

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[47] ISRO, "Communication Satellites," Indian Space Research Organization, Accessed November 14, 2020, https://www.isro.gov.in/spacecraft/communication-satellites.
[48] Andrew Morrison, "Smoke Break - It Costs $2 Million A Day to Maintain the GPS System, So Why Is It Free?" Scout Magazine, July 10, 2017, https://scoutmagazine.ca/2017/07/10/smoke-break-it-costs-2-million-a-day-to-maintain-the-gps-system-so-why-is-it-free/.
[49] Space Launch Report, "Delta II Payload Planners Guide, Delta II Data Sheet," October 20, 2018, https://www.spacelaunchreport.com/delta2.html.
[50] Pavel Podvig, "GLONASS," Russian Strategic Nuclear Forces, December 26, 2007, http://russianforces.org/space/navigation/glonass.shtml.

*In the regional context, India's indigenous navigation programs, namely GAGAN and NavIC, enable the Indian military to have precise navigation, troop deployment, and targeting capability for smart weapons without any foreign dependence.[51] In comparison, Pakistan's military is dependent on foreign constellations for provision of Position, Navigation and Time (PNT) services. This is a serious constraint and has far-reaching implications.*

## Intelligence, Surveillance, Reconnaissance (ISR)

ISR is comprised of coordinated and integrated acquisition, processing, and provision of timely, relevant, accurate, and assured information and intelligence to reinforce a commander's conduct of activities.[52] ISR plays a crucial role in supporting operations in land, sea, air, and space domains.[53] It involves numerous activities which pertain to the planning and operation of systems that collect, process, and disseminate data in support of current and future military operations. The intelligence data generated by these systems often comprises of a wide range of optical, radar, infrared images, or electronic signals. Reliable ISR data not only provides early warning of enemy threats, but also enables military forces to enhance effectiveness, coordination, and lethality. Consequently, the demand for ISR capabilities to support ongoing military operations has increased significantly.[54]

In the regional context, as already highlighted, India possesses a large fleet of ISR satellites, including optical, SAR, multi-spectral, hyper-spectral, and Electronic Intelligence Satellites. Consequently, the Indian military has access to all-weather, day / night, high-resolution imagery.[55] Besides, India has access to military grade imagery (better than 0.3 m resolution) from the US and Israel.[56] Availability of sub-meter resolution enables the Indian military to precisely identify various target and C2 centers.

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[51] ISRO, "Satellite Navigation," Indian Space Research Organization, Accessed November 14, 2020, https://www.isro.gov.in/spacecraft/satellite-navigation.
[52] "Intelligence Surveillance Reconnaissance (ISR)," Haivision (blog), https://www.haivision.com/resources/streaming-video-definitions/isr-intelligence-surveillance-reconnaissance/.
[53] NATO, "Allied Joint Doctrine for Countering – Improvised Explosive Devices" March 16, 2011, https://Www.Dtra.Mil/Portals/61/Documents/Missions/Nato%20ajp-3.15 (A) %20allied%20c-Ied%20mar%2011.Pdf?Ver=2017-03-10-134619-480.
[54] GAO, "Assess and Integrate ISR Capabilities and Oversee Development of Future ISR Requirements," US Government Accountability Office, April 23, 2008, https://www.gao.gov/htext/d08374.html.
[55] Defense Aviation Post, "India's ISR Capabilities: Implications for Pakistan," April 24, 2020, https://www.defenceaviationpost.com/2020/04/indias-isr-capabilities-implications-for-pakistan/.
[56] James Clay Moltz, Asia's Space Race: National Motivations, Regional Rivalries, and International Risks (NYC: Columbia University Press, 2011), 128.

*It is concerning that on a given day, Indian satellites make multiple passes over Pakistan. This implies that little military activity can be hidden from the enemy's surveillance. Thus, the Indian military is in a better position to plan military operations and carry out battle damage assessment during war. In comparison, Pakistan possesses only one operational satellite in ISR domain (PRSS-1 with 0.98 m resolution).[57] This satellite is not sufficient to meet the tempo and spectrum of modern military campaigns.*

## Meteorology

*Weather satellites play their part in facilitating military operations both in peace and war time scenarios. The data from these satellites are critical in the successful execution of a wide range of military operations.*

Since the 1960s, the US has operated two distinct meteorological polar-orbiting satellite systems: DoD's DMSP, and NOAA's Polar-orbiting Operational Environmental Satellite (POES) and Suomi National Polar-orbiting Partnership satellite, the first in the Joint Polar Satellite System. The US also takes aid of European satellite, the Meteorological Operational satellite. Furthermore, it takes assistance from both military and civilian weather satellites.[58]

*In the regional context, Indian possesses three Meteorological satellites, and hence, Indian military have an assured access to real-time weather data. On the other hand, Pakistan is dependent on foreign satellites for access to weather data which can have serious limitations in a time of need.*

## Counterspace Operations

According to the United States Air Force (USAF): 'Counterspace is a mission, like counterair, which integrates offensive and defensive operations to attain and maintain the desired control and protection in and through space. These operations may be conducted across the tactical, operational, and strategic levels in all domains (air, space, land, maritime, and cyberspace), and are dependent on robust space situational awareness (SSA) and timely command and control (C2). Counterspace operations include both Offensive Counterspace (OCS) and Defensive Counterspace (DCS) operations.'[59]

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[57] SUPARCO, "PRSS-1," Space & Upper Atmosphere Research Commission, Accessed July 2, 2020, https://giextensions.net/suparcovp/major-programmes/projects/prss-1/.
[58] NATO AGARD, "Space System Applications to Tactical Operations, AGARD-CP-460, NTIS N90-27438, Avionics Panel Symposium," (NATO Advisory Group for Aerospace Research and Development,1989), 195.
[59] USAF, "Air Force Doctrine Publication 3-14 Counterspace Operations, Doctrine Annexes 3-14, Counterspace Ops," US Air Force, August 27, 2018, https://www.doctrine.af.mil/Doctrine-Annexes/Annex-3-14-Counterspace-Ops/.

*India is actively pursuing counterspace capability, both in the kinetic and non-kinetic domains. Its successful anti-satellite test in 2019 manifested its nefarious aims in the space race.[60] The country is also actively pursuing development of Directed Energy Weapons (DEWs) for disrupting space-based services.[61] On the contrary, Pakistan does not have such programs on the horizon.*

## Conclusion

Space has proven to be an essential component to acquire socioeconomic benefits and support national security. That is why, all space-faring nations are eager to exploit this domain for their national interests. Pakistan is a large and a populous country, faced with numerous socioeconomic problems as well as security challenges. Since independence, it has been struggling with issues like poverty alleviation, healthcare, illiteracy, water scarcity, food, and energy shortage. Additionally, ever-increasing population, management of land and natural resources, climate change are some of the critical issues that are continuing to confront Pakistan. The government must utilize all available resources, including space-related technologies, and adopt a scientific approach to overcome these problems.

[60] "Mission Shakti: All You Need to Know about ISRO, DRDO's A-SAT Missiles," Livemint, March 27, 2019, https://www.livemint.com/news/india/mission-shakti-satellite-space-operation-pm-narendra-modi-address-to-nation-missile-test-1553675620855.html.
[61] "DRDO Building 'Directed Energy Weapons' Which Can Dismantle Ariel Targets Without a Shot Being Fired," EurAsian Times, Accessed July 2, 2020, https://eurasiantimes.com/drdo-building-directed-energy-weapons-which-can-dismantle-ariel-targets-without-a-shot-being-fired/.

# INTERNATIONAL SPACE LAW & NATIONAL SPACE LEGISLATION

## International Space Law & National Space Legislation

*International space activities are governed by laws with the aim to ensure peaceful use of space, provide equal opportunities to all nations for space exploration and scientific investigation, bind states to a set of rules and regulations for their actions in space, and prohibit its weaponization.*

Space laws determine the scope, characteristics, pace, feasibility, and development of space endeavors. These laws lay out the framework for initiation and governance of space activities at both the national and international level. Therefore, Space Law is the cardinal body of legislation governing space-related activities, encompassing both international and domestic agreements, rules, and principles.[62]

### International Space Law

In 1959, the UN General Assembly formed the Committee on the Peaceful Uses of Outer Space (COPUOS),[63] through Resolution 1472 (XIV), for the discourse and codification of International Space Law. During the time span of 13 years (1967-79) the Committee concluded five international space treaties and conventions existing today. These five treaties include the:

1. Outer Space Treaty 1967,
2. Rescue Agreement 1968,
3. Liability Convention 1972,
4. Registration Convention 1975, and,
5. Moon Agreement 1979.

Apart from these legally binding treaties, five sets of non-legally binding space principles have also been adopted by UNGA, which are the:

1. Declaration of Legal Principles on Outer Space,
2. International Broadcasting Principles,
3. Remote Sensing Principles,
4. Nuclear Power Sources Principles, and,
5. Declaration on International Cooperation.[64]

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[62] UNOOSA, "Space Law," United Nations Office for Outer Space Affairs, Accessed November 30, 2020, https://www.unoosa.org/oosa/en/ourwork/spacelaw/index.html.
[63] UNOOSA, "United Nations Committee on the Peaceful Uses of Outer Space," United Nations Office for Outer Space Affairs, Accessed November 30, 2020, https://www.unoosa.org/oosa/en/ourwork/copuos/index.html.
[64] UNOOSA, "Space Law Treaties and Principles," United Nations Office for Outer Space Affairs, Accessed July 25, 2020, https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties.html.

These treaties deal with:

*….arms control in space, liability for damage caused by space objects, the safety and rescue of spacecraft and astronauts, the prevention of harmful interference with space activities and the environment, the notification and registration of space activities, scientific investigation and the exploration of natural resources in outer space and settlement of disputes.*[65]

## UN Treaties and Agreements

The United Nations Treaties and Principles related to space provide a legal framework for formulating national space laws by assigning significant responsibility to every state party to meet its international obligations. These treaties and agreements are legally binding on the signatory states.

### 1. The Outer Space Treaty (1967)

The 'Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies', also called 'Outer Space Treaty', puts international responsibility on states for their national space undertakings by enacting national space legislation, and other accepted norms of behavior.[66] The fundamental framework of international space law is derived from the principles outlined in this treaty:

- The purpose of outer space exploration shall be support to mankind, in line with the national interest of all nations.
- All states are free to explore outer space.
- Placement of weapons of mass destruction on any celestial body or in orbit by any state is prohibited.
- No state can claim sovereignty or occupation in outer space.
- Astronauts shall be considered representatives of humanity.
- All celestial bodies, including the moon, shall be explored, and used for peaceful ends.
- All national space activities executed by government or private entities shall be the responsibility of the respective state.
- Liability for the damage done by space objects shall be on the launching states.
- Pollution of outer space and astronomical bodies shall be avoided.

Source: UNOOSA, "The Outer Space Treaty," United Nations Office for Outer Space Affairs, Accessed December 12, 2020, https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/introouterspacetreaty.html.

[65] UNOOSA, "Space Law Treaties and Principles," United Nations Office for Outer Space Affairs, Accessed July 25, 2020, https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties.html.
[66] UNOOSA, "Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies," United Nations Office for Outer Space Affairs, Accessed July 25, 2020, https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/introouterspacetreaty.html.

The Outer Space Treaty came into force on 10 October 1967. Up till now, 110 states have ratified it. Both Pakistan and India have ratified it.[67]

## 2. The Rescue Agreement 1968

This agreement also called the 'Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space' provides that 'States shall take all possible steps to rescue and assist astronauts in distress and promptly return them to the launching State and that States shall, upon request, provide assistance to launching States in recovering space objects that return to Earth outside the territory of the Launching State.'[68] The agreement became effective on 3 December 1968. As of February 2019, 94 states had endorsed it.[69] Both Pakistan and India have ratified it.

In 1967, there was no concept of space travel and tourism, therefore, the agreement does not provide a clear definition of astronaut (to be rescued), nor the definition of what comprises a spacecraft and its elements. Besides, it does not address who will bear the cost of the rescue mission. Therefore, this agreement has drawn criticism because of its limited scope.[70]

## 3. The Liability Convention 1972

According to the Liability Convention (Convention on International Liability for Damage Caused by Space Objects), 'A launching state shall be absolutely liable to pay compensation for damage caused by its space objects on the surface of the Earth or to any spacecraft and liable for damage due to its faults in space.'[71]

The convention provides that whether a space object is launched by a government or a non-government entity, the state from which it is launched will be responsible for the damages done by that object. Similarly, if two states jointly launch an object in space, both the states will be jointly liable for the damage done by that object. The convention also came up with mechanisms for the compensation of claims

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[67] UNODA, "Disarmament Treaties Database: Outer Space Treaty," United Nations Office for Disarmament Affairs, Accessed December 12, 2020, http://disarmament.un.org/treaties/t/outer_space.
[68] UNOOSA, "Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space," United Nations Office for Outer Space Affairs, Accessed July 20, 2020, https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/introrescueagreement.html.
[69] UNOOSA, "Status of International Agreements Relating to Activities in Outer Space," United Nations Office for Outer Space Affairs, Accessed July 20, 2020, https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/status/index.html.
[70] UNOOSA, "Rescue Agreement," United Nations Office for Outer Space Affairs, Accessed July 20, 2020, https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/introrescueagreement.html.
[71] UNOOSA, "Convention on International Liability for Damage Caused by Space Objects," United Nations Office for Outer Space Affairs, Accessed December 12, 2020, https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/introliability-convention.html.

for losses or damage caused by space objects. The convention was constituted on 29 March 1972, and came into force on 1 September 1972. Both Pakistan and India have ratified it.[72]

## 4. The Registration Convention 1975

Being a signatory of 'Convention on Registration of Objects Launched into Outer Space 1975' also known as Registration Convention adopted by the UN General Assembly in its resolution 3235,[73] a state bears the responsibility of making a registry that will register the information of every object launched into space. For this purpose, a 'space object register' of launches has been established by the UN to register information related to space launches provided by member states and intergovernmental organizations to the Secretary General of United Nations.[74] The information required includes:

- Name of the state that launches space object,
- A designator or a unique registration number allotted to the space object,
- Date and location of launch,
- Fundamental orbital parameters of the space object including 'Nodal period, Inclination, Apogee and Perigee', and,
- Generic information about the purpose and capacity of the space object.

It has been ratified by 69 countries, including Pakistan.[75]

## 5. The Moon Agreement 1979

The 'Agreement Governing the Activities of States on the Moon and Other Celestial Bodies' also known as Moon Agreement 1979 states, 'the Moon and its natural resources are the common heritage of mankind and that an international regime should be established to govern the exploitation of such resources when such exploitation is about to become feasible.'[76] However, the agreement has little relevance in international law as it has not been ratified by states that are engaged in human spaceflight, including the US, majority member states of the European Space Agency, Russia, China, and Japan. India has also not ratified it. By

[72] UNOOSA, "Convention on International Liability for Damage Caused by Space Objects," United Nations Office for Outer Space Affairs, Accessed December 12, 2020, https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/introliability-convention.html.
[73] UNGA, "RES 3235 (XXIX) Convention on Registration of Objects Launched into Outer Space, November 12, 1974," UN General Assembly 29th Session, Accessed July 20, 2020, https://www.unoosa.org/oosa/oosadoc/data/resolutions/1974/general_assembly_29th_session/res_3235_xxix.html.
[74] UNOOSA, "United Nations Register of Objects Launched into Outer Space," United Nations Office for Outer Space Affairs, Accessed September 28, 2019, http://www.unoosa.org/oosa/en/spaceobjectregister/index.html.
[75] UNOOSA, "Convention on Registration of Objects Launched into Outer Space," United Nations Office for Outer Space Affairs, Accessed September 28, 2019, https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/introregistration-convention.html.
[76] UNOOSA, "Agreement Governing the Activities of States on the Moon and Other Celestial Bodies," United Nations Office for Outer Space Affairs, Accessed September 28, 2019, https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/intromoon-agreement.html.

January 2019, only 18 states were parties to the agreement which highlights its ineffectiveness.[77]

## UN Principles and Resolutions

Apart from above mentioned legally binding space-related treaties and agreements, there are also five sets of non-binding UN resolutions and principles that have been passed by the General Assembly to control outer space activities.[78] These include:

i. The General Assembly Resolution 1962 (XVIII) '**Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space**', passed in 1963, laid the foundation of the Outer Space Treaty in 1967. The resolution stipulates fundamental guiding principles for the space activities of states that have been unanimously adopted by the UN member states and already mentioned earlier. This resolution also provides mechanisms to peacefully solve issues related to conflict of interests among different states in the exploration and use of outer space by providing them consultation.[79]

ii. The General Assembly Resolution 37/92, passed in 1982 by the General Assembly, constitutes '**Principles Governing the Use by States of Artificial Earth Satellites for International Direct Television.**' Considering that there are significant implications, including political, social, economic, and cultural, of direct broadcasting, these principles provide guidelines to the UN member states regarding the applicability of international law, rights and benefits, cooperation with other states, copyrights, peaceful settlement of disputes, and states' responsibilities for television broadcasting.[80]

iii. The General Assembly Resolution 41/65 specifies '**Principles Relating to Remote Sensing of the Earth from Outer Space**' for encouraging international cooperation in this domain. These principles define the relevant terms, distinguish between different types of data obtained from remote sensing, and set forth a framework to increase international cooperation among states to minimize the

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[77] UNODA, "Disarmament Treaties Database: Moon Treaty (Celestial Bodies)," United Nations Office for Disarmament Affairs, Accessed July 11, 2020, http://disarmament.un.org/treaties/t/moon.
[78] Henry Hertzfeld, "Current and Future Issues in International Space Law," ILSA Journal of International & Comparative Law 15, no. 2 (January 1, 2009): 325-35.
[79] UNGA, "1962 (XVIII). Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space," United Nations General Assembly, Accessed May 10, 2020, https://www.unoosa.org/oosa/en/ourwork/spacelaw/principles/legal-principles.html.
[80] UNGA, "37/92. Principles Governing the Use by States of Artificial Earth Satellites for International Direct Television Broadcasting," United Nations General Assembly, Accessed May 10, 2020, https://www.unoosa.org/oosa/en/ourwork/spacelaw/principles/dbs-principles.html.

probability of conflicts in this domain.[81]

iv. Resolution 47/68 adopted by the UNGA in 1992 provides '**Principles Relevant to the Use of Nuclear Power Sources in Outer Space**' to minimize the risk of accidents and to ensure the safety of workers and public from harmful radioactive material. Moreover, these principles also provide guidelines related to safety assessment, liability, and compensation, and to resolve states' disputes.

v. The General Assembly Resolution 51/122, also called '**Declaration on International Cooperation in the Exploration and Use of Outer Space for the Benefit and in the Interest of All States, Taking into Particular Account the Needs of Developing Countries**' was adopted in 1996.[82] It institutes that outer space is the shared heritage of all mankind and the benefits of its exploration should reach all states irrespective of their degree of scientific or economic development. It lays emphasis on international cooperation in order to promote space science and technologies, encouraging advancement of relevant capabilities, and aiding the transfer of technology and expertise among states based on mutual consent.

In addition to the above mentioned treaties and resolutions, Pakistan is also party to other space-related treaties like the:

- Treaty Banning Nuclear Weapons Tests in Atmosphere, in Outer Space and under Water 1963
- Agreement Relating to the International Telecommunications Satellite Organization 1971
- Convention on International Mobile Satellite Organization 1976
- International Telecommunication Union Constitution and Convention 1992
- Space Debris Mitigation Guidelines 2007.

## Domestic Space Laws

Every State Party to these UN treaties bears the responsibility to conduct and control its government as well as private space activities within its area of jurisdiction in accordance with tenets of international space law. To comply with these obligations, every State Party to the UN treaties is required to enact domestic space laws and develop a national legal framework to regulate its space activities consistent with its national legal system, specific domestic needs, and range of its national space activities.

[81] UNGA, "41/65. Principles Relating to Remote Sensing of the Earth from Outer Space," United Nations General Assembly, Accessed August 10, 2020, https://www.unoosa.org/oosa/en/ourwork/spacelaw/principles/remote-sensing-principles.html.
[82] UNOOSA, "General Assembly Resolution 51/122," United Nations Office for Outer Space Affairs, Accessed May 10, 2020, https://www.unoosa.org/oosa/en/ourwork/spacelaw/principles/space-benefits-declaration.html.

*To assist member states establish national space laws, the office of COPUOS has formulated a 'draft model law on national space legislation and explanatory notes.'[83] These guidelines aim to enable states to meet their international obligations and focus on authorization and supervision of national space activities, registration of space objects, liability and insurance, and transfer of ownership.*

Domestic space laws are not only required for meeting international obligations but are also important for safeguarding a state's national interests. Therefore, national space legislation should cover all aspects of national space activities, such as the implementation of a national space program and establishment of a competent authority for authorization, supervision, and registration of space activities duly empowered to formulate rules, regulations, and policies related to space.

The national regulatory framework also needs to focus on promoting scientific and technological development in the space sector, facilitating PPPs to attract investment, and most importantly, creating a regulatory mechanism for national coordination and integration of a wide range of activities related to space, at all tiers. Most space-faring nations have enacted national space laws specific to their national legal requirements and their specific needs.

*Pakistan being State Party to UN treaties is still struggling to develop national space legislation and has been unable to set up a national legal regime to authorize, regulate, and supervise space-related activities within its area of jurisdiction.*

## Need for National Space Legislation in Pakistan

Pakistan, despite being a signatory to all five agreements of space law, has not included these obligations in its domestic laws. This is primarily because space has not been addressed adequately in the Constitution of Pakistan. Although, SUPARCO was established through a Presidential Ordinance XX of 1981, in 1981, it lacks constitutional mandate to regulate and control national space activities and implement space policies.[84]

*As an emerging space-faring nation, Pakistan will face serious consequences both internationally and domestically, if it does not pursue national space law-making to address its legal regime in the space sector, related commercial activities and intellectual property rights.*

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[83] UNOOSA, "Draft Model Law on National Space Legislation and Explanatory Notes," Committee on the Peaceful Uses of Outer Space, April 8, 2013, A/AC.105/C.2/2013/CRP.6, https://www.unoosa.org/pdf/limited/c2/AC105_C2_2013_CRP06E.pdf.

[84] GoP, "Presidential Ordinance XX of 1981, in 1981," The Gazette of Pakistan, Government of Pakistan, Accessed July 20, 2020, http://www.na.gov.pk/uploads/documents/1336457518_907.pdf.

Internationally, developed space-faring nations will endeavour to maintain their control over space by making their laws rigorous with the passage of time, which could then be selectively used to deny technology, knowledge, and services to space-developing nations, like Pakistan, who are still struggling with the formulation of national space policy and space laws.

*Since Pakistan is a State Party to most UN space-related treaties and agreements, though non-binding, its non-compliance with the obligations set by these treaties may create difficulties in procurement of satellite design, manufacturing, and launch facilities from other countries.*

It may also lead to Pakistan's marginalization at the international level in the space domain and future space cooperation with other space-faring nations, bilaterally and multilaterally, may be undermined. Likewise, without a legal regulatory framework, it will be difficult for Pakistan to procure space technology, knowledge, and services from multinational non-governmental agencies.

At the domestic level, due to the absence of national space laws, Pakistan's commercial interests are also being compromised. For instance, foreign satellite operators are exploiting the inadequacies of the country's national space legislation, and making huge profits by selling their satellite bandwidths / other services in the territory at cheaper rates. This is not only adversely affecting revenue generation by domestic satellite services; but also causing huge financial loss to the national exchequer.

*Most countries, such as India, have regulations in which foreign SATCOM operators cannot sell their bandwidth in their own national territory, without paying heavy taxes and duties. Due to better regulatory statutes, India is earning significant revenues by marketing its satellite services. As a result of huge financial gain, India is re-investing and enhancing the number of its satellites to capture a big share of satellite services at the national and regional level.*

Without any defined space regulatory framework and policies, Pakistan has also not been able to exploit the full potential of PPPs in space-related commercial ventures which is becoming a norm in the space industry worldwide.

*Article 70(4) of the Constitution confers powers to the Parliament to make laws for implementing international obligations arising from the ratification of treaties under Federal Legislative List, Fourth Schedule, Part -1(Item 32).[85] Article 142 empowers Parliament and Provincial Assemblies to make laws related to the matters mentioned in the Federal Legislative List, while both the Federal and Provincial Legislatures have the powers to legislate in respect of the matters mentioned in Federal Legislative List. In case any subject is not enumerated in legislative lists, the Provincial legislature could legislate by virtue of Article 142 (c) of the Constitution.[86]*

In this context, it has become an absolute necessity that Pakistan formulate a comprehensive, forward-looking National Space Policy to harmonize space development, commercialization, marketing, and integration of space technologies.

[85] "Article: 70 Introduction and Passing of Bills, The Constitution of Pakistan, 1973," Zain Sheikh (blog), December 11, 2009, https://pakistanconstitutionlaw.com/.
[86] "Article: 140A Local Government, The Constitution of Pakistan, 1973," Zain Sheikh (blog), December 11, 2009, https://pakistanconstitutionlaw.com/.

# PAKISTAN'S SPACE PROGRAM & EXISTING CAPABILITIES

# Pakistan's Space Program & Existing Capabilities

## Historical Background

Pakistan instituted Space Sciences Research Wing of the Pakistan Atomic Energy Commission (PAEC) through an executive order by the President of Pakistan, on 16 September 1961. Later, this body was renamed as SUPARCO. It began functioning independently of PAEC from 16 September 1964 with Dr I.H. Usmani leading its activities as its Co-Chairman. On 21 May 1981, the President of Pakistan granted SUPARCO autonomous status. The Chairman SUPARCO founded three Technical Wings named 'Space Technology Wing,' 'Space Research Wing,' and 'Space Electronics Wing.' The Space Research Council (SRC) was also established in 1981 to oversee the policy formulation process regarding Pakistan's National Space Program. On 24 December 1984, SRC adopted the 'Long-Term Development Program of Space Science and Technology' in Pakistan. The program was formulated by SUPARCO and consisted of four components.[87]

1. The **first component** dealt with the establishment of satellite ground stations and ancillary facilities necessary for control of satellites as well as reception of satellite services data. This component was also responsible for analysis and dissemination of satellite data.

2. The **second component** dealt with the establishment of satellite tracking infrastructure such as microwave radars, optical sensors and laser tracking stations.

3. The **third component** dealt with the launch of communication satellites. The satellites in this class are multipurpose and used for beyond line of sight telecommunication, television and radio broadcasting, and scientific observations.

4. The **fourth component** was envisaged to be indigenous development of satellites and space launch vehicles. As a result of these efforts, Pakistan launched BADR-1, its first-ever experimental satellite, on 16 July 1990.[88] However, the subsequent years in the last decade of the Twentieth Century witnessed very slow progress in Pakistan's space program.

Due to this dismal performance, in December 2000, the Government transferred SUPARCO from Cabinet Division to the National Command Authority (NCA).

[87] SUPARCO, "History," Pakistan Space & Upper Atmosphere Research Commission, Accessed January 28, 2020, http://www.suparco.gov.pk/pages/history.asp.
[88] SUPARCO, "History."

Moreover, the SRC and its Executive Committee were dissolved and replaced by the Development Control Committee (DCC) under the NCA. This restructuring hoped to infuse new life into the ailing national space landscape; and SUPARCO was assigned to:

- To pursue R&D activities in space science, space technology, and related fields for achieving the objectives of self-reliance.
- Enhance indigenous capabilities in space technology and promote the peaceful applications of space for socioeconomic development.
- Prepare and propose long-term as well as short-term space programs and plans to the government.
- Develop satellites and satellite-launching vehicles.
- Establish satellite ground stations.
- Undertake surveys, scientific investigations, and other specialized tasks.
- Advise the government on all space-related matters.
- Liaise with national and international agencies.

Source: SUPARCO, "Functions," Pakistan Space and Upper Atmosphere Research Commission, Accessed January 28, 2020, http://www.suparco.gov.pk/pages/functions.asp.

In 2001, Pakistan launched BADR-2 - its second experimental earth observation satellite.[89] In satellite communication domain, the first geostationary satellite named PAKSAT-1 was launched in 2002. After a gap of almost nine years, a replacement geostationary telecom satellite, PAKSAT-1R, was launched in 2011 from Xichang, China.[90] In remote sensing domain, Pakistan launched its first dual-purpose earth observation and optical satellite, Pakistan Remote Sensing Satellite (PRSS-1) from Jiuquan Satellite Launch Centre, China in July 2018.[91] It is important to mention that along with PRSS-1, Pakistan also launched its indigenously built Technology Evaluation Satellite, PAKTES-1. In 2011, the NCA approved 'Space Program 2040' (later declared Space Program 2047).

*Space Program 2047 is aimed at the indigenous development of satellites and ground stations to bring the benefits of the full spectrum of space technology to the people of Pakistan and to reduce reliance on foreign facilities.[92] Pakistan is also planning to send its first astronaut in space by 2024, in collaboration with China.*

[89] "Development of Pakistan Space Program History Essay," UK Essays, November 2018, https://www.ukessays.com/essays/history/development-of-pakistan-space-program-history-essay.php#ftn8.
[90] "PAKSAT-1R," China Great Wall Industry Corporation, 2011, http://cn.cgwic.com/PakSat-1R/english/wx.html.
[91] Naveed Siddiqui, "Pakistan Launches Remote Sensing Satellite in China," Dawn News, July 9, 2018, https://www.dawn.com/news/1418966/pakistan-launches-remote-sensing-satellite-in-china.
[92] "NCA Okays Nuclear Power Prog 2050, Space Prog 2040," Geo.Tv, Accessed January 28, 2020, https://www.geo.tv/latest/26091-nca-okays-nuclear-power-prog-2050-space-prog-2040.

This brief preview shows that Pakistan's space program has witnessed many ups and downs. There have been a few successes; however the pace of Pakistan's space program has not been at par with contemporary developments.

## SUPARCO: Capabilities & Achievements

Since its inception, SUPARCO has come a long way in terms of its efforts to accomplish its assigned objectives. However, a realistic analysis of current capabilities, achievements and gaps is required for carving an effective future roadmap of Pakistan's space program. As per the official statement on its website, 'SUPARCO is mandated to conduct R&D in space science, space technology, and their peaceful applications in the country. It works towards developing indigenous capabilities in space technology and promoting space applications for socioeconomic uplift of the country.' The broad contours of its objectives include:

- Major Programs (Development / Application Programs),
- Products and Services,
- Education and Training,
- Research Studies, and,
- International Cooperation.

The analysis of its capabilities, progress, and achievements are presented in subsequent paragraphs.[93]

## Major Programs

### Development

SUPARCO's development programs include communication and remote sensing satellites and human resource development as sub-programs.[94]

*It is important for any space-aspiring nation, like Pakistan, to attain indigenous spacecraft development capability.*

#### Communication & Remote Sensing Satellites

The Commission has been endeavoring to develop its own indigenous satellite, since the late 80s. As a result, two experimental satellites, BADR-1 and BADR-2 were developed, albeit with partial success. However, until now, not a single operational satellite has been indigenously developed.

[93] SUPARCO, "Organisation," Pakistan Space & Upper Atmosphere Research Commission, Accessed August 9, 2020, http://www.suparco.gov.pk/ pages/organisation.asp.
[94] SUPARCO, "Major Programmes," Pakistan Space & Upper Atmosphere Research Commission, Accessed August 9, 2020, http://www.suparco.gov.pk/ pages/major-programmes.asp.

Currently, there are three operational satellites (namely, PAKSAT-1R, MM-1 and PRSS-1), all developed / procured and launched from foreign agencies. The fourth experimental satellite PAKTES-1, for test and evaluation purposes, has been mostly developed and integrated in Pakistan. However, its payload has been procured from a foreign source. Hence, despite decades' long efforts, Pakistan's indigenous satellite development and launch programs are lagging.

*SUPARCO's development programs require strategic revamping; and need to be invigorated to keep pace with satellite/launch development capabilities of contemporary nations. Further, overall development objectives must also include indigenization of critical sub-systems, ground systems, user terminals, and payloads. For this purpose, local academia / industry and other public-sector organizations need to be involved.*

### Human Resource Development

As far as human resource development and space professionals are concerned, limited achievements have been made to develop and groom space professionals who can contribute towards indigenization and self-reliance.

## Applications

SUPARCO's applications program includes Remote Sensing (RS) applications and GIS; space and atmospheric sciences; and tele-medicine.[95]

### RS & GIS Domain

Some progress has been attained in RS and Geographic Information System (GIS) domains. However, compared to contemporary players, Pakistan is trailing behind. The complete chain of RS & GIS process involves acquisition, processing, analysis, and dissemination of data from source to end users, in the fastest possible manner. For satellite imagery acquisition, historically, SUPARCO has been dependent on foreign sources (mostly French origin).[96] Additionally, ground systems for downloading imagery have been imported at exorbitant costs (indigenous development of these systems has not materialized). After launch of PRSS-1, imagery with 0.98m resolution is available; however, the satellite itself and associated infrastructure were imported. Nevertheless, full use of PRSS-1 by national entities as well as revenue generation from its services remains weak.

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[95] SUPARCO, "Application Programs," Pakistan Space & Upper Atmosphere Research Commission, Accessed July 20, 2020, http://www.suparco.gov.pk/pages/applications-programmes.asp.
[96] SUPARCO, "Remote Sensing & Geographic Information Systems," Pakistan Space & Upper Atmosphere Research Commission, Accessed July 20, 2020, http://www.suparco.gov.pk/pages/rsa-gis.asp?rsalinksid=1.

*Pakistan still lacks availability of advanced RS & GIS data, such as SAR / multi-spectral / hyper-spectral imagery. Moreover, revisit time of PRSS-1 dictates that more satellites are required to improve temporal resolution.*

In processing and analysis, SUPARCO possesses adequate capabilities. However, these capabilities need to be integrated with various ministries / departments for effective use and contribution in national development.

Timely dissemination of RS & GIS data and services to end user is also important. Many space-faring and space-emerging nations have their own national GIS / imagery portals / databases that are available to their populace; and have implemented advanced networking and dissemination facilities for prompt provisioning of satellite imagery / GIS data to end users.

*In India, citizens and relevant ministries / departments have seamless access to tremendous data / services in RS / GIS domains through a customized national GIS portal called 'Bhuvan.'[97] Due to this advanced facility, RS & GIS data / services have truly been integrated and socioeconomic dividends are being materialized. However, in Pakistan, such facilities are not readily available as per their specialized requirements.*

Implementation of value-added services for precision agriculture, minerals exploration, urban development, water management, disaster forecasting, and management need significant improvements.[98]

### Space and Atmospheric Sciences

SUPARCO is also pursuing a few programs in the realm of Space and Atmospheric Sciences. Specific areas include studies on climate change, natural hazards monitoring, and atmospheric research, space weather monitoring, renewable energy, and search & rescue operations.[99]

Some progress has been achieved in a few of the areas; however, most of these projects have not been sustainable, and need major enhancement in respective scopes.

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[97] ISRO, "Welcome to Bhuvan, ISRO's Geoportal-Gateway to Indian Earth Observation," Indian Space Research Organization, Accessed July 20, 2020, https://bhuvan.nrsc.gov.in/bhuvan_links.php.
[98] SUPARCO, "Remote Sensing & Geographic Information Systems," Pakistan Space & Upper Atmosphere Research Commission, Accessed July 30, 2020, https://suparco.gov.pk/applications-programmes/remote-sensing-geographic-information-systems/.
[99] SUPARCO, "Space and Atmosphere Sciences," Pakistan Space & Upper Atmosphere Research Commission, Accessed July 30, 2020, http://www.suparco.gov.pk/pages/sas-services.asp?spasslinksid=2.

*These studies / programs need to be pursued with the aim to improve national / international collaborations with relevant organizations in academia and industry; as well as publication of scientific results / findings in reputable international platforms.*

### Tele-medicine

This program is limited to a pilot project in collaboration with Jinnah Post Graduate Medical Center.[100]

*Considering the medical needs in far-off, backward areas of Pakistan, similar services are urgently needed. Hence, the scope and collaborators of this program need substantial expansion.*

## Products and Services

The Commission's second prime objective includes products and services in which it is facilitating users in SRS, GIS, land surveying, Space and Atmospheric Sciences, atmospheric data receiving & processing, and IT. In these areas, selected projects have been undertaken.[101]

*Compared to other areas, significant achievements and projects have materialized in GIS. Nevertheless, in other areas, namely land surveying, Space and Atmospheric Sciences, substantial progress is required in the scope, quality, and quantity of projects/programs. Besides, national / international partner organizations need to be co-opted and practical and result-oriented R&D needs to be conducted to diversify space sciences and technology.*

## Education and Training

Education and training is SUPARCO's third objective. It includes conduct of short courses, seminars, and workshops. While Space Technology encompasses vast and miscellaneous disciplines, at present, education and training is mostly focused on Remote Sensing and GIS.[102] In this regard, scope and number of training courses needs to be increased to include diverse space technologies.

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[100] SUPARCO, "Tele Medicine Program," Pakistan Space & Upper Atmosphere Research Commission, Accessed July 30, 2020, http://www.suparco.gov.pk/pages/tele-medicine.asp?telelinksid=2.
[101] SUPARCO, "Products and Services," Pakistan Space & Upper Atmosphere Research Commission, Accessed July 30, 2020, http://www.suparco.gov.pk/pages/products-services.asp.
[102] SUPARCO, "Education and Training," Pakistan Space & Upper Atmosphere Research Commission, Accessed July 30, 2020, http://www.suparco.gov.pk/pages/education-training.asp.

*Training in specialized fields, including but not limited to, spacecraft development, satellite communication, satellite navigation, satellite meteorology, instrumentation, propulsion, robotics, feedback control systems, and astro-dynamics should be pursued. Besides, SUPARCO needs to encourage more educational institutes / universities to incorporate space-related education in their respective curricula. Integration of space education at all tiers of national education system, starting from school level to the university level need to be implemented.*

In parallel, to pursue a sustainable program at the national level, job opportunities should be created for the employability of graduates in space disciplines.

## Research Studies

SUPARCO's fourth primary objective includes preparation of research studies for publication on national and international platforms.

*Careful analysis of this depicts that compilation and publication of research studies, in the shape of quality research papers, needs major improvement. Publication of research in reputable international journals is missing.*

In this regard, SUPARCO in collaboration with academia, Higher Education Commission, Pakistan Science Foundation and Ministry of Science and Technology needs to formulate a focused and comprehensive program to enhance the contribution of Pakistani scientific community in international scientific / literary print platforms. Moreover, quality research projects should be funded from which research could be published in academic literature. In this regard, scientific collaboration with international space organizations / academic institutes needs greater encouragement to foster a culture of scientific research in Pakistani organizations.

## International Cooperation

The Commission has established collaborations with multiple international organizations; and as discussed earlier, is party to five major UN treaties on outer space. SUPARCO's most significant partnership is with the Asia Pacific Space Cooperation Organization (APSCO); and is also a founding member of Inter-Islamic Network on Space Sciences and Technology (ISNET).[103]

[103] SUPARCO, "International Cooperation," Pakistan Space & Upper Atmosphere Research Commission, Accessed July 30, 2020, http://www.suparco.gov.pk/pages/cooperation.asp.

This study's analysis reveals that the Commission is mostly contributing to monitoring and sharing of data in weather, geo-magnetic and COSPAS-SARSAT studies. However, depth and breadth of these collaborative initiatives needs major boost to include all space-related areas.

*In this regard, collaboration with space-emerging nations needs to be seriously cultivated in space science disciplines; and collaborations strengthened to produce commercial, scientific, and national security dividends. Joint R&D, mutual sharing of satellite resources / data, and space products / services with friendly countries and emerging nations, should be actively pursued based on a mutually beneficial and commercially viable model.*

## Pakistan's Space Organizational Setup

As discussed earlier, Pakistan's space organizational setup was reorganized through a Presidential Order Ordinance XX of 1981. As per this ordinance, the President of Pakistan was the chief authority of Pakistan's national space program. However, in 1987, the supervision of the space program was delegated to the Prime Minister. Later, in December 2000, the Government transferred SUPARCO from Cabinet Division to the Strategic Plans Division (SPD) under the NCA.

*This setup is not in line with the international practices followed by developed space-faring nations.*

Internationally, most national space programs are directly controlled by the Chief Executive of the state / central government through apex space bodies, e.g., space commissions, authorities, and departments. These bodies are responsible for legislation of national space laws, formulation of national space policy, developing and overseeing the implementation of a national space program, providing budgetary resources, and acting as a bridge between various ministries and institutions to synergize the national effort through a well-structured organizational setup.

*The role and task of each functionary in the national space organizational setup is well-defined, regulatory, and executive functions are assigned to separate bodies and control of civil and military space programs is clearly demarcated.*[104]

[104] For reference, see the space organization structures of the US (https://fas.org/spp/military/commission/report.htm), Germany (https://a3space.org/wp-content/uploads/2017/09/DLR-uloga.pdf), Canada (https://www.asc-csa.gc.ca/eng/about/csa-organization.asp), Japan (https://pacforum.org/wp-content/uploads/2019/04/issuesinsights_Vol19WP3_0.pdf), India (https://www.isro.gov.in/about-isro/organisation-structure), Russia (http://en.roscosmos.ru/119/), and China (http://www.cnsa.gov.cn/).

It is apparent that Pakistan's performance and its existing capabilities in space are far from the satisfactory. Besides numerous factors, as already highlighted, this is also because of lack of attention by successive governments.

# PROPOSED NATIONAL SPACE POLICY FOR PAKISTAN

## Proposed National Space Policy for Pakistan

*Space policy refers to the decision-making process by the political leadership of a State vis-à-vis employment of the public policy for its outer space activities as well as the use of their spin-offs for both civil and military intentions.*[105]

The process of formulation of space policy is unique in many aspects mainly because of the involvement of distinct but interdependent interest groups and organizations (both government as well as non-government) with diverse agendas and aspirations.

*Multidimensional and complicated inputs, budgetary constraints and allocation, access to technology, availability of specialized human resources, and the dual usage of space technology make the policy formulation process even more complex.*[106]

The policy at the national level, therefore, seeks to create convergence in the agendas of various divergent groups. It also addresses a broad range of issues that span from national defense and security, commerce, science and technology, all aspects of socioeconomic development, human resources, and a host of other quantifiable and less quantifiable issues.[107]

Generally, the process of space policy formulation involves three broad stages:

1. setting goals by the national leadership,
2. establishment of appropriate means by the administrative agencies to achieve these goals, and,
3. allocation of resources.

The initial inputs which form the basis of the policy at the national level and outline the objectives for various sectors, often come from government agencies, private interest groups, academia, and industry.[108]

The policy ought to be in line with the grand strategy, serve national interests, and must be based on realistic objectives taking into consideration the ground realities, national ambitions, and international environment. Careful selection of attainable goals is of utmost importance. The goals that are too impractical, cost

[105] Nathan C. Goldman, *Space Policy: An Introduction* (Ames, IA: Iowa State University Press, 1992),vii.
[106] Eligar Sadeh and Brenda Vallance, "The Policy Process," In *Space and Defense Policy*, eds. Damon Coletta and Frances T. Pilch, (Oxford: Routledge, 2009), 125.
[107] Sadeh and Vallance, "The Policy Process."
[108] Sadeh and Vallance, "The Policy Process," 125.

prohibitive, based on assumptions that are unrealistic and not in consonance with international obligations as well as the environment, will always be elusive and a recipe for failure.[109]

*The most important aspects that a space policy addresses at the national level is the formulation of a national administrative hierarchy, clear delineation of authority, demarcation of distinct spheres of responsibilities and creation of linkages at all levels between various stakeholders. The hierarchical issues and those related to control remain at the top of the challenges faced during the process of policy formulation.*[110]

Since space programs in most countries have been driven by security needs and spearheaded by the defense sector, militaries and governments tend to seek greater control over national space activities. However, given the diverse nature of space-related pursuits and their opportunities, greater involvement of civil and commercial sectors and the growing competitive international space environment, the solutions to space power are unlikely to come from a single sector or the military alone.[111] For the attainment of national objectives, synergy in efforts with participation from all stakeholders is key.

*Yet of the utmost importance in this regard is the formulation of a centralized controlled mechanism, especially for developing countries, to monitor and ensure implementation of policy directives for the realization of national goals and programs.*

However, with the growing involvement of commercial and civil sectors in international space initiatives and programs, such as Elon Musk's SpaceX and Richard Branson's Virgin Galactic, the future of Space lies in the hands of the private sector as much as in the hands of government. Therefore, too much government control could impinge on private investment in the space sector, especially when a government alone may not be able to fund its entire national space program.[112]

A national space policy, therefore, creates a well-thought-out, viable institutional mechanism to create linkages between state-controlled and commercial activities,

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[109] James A Vedda, "Considerations for the Next National Space Policy," The Aerospace Corporation, (March 2017), 3.
[110] Sadeh and Vallance, "The Policy Process," 127.
[111] Damon Coletta, "Thinking about Space and Defense," In *Space and Defense Policy*, eds. Damon Coletta and Frances T. Pilch, (Oxford: Routledge, 2009), 7.
[112] Coletta, "Thinking about Space and Defense," 3.

ensuring preservation of national priorities and safeguarding state interests, while creating a conducive environment for promoting commercial entrepreneurship.

Growing dependence of both civil and government sectors upon space technologies and their spin-offs necessitate favorable treatment of space commerce to serve the socioeconomic development of a state.[113] The significance of space commerce for a national space program implies that the private sector should be encouraged to fund research and development to attain long-term national space aspirations. Therefore, national space policy should facilitate and prioritize PPPs, and also lay down clear guidelines to encourage the commercial sector in the development of a national space program.[114]

Moreover, a viable national space policy also focuses on development of scientific research, development of progressive space technologies and infrastructure, creation of industrial and technological potential for future space projects and development of human resources.[115]

*Pakistan's national space policy, therefore, needs to be cautious, balanced, and prioritized, and above all in line with domestic and international compulsions. The goals must be realistic and achievable. However, it must have all internationally accepted elements and instruments of space policy.*

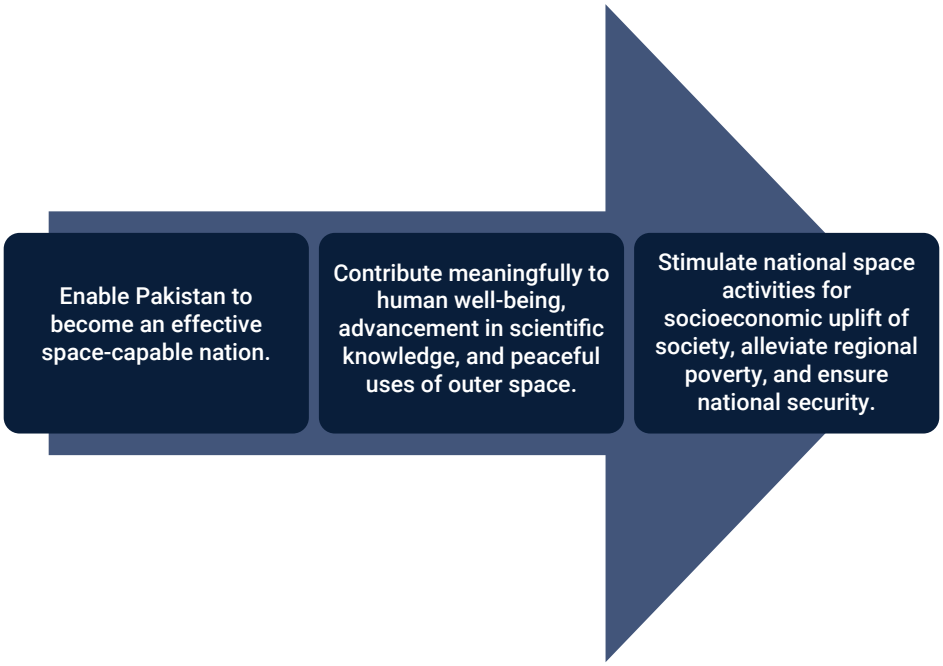
## Aim of Pakistan's National Space Policy

A broad-based, futuristic, and all-encompassing space policy focuses on an innovation-driven approach to support regional and national socioeconomic activities.

[113] James A Vedda, "Considerations for the Next National Space Policy," The Aerospace Corporation, (March 2017), 3.
[114] Vedda, "Considerations for the Next National Space Policy," 5.
[115] Anastasia Edelkina, Oleg Karasev, and Natalia Velikanova, "Space Policy Strategies and Priorities in Russia," SSRN Electronic Journal (2015), https://doi.org/10.2139/ssrn.2588993.

The major contours of Pakistan's National Space Policy entail contribution in advancement of scientific knowledge in the space domain for the welfare of mankind; and participation in international efforts to ensure peaceful use of outer space for safe and free space operations for all nations. Therefore, Pakistan's National Space Policy should take all national stakeholders on board with the primary focus on economic uplift of society as well as ensuring national security.

Figure 3: Aim of Pakistan's National Space Policy




*The envisaged National Space Policy (NSP) should enable Pakistan to become an effective space-capable nation; contribute meaningfully to human well-being, advancement in scientific knowledge, and peaceful uses of outer space. Besides, the NSP should stimulate national space activities for socioeconomic uplift of society, alleviate regional poverty, and ensure national security.*

## Proposed Cardinal Principles of Pakistan's Space Policy

For success in space technology and to ensure multifaceted collaboration with the international community, Pakistan will need to follow these principles:

***Space is a common heritage of mankind.***

- Pakistan will remain committed to peaceful use of outer space, in accordance with international laws, to ensure smooth, fair, and equal opportunity access to this boundless frontier. Hence, it will ensure responsible use to uphold the integrity, continuity, and freedom of operations in space.

- Pakistan will be committed to enhancing its share in global efforts related to advancement in space-related scientific knowledge and research. In this regard, a collaborative framework between national and international stakeholders will be developed to have fruitful and tangible results.

***A thriving commercial space sector is vital for improving socioeconomic conditions of any country.***

- Pakistan will ensure effective commercialization of indigenous space-based services for its envisaged economic growth roadmap.

- Pakistan will encourage foreign investment in the space sector. At the same time, the government will facilitate the home-grown commercial space sector to remain globally competitive and enable innovation-driven entrepreneurship.

***Peaceful use of outer space needs to be coupled with a policy of non-interference in other nation's space systems, including support infrastructure.***

- Pakistan will accept that purposeful interference with foreign space systems is a violation of international laws and rules.

- Pakistan will employ appropriate actions to protect its space assets from willful interference and ensure uninterrupted space operations in support of its national economy, national security, and advancement in space science.

## Proposed National Space Policy Objectives

Considering the above established principles, Pakistan will pursue the following goals in all spheres of its space endeavors:

- Expedite and focus on indigenous development of Space and Terrestrial Systems / user terminals for effective utilization of available satellite services at the national level, as well as participate in global commercial markets.

- Enhance international cooperation for mutual sharing of space-based services, space-related scientific data, and exchange of experts / professionals.

- Strengthen R&D infrastructure and facilities for indigenous development of spacecraft, launch infrastructure, launch vehicles; and pursue futuristic research in space-related disciplines.

- Cultivate bilateral agreements with the international community for participation in global scientific and industrial projects for contribution in the knowledge-driven economy in space disciplines.

- Reinvigorate the private commercial sector to invest in space technology domains. While foreign entities need to be encouraged to invest in Pakistan's viable market, local entrepreneurs would be supported through attractive incentives and policies to capitalize on the global space economy.

- Develop an ecosystem for integration and value-addition of space services for poverty alleviation, natural resource management, terrestrial exploration missions, disaster warning and management, and generation of novel scientific data.

- Rejuvenate space exploration and discovery missions about the solar system in collaboration with space-faring nations.

- Reassure participation in international efforts for peaceful, safer, and interference-free use of outer space through involvement in international/ policymaking forums.

The execution of specific actions for fulfillment of the above-mentioned goals should be in conformance with national policies in foreign, security and finance sectors. No action should be undertaken that violates any applicable international / national law; and an equal opportunity culture ought to be fostered by all national departments and agencies.

## Proposed Policy Guidelines for Pakistan's NSP

The subject of outer space and the modalities / technicalities associated with it are not simple, rather they are extremely complex and interdisciplinary. However, after a detailed study of Pakistan's space program, this paper provides specific policy guidelines as a way forward.

## Generalized Guidelines

To effectively implement the objectives discussed earlier, all ministries, departments and agencies in Pakistan shall ensure adherence to the following protocols:

### Space Capability Development for Self-Reliance

Pakistan is a space-emerging nation with immense potential. Existing space capabilities are a mixture of foreign as well national capabilities. All departments and agencies shall strive to attain indigenous capabilities and capacities, for Pakistan's growth as an effective member of space-faring nations, and its contribution in global efforts for human well-being. Critical technologies and commercial systems are to be developed through innovation-driven research and entrepreneurial outlook. All concerned departments and agencies are to pursue the following capabilities, which are critical for space mission assurance and resilience.

- Development of launch systems for cost-effective, reliable, and assured access to space in support of commercial, civil, and security activities.
- Initiation of space systems / sub-systems for self-reliance, indigenization, and cost-effective pursuance of national objectives.
- Formulation of plans and attainment of capabilities to operate in space-denied environment.
- Incorporation of safety, security, and redundancy features in space systems for assured availability of such systems / services in facilitating critical government functions.
- Inauguration of a roadmap keeping in view national priorities and resources.

### Human Resource Development

A trained workforce, along with a viable job market, is essential for pursuing effective and sustainable space activities.

- Space professionals shall be able to operate and optimally maintain existing space systems for mission assurance; as well as contribute in innovative activities for novel scientific discoveries, development of space systems for

productive commercial activities, and national security.

- All concerned organizations, in collaboration with academia and industry, shall formulate measures to create an efficient space workforce at all tiers along with the creation of ample job opportunities in commercial, governmental, and industrial sectors.

- All concerned agencies shall encourage inclusion of space technologies in the emerging Science, Technology, Engineering, and Mathematics (STEM) programs in Pakistan to attract future scientists, engineers, operators and skilled manpower in this domain.

## Promote Inter-ministerial Collaboration

Space technology is a multidisciplinary field with numerous dimensions. A well-integrated collaborative framework is required, between several departments / agencies, for evolution and strengthening of Pakistan's space program in line with contemporary changes.

- All concerned departments, organizations, and agencies shall pursue effective, broad-based and goal-oriented partnerships for promoting collaboration, cooperation, coordination, and knowledge/expertise-sharing mechanisms.

- Available expertise in departments and agencies will be mobilized and integrated for common national goals as well as to leverage existing capabilities for a cost-effective and broad-based space program.

- Wherever possible, joint programs, ventures, and strategies are to be developed through effective lateral linkages.

## Strengthen International Cooperation

Historically, phenomenal progress in the space sector has been attained due to collaborative endeavors amongst multiple nations. Today, a growing number of countries have entered the space marathon and are contributing in an exciting journey towards glory.

- Pakistan shall strengthen bilateral and multilateral ties with global players, friendly allies, and the international scientific community for decisive contribution in advancement of space sciences and technology; pursuance of common objectives and mutual projects; and fulfillment of space-based national requirements.

- All concerned departments, agencies, and academic institutions are to identify avenues of potential collaboration; and strengthen bilateral and multilateral ties. In this regard, diplomatic channels through Ministry of Foreign Affairs would also be employed.

- The main contours of international cooperation shall constitute the following elements:

    1. Participation in international forums and legislative activities for ensuring peaceful use of outer space.
    2. Contribution in international efforts for the safety of life, including but not limited to search and rescue; disaster management; climate change observations; and preservation of space-related projects.
    3. Promotion of bilateral trade for fulfillment of national space requirements as well as facilitating new markets for commercialization of Pakistan's indigenous space products and services.
    4. Mutual exchange of space professionals, students, scientific experts, and operators for knowledge / expertise-sharing.
    5. Adoption of a mutual framework for assured access to common space products / services in satellite communication, navigation, meteorology, and earth observation.
    6. Participation in international efforts for preservation of space through space monitoring, debris mitigation and collision avoidance endeavors.

## Allocation of Orbital Slots and Radio Frequency Spectrum

- The Government of Pakistan shall endeavor to timely secure and occupy orbital slots, vital for fulfilling national requirements in commercial, civil, and security fields.

- The requirements of radio frequency spectrum shall also be worked out and secured.

- All concerned departments and agencies shall identify such needs and pursue their acquisition, operations, safety, and sustainability.

- Requisite regulatory framework will be put in place to ensure interference-free operations for critical functions.

## Specialized Sector Guidelines

Pakistan will pursue space endeavors in three discrete spheres - namely Scientific, Commercial, and National Security needs. Each of these spheres has its own peculiar dynamics and requirements. To ensure seamless operations and production of synergistic effects, an efficient organizational hierarchy is to be implemented with clearly defined individual guidelines to ensure accomplishment of a broad-based and productive space program.

## Space Domain Hierarchy

- SUPARCO, as the primary national space agency, is responsible to the Prime Minister of Pakistan through the Cabinet Division. SUPARCO is to supervise and coordinate space-based activities in scientific and civil domains.

- SUPARCO, in collaboration with relevant ministries/stakeholders/ organizations (as nominated and specified in subsequent paragraphs), will be responsible for:
  - i. Execution and implementation of national space program in civil / scientific domains.
  - ii. Coordination with all relevant ministries, government departments, military services, and agencies for planning and conduct of space-related activities.
  - iii. Act as a cardinal nerve center for coordinating space activities and enhancing regional and international cooperation.

Specific responsibilities of respective ministries / agencies are discussed in subsequent sections.

## Scientific Space Guidelines

*The objectives of scientific efforts in the space domain are to: improve the quality and safety of life on earth; explore the mysteries of the origin of life, solar system, and universe; discover resources in outer space; and authenticate universal laws and factors affecting life on earth.*

To attain these objectives, SUPARCO shall:

- Coordinate with the Ministry of Defense to initiate human space flight efforts and send Pakistani astronauts in space in collaboration with friendly countries.

- Identify international scientific endeavors for participation by Pakistan, in collaboration with the Ministry of Science and Technology and Ministry of Foreign Affairs.

- Identify locations in Pakistan, suitable for establishment of specialized space ground assets, observatories, ground receiving stations, and scientific instruments in support of international scientific projects, in collaboration with Survey of Pakistan.

- Conduct cutting-edge research and development in space disciplines through Academia-Industry linkages, in collaboration with Higher Education Commission and Ministry of Commerce and Industry.

- Invigorate pioneering space-based research to identify root causes and workable solutions for management of national/regional natural disasters, such as seasonal floods, earthquakes in collaboration with the National Disaster Management Authority.

- Pursue innovative R&D for development of next generation spacecraft, launch systems, ground systems and user terminals for effective contribution by Pakistan in space science and technology.

- Enhance the study of local and global climate change, melting of glaciers, land cover changes, forest management and rise in sea level in collaboration with Pakistan Meteorological Department, National Institute of Oceanography, Pakistan Forest Department and Pakistan Geological Survey.

- Identify, monitor, and develop capabilities for water resource management in collaboration with the Ministry of Water Resources.

- Participate in international weather and environmental monitoring programs managed by the World Meteorological Department in collaboration with the Pakistan Meteorological Department. Wherever possible, local monitoring stations are to be established for collection and sharing of data with the international community. Furthermore, development of meteorological satellites / payloads is to be pursued in collaboration with friendly countries.

- Identify the mechanisms and networking protocols for swift sharing of scientific / RS data with the government and international community.

- Initiate and participate in lunar and planetary exploration missions through developing instruments for flybys and robotic landers.

- Identify and develop scientific instruments that could be integrated in international scientific space missions.

- Enhance orbital presence in near space in the shape of satellites and probes.

## Commercial Space Guidelines

*A vibrant and thriving commercial space sector is a pre-requisite for a sustainable, long-term and potent national space program.*

Commercial endeavors entail activities conducted by the private sector for revenue generation, investment in ventures with certain inherent risk factor, establishment of job markets, trade and exports of local goods, and provision of services for revenue generation.

To promote a healthy commercial space sector, concerned departments and agencies shall:

- Identify national economic requirements and challenges; and their possible solutions which could be materialized by employing space science and technology.

- Forecast and identify regional and national dynamics in areas of telecommunications and entertainment; and encourage the commercial sector to invest in space-based and ground satellite communication infrastructure.

- Attract Foreign Direct Investment (FDI) in space systems development and operations. In this regard, cost-effective skilled human resource should be the main feature for development of a profitable industrial hub in the space domain.

- Purchase space-based services from local commercial entities to fulfill government needs, if required.

- Market and commercialize spin-offs, arising because of R&D in the space domain, for product development that could be marketed in commercial sectors.

- Encourage the local space industry by giving tax incentives; implementing measures for ease of doing business; and implementing Preferential Trade Agreements with international actors for promotion of indigenous space-related products.

- Collaborate with the following ministries for enhancing the profitability and value addition of particular products / services by operationalizing specific

space-based and ground-based systems (Table 2):

Table 2: SUPARCO Ministerial Collaborations

| No. | Name of Ministry | Purpose of Collaboration |
|---|---|---|
| 1 | Ministry of Agriculture | Implementing precision agriculture, monitoring of crop health, and ehancing agriculture yield |
| 2 | Ministry of Tourism | Implementing adequate commniction, search and rescue, safety, and navigation functions to promote tourism<br>Providing modern space-based sevices to tourists |
| 3 | Pakistan Mineral Development Corporation | Employment of space technology in discovery of new minerals, especially in Northern and Western regions |
| 4 | Ministry of Commerce and Industry | Establishment of small and medium scale enterprises in space systems development domain<br>Formulation of regulatory framework to promote employment of indigenous space-related sub-systems and ground systems |
| 5 | Ministry of Information Technology & Telecommunication<br>Frequency Allocation Board<br>Ministry of Defense | Ensuring the operation of only authorized license users<br>-<br>Strict legal actions for unlawful and un-licensed users |
| 6 | Ministry of Law and Justice<br>Ministry of Parliamentary Affairs | Formulation of legal framework |

## National Security Space Guidelines

The Ministry of Defense, in collaboration with SPD and Services Headquarters, shall:

- Ensure availability of space-based systems, ground systems and space services for fulfillment of national security needs, as stipulated by the security agencies of Pakistan.

- Coordinate with SUPARCO for developing a roadmap for indigenous development of critical systems and infrastructure for self-reliance and fulfillment of national security needs.

- Cultivate partnerships with friendly countries and allies for availability of assured services in times of conflict.

- Conduct R&D in areas that are critical for national security.

- Maintain effective liaison with the Joint Staff HQ and respective Service Headquarters to identify their specific requirements in communication, navigation, meteorology, and RS domains; and formulate a comprehensive roadmap for actualization of operations while avoiding duplication of efforts.

- Development of systems, sub-systems, and user terminals with indigenous software, firmware and homegrown technologies for mission assurance and resilience to any intentional interference, disruption, or degradation.

- Maintain close liaison with national think tanks, strategic institutes and academia to evaluate regional threat perception in the space domain for formulation of appropriate strategies.

- Ensure that, when required, all departments and agencies shall collaborate to produce synergistic effects in support of national security needs, at a given time and place.

- Contribute and participate in international efforts towards ensuring safety and integrity of outer space as well as safety of ground systems.

# CONCLUSION & WAY FORWARD

## Conclusion & Way Forward

The space age, in a brief time, has had a profound and lasting impact on every aspect of human life. It has radically transformed commercial, civil, and security sectors. Due to its increasing role in these spheres, activities in the space sector are growing at an exponential rate and increasingly public and private entities are investing heavily in R&D for acquiring next generation capabilities in both civilian as well as military domains. Disposable space systems are being replaced by reusable systems and permanent structures in space.

*Efforts are also underway to establish more enduring operations on the Moon, asteroid mining is being ventured into, and more destructive and disruptive technologies are being deployed for greater control over space. This is resulting in a fierce and intense competition in space, where the major space-faring nations are seeking to shape the environment in space consistent with their national aspirations.*

While the world is progressing towards mastering next generation capabilities and bracing to meet the future challenges of space, Pakistan, despite an early start, is far from making satisfactory progress in this field. This study has highlighted many tangible reasons for such a performance.

*However, the failure of successive governments to accord due priority to this all-important domain, and lack of determined national efforts to ensure successful implementation of Pakistan's space program, are the most prominent.*

It has also been highlighted that for the success of Pakistan's Space Program, it is vital for the national leadership to set goals, develop a credible and competent organizational setup, allocate adequate resources and provide administrative, legal as well as constitutional support. To make this happen, active advocacy, as was available in case of the country's nuclear program, would be crucial.

This study has also brought to fore critical areas where Pakistan needs to concentrate and has highlighted measures which the state needs to adopt for the gainful exploitation of space exploration. The suggested way forward for the success of Pakistan's National Space Program is given below:

***Develop a comprehensive legal framework and establish a competent space organizational setup.***

The foremost requirement to put the national program back on track is to develop a

national space setup consistent with international best practices, duly empowered to develop a domestic regulatory framework; regulate national space activities; ensure coordination between various governmental and non-governmental organizations; and oversee implementation of the national space program.

For Pakistan's national space setup to become internationally accepted and internally effective, it is recommended to be put directly under the Prime Minister through a space commission or a ministerial council. This apex body is recommended to comprise of the Minister of Science and Technology, Minister of Defense, Minister of Foreign Affairs, Minister of Finance, Minister of Defense Production, Minister of Commerce and Industry, Minister of Planning and Development, National Security Advisor, representatives of tri-services, Chairperson National Disaster Management Authority (NDMA), and Chairperson SUPARCO. This body should be responsible for setting national space objectives, formulating legal and policy guidelines (as outlined in the earlier sections of this paper), allocating budget, and overseeing implementation of both civil and military space programs.

For the military space program, the apex body should be linked with SUPARCO through the NCA. While to control and oversee implementation of the civil space program, a space department / space authority under the space commission / ministerial council needs to be created having both regulatory and executive functions. The authority should be broadly mandated to formulate policies and regulations for national space activities and oversee implementation of the national space program on behalf of the apex body. It should also coordinate and collaborate with other departments for synergizing national efforts, provide requisite services, enhance international cooperation, and administer R&D facilities, besides, providing guidelines and setting goals for SUPARCO for the civil space program.

This reorganization of the national space setup can be carried out through an act of Parliament utilizing appropriate constitutional provisions. Since, this is a complex activity, it is recommended that a committee consisting of experts of various fields should be formed to arrive at a logical, comprehensive, and mutually agreed organizational setup for the country's national space program.

### *Formulate a National Space Policy (NSP).*

The suggested policy is an attempt to start an informed and educated debate to arrive at comprehensive, mutually agreed, discussed and practicable elements of a National Space Policy (NSP). Pakistan must develop an all-encompassing

NSP at the earliest to reinvigorate its space program and to ensure its successful implementation.

To formulate the NSP, a committee of experts should be formed at the national level to discuss and deliberate all elements of the policy, and propose comprehensive guidelines, which should be in line with Pakistan's national interests. The policy objectives must not be overambitious rather attainable and then cater for both short-term and long-term measures for all related sectors.

***Institute measures to enhance space-based military capabilities and integrate space-based assets in military war-fighting concepts and doctrine.***

To offset growing strategic imbalance in the region and meet growing demands of evolving warfare, Pakistan needs to develop and integrate space technologies and capabilities into its military war-fighting concepts and doctrine for ISR, missile launch detection, command and control, strategic communications, navigation, and other relevant areas.

Sufficient capabilities exist within the Armed Forces and the defense-related public sector that could be harnessed to achieve considerable progress indigenously in the space sector. These domestic efforts can further be augmented by collaboration with friendly advanced space-faring countries. In this regard, indigenous development of military-specific ground stations and user terminals as well as satellites for specific military purposes (communication, navigation, and ISR) can be undertaken in a phased program. This, besides enhancing the strategic capabilities of Pakistan's Armed Forces, will also guarantee greater freedom during any future military operations.

Pakistan also needs to develop counterspace measures (Cyber, ECMs, ECCMs, and AI) and evolve concepts to deal with the adversary's growing space capabilities.

***Institute measures to increase utilization of civil applications of space for socioeconomic development, better governance, and future planning. Formulate policies to incentivize participation of the private sector in commercial space activities and public-private space ventures.***

For its economic growth and sustainable development, Pakistan needs to utilize the services provided by space technologies for the social uplift of its people. As the majority of Pakistan's population is living in rural areas, space technologies can contribute to the provision of quality education, vocational training, market news, and better healthcare facilities in remote areas. The government can learn

from the idea of 'Village Resource Centers (VRCs)' implemented successfully by India, through which space-based services are directly being provided to villages in cooperation with state and non-state entities. Especially during COVID-19, tele-health and tele-education have emerged as important applications of space-based services.

Pakistan also needs to focus on the utilization of space technologies for commercial purposes. The country can exploit the potential of its huge market and generate a great deal of revenue by facilitating the commercial usage of space services and encouraging private sector investment, especially, in the telecommunications sector. This would, besides generating more economic activities, and creating more employment opportunities will help in cost reduction and sustenance of the space program. To achieve this and to promote PPPs, Pakistan must formulate practical policies and guidelines.

The government must also make all endeavors to integrate space-related services for better governance, efficient day-to-day functioning, sustainable development, and future planning, besides social well-being of its people.

Lastly, to benefit from the reducing costs of satellite manufacturing and launching, as well as other space-related equipment and infrastructure, Pakistan needs to harness local capabilities and synergize national efforts to produce these equipment indigenously or in collaboration with friendly space-faring countries.

***Formulate a comprehensive national space capacity building and human resource development program.***

For the success of Pakistan's national space program, a diverse workforce equipped with prerequisite skills and expertise to perform sustainable multifaceted space-related activities in the civil, commercial, and military domains is extremely essential. Such a force should not only comprise scientists and engineers skilled to manufacture, launch, and operate space systems, but also include experts in other space-related fields like cyber, programming, data analysis, and space operations.

Concurrently, the national cadre of space professionals needs to include academics, policymakers, project managers, legal experts in space law, and business leaders in space commerce for meeting future challenges. Pakistan, therefore, needs to embark upon an all-encompassing national program aimed at enhancing space-related capacity building and human resource development, with the broad aim to achieve self-sustainability.

For developing a national space-related capacity building and human resources development program, a committee comprising of academics and space professionals needs to be formed under a central agency with the mandate of chalking out a strategy with clear objectives, identifying subjects, areas of specialization, critical mass of trained personnel in each area and overseeing implementation.

Identification of public and private academic institutions for conducting customized programs in space-related disciplines will be pivotal in the successful initiation of such a national effort. In this regard, Higher Education Commission of Pakistan, Ministry of Education, and Ministry of Science and Technology will have to be at the forefront to promote inclusion of space-related curriculum in academic institutions.

***Institute measures to strengthen international cooperation and collaboration.***

Space, besides, being considered a soft power tool for influencing and shaping the international environment, and establishing norms of conduct in space, offers ample opportunities for international collaboration. If managed well, international cooperation in space, has the potential to provide tremendous benefits in the shape of cost reduction, efficiency, sustainability, and diplomatic prestige.

For Pakistan, establishing relations and forming alliances in the field of space with friendly space-faring nations is crucial for the sustainability of its space program as well as for its national needs. The government must, therefore, seek to establish relations with friendly countries like China, Turkey, and other space-faring countries for cost-sharing, transfer of technology, and provision of requisite downstream technologies in the space domain.

# ANNEXURE

# List of Abbreviations and Acronyms

| | |
|---|---|
| AI | Artificial Intelligence |
| APSCO | Asia-Pacific Space Cooperation Organization |
| ASAT | Anti-Satellite |
| AU | Air University |
| AWACS | Airborne Warning and Control System |
| BMD | Ballistic Missile Defense |
| C2 | Command and Control |
| CD | Conference on Disarmament |
| COPUOS | Committee on the Peaceful Uses of Outer Space |
| COSPAS | Cosmicheskaya Systyema Poiska Aariynyich Sudov |
| COVID-19 | 2019 Novel Coronavirus |
| CPEC | China-Pakistan Economic Corridor |
| DCS | Defensive Counterspace |
| DEWs | Directed Energy Weapons |
| DMSP | Defense Meteorological Satellite Program |
| DRR | Disaster Risk Reduction |
| DTH | Direct To Home |
| ECCMs | Electronic Counter-Countermeasures |
| ECMs | Electronic Countermeasures |
| FDI | Foreign Direct Investment |
| FDRA | Fiscal Disaster Risk Assessment |
| GAGAN | GPS-aided GEO Augmented Navigation |
| GEO | Geosynchronous Equatorial Orbit |
| GIS | Geographical Information System |
| GLONASS | Global Navigation Satellite System |
| GPS | Global Positioning System |
| GSAT | Geostationary Satellite |
| HQ | Headquarters |
| ICO | Intermediate Circular Orbit |
| ISNET | Inter-Islamic Network on Space Sciences and Technology |

| | |
|---|---|
| ISR | Intelligence, Surveillance, and Reconnaissance |
| LEO | Low Earth Orbit |
| NASA | National Aeronautics and Space Administration |
| NavIC | Navigation with Indian Constellation |
| NCA | National Command Authority |
| NCW | Network-Centric Warfare |
| NSP | National Space Policy |
| NUST | National University of Sciences and Technology |
| OCS | Offensive Counterspace |
| OST | Outer Space Treaty |
| PAEC | Pakistan Atomic Energy Commission |
| PakTES | Pakistan Technology Evaluation Satellite |
| PNT | Positioning, Navigation, and Timing |
| POES | Polar-orbiting Operational Environmental Satellite |
| PRSS | Pakistan Remote Sensing Satellite |
| PTAs | Preferential Trade Agreements |
| RS | Remote Sensing |
| SAR | Search and Rescue |
| SARSAT | Search and Rescue Satellite Aided Tracking System |
| SATCOM | Satellite Communication |
| SDGs | Sustainable Development Goals |
| SRC | Space Research Council |
| SSA | Space Situational Awareness |
| STEM | Science, Technology, Engineering, and Mathematics |
| SUPARCO | Space & Upper Atmosphere Research Commission |
| UET | University of Engineering and Technology |
| UN | United Nations |
| UNCOPUOS | United Nations Committee on the Peaceful Uses of Outer Space |
| UNOOSA | United Nations Office for Outer Space Affairs |

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