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An Analysis Of The Important Of Space Research In The Management Of National Security

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ABSTRACT

Space research plays a crucial role in strengthening national security by enhancing communication, surveillance, navigation, and disaster management capabilities. In India, the evolution of space research since the establishment of the Indian National Committee for Space Research (INCOSPAR) in 1961 and the Indian Space Research Organisation (ISRO) in 1969 has transformed the nation's strategic and defense potential. Indigenous satellites such as INSAT, IRS, and GSAT, along with advanced launch vehicles like PSLV and GSLV, have contributed significantly to defence communication, remote sensing, and border monitoring. Space-based intelligence has improved military readiness, maritime surveillance, and cyber protection. Moreover, space technology supports environmental monitoring and resource management, which are vital for national stability. This paper analyses how India's space achievements ensure technological self-reliance, strategic deterrence, and security preparedness in an increasingly space-dependent global environment.

Keywords: Space Research, National Security, ISRO, Satellite Technology, Strategic Development

Introduction

India's participation in space research started in 1961 when the Indian national Committee for Space Research was set up under the chairmanship of Dr.Vikram Sarbhai. The India Space Programme is directed to the goal of self-reliant use of the Space Science and Technology for National development, its main thrust being- (1) Satellite Communications for Various national use, (2) remote sensing for resources survey and management, environment monitoring and meterological services and (3) development and operationalisation of indigenous satellites and launch vehicles for providing these services. The Indian Space Programme was launched in 1962 when the Indian National Committee for Space Research was formed. To this were added the Indian Space Research Organisation in 1969, and the Department of space promote the unified development and application of Space Science and Technology for Identified National Socio-Economic Objectives.

What is space?

The term space is used to denote the entire universe, i.e. the earth and ites atmosphere, the moon, the sun and the rest of the Solar System with its other planets and their satellites, and all the stars and galaxier spread over the infinite skies.

What is Space Research?

The Space research programme is carried out under an overall control of the Indian Space Research Organisation. Research in the space sciences is based at the Physical Researchh Laboratory with significant research and development being carried out by the space physics Laboratory at VSSC and the Technical Physics Division at SAC. The near –earth environment, upper atmosphere and sun-earth relationship are some of the main areas of interest. Important is also supported in several institutions by the multiagency Indian Middle Atmosphere programme and the Advisory Committee for Space Sciences.

Space Research Centres

Research centres around the country are as follows:
(a) Vikram Sarabhai Space Centre (VSSC)- Trivandrum
(b) Indian Space Research Organisation Satellite Centre (ISAC)-Banglore.
(c) Shar Centre, Sriharikota, Andhra Pradesh.
(d) Space Application Centre (SAC) – Ahmadabad.
(e) Liquid Propulsion System Centre (LPSC) – Banglore, Trivandrum and Mahendragiri
(f) Telementry Tracking and Command Network (ISTRAC)- Banglore.
(g) Development and Educational Communication Unit (DECU)-Ahmedabad.
(h) National Remote Sension Agency (NRSA)-Hydrabad.
(i) Physical Research Laboratory (PRL)- Ahmedabad.

The above-mentioned research centres may be described the following.
(a) Vikram Sarabhai Space Centre (VSSC): It centre is Trivandrum. It was set up in 1963 for development of satellite launch vehicles such as SLV, ASLC, PSLV, and GSLV. The Rohini Sounding Rocket (RSR) Programme Coordinates development, production and launch of the Rohini series of sounding rockets for upper atmospheric and metrological research. VSSC has advance mechanical, chemical, material and electronics facilities to meet the fabrication, simulation and testing needs of the ongoing projects and programmes. An Ammonium perchlorate plant is located in Alwaye, Kerala, VSSC's new extension, the valiamala complex has originated from the major needs of the PSLV. Beyond ASLV and PSLV, the next major step of VSSC will be the development of the geostationary launch vehicles (GSLV) with the cryogenic upper stage to launch the indigenous second generation INSAT –II spacecraft.
(b) ISRO Satellite Centre (ISAC) : The ISRO Satellite Centre is the satellite technology base of the Indian space programme. It is responsible for the implementation of indigenous spacecraft projects for various scientific, technoilogical and applications missions. To this end. The centre has been carrying out design, Fabrication, testing and management of satellite projects and has successfully completed eight spacecraft projects.
(c) Shar Centre: The Shar Centre, Sriharikota, Andhra Pradesh. It is the main operations base of ISRO and runs ISRO's satellite launching range. The Centre includes ISRO 's Range Complex. Static Test and evaluation complex, solid propellant Space Booster plant, Shar Computer Facility, Programme planning and evaluation Group, Shar central Designs, Reliability and Quality Assurance Group and Sriharikota common facilities. IREX comprises the SHAR, launch complex as well as TERLS and Thumba and the Balasore rocket launching Station, STEX and SPROB constitute ISRO's largest static testing and Solid propellant production facilities.
(**d) Space Applications Centre:** It centre is Ahmedabad. It was set up in 1968 for planning and execution of R and D projects of ISRD for the practical application of space technology. The SAC's main areas of activity satellite-based telecommunication and T.V remote sensing for natural resources survey and management, environmental monitoring, meteorology and geodesy. SAC has contributed significantly to the development of application payloads for ISRD's remote sensing and communications spacecraft, the utilization of ground systems and the application techniques for satellite communication and remote sensing.
(e) Liquid Propulsion Systems Centre: It has its facilities at Bangalore, Trivandrum and Mahendragiri. It is responsible for the development of liquid and cryogenic propulsion Systems for launch vehicles and satellites. The IPSC is equipped with precision and special fabrication, integration and test facilities. The test facilities for testing liquid propellant rocket engines are located at Mahendragiri in Tamil Nadu.
(f) Telemetry Tracking and Command Network: It centre is Bangalore. It has stations at Sriharikota, Trivandrum, Bangalore, Lucknow and Car Nicobar to provide Tracking, Telementry, and command support for ISRO missions.
(g) Development and Educational Communication Unit: It centre is Ahmedabad, in close cooperation with Doordarshan/Ministry of Information and Broadcasting is responsible for the production of development and educational TV programmes, related research and training especially in support of INSAT services.
(h) National Remote Sensing Agency: It centre is at Hyderabad, and autonomous registered society, utilizes modern remote sensing technique for assistance in the planning and management of the country's natural resources and provides operational support to various uses. NRSA has equipment for surveying. Identifying, classifying and monitoring several types of earth resources. The main centre is located at Balangar and the satellite earth station in the Shahnagar complex. The Indian institute of Remote sensing (IIrs) Dehradun, is a part of NRSA and is the main training centre in the country for remote sensing and aerial photo interpretation techniques and courses.
(g) Physical Research Laboratory: Ahmedabad is the centre for research in space and allied sciences. The main research programmes are in solar planetary physics, infrared astronomy, geocosmophysics, theoretical physics including climatology, plasma physics and laboratory astrophysics, archaeology and hydrology. PRL also manages Udaipur solar observatory.

Space Applications

The thrust of the Indian Space programme has been to develop skills and capabilities to design and build satellites and satellites launch vehicles; to define areas of application such as telecommunication, broadcasting and remote sensing, and to design and fabricate instrumentation for such applications, and to commission and utilize operational applications systems to ensure the benefits of space science and technology for the socio-economic development of the Nation.

India's Space Missions

(a) Aryabhata: INDIA's first satellite, fabricated by ISRO, Bangalore. The Satellite was Aryabhata, Quasi-spherical in the space with 26 flat faces, having a diameter of 1.6 metres and a height of 1.2 metres. It was powered by Silicon Solar Cell arrays and Nickel Cadmium Batteries. Its temperature was adjusted by passive thermal control. The Satellite was spin stabilized. The Satellite was taken to the Soviet Union and tested again to ensure that it can ride an Inter cosmos rocket. It was launched on April 19, 1975 into a near earth circular orbit of 594 km altitude, at an inclination of 50.40 to the equator. It orbited the earth once every 96.41 minutes. Thousands of commands were sent successfully to the satellite. They all worked exception one area.

(**b) Bhaskara I:** It was encouraged by the success of the first satellite, ISRO drew up a mere ambitious design for the second. It was aimed at utilization of satellite technology for development. Accordingly, it was decided that the satellite would carry remote sensing sensors which would detect and assess natural resources from space. It took nearly four years to develop. It was launched by the Soviet Union. It went into orbit on June 7, 1979. The Satellite weighed 444 kg with a diameter of 1.55 m and height of 1.18 m. the 26 faced, Quasi-spherical satellite had two television cameras and three microwave radiometers for the remote sensing mission. It was named Bhaskara, after a leading Indian Astronomer of the sixth century and another eminent mathematician of the twelfth century. Bhaskara was more Sophisticated than Aryabhata. The Satellites T.V. Camera operated and the entire country was covered thrice.

(c) Bhaskara II: Bhaskara I was fabricated based on the lessons learnt from the first remote sensing mission. Power distribution systems concerning T.V. were, made fool-proof. Indigenous thermal coating, solar cells and panels continued to find a place. The satellite was launched on 20 November 1981, by the Soviet Union. Ground stations at Sriharikota and Ahmedabad handled the reception of data and control. It attained the planned near-earth orbit of about 525 km with an inclination of 50.7°. Its spin axis was brought perpendicular to the orbit plane to facilitate the development of T.V. camera. The infrared horizon sensor, magnetometers and a sun sensor functioned normally.

(d) Rohini Satellite: The Soviet Union was offering its facilities for launching Indian Satellites, ISRO was developing a satellite that could be orbited by an Indian rocket. The result of the effort was Rohini satellite (RS-1). It was the first Indian Satellite launched from Indian Soil by an Indian rocket. It was boosted by the second experimental SLV-3 in 1980. Its main object was to monitor the fourth stage performance of the launcher. The performance of the 35 kg satellite exceeded expectations. It was launched into a slightly higher orbit than predicted. It was placed in an elliptical orbit of 325 km by 950 km with a period of 97 minutes instead of the planned 276 km by 472 km. ground stations in Trivandrum, Sriharikota, Car Nicobar and Fiji received good signals. Telemetry data from it were processed by computer systems in Sriharikota and its orbited parameters were predicted.

Even as Rohini-I went into orbit, work began on Rohini –II at the ISRO satellite centre, Bangalore. The second satellite was launched in the first development mission of SLV-3 of 31 May 1981. The 42 kg satellite was designed to have spin axis orientation manoeuvres. Designed to be in orbit for 300 days, it went into orbit 12 minutes and 30 seconds after lift-off. The satellite carried a new remote sensing device called landmark sensor. RS-D2 on the successful SLV-3 mission in April 1983 carried a two-band imaging system called the SMART sensor, which could identify and carried land features. A new series of Rohini satellite, viz, stretched Rohini satellite series (SROSS) covering selected scientific application payloads for launch by the ASLV has been planned. However, the ASLV mission has so far not been successful. In march 1987 and again in July 1988, the Augmented satellite launch vehicle failed. As such the SROSS satellite could not be put into orbit.

(e) Ariane Passenger Payload Experiment (APPLE) : APPLE was launched on June 19, 1981 by the European space Agency-APPLE has been used successfully to conduct experiments in communications relating to domestic communication, radio networking, data relay, remote area communication , etc. APPLE had two c-band transponders. APPLE gave ISRO experience not only in building a 3-axis stabilized geostationary satellite, but also in orbit raising and geostationary satellite, but also in orbit raising and geostationary elements were developed indigenously for the satellite.

(f) India's Remote Sensing Satellite: IRS -1A was launched from the Soviet Union in March 1988. The tenth satellite to be put into space by India, it systems and subsystems were designed and fabricated indigenously. India is the first developing nation and became the fifth nation after USA, USSR, France and Japan to have accomplished remote sensing of the earth's resources from space.

(g) National Natural Resources Management System (NNRMS): The NNRMS from its headquarter in Bangalore. It has three major component- (i) application projects –(ii) infrastructure and manpower development, and –(iii) establishing a National Natural Resources Information System. The applications project will be in major resources Information System. The applications project will be in major resource sectors such as agriculture, land use, water resources, forestry, geology, marine resources and environment. Major contributions in the disciplines of soil, vegetable mapping and mineral targeting will be made from the National Bureau of Soil Survey and land use planning, forest survey of India and Geological Survey of India respectively.

Indian National Satellite System (INSAT)

The INSAT system is a multipurpose operational satellite for domestic long-distance telecommunication, earth observation, and nation-wide radio and television broadcasting. Under INSAT series, the following launches have taken place.

(a) INSAT-1A: INSAT-1A built for the Indian space Research organization by the Ford Aerospace corporation of the USA and launched by US National Aeronautics and Space Administration from Cape Canaveral on April 10, 1982, was the first of the first generation Indian National Satellites, which combined the service of telecommunication, meteorology, TV relay and radio broadcasting. The satellite, which was parked 37,000km out in space over Indonesia, ended its life prematurely on September 6, 1982, within five months of its launch and thus, gave a severe setback of India's programme.

(b) INSAT-1B: It was launched on August 30, 1983 from Cape Canaveral in Florida and became the third Asian Nation to have its own multipurpose communication satellite. It completed its design its life on seven years on August 30, 1990.

(c) ISAT- 1C: The third in INSAT series, it was fabricated in USA and was launched on July 22 ,1988 by the European space Agency from Kourou in French Guiana. It was designed for a life span of ten years. However, it developed certain electrical snags and was declared unusable in November 1989.

(d) INSAT -1D: It was brought from the USA and the fourth and last in the series, was successfully launched from Cape Canaveral on June 12, 1990. It is operating at its full capacity and is expected to be usable till 1996.

INSAT-2 SERIES

The INSAT-2 series satellites are more sophisticated and improved various of their predecessors belonging to INSAT-1 series. INSAT-2 has 50 percent higher capabilities and better resolution for meteorological imaging as well as additional payload for search and rescue operations. The INSAT-1 series had complicated multi-axial deployment system for the solar panels while the INSAT -2 has a simpler system with T-shaped arrays consisting of three full panels and two half ones unfolding like an accordation, a technique successfully used in IRS satellites.

A) INSAT -2A: India's first home made, second generation communication satellite, INSAT-2A, was launched by the European space Agency Ariane-4, from Kourou in French Guiana on July 10,1992. It was positioned in its specified slot in the geostationary orbit, 36000km above the Indian Ocean, South of Trivandrum and became fully operational in August 1992. It is equipped with transponders that give it 50% more capacity than the INSAT-1 series. It is likely to help India reduce her dependence on the leased satellite ARABSAT for TV operations, on which the country was spending Rs. 2 crore of foreign exchange every year.

B) INSAT-2B: The second Indian made multipurpose satellite INSAT-2B blasted off into the space on July 23, 1993 by the Ariance launch vehicle from Kourou, French Guyana in South America, and later successfully injected in to geosynchronous Transfer Orbit. INSAT-2B carries 18 c-band transponders including six in –extended c-band; 2 high power s-band transponders, a very high-resolution radiometer for meteorological imaging, a data relay transponder and search and rescue pay land.

It was the fourth Indian satellite to be launched from Kourou. INSAT-2B is the 18th satellite to be launched by ISRO. The Kourou launch started with APPLE in 1991. The other three vehicles are INSAT-1C, 2A and 2B-India's space programme is basically peace-oriented with the launch of INSAT-2B, the country is poised for a total communication. The INSAT-2B, has tremendous capacity and 50 percent more than the previous satellite.

Launch Vehicle Technology

Following are the launch vehicle Technologies:

(a) Satellite Launch Vehicles (SLV-3)
(b) Augmented Satellite Launch Vehicles (ASLV)
(c) POLAR Satellite Launch Vehicles (PSLV)
(d) Geostationary Launch Vehicle (GSLV)
(e) IGMDP and Prithvi
(f) Agni
(g) Agni test flights

(a) Satellite Launch Vehicles SIV -: The developmental flight of Indian's first satellite launch vehicle, SLV-3 , took place on May 31, 1981 from SHAR Centre at Sriharikota . It placed a 38 kg Rohini (RS-D2) satellite into a near earth orbit. However, the orbital life of the satellite ended prematurely after 30 days. Rohini-2 (RS-D2) a 41.5 kg satellite was launched by SLV-3 on April 17, 1983, which completed the planned development of SLV-3. The next two launched of SLV-3 took place in 1981 and 1983. The 2207-meter-long SLV -3 was four stage solid propellant vehicles with a launch weight of 17 tones. The first two stages used 15 CDV6 steel for their casing, and the last two had bodies made from fiberglass. The equipment bag seated on top of the third stage contained inertial guidance systems to steer the vehicle along a predetermined trajectory, and the electronics for telemetry, telecom and tracking. Altitude control of the vehicle was achieved using Secondary injection Thrust Vector Control System (RCS) for the second stage. The SLV -3 programme was terminated after four flight.

(b) Augmented Satellite Launch Vehicle (ASLV): The Augmented Satellite Launch Vehicle (ASLV) is designed to place a 150kg satellite (SROSS) into a 100 km orbit. This constitutes an addition of two first stage

rocket motors as strap-one to the sides of the SLV-3 first stage. The heat shield, which protects the satellite from the heat generated as the vehicle speeds through the dense atmosphere, has been made large to accommodate the large spacecraft. The ASLV is a five-stage rocket using solid propellant in all of them and it is different from the earlier SLV-3 in using closed loop scheme for the second and third stages. It is also augmented in the sense that it has a 150 kg payload, almost thrice the payload of SLV-3.
The first developmental flight on ASLV took place on 24 March 1987. But the vehicle could not put the SROSS-1 satellite in to orbit because of a malfunction in first stage motor of the launch vehicle. However, it validated a number of new technology elements relation to the launch vehicle, spacecraft, launch complex ground stations. India's second attempt at deploying a satellite in pace on the augmented Satellite: Launch Vehicle. (ASLV-2) failed on July 13, 1988 as the rocket fell into Bay of Bengal after a 150 second Flight. The ASLV-D2 served to re-assert the success of the strap on booster motor technology in rocket launching.
(c) Polar Satellite Launch Vehicle: ASLV was the forerunner of the more powerful Polar Satellite Launch Vehicle, PSLV designed and fabricated at the VSSC Thiruvananthapuram. The polar satellite launch vehicles (PSLV) is India's third generation launch vehicle being developed in place 1000 kg class operational remote sensing satellites into a sun –synchronous polar orbit. The PSLV will have five stages. The first stage has a diameter of 2-8 m and carries 125 tons of solid propellant. This is flanked on the sides by six strap-on boosters derived from the SLV -3 first stage. The second stage is liquid engine using 37.5 tons of liquid propellants. Control is achieved by gambling of the engine and hot gas thrusters. The third stage uses solid propellant and has a flexible nozzle for attitude control. The fourth stage uses two liquid engines. A large complex has been established at Valiamala for developing and testing PSLV elements.
(d) Geostationary Launch Vehicle (GSLV): The Geostationary Launch Vehicle (GSLV) which is intended for heavy satellite (upto 2500 kg). India's plan for the near future is to be able to develop indigenous capability to launch INSAT type satellites into the geostationary satellite launch vehicle (GSLV). This would include the design and development of a cryogenic rocket engine using liquid hydrogen and liquid oxygen as propellants.
(e) IGMDP and Prithvi: The task of the IGMDP was to develop four missiles-2 sams. ATGM and one SSM. The Prithvi SSM was a denovo project for ATGM. It was not based on any existing model of a missile. The Prithivi missiles is a single system powered by twin liquid propellant engines. The Prithivi is not a nuclear delivery system. This provides the missile with the ability of "tailored" trajectory instead of the purely ballistic one followed by the older missiles like SCUD. The Prithivi system features pre-programming capability to provide six alternative paths to a target, thereby making it much more difficult to be defeated by anti-missile systems like the patriots. There are the two types of conventional warheads which have been tested for the prithivi, the high-explosive and pre-fragmented monolith types. There are plans to test the cluster-type as well. The Prithivi has been essentially seen as a battlefield missile to be integrated into the artillery arm of the Army and quite similar to the US ATACMS.
The Prithivi has been involved in the AGNI project, Prithivi forms the second stage of the AGNI.
(f) The AGNI: the military implications of the SLV -3 programme were not as obvious as they appear as firs sight. At no stage was there any intention of converting the SLV-3 into a missile Guided missile Board decided that a system capable of testing a full scale payload be used, with the ability to lift a 1000 kg payload into space to achieve re-entry velocity of about3 km per second for this a multi- stage system was conceived using the SLV-3 's first stage , a 10 m long, 9 tone, m diameter system as the test-bed for providing technologies for long range missiles. This was the AGNI "experimental" programme. The first stage or S-I an average thrust or 50 tonnes for a Buru duration of 50 seconds. It has two control systems, the Secondary thrust Vector Controls (STVC)and Hydraulic Fin Tip Control (HFTC) Agni-I was 14 tonnes in weight and 19 m long. Agni-II was 21m long with a 16-tone take-off weight and Agni –III was 19 tonnes in weight and 21 m, long. All three have had the average diameter of 1m.
(g) AGNI TEST FLIGHT: Three test flights of the Agni have taken place. The first test flight occurred on May 21,1989 and its objective were to establish re-entry vehicle design and technology, control, navigation and guidance for long –range, missiles. The second- stage burn was 50 secs. The second test of the Agni on May 29,1992 was a failure, caused by the trivial error of not changing the location of the sensors when the vehicle itself was elongated by 2 metres. The third test on February 19, 1994, therefore, combined the missions of Agni –II which were to established manoeuvring re-entry technology and longer range. The additional 5 tons of weight presumably in terms of the additional fuel in S-2 which had a longer burn phase of 100 secs. Some other modifications were also carried out as a result of the analysis of the Agni-II failure. The success of the third test therefore, confirmed these changes as well as met the key mission objective: terminal manoeuvring during re-entry. At the end of the originally sanctioned three test flight, the government has announced that the "technology demonstrations" was over the decision had to be taken as to the next stage. Agni is only a technology demonstration; hence it is not being inducted into the armed forces.

Conclusion

Space activities carried out during the last two decades have reached a stage were investments made in Research and Development are beginning to fructify in terms of the ability to establish national operational space services for meeting the objectives laid down. The main thrust in the Seventh Plan will be to make the satellite-based domestic, broadcasting, communications, and remote sensing operational, based on indigenous satellite and launch systems. Significant progress will be made in interlocking the various segments of the national Space effort, by completing the linking between the launch vehicles, space craft, application and utilization programmes. Reducing external dependence and rapid development of Indian launch vehicles for operational satellites are integral to these objectives. Concomitant organizational and structural changes would be implemented.

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