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# SPACE TECHNOLOGY FOR NATIONAL SECURITY

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## Introduction

The afternoon of 13 March 2016 saw the successful insertion into its planned orbit of the satellite, Indian Regional Navigation Satellite System -1F (IRNSS-1F), by the thirty third consecutive successful mission of the Polar Satellite Launch Vehicle Commercial-32 (PSLV C-32) - the Indian Space Research Organisation's (ISRO's) workhorse PSLV rocket[1]. This was the PSLV's thirty second commercial mission hence named PSLV-C32[2]. The initial experimental test launches of ISRO's rockets carry mission numbers prefixed by 'E', for instance SLV E-1 while development missions are prefixed with a 'D', for instance PSLV D-2 and commercial missions carry the prefix 'C' for the mission number. With this successful launch two important capabilities were demonstrated by ISRO. Firstly, the PSLV has once again proven its reliability and high precision launch capabilities. Secondly, ISRO has moved a step closer to completion of the full planned constellation of IRNSS satellites. The seventh and last satellite of the IRNSS system is planned to be launched during April 2016[3]. These events have a bearing on the country's overall power and capabilities and require analysis.

## Capability Progression and Future Technology Development

India's space program commenced with formation of Indian National Committee for Space Research (INCOSPAR) in the early 1960s and later in the same decade with the formation of ISRO[4]. Initially, the organisation experimented with imported sounding rockets of French and US origin. In the 1970s, in an effort to better exploit space technology for national development, ISRO ventured into satellite design and manufacture. Early satellites such as Aryabhata, which was launched by the USSR from Baikonur aboard a Soviet launch vehicle, Ariane Passenger Payload Experiment (APPLE), carried aloft on the European Space Agency's (ESA's) Ariane launch rocket, were the country's early experimental satellites[5]. After achieving a level of confidence in satellite design and exploitation ISRO proceeded to work towards plugging the launch technology gap in the country. The Satellite Launch Vehicle (SLV) launched with a measure of success in 1979, 1981 and 1983 led on to the Augmented Satellite Launch Vehicle (ASLV) and then to the Polar Satellite Launch Vehicle (PSLV). The SLV was capable of placing mere 40 kg class payloads into Low Earth Orbit (LEO)[6]. The ASLV launched between 1987 and 1992 served to prove technologies that could be utilised in later launch vehicles. The ASLV was able to place payloads weighing up to 150 kg into LEO or 400 km circular orbits[7]. The ASLV essentially comprised a SLV core mated with booster rockets arranged around its base to give higher thrust. The ASLV also featured solid propellants in all stages[8]. The PSLV that was used to launch the IRNSS-1F satellite has emerged as one of the most reliable launchers in the world. It can carry payloads weighing 1,750 kg to sun synchronous polar orbit (SSPO), 1,450 kg to geostationary transfer orbit (GTO) and has been used to place satellites in geosynchronous orbit (such as the IRNSS satellites), and geostationary orbit. PSLV comprises a solid fuel core[9]. In its enhanced versions such as the PSLV-G and PSLV-XL up to six solid fuelled strap-on rockets are attached around its first stage to boost thrust. A PSLV-XL rocket was used to launch India's Mars Orbiter Mission (MOM) in 2014[10]. ISRO is testing and developing its Geostationary Satellite Launch Vehicle (GSLV) in its Mk-I, Mk-II and Mk-III variants to boost the individual payload lift capability to above four tons per launch. At present India still requires to purchase launch facilities on foreign rockets for its heavier satellites[11]. Heavy lift launch capability will also be needed for the proposed manned space flight phase of space exploration by India. The GSLV incorporates high thrust cryogenic engine technology. ISRO is also developing a launcher called LVM-3 to lift up to 4,000 kg payloads to GTO and 8,000 kg to LEO[12].

The progress and achievements of ISRO are commendable and have given the country a leading position in space technology development and exploitation for national development. India is today self-sufficient in satellite technology and launch technology. The country also has a wealth of experience in utilisation of space technology for national development and myriad uses for human development. These range from mapping of parameters required for agriculture, to education, communication, etc.[13] Unlike most other countries India has advanced its space program entirely for civil human development purposes. Military applications are limited to utilisation of a few transponders aboard satellites for communication and access to some imagery from ISRO's remote sensing (IRS) satellites. Starting out with resolutions of a few meters the later ISRO optical earth observation satellites, cartographic satellite (CARTOSAT) and Technology Experimental Satellite (TES) have achieved sub-metric resolution. ISRO has also moved on to value added services. The Global Positioning System (GPS) Aided Geo Augmented Navigation (GAGAN) system has been developed and operationalised by ISRO. GAGAN aims to improve the accuracy of GPS signals through implementation of a satellite aided regional differential GPS system for all, especially commercial users, over the Indian landmass. However, it suffers from the drawback of relying upon foreign owned and operated GPS navigational signals[14]. Such signals are open to degradation and / or denial by the system operator (s). In order to overcome this deficiency ISRO has initiated the IRNSS program. This program envisages coverage over a swath of 40 degrees by 40 degrees in latitude and longitude, which would enable full coverage of Indian territory and about 1500 km beyond India's borders and coastlines. Such coverage should suffice for India's needs. IRNSS uses a unique configuration to achieve the desired system with a mere seven satellites of which the last is expected to be launched in April 2016. With this system becoming fully operational later this year, India would achieve strategic independence in accurate satellite based navigation for all uses – from military to commercial[15]. IRNSS coverage can be extended when required through adding satellites adjacent to the initial constellation centered over India.

**Analysis of ISRO's Current Development Programs**

A few issues related to access to space, however, remain. Launch rockets are a mature technology but suffer from the drawback of taking a long time to manufacture and a long time to prepare for launch due to limited speed of fuelling with volatile rocket fuels. Being single use items they are also relatively expensive. The national interest may require short notice launch of satellites to deal with several different contingencies. Such situations with the current technology require satellites of various types pre-fabricated and prepared for launch, including being mated to launch rockets that have also been fabricated in advance and at least partially fuelled to reduce launch lead time. Despite all such measures a rocket launch still would take several days from being ordered till lift off. Such a situation would lead to a lack of strategic and tactical flexibility in the country's ability to fully exploit space technology to achieve national security goals.

ISRO has been working on a reusable launch vehicle for some time now. News reports indicate that the assembly of ISRO's Reusable Launch Vehicle Technology Demonstrator (RLV-TD) is nearing completion and tests are being carried out on the vehicle. A test launch is possible around mid-May 2016[16].

Such a launch vehicle is likely to utilise a combination of rocket engines and supersonic combustion ramjet (Scramjet) engines. A rocket engine would initially boost the vehicle to very high supersonic speeds of around Mach 3 to Mach 4. At this stage the compression required for a scramjet to operate would be achieved and the scramjet - that uses atmospheric oxygen, hence providing lower weight of the basic vehicle— would enable carrying higher useful payloads. A scramjet carries only fuel and no oxygen / oxidiser unlike a rocket engine that needs to carry both fuel and an oxidiser. The scramjet phase would boost the vehicle to very high speeds into the upper atmosphere close to or past the Karman line[17]. The payload carried aboard could now be injected into orbit. In cases where very high altitudes are required to be reached, the vehicle could carry the payload mated to another smaller rocket engine which would now ignite to take the payload to altitudes beyond the scramjet's capability. Its mission carried out, the vehicle would now glide back to earth to either land like an aircraft or be recovered through use of parachutes or ditching into the sea. The vehicle could now be prepared for reuse thus saving considerable cost. Such technology, in addition to cost saving, could also provide quicker access to space when needed as full fabrication of a complete launch vehicle would not be required for each launch. A fleet of even four or five such RLVs could provide the flexibility needed by the country to face different contingencies effectively.

Indications are that in the near future India could achieve considerable progress in operationalising reliable and quick response space access capabilities. Such a development would provide a big boost for the country's strategic autonomy and capability to protect the national interest.

**Conclusion**

ISRO has, since its formation in the 1960s, made considerable progress in development of satellite technology and space launch rocket technology. Having achieved self-sufficiency in satellite technology, ISRO has moved on to refining its value offerings from its satellites. Alongside, it has also developed a robust national space launch capability. Having established the PSLV as a reliable and proven workhorse it is now working on enhancing its heavy lift capability. In parallel, ISRO has also been working on development of reusable launch vehicle technology and hopes to demonstrate its first reusable launch vehicle in May 2016. These developments point towards a considerable enhancement of India's scientific and technological base and the ability to exploit space technology for national development and security.

***(Disclaimer: The views and opinions expressed in this article are those of the author and do not necessarily reflect the position of the Centre for Air Power Studies [CAPS])***

**Notes**

[1] Spacedaily.com, "ISRO launches PSLV C32, India's sixth navigation satellite", http://www.spacedaily.com/reports/ISRO_launches_PSLV_C32_Indias_sixth_navigation_satellite_999.html, accessed on March 14, 2016.

[2] Ibid.

[3] Lisa Jani, "ISRO for Improving National Space Programme", http://www.oneindia.com/feature/isro-improving-national-space-programme-2037890.html, accessed on March 16, 2016.

[4] Isro.gov.in "ISRO timeline", http://www.isro.gov.in/about-isro/isros-timeline-1960s-to-today#73, accessed on March 20, 2016.

[5] Isro.gov.in, "ISRO Missions", http://www.isro.gov.in/, accessed on March 21, 2016.

[6] Isro.gov.in, "SLV", http://www.isro.gov.in/launchers/slv, accessed on March 21, 2016.

[7] Isro.gov.in, "ASLV", http://www.isro.gov.in/launchers/aslv, accessed on March 21, 2016.

[8] Ibid.

[9] Isro.gov.in, "PSLV", http://www.isro.gov.in/launchers/pslv, accessed on March 21, 2016.

[10] Ibid.

[11] isro.gov.in, "Geosynchronous Satellite Launch Vehicle (GSLV)", http://www.isro.gov.in/launchers/gslv, accessed on March 22, 2016.

[12] Isro.gov.in, "LVM-3", http://www.isro.gov.in/launchers/lvm3, accessed on March 26, 2016.

[13] Isro.gov.in, "Applications", http://www.isro.gov.in/applications, accessed on March 22, 2016.

*[14] Isro.gov.in, "A step towards initial Satellite based Navigation Services in India: GAGAN & IRNSS", http://www.isro.gov.in/applications/step-towards-initial-satellite-based-navigation-services-india-gagan-irnss, accessed on March 26, 2016.*

[15] Ibid.

[16] PTI, "ISRO plans technology demonstration of Reusable Launch Vehicle mission by mid-May", http://indianexpress.com/article/technology/science/isro-plans-technology-demonstration-of-reusable-launch-vehicle-mission-by-mid-may/, accessed on March 28, 2016.

[17] The Karman line is the universally accepted line separating the atmosphere from space and lies at about 100 kilometers above sea level. Universetoday.com, "How High is Space", http://www.universetoday.com/25410/how-far-is-space/, accessed on March 28, 2016.