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Diversification of the Indian space programme in the past decade: Perspectives on implications and challenges

Narayan Prasad Nagendra

Dhruva Space, #258, 12th Main, AGs Layout, Arehally, Subramanyapura PO, Bangalore, 560061, Karnataka, India

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ABSTRACT

From the humble beginnings of the sounding rocket programme at the Thumba Equatorial Rocket Launching Station (TERLS) in the early sixties the Indian space programme has come a long way to realise independent capabilities in space, launch and ground segment to provide various civilian applications and services to the country. In the past decade, the activities of the Indian Space Research Organisation have witnessed a substantial rise which reflects on the number of missions as well as the budget of the space agency. The present work explores the diversification of the Indian space programme in the past decade with a detailed study on the capabilities and technologies realised with the sustained support of the Government of India into the space programme. Perspectives on the implications (for diplomacy, security and private industry) of the success achieved in the space programme alongside the challenges that may be faced in policy with the rising expectation for various services by different stakeholders within the country have been discussed.

1. Introduction

India has been investing in space activities starting from the early 60's with a fundamental goal of delivering space based service benefits to its citizens. With this as a baseline, programmes such as the Indian Remote Sensing (IRS) and Indian National Satellite System (INSAT) have evolved over a period of time to provide services such as remote sensing and Earth Observation (EO) from Low Earth Orbit (LEO) and telecommunication services (telephony, television, internet, etc.) from Geosynchronous Earth Orbit (GEO). India has developed capabilities of transportation of satellites to LEO and GEO with a vision of self-reliance in timely, cost effective delivery of services. Similarly, a ground network of several nodes for data gathering has been setup under various collaborative mechanisms to establish a global chain of command and control for its space assets. With these in place, the Indian space programme has witnessed significant scaling up activities in outer space over the past decade. These include achieving many first's in outer space capabilities in space, launch and ground segment capabilities.

The present work presents a detailed overview of the sustained progress made in India's space programme with an analysis of budget spending over the past three five-year plans allocated to the Indian Space Research Organisation. The diversification of the space programme and near term outlook on several planned missions are presented considering the interest of exploiting space for scientific exploration, remote sensing, navigation, defence, telecommunications. Based on this foundation, perspectives on implications for diplomacy and space based security as well as and challenges to develop a globally relevant space industry have been presented to provide insights on carrying forward the capacity built in the Indian space programme beyond societal applications.

Table 1 provides a list of Indian Space Research Organisation's (ISRO) significant missions achieved as first's in the history of outer space activities in India. It is important to note that ISRO has not only made strides in successfully orbiting satellites around Moon and Mars in its first attempt, but has significantly created resources to support such missions. These include developing heavy lift launch vehicles such as the Geosynchronous Satellite Launch Vehicle (GSLV) (which successfully demonstrated the working of an indigenous cryogenic upper stage), installation of India's first Deep Space Network (DSN) with a 32 m dish antenna, all of which are critical in supporting the continuation of such efforts from the country. ISRO's efforts are not only significant in development of technology and infrastructure for planetary and interplanetary missions, but are also stretching in developing human resources with a focus on creating thrust for the development of space science and technology in the country. To this end, ISRO is probably

E-mail address: narayanprasad@dhruvaspace.com.

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Table 1
India's major accomplishments in the last decade.

Timeline	Mission	Remarks
5-May-05	CARTOSAT-1	First satellite in a series of high-resolution panchromatic imagery satellites with high pointing accuracies [1]
22-Jan-07	SRE-1	In-orbit on-board experiments, re-entry and recovery [2]
23-Apr-07	PSLV C8	Antrix Corporation's first fully commercial launch [3]
14-Sep-07	IIST	Indian Institute of Space Science and Technology (IIST) is Asia's first space institute with specific focus to space science, technology and applications [4]
25-Nov-07	Deep space network	Installation of the 32-m dish antenna [5]
8-Nov-08	Chandrayaan-1	Spacecraft captured into orbit around the Moon [6]
14-Nov-08		Moon Impact Probe (MIP) placed on Lunar surface [7]
24-Sep-09		Traces of water found on Moon [8]
26-Apr-12	RISAT-1	Indigenously built SAR satellite added to EO fleet [9]
1-Jul-13	IRNSS-1A	First satellite in a series of seven navigation satellites [10]
30-Aug-13	GSAT-7	Advanced multi-band communication satellite dedicated for military use [11]
1-Dec-13	Mars Orbiter Mission	Heliocentric cruise injection successful [12]
5-Jan-14	GSLV D5	Indigenous cryogenic engine flown successfully [13]
24-Sep-14	Mars Orbiter Mission	Spacecraft captured by Mars's gravity [14]
19-Dec-14	GSLV Mk-III X	Flight demonstration of first two stages of heavy lift vehicle & successful Crew Module Atmospheric Re-entry Experiment (CARE) re-entry [15]
27-Aug-15	GSAT 6	Successful deployment of S-Band Unfurlable Antenna of 6 m diameter [16]
28-Sep-15	Astrosat	India's first dedicated multi wavelength space observatory [17]

the first major space agency to create a flagship institute (Indian Institute of Space Science and Technology) with undergraduate, postgraduate and doctoral programmes focussed on space science and technology.

These sustained efforts within national space activities have created several pockets for international cooperation and collaboration at several bilateral and multilateral levels. Some of the examples include flying of scientific payloads on scientific exploratory missions such as the Chandrayaan, extending cooperation with support to flagship programmes under Asia Pacific Regional Space Association Forum (APRSAF), extending support to leverage India's space assets on bilateral basis (e.g. India-Brazil IRS data augmentation agreement of 2014). Hence, the diversity of space activities alongside the successes in space for ISRO and India have potentially created several ripple effects which include a case for increased participation of the private space industry in national activities, utilisation of outer space for national security, utilisation of advances in space activities as an instrument of foreign policy, building towards human space flight among others.

2. Reflection of budget and performance of Indian space activities

One of the fundamental aspects in the assessment of scaling up activities in outer space by India is in considering the increase in budgets and the number of missions taken up by ISRO. It is important to note that ISRO considers launch vehicle and satellite building as separate missions. Typically, ISRO conducted 10–13 missions in each of the 8th, 9th and 10th plan periods [18]. However, due to the ISRO taking up scientific exploration, high resolution imaging missions and development of navigation systems, the Indian space programme has witnessed a 'doubling effect' in its missions and budgets over the past two Five year plans. Fig. 1 provides insights into the budgetary increase that the Indian space programme has witnessed over the past 10 years. ISRO's budget during the 10th Five-year plan was INR 12,165 Crores (US$1.87b, assuming US$1 = 65) with a total of 20 missions (13 satellite and 7 launch vehicles) [19]. The latest Five-year plan between 2012 and 2017 has seen a budgetary increase for ISRO to INR 39,750 (US$6.11b) Crores with 58 planned missions (33 satellites and 25 launch vehicles) [20].

Fig. 2 provides a comparison of the space expenditure against the growth of the GDP of the country. India invested about 0.092%

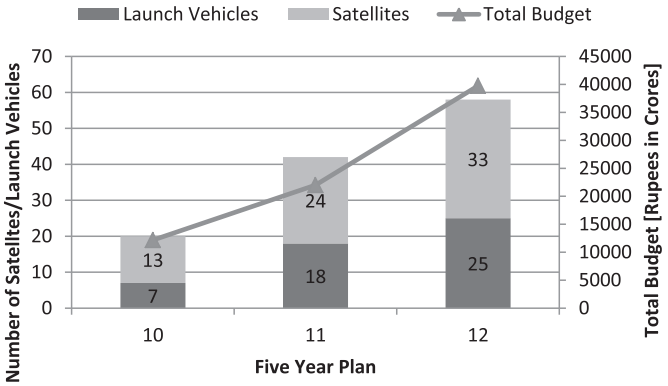

Fig. 1. Increase of ISRO budgets over five year plans.

of its GDP in space activities in 2002 and in the most recent figures (2013) indicate about 0.064% of GDP invested in space activities. The combined average of 2002–2013 is about 0.08% of GDP [21]. Although India has witnessed a budgetary increase for its space activities, it is important to note that the overall budget allocated towards space activities is less than a decade ago (as a percentage of GDP). These are indicators of strong economic growth that allow the expansion of space activities, while these activities support the economic progress of the nation. Fig. 3 provides insights on the annual growth of the Indian space activities against the global industry. While the global space industry has been expanding at an average of 8.6% within the period 2003–2013 [22,23] the Indian budgetary allocation in the same period is estimated to be growing at an average of 9.74%, marking the emergence of Indian space activities in a larger fashion within the past decade. The Indian space programme also witnessed larger international commercial gains with the profits of ISRO's commercial wing Antrix Corporation's profits increasing in the period. Within 2003–2013, Antrix's profits have witnessed an average growth of 16.3% [24,25]. These are mainly backed by the success of the PSLV, the satellite launching workhorse of ISRO alongside some of the commercial returns via remote sensing imagery and transponder capacity. With the growing national space activities, ISRO's vendor development and industrial policy that has systematically developed several Small and Medium Scale Enterprises (SMEs) contributing in the success of ISRO's mission have witnessed a growth of about 6% in the period