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Indian space transportation programme: Near term outlook and issues for commercialisation

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ABSTRACT

The Indian space transportation programme has grown from strength to strength with the launching of sounding rockets in the 60's to the development of heavy lift vehicles for telecommunication satellites in the present decade. With the growing market confidence in Indian Space Research Organisation's ability to reliably deliver payloads to low Earth orbit with its Polar Satellite Launch Vehicle, there is an inherent opportunity for India to cater to the commercial market. The present work assesses the current launch capacity of India in retrospect of international launches and provides India's outlook for the space transportation in the current decade. Launch capacity correlation with the requirements within the Indian space programme as well as the current space transportation infrastructure have been considered to identify bottlenecks in catering to the current national requirements alongside securing a greater market share in the international launch market. The state of commercialisation of launch vehicle development has been presented to provide an overview of policy and organisational issues for commercialisation of space transportation in India.

1. Introduction

India's modern rocketry programme was initiated with a humble beginning in using operational sounding rockets known as the Rohini sounding rockets for space science experiments. India's launch vehicles have now grown up through several phases of development, over a span of three decades from Satellite Launch Vehicle (SLV-3) and Augmented Satellite Launch Vehicle (ASLV) to the current Polar Satellite Launch Vehicle (PSLV) and Geosynchronous Satellite Launch Vehicle (GSLV). The current inventory of the Indian space transportation programme consists of advanced rockets such as the operational PSLV and the developmental GSLV, which have enabled the Indian Space Research Organisation (ISRO) to achieve the capabilities to launch its satellite fleet for remote sensing, navigation, communication, science and security missions. Table 1 provides a record of launch events of the PSLV and GLSV by India. The PSLV has been the workhorse of ISRO and maintains a track record of 26 consecutive successful flights as of June 2014 [1]. Based on the type of payload, it is currently being flown in three versions namely, the PSLV-C (4 stage PSLV-C Core with 6xS-9 strap-on booster), PSLV-CA (4 stage PSLV-C Core Alone) and the PSLV-XL (4 Stage PSLV-C core with 6xS-12 strap-on boosters) [2]. The PSLV has undergone various transitions such as improvement of payload capability to 1600 kg to Sun Synchronous Polar Orbit (SSPO), development of a dual launch adaptor (for launching two 500–600 kg payloads), implementation of Vikram 1601 processor with floating point capability and adopting an advanced inertial navigation system built with ring laser gyros [3]. With such technological improvements the PSLV has achieved a reliability of 96.29% (26 out of 27 flights successful) and is a proof of India's technological advancement in the

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Table 1
Launch Vehicle Record for Indian Launchers.

Variant	Payload capability [kg]	Number of launches	Launch pad		Success rate				Commercial launches	
			First	Second	Success	Partial success	Failure	Success [%] (including partial)	Primary	Secondary
PSLV-C	1600 to SSPO	11	10	1	9	1	1	90.91	0	4
PSLV-CA	1110 to SSPO	10	7	3	10	0	0	100.00	4	5
PSLV-XL	1140 to SSPO	6	4	2	6	0	0	100.00	0	0
Mk I(a)	2000–2500 to GTO	2	2	0	1	0	1	50.00	0	0
Mk I(b)		3	1	2	1	1	1	66.67	0	0
Mk I(c)		1	0	1	0	0	1	0.00	0	0
Mk II		2	0	2	1	0	1	50.00	0	0
Mk III	4000 to GTO	Under development								

development of reliable space transportation systems to deliver payloads to the Low Earth Orbit (LEO).

While the PSLV has achieved a successful operational incubation into the Indian launch vehicle programme, it has a limited payload capacity and cannot be used to deliver communications satellites of 2-ton class to Geo-Synchronous Transfer Orbit (GTO). Hence, India embarked on the development of the GLSV in the early 90's. India had entered into an agreement with the Soviets to gain the technology know-how in developing cryogenic engines (KVD-1) along with initial supply of engines for developmental flights. However, due to the US fears of trickling of technology from the civilian programme to the ballistic missile programme, there was a blockade of this technology transfer to India quoting the Missile Technology Control Regime (MTCR). Eventually India had to settle for a supply of 6 engines without technology transfer which sparked the development of an indigenous cryogenic engine [4]. While a programme for the development of an indigenous cryogenic engine was underway, the cryogenic engines supplied by Russia were put to use with limited success (50% reliability). In 2010, India test flew its indigenous cryogenic upper stage and failed to achieve success. The same was the case with a Russian engine in the same year. Following a four-year rigorous testing and troubleshooting, India was able to achieve success with its indigenous cryogenic upper stage on January 5, 2014. The GSLV D5 mission placed the 1982 kg GSAT-14 in an accurate orbit [5]. The GSLV Mk-II will still need at least two more successful flights to gain launch vehicle user confidence in the global launch market.

ISRO is currently developing the GSLV Mk-III, a launch vehicle that is to carry payloads of 4500–5000 kg class into GTO [6]. The experimental flight of GSLV Mk-III is under consideration to be flown in October 2014. The payload for the mission is a crew module, which is the core of a future Human Spaceflight Programme (HSP). The HSP will enable a couple of astronauts to fly close to Earth for a few days. The test aims for the recovery of a dummy crew module from sea [7]. The experimental flight shall validate the flight versions of solid stages (S200), liquid stage (L110) and a passive cryogenic stage (C25) and will provide a leeway for the testing of an operational cryogenic stage, currently planned in 2016–2017 timeframe [8]. The development of the GSLV Mk-III launch vehicle is also an extremely important step towards the augmentation of the capacity of the Indian space programme to launch 4-tonne class communication satellites to GTO and thereby significantly reducing the demand-supply gap of transponders in the country [9].

Following the development and operationalization of the GSLV Mk-III, the Indian space transportation programme is set to embark on the development of Reusable Launch Vehicles (RLV). ISRO has a continuous programme in the development of the semi cryogenic engine, which is to power the future heavy lift Unified Launch Vehicles (ULV) and RLV of India. A roadmap is drawn to develop technologies for the semi cryogenic engine, which includes realisation of a combination of cryogenic as well as earth storable propellants, developing a thrust of 2000 kN for the booster engine of the common liquid core of ULV. The engine is to be realised and qualified over a span of 6 years, with first four dedicated to subsystem development and the remaining two years for the development and qualification of the engine [10]. Further, there is a roadmap to develop Single Stage to Orbit (SSTO) with air breathing propulsion system and the Two Stage to Orbit (TSTO) with air breathing system, which is intended to substantially reduce the launch costs [11].

2. Launch capacity and home requirements

Worldwide orbital launch capability is limited to a select number of countries, which also includes India. Over the past three years, India has had a launch capacity of a maximum of three launches a year. The PSLV has remained the workhorse of ISRO and has been the only reliable launch vehicle over the past decade for India. Table 2 provides an overview of the worldwide launch capacities for the past three years [12]. The number of launch events conducted by India in contrast with world leader in number of launches is almost a tenth in number. In order to attract more foreign clients as well as to keep up the pace of orbital space transportation for home grown requirements in India, there is a need to increase a number of launches per year.

India currently has two launch pads located at the Satish Dhawan Space Centre, Sriharikota, out of which all flights including the PSLV, GSLV and their variants are flown out of [13]. ISRO is currently contemplating building a third launch pad at Sriharikota for future missions including the GSLV Mk-III. A Rs. 500 Cr initial investment has been made for the launch