 

IAC-14.E3.2.7

# FUTURE INDIAN SPACE - RENEWING POLICY DIMENSIONS

Main Author: Dr. Mukund Kadursrinivas Rao
National Institute of Advanced Studies (NIAS), India, mukund.k.rao@gmail.com

Prof. Sridhara Murthi K. R.
National Institute of Advanced Studies (NIAS), India, krsmurthy09@gmail.com

Dr. V S Ramamurthy
National Institute of Advanced Studies (NIAS), India, vsramamurthy@nias.iisc.ernet.in

## ABSTRACT

Indian space activities have made tremendous progress in the past 50 years with successful programmes of Indian communication satellites in INSAT; Indian EO satellites in IRS and Indian launch vehicles in the PSLV and GSLV. India has also had a mission to Moon - Chandrayaan-1; a mission on-way to Mars and the IRNSS. Successful foray into global markets have also been achieved. In the 12th Five Year Plan (2012-2017), Indian is planning for 58 missions with an investment of almost 6 B USD (at 2013 rates).

Today, Indian Space Programme is at a cusp with the need for a LONG TERM STRATEGY FOR SPACE – basically creating a roadmap that will look 30-50 years ahead and address several key questions in the public domain. Indian space needs to orient for a quantum jump in technological growth, adopt organisational models and collaborative strategies that will ensure economic efficiency and position a vibrant private sector. Important questions are being raised on the public and national consequences for Indian human space-flight and planetary exploration programme; how India must quest for a larger share and role in global space market; strategies to deal with changing political and economic environments and focused imperatives of international cooperation.

National Institute of Advanced Studies (NIAS) in India has undertaken a suo-moto study for assessing Indian Space endeavour and addressing design of a futuristic Indian Space Policy. NIAS has studied the past 40 years of Indian space with an in-depth analysis of the evolving eco-system, unique performance dimensions of the achievements and critical gaps. A careful analysis of the existing policies - SATCOM policy and RSDP has also been carried out. The Indian Space industry sector and their present role but immense potentials has also been assessed.

Looking ahead, NIAS argues the case for the a comprehensive "Indian Space Policy" which addresses the long-term strategy of Indian space – public goal of space as a national capability building; a national commitment to provide operational space service in the country; a good regulatory regime that promotes the Indian Space enterprise; enabling a vibrant and equitable eco-system of government-private sector partnership; systems to undertake advanced technology development; public and national commitment for human space-flight and planetary exploration mission investments; performance and social audits of space exploration activities etc.

The paper discuses salient aspects of the NIAS study and outline key highlights and strong argument for a comprehensive Indian Space Policy.

## I. BACKGROUND

Outer Space has been a source of curiosity and inspiration for human kind since time immemorial. Since the launch of Sputnik, more than 50 years ago, the roles and meaning of space for humanity had been widely diversifying. What started as a competition for military superiority between the two super powers then is transformed today into multi-dimensional endeavours of large number of actors, both from the governments and private sector, impacting the social, economic, and scientific and security dimensions of global human society. Space has become a part of daily life for a majority of the citizens of the globe.

National Institute of Advanced Studies (NIAS) has undertaken a "suo-moto" policy-analysis study for assessing Indian Space achievements and also for addressing future aspects of Indian Space Policy. In doing so, NIAS has studied the following elements:

- studied the global space sector and seen the models of space implementation in US, Europe, Japan and other nations.
- analysed the past 40 years of space programme with an in-depth eco-system and performance-analysis to bring out the unique dimension of the achievements of Indian Space.
- careful analysis of the "official" policy instruments – SATCOM policy, Remote Sensing Data Policy (RSDP) and their performance
- finally builds the case for the a comprehensive "Indian Space Policy" - addressing the long-term strategy of Indian space.

## II. OVERVIEW OF SPACE POLICY ASSESSMENT

As part of this study, we have attempted to make an assessment of global space policy efforts and what some of the other nations have been doing on Space Policy – mainly to gain an in-sight to space policy and to help in the context of future Indian space.

USA

US announced a renewed National Space Policy in 2010[1] which replaced the Policy of August, 2006. The 2010 Space Policy called for "Leading Collaborative, Responsible, and Constructive Use of Space" and included committing to many long-standing tenets in space activities; calling on all nations to share its commitment to act responsibly in space to help prevent mishaps, misperceptions, and mistrust; engaging in expanded international cooperation in space activities; committing to a robust and competitive industrial base; recognizing the need for stability in the space environment; advancing a bold new approach to space exploration; committing to the use of space systems in support of its national and homeland security; utilizing space systems, and the information and applications derived from those systems, to study, monitor, and support responses to global climate change and natural disasters.

In 2012, NASA also began to rebuild the advanced space technology program in the agency with plans laid out in 14 draft technology roadmaps[2] - Launch Propulsion Systems; In-Space Propulsion Systems; Space Power and Energy Storage; Robotics, Tele-Robotics and Autonomous Systems; Communication and Navigation Systems; Human Health, Life Support and Habitation Systems; Human Exploration Destination Systems; Science Instruments, Observatories and Sensor Systems; Entry, Descent and Landing; Nanotechnology; Modeling, Simulation, Information Technology and Processing; Materials, Structures, Mechanical Systems and Manufacturing; Ground and Launch Systems Processing and Thermal Management Systems. The US National Research Council (NRC)[3] considered the 14 draft technology roadmaps and provided specific guidance and recommendations on how the effectiveness of the technology development program can be enhanced in the face of scarce resources.

US also renewed its Space Transportation Policy[4] in November 2013 - replacing the 2004 U.S. Space Transportation Policy, The goals defined are to maintain America's competitiveness in the aerospace sector by developing "space transportation capabilities that are innovative, reliable, efficient, competitive, and affordable, and that support U.S. interests". The key provisions are providing support the US aerospace industry; strengthen the US economy and create high-quality jobs; encourage partnerships with private industry to put U.S. government instruments on non-governmental spacecraft; reaffirm the importance of assuring U.S. access to space; continue progress in support of the bi-partisan plan for space exploration; foster cooperation with industry on guidelines for the development and expansion of the U.S. commercial human spaceflight market.

In December 2004, renewed its U.S. Global Positioning System Policy[5] and specified the goal is to ensure the United States maintains space-based PNT services, augmentation, back-up, and service denial capabilities. The key provisions are 'no direct user fees for civil space-based PNT services; open, free access to information necessary to develop and build equipment Performance improvements for U.S. space-based PNT services; promotion of GPS standards; International compatibility and interoperability for end-user benefit; protection of radio-navigation spectrum from disruption and interference; Recognition of national and

[1] http://www.whitehouse.gov/sites/default/files/national_space_policy_6-28-10.pdf

[2] http://www.nasa.gov/offices/oct/home/roadmaps/#.VAE8AfmSySp

[3] National Research Council. NASA Space Technology Roadmaps and Priorities: Restoring NASA's Technological Edge and Paving the Way for a New Era in Space. Washington, DC: The National Academies Press, 2012.

[4] http://www.nasa.gov/sites/default/files/files/national_space_transportation_policy_11212013.pdf

[5] http://www.gps.gov/policy/docs/2004

international security issues and protection against hostile use; establishment of high-level national management structure (Departments of Defense and Transportation) and for NASA to develop requirements for use of GPS and augmentations to support civil space systems'.

The Civilian Remote Sensing policy was recast in 2003[6] with a goal "to advance and protect U.S. national security and foreign policy interests by maintaining the nation's leadership in remote sensing space activities, and by sustaining and enhancing the U.S. remote sensing industry. Doing so will also foster economic growth, contribute to environmental stewardship, and enable scientific and technological excellence". Towards this, the US Policy states that US will rely to the maximum practical extent on U.S. commercial remote sensing space capabilities for filling imagery and geospatial needs; focus U.S. Government remote sensing space systems on meeting needs that can not be effectively, affordably, and reliably satisfied by commercial providers; develop a long-term. sustainable relationship between the U.S. Government and the U.S. commercial remote sensing space industry; provide a timely and responsive regulatory environment for licensing the operations and exports of commercial remote sensing space systems and enable U.S. industry to compete successfully as a provider of remote sensing space capabilities for foreign governments and foreign commercial users, while ensuring appropriate measures are implemented to protect national security and foreign policy

The US shift to privatisation and larger industry involvement has been very apparent in recent 5-8 years. One has seen emergence of private industry taking on total space-system projects and bringing in private investment into space projects in USA. Some of the many such initiatives are from Virgin Galactic - Space Ship 2 – dual fuselage aircraft; Orbital Sciences - Antares rocket, Cygnus cargo vehicle, launch abort system for Orion capsule; Bigelow Aerospace - Inflatable, resilient space habitat – BEAM for NASA; Blue Origin - 9-engined rocket pod, Commercial Crew Development , Launch Escape System (LES); Lockheed Martin/Boeing and ULA - Orion crew capsule for Space Launch System, CST-100, core stage for Space Launch System; Sierra Nevada Space - Dream Chaser commercial crew vehicle; Space-X - SpaceX Falcon 9 rocket, uncrewed spacecraft to the ISS and many others.

**In our analysis, post-2010, US has brought about a major shift in its space activities – first, renewing its space policy with a leadership goal in space; second, drawing up a long-term roadmap vision for national space and shifting space activities into private sector in a major way.**

Japan

Japan space activities are governed by Basic Space law of 2008 – which clearly states that Japan's national policy on space development and utilization is to be addressed as part of its national strategy in relation to other strategic priorities, such as industrial development, foreign affairs and national security, and science and technology[7].

Under the Basic Space law, the New Basic Plan on Space Policy (2013)[8] identifies two fundamental goals - expanding Space Utilization to create new services and products for improving the quality of everyday life on the earth, such as weather forecasting, communication/broadcasting, and navigation etc. (space systems as social infrastructure) and space technology to offer effective measures for disaster management and national security by ensuring the capability of autonomous space activities, maintain and advance technological capabilities for space activities and enhance international competitiveness of Japan's space industry. Thus, Japan's its space programmes include four social infrastructures for expanding the utilization of space and ensuring autonomy - Positioning Satellites, Remote Sensing Satellites, Communications/Broadcasting Satellites and Launch Vehicle System; three programs for pursuing of the development and utilization of space in future - Space Science Program, Human Space Activity Program and Space Solar Power Program and also announced eight cross measures to promote the strategic development and utilization of space.

**In our analysis, Japan has emphasised the social character of space that it would pursue; to use space for international cooperation and advance Japan's technological and industrial capabilities improving competitiveness.**

[6] http:// www.whitehouse.gov/files/documents/ostp/press_release_files/fact_sheet_commercial_remote_sensing_policy_april_25_2003.pdf

[7] http://global.jaxa.jp/article/special/michibiki/kunitomo_e.html

[8] Space Policy & Governance in Japan - Hideaki Shiroyama, The University of Tokyo. Presentation made at NIAS, Bangalore at NIAS-Univ. Of Tokyo Roundtable Meeting on Regional Space Policy held on August 14, 2014.

China

China also announced its 5-year Space Plan in 2011[9]. The plan outlines China's space vision and specifies the following:

- build a stronger space transportation system, improving its launch vehicle series and enhance capabilities of entering space
- build a space infrastructure frame and develop a long-term, sustained and stable service capability through new-generation GEO meteorological satellites, stereo mapping satellites, radar satellites for environment and disaster monitoring, electromagnetic monitoring test satellites and other new-type EO satellites; improved satellites for fixed communications services, television and radio service satellites and data relay satellites and satellites for mobile communication service; develop "three-step" - experimental to regional to global (Beidou) satellite navigation system and develop Hard X-ray Modulation Telescope satellite, new technology test satellite and returnable satellites
- Develop human spaceflight projects as a foundation for future human spaceflight - launch the Shenzhou-9 and Shenzhou-10 spaceships; unmanned/manned rendezvous and docking with in-orbit Tiangong-1 vehicle; launch space laboratories, manned spaceship and space freighters - astronauts' medium-term stay, regenerative life support and propellant refuelling and technological preparations for the construction of space station and conduct studies on the plan for a human lunar landing - orbiting, landing and returning samples
- enhance the reliability and automation level of launch sites, strengthen the capability of launch and satisfy the national launch demands
- improve space TT&C network, build deep-space TT&C stations
- improve satellite applications and service system, expand satellites application scope, and promote the national new strategic industries - receiving, processing, distributing and applying satellite data and strengthen the applications of communications and broadcasting satellites in public service and major industries of the national economy.
- strengthen development of and quality of space science research and enhance popularization of space science knowledge
- strengthen space debris monitoring and mitigation - for spacecraft protection
- formulate policies and measures - making comprehensive plans for and prudently arrange space activities; strengthening innovation capability in space science and technology; vigorously promoting development of the satellite application industry; strengthening basic capability in space science, technology and industry; strengthening legislative work; guaranteeing sustainable and steady financial investments for space activities; Strengthening training of professionals for the space industry and encourage organizations and CITIZENS to participate in space-related activities
- Develop international exchanges and cooperation - support UN activities for peaceful use of outer space; emphasizing regional space cooperation in the Asia-Pacific ; reinforcing space cooperation with developing countries and appropriately use both domestic and foreign markets and both types of resources

**In our analysis, the 5-year ambitious plan covers the total spectrum related to space activities and lays stress on technology development, applications of space, space exploration and space-station, space policy-making, space for international cooperation and involving citizens in space activities.**

It is to be noted that the China Space Plan is silent on aspects related to space commercialisation and privatisation of space. Acquiring strategic capabilities seem to be the focus.

Other nations

As part of our study, we have also made an assessment of space policies in Russia, Canada, Malaysia, Europe and other nations.

Observations from the policy assessments

In our over-arching assessment of space policies, we find some common tenets related to space that find expression across space policies of many nations. Nations see the instrumental roles of space as:

- Emphasis of nations' right-to-access space
- National pride
- Technological capability-building
- Meeting national development needs
- Enhancing scientific knowledge
- Leadership
- Innovation in technology
- Industrial strength
- Explore and reach-out
- Commerce and business

[9] http://news.xinhuanet.com/english/china/2011-12/29/c_131333479.htm

- Sustainable applications – climate, disaster, natural resources, and other areas
- International cooperation
- Space habitation, planetary exploration, data
- National security
- Debris management
- International peace and security

As we study the developments, space will be more and more a part of daily life for a majority of the citizens of the globe and thus space activities will continue to be multi-dimensional endeavours of large number of actors - both from the governments and private sector and impacting the social, economic, and scientific and security dimensions of global human society. Space systems will be a part of critical infrastructures both at national and international levels. Diverse roles of space as mentined above will expand to address the new challenges of the world and in assisting sustainable development strategies.

At the same time, scientific research from space and probes into deep space and planetary bodies will greatly expand understanding of the origins of our universe, solar system and our home planet itself. As envisaged by several thought leaders, venturing into other planets and space-objects will not be a choice but an imperative of long term survival, and it is not for mere satiation of our innate spirit of adventure or natural drive for exploration but it is to discharge a basic responsibility that we owe to our species.

In summary, global space scene indicates that space is at the heart of strategic decision making in the most advanced and rapidly transforming space faring nations; that it is a critical capability for advancing growing number of services that form backbone of economic growth, good governance and meeting societal needs; it is an important resource for security and defense; a driver of enriching research; an effective tool for monitoring environment and managing natural resources; a powerful instrument of forging international relations and a catalyst for invigorating technological progress and growth of high technology industry.

We also see that most space policy exercises seem to recognize the importance to look far-ahead and forward and to obtain external inputs from "think-tank" organisations – the justification could be that external agencies can undertake and spell-out multi-dimensional issues related to space in a critical manner – which then becomes critical input to governments to consider.

## III. INDIAN SPACE PROGRAMME – PAST 40 YEARS

Indian space activities originated from purely scientific interests of a large scientific community in 1960s with the sounding rocket launch experiments. The early space efforts owe much to the vision given by Dr. Vikram Sarabhai - "……to be second to none in the application of advanced technologies to the real problems of man and society". This extraordinary vision was based on realism and pragmatism and with deep insights into the then socio economic context of the country. Soon, by late 1960s, India had accreted a programmatic concept of basic experiments on the technology and user-development front to found a "end-to-end" systems concept that was very critical for space systems. The mantra of self-reliance that Dr Sarabhai gave became the life current that enabled space program to overcome numerous challenges in learning and experimenting with new technologies.

From a policy analysis, the Indian space program evolution can be broadly categorized under three distinct phases:

- The proof of concept demonstrations of the use of the vantage point of Space for addressing the country's developmental needs and these were exemplified by the Satellite Instructional Television Experiment (SITE), the Satellite Telecommunications Experimental Project (STEP), and use of Landsat satellite data for natural resource management applications. The space segment was procured with international cooperation. By early 1970s, India was on its way to develop its first satellite – Aryabhata and started the "grand plan" of an indigenous end-to-end space technology development capability.
- The experimental phase saw the development of an end-to-end experience in the realization of space systems - experimental earth observation satellites like Bhaskara I and Bhaskara II; India's first experimental geostationary satellite APPLE and the initial space launch vehicles such as SLV-3 and ASLV characterise this phase. It facilitated competence building at the core level. Thus, by late 1970s and in 1980s, India invested considerably in building laboratories and facilities and also initiated a 3-pronged programme – Indian communication satellites in INSAT; Indian EO satellites in IRS and Indian launch vehicle programme through the Polar and Geo-synchronous launch vehicles.
- The operational phase was then taken up with an understanding of and analyzing the complex interplay of - evaluation of alternate approaches to arrive at the most optimal solutions; decide on

exercising buy or build options parallel indigenous development plan to achieve self-reliance goals. This phase resulted in establishment of National Systems such as (i) Indian National Satellites (INSATs) / GSATs for communications, broadcasting and weather observations (ii) Indian Remote Sensing Satellite Series and (iii) Polar satellite Launch Vehicle, PSLV - all examples of operational space systems that have to meet stringent operational service performance criteria.

By early 2000, India had achieved a technological maturity of space systems and utilisation and this challenged it to envision missions to far-away Moon and thus came about Chandrayaan-1 – which originally started (in 2000) from a simple question "Can we go to the Moon?". Soon by 2002, India also started planning for its own Positioning Satellites systems in Indian Regional Navigational Satellite System (IRNSS).

Yet another aspect that emerged in mid 1990s and early 2000s was forays of Indian space products into the global market place – through Antrix Corporation which marketed Indian space capabilities globally and thereby capitalizing revenue models for Indian space. Most of the developments and manufacturing were organised into various units of about 16000 strong Indian Space Research Organisation (ISRO) with contract-mode industry-interfaces – which helped in the overall development process for ISRO.

Towards 2010s, India had challenges to comprehend because of failures of GSLV – even as PSLV emerged as a reliable launch vehicle for 2t class spacecraft and the work-horse for ISRO. But the successive failures of GSLV have posed tremendous challenges which are being systematically overcome in recent times. Yet another challenge that faced India was the gap in satellite communication transponders that started stifling the service segment of DTH, social broadcasting, data communications – and more so in terms of slowing down technology development in newer areas (like Ka-band and large class satellites etc).

In 2011, ISRO took upon a new challenge of a foray to Mars in the 2013 orbit-window for Mars. The Mars Orbiter Mission (MOM) was successfully launched in November, 2013 and has already completed more than 90% of its traverse to Mars as we write this paper. Soon, on September 24, 2014, MOM is envisaged to enter Mars orbit and starts its experiments of imaging and measurements. But more significantly, MOM would establish the fact that India can successfully undertake long-duration planetary missions and would have gained the basis experience in this regard.

Thus, one can see that over the past 50 years, India has made significant progress in space technology – achieving projects, missions, programmes and developing new applications.

## ANALYSIS OF SATCOM POLICY AND REMOTE SENSING DATA POLICY

Towards end of 1990s, India had a mature satellite communications programme through its INSAT system and a remote sensing satellite through its IRS. Much of the space development and utilisation was pushed by ISRO with a visionary drive that envisaged a foundation of national-anchoring for Indian space but a growth in commercial and privatisation activities – for it was envisaged that it would be just impossible for ISRO to take up efforts to meet the growing demands that would emanate from 2000s and ahead. Thus, ISRO took up considerable think-tank activities to have a 2-pronged strategy of protecting national space interests and at same time preparing for large-scale commercial demands.

It was during these times that the Satellite Communication (Satcom) Policy was taken up and adopted by Indian government in 1999 and the Remote Sensing Data Policy (RSDP) was taken up and adopted by Indian government in 2001.

### Satcom Policy[10]

The SATCOM Policy was adopted by India in 1999 but its evolution started from 1997 time-frame. The Satcom Policy-1999 was based on then technical developments in satellite technology as well as in the associated/alternate communications technologies and the aim was to develop a vibrant satellite communications regime for India that catered to national and commercial needs.

The main goals of the Satcom Policy-1999 were as follows:

- build national capabilities in satellite communications by way of a healthy and thriving communications satellite, ground equipment and satellite communications service industry AND sustained utilisation of Indian space capabilities - satellites, launch vehicles and ground equipment design
- Make available INSAT systems for social-applications development and ensuring that INSAT

[10] Satellite Communications (SATCOM) Policy, 1999 (http://www.isro.org/news/pdf/satcom-policy.pdf)

system benefits a larger segment of the economy and population
- Encourage and promote privatisation of satellite communications in India by way of encouraging private sector investment in space industry and also attracting foreign investments

Some of the innovative aspects of the Satcom policy-1999 were to change the paradigm at that time and included:

- authorizing capacity of Indian National satellites (INSAT) to be leased to non-government (Indian and foreign) parties on commercial terms. This was essential so that commercial services could ride on INSAT – envisaged to spur the DTH and VSAT market in India to a large extent.
- allow Indian parties to provide services including TV up-linking through Indian satellites – thereby to open up a variety of TV channels in India.
- co-ordinate and register satellite systems and networks by and for Indian private parties. The intent was clearly stated but this has not happened till 2014.
- satellites for government use to be made available by Department Of Space. However, there have been severe shortages in transponders available from DOS for social applications and thus impacting educational satellite services, tele-medicine services through satellites, state development communications and e-governance services. gap in demand-supply – growing demand for satellite capacity is a challenge
- DTH preference on Indian Satellite Systems
- The operations from Indian soil using foreign satellites under certain conditions

It was envisaged in 1999 that Satcom Policy would ultimately bring great benefit to India by way of big boost for DTH business, Vsat services, robust connectivity for education outreach across the country, reliable telemedicine connectivity, increased capacity leasing and a great growth in Indian ground equipment manufacturing. It was also envisaged that ultimately the Satcom policy-1999 should help position JVs for communication satellite ventures and also bring in a variety of new value-added services,

The corner stone of the SATCOM Policy[11] was the preference to be given to Indian Satellite Systems (ISS) while giving service licenses – thereby ensuring "protective cover" for INSAT for Indian services against any "market on-slaught" from global commercial systems. However, the pragmatism of the Satcom Policy is that it does not in any way prohibit the use of foreign satellite systems – which, after a due process, can be treated on par with ISS for service licensing in India. This has not happened – mainly due to deficiencies of appropriate procedures in implementation and subsequent emergence of canalisation of lease of foreign satellite capacity through DOS nominated agency – which has brought bureaucratic impacts.

The Satcom policy is silent on orbit-spectrum situation for Indian interests – which anyway is coordinated by ISRO and DOT. There is also a problem that there are not many such slots available globally for acquisition. Unfortunately, even as of 2014, additional orbit-spectrum resources for expansion of much needed infrastructure are eluding solution .

Remote Sensing Data Policy[12]

The Remote Sensing Data Policy (RSDP) defines the Indian regulations for acquisition, dissemination of satellite images in India - earlier, RSDP-2001 and now RSDP-2011[13] governs how satellite images are to be acquired and distributed – allowing upto 1m images to be openly dissemination to users. The RSDP embeds the concept of "regulation" to address the dissemination for 1m images.

Thus, the RSDP-2001 provided the earliest "framework" for a comprehensive imaging policy – for the first time remote sensing was identified as a "public good" and the concept of national commitment to continued imaging programme through IRS was included. The RSDP introduced the concept of "one-window" access to any image (Indian or foreign satellite) - which today appears to be against "free market" concept. Another concept that RSDP-2001 started was of "regulatory use-determination" (mainly to stave off the hard-block of private sector access to 5.8m images "could become a security concern") whereby images upto 5.8m would be "available on non-discriminatory basis" but images better than 5.8m would be "regulated" for private sector users on case-by-case

[11] K. Narayanan (2014). SATCOM Policy Review: Preliminary Views. Private Communications received by NIAS in May, 2014

[12] Mukund Rao and K R Sridhara Murthi, Perspectives for a National GI Policy, (Report R 11 - 2012) National Institute of Advanced Studies, Bangalore, September, 2012. Report No: R11-2012. (www.nias.res.in/docs/R11-2012-GI-Policy.pdf)

[13] RSDP (2011), Remote Sensing Data Policy, 2011 from http://www.isro.org/news/pdf/RSDP-2011.pdf

basis. The RSDP-2001 carried yet another major aspect – images would be screened to obliterate some geographic regions (then called Vital Areas/Vital points) so that such "map-erasing" methods also are applied to images. The RSDP also required foreign satellite images TO BE routed through the national agency – National Remote Sensing Centre (then Agency), NRSC.

It is clear that in RSDP-2001 was adopted when Indian imaging corresponded to 5.8m and the availability of Indian 2.5m or 1m was in still in "planning stage" – while 1m images from IKONOS, in 2000, made way into the image market, including in India. Thus, even though the RSDP clearly emanated from the competitive challenge of US 1m images against the Indian 5.8m IRS system in the Indian market – it was certainly a protective regime for IRS till it could also match with commercial 1m image availability from IRS systems (which happened only in 2006).

But there was a major path-way crafted in RSDP-2001 in the concept of "licensing" RS satellites and RS data acquisition/distribution in India – creating that "window-opening" for future Indian private RS satellites and Indian private agencies to acquire/distribute any satellite images in India. Such privatisation was envisaged even way back in late 1990s and was embedded into RSDP-2001. However, till 2014 no such licensing application has been encouraged and NRSC has continued to be the single "monopolistic" data provider. However, of late market-talk indicates few private players considering licensing applications for acquiring or distributing foreign satellite images in India – though the stage of private Indian RS satellites is still far away.

By 2005-06, India also launched 2.5m and 1m images but by then the larger proliferation of 1m images from US commercial satellites had also happened. Thus, the 5.8m thresh-hold of RSDP-2001 as "regime for non-discriminatory access" was found detrimental to Indian cause/users and was soon rendered irrelevant. Therefore, in RSDP-2011 a lower bar for "non-discriminatory access" to 1m was promulgated – but then fully retaining all other aspects of RSDP-2001.

The impact of RSDP has not been quite as envisaged – neither did the "protective regime" in early 2000s help stave the challenge of foreign 1m images because US 1m images became widely popular as against 5.8m/2.5m images and very limited 1m images from IRS systems; NOR did it help develop and position Indian private RS systems for satellites and distribution. With NRSC the "sole agency" for distributing images, it has become further monopolistic as it adopts IRS-centricity and pushes 2.5m and limited 1m images – thereby denying Indian users 0.3m level images for national development. At the same time, Indian is unable to match the resolution quality of US commercial systems (that have reached 0.3m level in global market) and has plans for a 0.5m imaging IRS in 2017 time-frame.

## INDIAN SPACE ACHIEVEMENT METRICS

India does not have a formal National Space Policy that has been legislated or formalised into a public-domain document. Indian space is still guided by Vikram Sarabhai vision of "……applications to the real problems of man and society" – which still serves as a national space policy tenet and has been guiding the developments over past 44 years. The programmatic definitions of Indian Space are made in the Five Year Plans of the Indian Government.

As of 2014, here are some metrics of the past 40 years and over the past 8 Five Year Plans (1974-2017):

- A cumulative budget of about INR 80.4 billion has been allocated by Indian government but actual utilisation has been INR 490 billion.
- Approval for 200 missions has been accorded by Indian government but 125 missions have been accomplished - out of which 111 missions have been successful.
- Independent access to space through a reliable and operational PSLV launch vehicle and a proven pre-operational Geostationary launch vehicle, GSLV incorporating an indigenously developed cryogenic upper stage
- World class satellite capability that cover a wide variety of applications satellites – INSAT, IRS and IRNSS for telecommunications, broadcasting, weather observations, remote sensing and navigation and scientific spacecraft including orbiters to the Moon and Mars.
- Wide use of INSAT communications systems have resulted in the wide outreach of TV signals (from early 1980s onwards) to almost whole of the country and growth of large-scale DTH and VSAT data communication business.
- The availability of low-priced and easily available IRS images (from about 20 IRS missions) and a great thrust to use of images and geographical information techniques proliferated IRS data into

many governance and national building activities – by way of inventory and maps of natural resources, critical support to disaster management activities and environmental monitoring.

- Weather and ocean services modelling have derived a great boost from the availability of INSAT and Oceansat images/data on a variety of ocean and atmospheric data – thus consolidating the scientific services of meteorological department and Earth Sciences.

- Forays in planetary missions have been made through Chandrayaan-1 and MOM-1 to establish the technological capability of Indian space to undertake far-reaching planetary exploration and also undertaking advanced scientific studies.

- Unique missions for astronomical observations – Astrosat and operational Positioning Services – through IRNSS constellation have been planned but are yet to be launched or fructify.

- Global commercial operations of Indian space in 43 commercial/foreign satellites on its PSLV; sale of IRS images and value-addition services and, more lucratively, transponder lease business in India are estimated to have resulted in revenue earnings of about INR 50 billion over the past 20+ years. It must be noted that this estimated revenue earnings includes a after-tax profitability of anywhere between 10-12% - thereby, meaning that Indian government has net-earned about INR 5 billion in profits.

Presently, in the 12th Five Year Plan (2012-2017), Indian Government has allocated INR 39 billion and has approved 58 missions over the 5 years period. The plan also makes forays into heavy communications satellites, advanced EO and weather satellites, achieving operational status of geo-orbit launch systems and also advanced missions for exploration of Mars, lander on Moon and IRNSS constellation.

## IV. LOOKING AHEAD – RENEWING POLICY FOR SPACE IN INDIA

(Much the ideation and concepts, in this section, have been adopted from a talk given by Dr K Kasturirangan in April, 2014[14])

[14] India in Space – A conceptual framework for the 21st century - Dr K. Kasturirangan, Member, Planning Commission. Dr Satish C Seth Memorial Futurology Lecture series 5 at Indian Council of Management and Future – April 8, 2014.

India's achievements in space technology and applications, viewed at an overall national level, have created a deep sense of "national pride" and a "public ownership" of the programme with consistent support from different political parties. National space activities are valued as a critical and most-coveted development/achievement. India is a nation of high ambitions of large hard-working and intelligent population – who struggle and aspire to be way ahead in life and "be second to none" - fortunately, achievements of Indian space has provided that outreach to society.

Looking ahead, what are the challenges that face Indian Space?

- Building further focus and an un-interrupted future national capability in space is quintessential - the nation needs to be assured that space systems that best respond to national needs are made available all the time and that gaps in services do not get created as has been witnessed in satellite transponder capacities or high resolution imageries. A pragmatic long-term planning of Indian space is required with a visionary partitioning of roles for different segments in the national eco-system.
- Building a combinative ISRO and industry capacity is critical for future space success. Especially in areas of operational satellites for communications, remote sensing, security, positioning, disaster management requirements – the concept of industry building, owning and operating space systems must be positioned. It will be advantageous to expand space capacity in the nation and enable a space eco-system into private sector space in India and enable a combinative national space capacity of ISRO and industries to emerge.
- Maintaining the state-of-art in space technology and adopting a leap-frogging approach are essential so that India can be on par with state-of-art systems. This would require careful and judicious flexibility to "buy or build" approach for critical gap areas, assimilate and source/partner for newer technology systems, parallel approaches of source-and-develop for critical dependency systems etc. Such an approach is most critical if one has to maintain the excellence and also be equal and compete in global systems.
- Space has triggered many new services and products/applications – which reach out all over the country and deep into society at multiple levels - administratively and jurisdictionally. Newer institutional frameworks are called for down-stream national-level applications and delivery systems – especially to address delivery systems for large demand for societal applications related to space. In

an end-to-end concept, national space agencies must not "carry the burden" to undertake large national-level societal applications that emanate from administrative and governance demand. Space must be an instrument to spawn newer and larger structures/organisations for applications and usage.

- Intensifying a two-way international cooperation is a desirable strategy – On one side, to embark on major exploratory programmes through synergy of partnership and assimilating technology and experiences from other nations and on the second side, for reaching/bringing Indian capability in the global markets of space. This combined approach must be intensified by active participation in multi-lateral space frameworks and selective bi-lateral space cooperation – especially in future human space flight and planetary exploration activities.

We make an assessment that the need is for National Space Policy – basically looking far ahead and creating a roadmap that will look 30-50 years ahead but also knit and integrate the various elements into efficiently-performing assets for Indian capability.

WHY POLICIES ARE IMPORTONT …..MORESO NOW

India is on a path of progress and growth and is a vibrant, growing, knowledgeable and aspirational society. With 1.25 b population out of which >70-80% are literate and >30% young population who are educated, aspirational, intelligent and tech-savvy, democratic demand will be for economic growth and high technological advancement. By 2025, Indian GDP would approach $9-10 trillion powered largely by domestic demand and the transformation to a highly industrialized and technologically advanced economy. Thus, Indian society will see large circulation of capital and demand will be for protect national interests – within and outside; increasing legal and redressal systems. With such a level of demographics and economic growth, society would develop as open and rights-based where citizens/society would demand justness, transparency, equitable systems and would question every action of government. Governance will have to cater to guaranteed public delivery, achievement as per commitments/plans & compliance with legal norms and alignment with global environment.

Such a national development will benefit from a comprehensive POLICY REGIME – where policies as a principle or rule create certainty, guide decisions and achieve rational outcomes - a "Statement of Intent" or a "Commitment". In our understanding, policies that consider combination of situational analysis and evaluation and "involves systematically studying the nature, causes, and effects with particular emphasis on systematic determining of policies will achieve best given goals."

SPACE ACTIVITIES – WHY POLICY?

We visualise that in coming years there will be a burgeoning need for space based services and this will require more robust space infrastructure and timely and reliable access to such infrastructure for social and commercial service delivery systems. Revisit of current institutional arrangements or creation of new institutional measures will be necessary to meet the large scale demands of diverse sectors and removal of disconnects that afflicts efficiency of delivery system.

Satellite services are critical for India's development and society/citizen services – thus a long-term and success-oriented commitment of government support and resources for pursuing satellite technology development is essential. Of course, this commitment must also be dove-tailed to key services/ministry sectors to utilise space inputs in a service manner.

Space science and planetary missions have a major role to play in catering to national scientific/education goals and aspirations – thus, a long-term continuity of planetary/science missions and programme is important – with well-defined science benefits.

In coming years, there are going to be a large number of Indian space assets (in-orbit) – their tracking, monitoring, de-activation schemes/protocols and national liability protection become important. At same time, protection of Indian space assets and usage and safe-guard from debris, attacks and stifling contingencies will require extreme level of technological and legal protection regimes.

India will have to renew and develop more robust and operational launch vehicles for the continued and un-hindered access to space and at same time strengthening national technological capability in the complex regimes of launch vehicle technology.

Space activities will require high level of resource investment spread over years and decades – thus a long-term programmatic and investment road-map becomes critical as the high-level of investments for space activities must be well-justified with declared national benefits and transparency of progress in expenditures too.

Indian space will have to go 2-pronged – on one side to meet its national needs, India will have to build and boost national capacity with Indian private sector and

appropriate global commercial sector; and for larger science and planetary activities frontal international cooperation at bi- and multi-lateral level will have to be the medium of collaborative programmes/investments sharing.

India will have to build and encourage Indian private sector in space business – not just to meet national needs but also to be globally competitive and efficient – so that Indian private sector will be able to build/develop national/global space business enterprises. Level playing fields for business and models of profitable revenue generation will have to be driven.

Finally, space will have to be developed as a vital tool for national security interests and safe-guarding Indian national interests.

India needs a National Space Policy that has agreed-upon road-map and vision of long-term (say, 20-30 years) and "compartments" of short-term missions and plans – but more importantly a holistic policy covering the gamut of space activities that will have to be pursued.

Justification of space at national level and endorsement of nation – political, bureaucratic, industrial, scientific and citizens will go a long way in furthering space and building the resilience for ups-and-downs of space activities.

Satellite communications will still be strongly justified as a vital element of national communications infrastructure for efficient and reliable communications of voice, data, image/video on various platforms and providing principal communication services for social sectors - tele-education as a medium of next generation education services, boost tele-medicine for contributing to securing health in society, DTH broadcasting for TV and mass media communication, for virtual private networks of government, banks, railways, defence, aviation and other areas. At same time, space will also play a role as critical "redundant" secure communications infrastructure in times of national emergencies, disasters, special events; national security and defence;

Satellite remote sensing and satellite positioning must provide on-demand imaging, observation and positioning services – thereby aiding to development of a National GIS, which holistically, in turn, will position GIS Decision Support Systems (DSS) that help bridge regional disparities in rural development and poverty reduction; support food security – agriculture and farmer benefits; infrastructure development; natural resources management and environment sustainability; operational national weather, ocean and climate services; support "operations" of city-management, aviation, logistics, railways, defence and other services.

Space justification must be in terms of helping build operational and sustaining national disaster and weather resilience; meet national security and defence needs – to secure the nation.

Justification for Indian space as an instrument for international cooperation will be most essential. While international cooperation must found science and planetary missions, regional space cooperation to share experience and knowledge will enable India to build a more comprehensive space regime in global efforts. In recent announcement, Hon'ble PM of India has made an announcement of India offering a SAARC-satellite and enabling sharing of Indian experience – a classic example of international cooperation tool of space.

Ultimately, citizen empowerment is most critical so that efforts must be to bring space benefits to every citizen of the country. Thus, an inclusive processing of involving citizens – especially the youth in space is most essential and important.

Space is also essential to grow science and knowledge endeavour for next generation.

NATIONAL SPACE POLICY …..POSSIBLE TENETS

Indian space policy must include following explicit tenets:

- Set a long-term vision for Indian space that is in complete alignment with stated national goals and also cover a 20-30 years for space activities
- Express sovereign right to access space and bring benefit to Indian citizens from space activities – basically, pursuit of (civilian) space activities and access to space and involve in shaping international space policies, agreements, rules etc
- Creation of social/economic multiplier by committing un-interrupted space-based national and commercial services for intensive social and national contribution - theme-oriented space configuration plan and develop/procure space assets planning. This can cover communication, remote sensing, positioning etc
- Establishing India's own global navigation system to achieve autonomy in access to global satellite navigation signals and also performances comparable to the best of the breed global systems

- ensure and justify future investments in space - especially high-investments for human space-flight capacity and continuity planetary missions by constantly providing a technology and investment roadmap.
- ensure wide usage and applications of space by government, industries and citizens
- facilitate and develop strong Indian industrial capability in space technology – so that Indian private sector can develop and provide space assets to meet national demand and pursue global space markets - providing India space products and services
- undertake advanced technology development – especially in creating roadmap towards a robust launch capacity, lower costs of access to space - Reusable Launch Vehicle Technology, human rating of launch vehicles and advanced planetary programmes and human space-flight related technology
- Space for security needs – establish parallel production-line and for protection of India's space assets should receive adequate attention. Creation of specialized facilities for increasing Space Situation Awareness (SSA) and effective means to deal with denials has to be developed
- Enhancing academics and research in space technology for qualitative developments and even some disruptive developments in space by spread of space activities in university systems and a healthy competition among academic research organisations
- adopt a space governance model that outlines national and global level compliance to legal regimes and self-conduct
- strong promotion of international cooperation in space at bi-lateral, multi-lateral and business levels
- determine and define metrics for evaluating space programmes and mission achievements/performance and performance and social audits. This is essential for commitment for mid-course corrections, policy and strategy changes
- commit to regular policy/strategy roll-over reviews and updations at national level.

A possible visualisation of National Space Policy is given in **Figure-1**. In such a possible policy framework, a possible scenario for near-future space development is shown in **Figure-2**.

In the far term of 50 years, the range of space applications would have expanded wide and into different areas of governance, commerce and services. The Space Policy needs to outline how maintaining national and societal relevance of space and creating a society-oriented space configuration is sustained; developing technologies related to aerospace plane, lunar bases and space tourism, planetary habitats, inter-stellar space exploration, contributing in developing regulatory developments and sustainable space operations.

We propose the following components for the comprehensive Indian Space Policy:

- Indian Space Vision – in alignment with national vision. This can be long-term vision of space programmes/missions (this could be rolled over every 5-10 years).
- A comprehensive Satellite Communications Policy that ensures un-interrupted and advanced satellite services for communications – public services, commercial and citizen services
- A pragmatic Remote Sensing Policy that commits availability of best quality remote sensing satellites data for land, oceans and atmosphere for national development – government needs, commercial needs and research needs
- A far-looking National Positioning Systems Policy that maintains national space-based Positioning services, augmentation service in an operational manner – for security, governance, commercial and citizen services.
- Indian Space Transportation Policy that ensures India's technological competency in space launch sector by way of development of efficient and advanced space transportation systems that are reliable, efficient and affordable and that support Indian space access needs operationally and also support launch business of global markets competitively.
- A National Space Science policy which covers a long-term and continuity planetary science plan of exploration, research and knowledge capability for India and builds science and research capability in Indian universities and institutions.
- A Space Industrialisation Policy that envisions developing and positioning a vibrant and superior Indian space industry capability which can simultaneously undertake full-scale space missions development for national needs and global markets.
- A National Space Applications Policy which will encourage "integration actions" of dove-tailing space technology into user domain of governance, business and research education by way of end-to-end user solutions concept.
- Indian Space International Cooperation Policy that will outline the international cooperation aspects as a 2-way mechanism – of India gaining/participating from cooperation and of India contributing in international arena. Issues of international Space

Governance – debris, code of conduct, planetary treaties etc are key for future and a policy perspective is essential.

- Human Spaceflight programme element that clearly outlines the full panorama of human spaceflight plan and national commitments that are required.
- National Space Security policy that outlines the space security aspects of Indian national space.
- A Public or Citizen Space Charter which enables defining (on regular periodicity) the benefits that Space Policy is bringing to India and its citizens and provides metrics for measuring performance.

At some time in coming years, space legislation would also be appropriate to position a long-term commitment and public endorsement.

NIAS feels that such a comprehensive policy exercise is essential and needs to be taken up. NIAS proposes to continue working on these lines.

## V. CONCLUSIONS

When Earth (and the nation) is viewed as a single object, all the identities that create barriers will also melt away and a single identity of "humanity" alone stays. Space can reinforce such a unique vision of evoking a national identity but creating an universal identity and serve a broader purpose for national development and human civilization. Seeds and expression of such visions are seen in the intellectual adventures of ancient India.

Great heights were achieved in the post independent India in space endeavours through unfolding the utilitarian and pacific visions of Space. India must expand its role into the next stage of exploratory regime of space to scale new heights and become a significant contributor to meeting national needs, explore beyond and understanding of cosmos in modern terms and become a major partner of the Global Exploration Efforts of Space in the 21st Century – for which a **National Space Policy is critical**.

This study is undertaken by NIAS to demonstrate a unique and rational approach which integrates scientific analysis of all core issues and over-arching assessment of staking issues in the development of the necessary space policy tenets. The perspectives of policy brought out by the study, although depicted in the national context of India, are highly relevant to different regions of the globe since they strike at the roots of fundamental issues that characterise the structures in which generation and applications of space are being pursued.

## ACKNOWLEDGEMENTS

The authors are thankful to Dr K Kasturirangan, Emeritus Professor, NIAS/Former Chairman of ISRO for very in-sightful discussions that have helped us in undertaking this policy assessment study and propose a policy direction for Indian space. The authors are indebted to ISRO system – the first 2 authors carry with them a large repository of space ideation throughout their professional association. The authors are also thankful to a large number of colleagues in space activities in USA, Japan, Canada, Europe etc for providing us in-sights into space plans and programmes. In specific, we are also thankful to Dr Baldevraj – who has taken over as Director of NIAS from Sep 1, 2014 for continuing the encouragement and motivation from NIAS. The second author acknowledges Jain University where his teaching experiences had provided insights on aspirations of young generation for the field of aerospace.

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**FIGURE -1: NATIONAL SPACE POLICY - ELEMENTS**

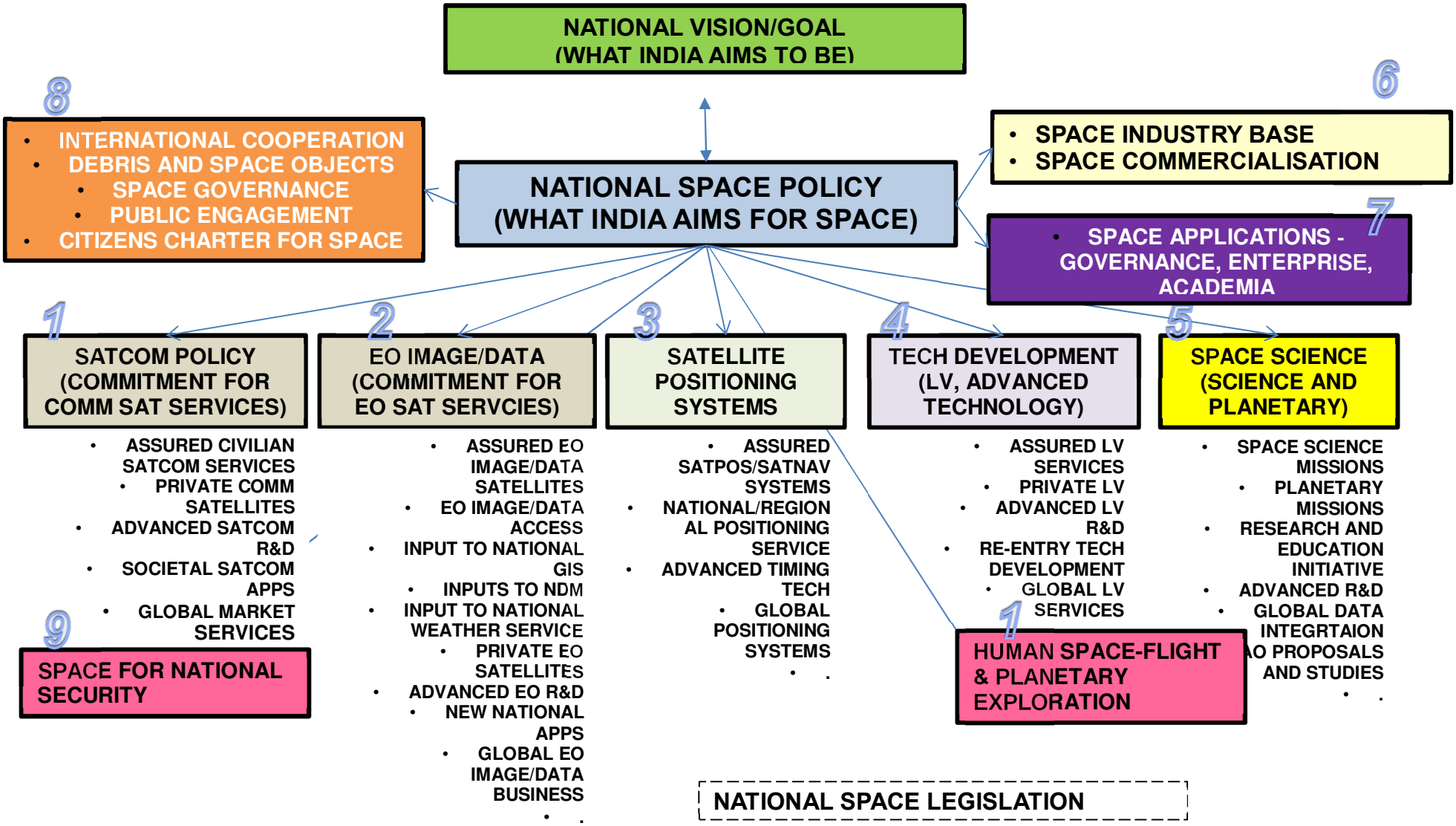

 

FIGURE -2: POSSIBLE SCENARIO IFFF IN NEXT 10-12 YEARS…. ANYWHERE AROUND

| ~100-150 MISSIONS | HUMAN SPACE-FLIGHT PROG INITIATED | ++PLANETARY/ SCIENCE MISSIONS | LARGER GLOBAL BUSINESS | ~INR 1000 B INVESTMENT |
|---|---|---|---|---|

| SEGMENT | PRESENT | FUTURE |
|---|---|---|
| Technology Development/ Investments | Government<br>Academia | • Government<br>• Academia<br>• Indian Space Industry |
| Satellites – build, operate | Government | • Government (Advanced, Science, Planetary, HSF)<br>• Industry (Operational Satcom, EO) |
| Launch – build and market | Government | • Government (Advanced)<br>• Industry (Operational) |
| Ground Systems development | Government<br>Industry | • Industry |
| Space based Services | Government<br>Industry | • Government (Societal, Advanced)<br>• Industry (Operational, Commercial)<br>• Academia (Science, Planetary) |
| Planetary Exploration and HSF | Government | • Government (National/Intl. Coop Missions)<br>• Academia (Science)<br>• Industry (Dev Support) |
| International Cooperation | Government | • Government (Multi-lateral)<br>• Industry (Commercial) |
| Investments | Government – 100% | • Government – 50% (??)<br>• Industry – 50% (??) |

 