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# Overview of
# Indian Space Sector 2010


**World Space Biz - 2010**
**August 2010**
www.deloitte.com/in

# Contents

# 1. Foreword from Antrix

The commercial space sector has experienced unprecedented growth over the past decade. The increasing capacity in the space services (such as telecommunications and imaging from space) across the world has driven down the cost of commercial space services drastically. If space has to remain as a major driver for growth issues like conducive space environment, eduction of the cost of access to space, global application of space technology to serve individual families and small communities throughout globe needs to be addressed. After the successful launches of INSATs, IRS series and Chandrayaan-1 by Indian Space Research Organisation (ISRO),many avenues have opened up for Indian Space Industry. ISRO is now planning to launch Chandrayaan 2 along with various other space missions, recording further growth.

Future satellites planned for launch by ISRO will address added applications in communications, navigation, disaster management and all weather remote sensing. With this vibrant program, there will be challenging opportunities for industries in India and abroad to provide equipment and services. Even Small and Medium Enterprises can play a significant role.

With growing need of use of technology in the field of infrastructure, weather forecasting, disaster management, telecommunications and agricultural guidance services, Bengaluru Space Expo cum conference 2010 (BSX 2010) aims at developing a strong base to meet such demands. BSX 2010 is the only event which attracts the participation of all ISRO centres along with the commercial arm Antrix Corporation and hence provides a unique platform to discuss the ongoing and possible future projects. It will highlight India's strengths in various areas of space, including manufacturing, launch services, communication, meterology and space sciences.

On the occasion of BSX 2010, this first ever report on the overview of Indian Space sector 2010 is fitting. There are glimpses of international and Indian space scenario, trends of future development, the present state of Indian industry and the opportunities/ business potential for the industry.

Dr. Vikram Sarabhai, the founder and architect of Indian space program envisioned strong role of a self sustaining industry in the space activities and applications.

We hope that the second Bengaluru Space Expo and the World Space – Biz, organized by the Confederation of Indian Industry with co-sponsorship of Indian Space Research Organisation and Antrix Corporation, will provide a unique forum to promote the cause of healthy growth of space industry across the globe.

**K.R. Sridhara Murthi**
Managing Director
Antrix Corporation Limited

# 2. Foreword from CII

Indian Space Programme is an Indigenous effort with a capability to provide various socio-economic developmental applications. The role has been to develop space-technology, system management and new applications that relevant for India. INSAT system has been established for communication, broadcasting and meteorology. The Indian remote sensing satellite system has been established for resource survey management. India has also acquired capability to launch satellites into Polar as well as Geo-Synchronous satellite orbits through PSLV and GSLV launchers respectively.

Over the years considerable infrastructure and expertise is developed within the Indian hi-tech industries to provide support to space missions (satellite and launch vehicles). The structural hardware of communication satellite is produced at Hindustan Aeronautics Ltd (HAL) which is one of the leading aerospace industry in the Asia pacific region. All the satellite structures since the experimental phase to the present operational era are produced at HAL. The satellite propulsion systems are largely taken from production capability of HAL and other private sector industrial giants like L&T, Godrej and MTAR. The communication payload and its components are normally made at the electronics division of HAL, BEL and also at a number of small to medium scale private enterprises. The applications specific integrated circuits (ASICs), hybrid micro circuits (HMCs) and printed circuit boards are routinely produced to space quality requirements at hi-tech industries like WIL, HAL and at leading boundaries in Europe, as per our design. Solar array, battery assemblies are fabricated utilising the production capacities at and some local private enterprises.

The main focus of this second Space Expo 2010 at Bengaluru is to showcase the latest technological advancements, related products and technical services. It will provide a platform for space agencies, specialists, entrepreneurs and space industry heavyweights to display their visions to the decision makers. The Expo would facilitate joint venture, technology transfer, marketing arrangements and will also provide opportunities to network with the who's who of space industry from all over the world. The Exhibition would also be showcasing Asia's Achievements and prospects for space sector. India has made major strides in space research, development and its application for the socio-economic upliftment. World Space-Biz 2010 is a concurrent International Conference on space business with Space Expo 2010.

It is with the above objective that CII in partnership with Antrix and Deloitte is publishing this report to bring to the notice of various stakeholders of the opportunities for them for the Space requirements in India.

We hope that this report will enable the domestic and the global companies to understand the emerging business opportunities in the areas of space. Further, this will help foreign companies to understand the Indian capabilities for making investments in India in this sector.

**Gurpal Singh**
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# 3. Preface from Deloitte

India's involvement in the space sciences dates to the 1920s when Scientist Mr. S.K.Mitra conducted a series of experiments in Kolkata to sound the atmosphere using ground-based radio techniques. The Government of India started to invest in space in 1950s, shortly after Independence. From 1950 to 1962, the Department of Atomic Energy funded research in the space sciences. The Indian National Committee for Space Research (INCOSPAR), established in 1962, was the progenitor of the Indian Space Research Organisation (ISRO) that was established under the leadership of Dr. Vikram Sarabhi in 1969. Aryabhata, India's first Satellite was launched in 1975. Since then India has launched more than 50 satellites including low-earth orbit Earth observation systems, geostationary communications systems and a lunar probe. India has also developed an indigenous launch vehicle capability starting with the SLV-3 in the late 1970s and progressing more capable versions including the ASLV, the PSLV, the GSLV and the GSLV III. In parallel with these significant accomplishments, India has developed world-class programs in academia and an outstanding space industrial base.

India's space budget for FY 2011 is ₹57.78 billion (US $1.26 billion) making it the 6th in the world, which accounts for about 0.14 percent of GDP. Almost half of the budget is focused on development and operation of launch vehicles and related activities. The remaining is devoted to space technology and applications, satellite operations and satellite communications.

India's space program has focused on societal benefits such as tele-education, tele-medicine, and remote sensing applications. As a result, space is integral to the daily lives of India's citizens. EDUSAT has linked more than 35,000 classrooms to enable interactive lectures, internet-based training and classroom-to-classroom dialogues. The Indian Remote Sensing program provides vital support to the National Natural Resource Management System and the accomplishments in space science and exploration have inspired both old and young alike.

In addition to the numerous internal benefits, India's space program has brought many Indian and international benefits. There is a development of National industries capabilities in several area of activity and about 500 small, medium and large scale industries are contributing to various space activities. India has participated in numerous international space programs with Russia, Europe and the U.S.A and the successes in space endeavour both national and international have burnished India's already bright reputation.

We are pleased to present this report by release at BSX 2010, Benguluru, organized by Confederation of Indian Industry in association with Antrix Corporation limited and ISRO. We trust this report would provide an insight to existing and prospective Indian and overseas companies with regard to opportunities in India in space sector.

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Indian Manufacturing Leader
Senior Director
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# 4. Executive Summary

**Introduction Text**

The primary objective of the Indian Space Programme is to establish operational space services in a self-reliant manner in the thrust areas of satellite communication and satellite based information for management of natural resources and satellite meteorological applications. The indigenous development of satellites, launch vehicles and associated ground segment for providing these services is integral to this objective. The Indian space programme was driven by the vision of Dr. Vikram Sarabhai, considered the father of Indian space programme. As stated by him:

*"There are some who question the relevance of space activities in a developing nation. To us, there is no ambiguity of purpose. We do not have the fantasy of competing with the economically advanced nations in the exploration of the moon or the planets or manned space-flight. But we are convinced that if we are to play a meaningful role nationally,and in the community of nations, we must be second to none in the application of advanced technologies to the real problems of man and society [1]."*

As pointed out by the former President of India, Dr. APJ Kalam[2] :
*"Mankind's 21st century thrust into space would herald in the world's next industrial revolution, which might be called the 'Space Industrial Revolution'. This does not mean that the revolution will take place only in space; it essentially means the creation of architectural and revolutionary changes leading to new space markets, systems and technologies on a planetary scale."[3]*

The Space Programme in India, over the years, has paved the way for creating cost-effective space infrastructure for the country in a self-reliant manner and the economic and social benefits brought in by the application of space technology to the national development have been significant. The Space Programme in India is poised to play a pivotal role in the national development.[4]

**Background and Objectives**

The Indian Space Programme had a beginning with the launch of first sounding rockets in November 1963 from the Thumba Equatorial Rocket Launching Station (TERLS) at Thumba, an obscure fishing village near Thiruvananthapuram for the investigation of ionosphere using sounding rockets. Further, the Indian Space Programme was institutionalized in November 1969 with the formation of Indian Space Research Organisation (ISRO). The Space programme got further fillip in June 1972, when the Government of India constituted the Space Commission and established the Department of Space (DOS). The ISRO was also brought under the newly formed DOS in September 1972. Since then and over the last five decades, the ever challenging task of space technology development and utilization, has not only graduated from experimental and demonstration phases to an operation era, but also provided its potential to address the national needs.The space program has come a long way since. Today, India is one of a handful of nations that has the technological capability to fabricate small, medium and large satellites as well as launch vehicles for low Earth Orbit (LEO) and geostationary earth orbit. India ranks among the top six space faring nations of the world in terms of budget and technological capabilities.

India ranks among the top six space faring nations of the world in terms of budget and technological capabilities.

The overall thrust of the space programme during 11th five year plan (2007-12) is to sustain and strengthen the already established space based services towards socio-economic development of the country and undertake advanced space missions including Human Space Flight Programme and Planetary Exploration.

DOS has taken several policy initiatives and pro-active measures to enhance the effectiveness and outreach of the Space programme. The policy framework of the DOS encompasses the areas of satellite communication, remote sensing data distribution, Industry participation, commercialization, human resource development, extra-mural research, international co-operation, effective user participation

1 About ISRO, www.isro.gov.in

2 Dr Kalam was an eminent Aeronautical Engineer, contributed for the development of India's first Satellite launch vehicle SLV III:

3 In an article by Dr APJ Abdul Kalam

4 www.isro.gov.in

and continuous upgradation of technological capabilities. Societal applications has been a thrust area of the Space programme and the DOS has initiated several programmes such as Tele-education, Telemedicine, Village Resource Centres to take the benefits of space technology to the door-steps of common man.

Towards fulfilling the objectives of promoting development and application of space science and technology to assist in all-round development of the nation, the DOS has evolved the following programmes:-

(a) Launch Vehicle programme having indigenous capability for launching space-crafts;
(b) INSAT Programme for telecommunications, broadcasting, meteorology, development of education etc;
(c) Remote Sensing Programme for application of satellite imagery for various developmental purposes; and
(d) Research and Development in Space Science, Technology for sub serving the end of applying them for national development.

The Polar Satellite Launch Vehicle (PSLV) is well proven through fifteen successive successful flights and has emerged as a reliable cost-effective launch vehicle. The successful launch of two developmental flights of Geosynchronous Satellite Launch Vehicle, GSLV-D1 and D2 in 2001 and 2003, followed by first operational flight in 2004 and launch of GSLV-F02 and F04 carrying INSAT-4C and INSAT-4CR launched in 2006 and 2007 and was a major achievement in the Indian Space Programme.

Front ranking scientific investigations are being carried out in the fields of astronomy, atmospheric sciences, planetary science and long term climatic research using satellites, balloons, sounding rockets and ground instruments. India's first mission to moon, Chandrayaan-1 was successfully launched on October 22, 2008 on-board the PSLV C-11. The payloads of Chandrayan-1 have sent useful scientific data about Moon. The data collected from various payloads of Chandrayaan-1 were analysed by worldwide scientists and the final products were presented and discussed in Chandrayaan-1 Science meet held at Bangalore on 29th January 2009 and subsequently an International Symposium on Low Cost Planetary Mission held at Goa from 31st August 2009 to 4th September 2009. The development of a multi-wave length astronomy satellite ASTROSAT has also been taken up. The Indian Space programme has enabled a significant role for national industries in realization of space systems. A strong bond with academic institutions exists through extensive research partnership. Unique organisational systems have been evolved in the national space programme for fulfilling diverse functions like development, operations and applications of complex space systems. The space programme has enabled significant technology growth in multiple disciplines as spin-off benefits.

Indian capabilities in space represent a wide spectrum of expertise ranging from the conceptual design to building and operating a variety of space systems, which are matched only by a few nations in the world. In view of these multiple dimensions and capabilities, India is recognized as a leader in space applications that have a wide impact on society.[5]

Despite the recent economic situations, the space industry remains robust because of the essential benefits that it provides. We see this in the US's decision to emphasize commercial resupply of the International Space Station and the reallocation of fiscal resources from Space Shuttle/manned space to earth observations and exploration. Some of the other economies have stable or increasing space budgets ranging from 0.05% to 0.2% of GDP.

Space programs have aspirational and motivational values attached apart from the revenue generated from development and execution of space projects. The returns more than justify utilizing tax payers' money in funding these projects. Manned Space Programs are now generating significant interest apart from other surveillance, monitoring and forecasting projects all over the world. The Government has allocated expenditure budget of ₹ Rs.57.78 billion (USD 1.26 billion) comprising of ₹ 50 billion (USD 1.09 billion) 'Plan' outlay and ₹ 7.78 billion (USD 0.17 billion) 'Non-plan' outlay for financial year 2010-11, which is increased by about 22% from the previous year. The budget proposals for the DOS for 2010-2011 have been formulated under the frame work of Decade Profile 2010-2020 and proposals for

5 http://www.isro.gov.in

Eleventh Five Year plan (2007-2012). The outlay has been arrived at taking into account the programmatic targets set for 2010-2011.

As regards involvement of Indian space industry, it has made significant contribution towards realization of systems and subsystems required for Indian Space programme and continues to do so. International cooperation is an integral part of space activities and ISRO continues to lay importance on bilateral and multilateral relations with international space agencies and space related bodies with the aim of taking up new scientific and technological challenges, building and strengthening existing ties between countries. Space industry is inherently technology intensive and is dependent on long term research and development for its future viability. Space ventures promise an evolving sector with huge returns. But the execution risks are too high. Risk elements involved in space sector are related to technological, industrial, commercial, financial, legal / legislative and in particular insurance.

The major achievements in space research during the last three years (April 2007-March 2010) are as below:

- Successful launching of India's first Lunar Mission Chandrayaan-I and detection of traces of water, ice and hydroxyl molecules on the lunar surface based on the scientific data obtained from Chandrayaan-I which is a major discovery in planetary science having tremendous implications in planning future long term lunar and planetary explorations.
- Successful launching of 10 satellites in a single mission of PSLV C9 – Cartosat-2A satellite (an advanced cartographic satellite); IMS-I satellite (for natural resource management applications) and eight nano satellites from Universities of Canada, Europe and Japan.
- Successful launch and operationlisation of RISAT-2, a Radar Imaging Satellite with the capability to take images of the earth during day and night as well as cloudy conditions and ANUSAT, first experimental communication satellite built by an Indian University onboard India's PSLV C 12.
- Successful launch and operationalisation of OCEANSAT-2 satellite onboard PSLV C 14, for Ocean and Coastal studies.
- Application of space technology for societal benefits in the areas of rural development, Health-care, Education, Agriculture, Natural Resources Management and Communication infrastructure through programmes of Tele-education, Tele-medicine, Village ResourceCentres, location of potential zones of drinking water based on satellite data, advisories of fishermen on potential fishing zones, Disaster Management Support programme etc.,

The Report of the working group on Space on the Eleventh Five Year Plan (2007-12) proposals of the ISRO highlighted the major goals for strengthening the position which are as follows:

***Capabilities in Space Communications and Navigation***

- Augmentation of INSAT system to meet the demand of 500 transponders by end of plan period
- Development of high power ka band satellites and ground systems for point-to-point connectivity
- Building navigational satellite systems and related services
- Focus on RandD in Satellite communications
- Institutionalisation of Tele-medicine, tele-education and VRCs
- Communications systems/support for Disaster management
- Progress towards self sustenance of INSAT/GSAT system

***Leadership in Earth Observations***

- Improved imaging capability and continuity of data/services through three thematic series of EO systems-land and water resources, cartography and ocean/atmosphere
- Development of advanced microwave imaging capability
- Strengthening Ground Systems and SNRMS
- Establishment of National Natural Resource Data base
- Undertake major applications projects in the area of Agriculture, land and water
- Resource management, DMS, infrastructure and urban/rural development etc.

# ISRO's long-term plan 'Vision 2025' for Space Research Programme encompasses development of reusable launch vehicles, human space flight, enhanced imaging capability, satellite based communication and navigation systems and planetary exploration.

*Major thrust in Space Transportation system*

- Operationalisation of GSLV Mk 11 with 4T launch capability
- Perfect payload recovery and re-entry technologies
- Conduct demonstration flights of reusable launch vehicle
- Critical technologies for Manned Mission

*Space Science Enterprise*

- Advanced Space science endeavours – Chandrayaan, Multi-wavelength X-ray astronomy, Mission to Mars and AsteriodComet fly by missions.

The major programmatic targets for 2010-2011 are the following:-

- Launch and operationalisation of Cartosat-2B onboard PSLV launch vehicle. Cartosat-2B support large scale cartographic mapping and thematic applications;
- Launch of GSAT-4 Satellite onboard third development flight of GSLV-D3 employing indigenously developed Cryogenic Stage. GSAT-4 is a low cost experimental communication satellite in Ka band. It also carries Navigation Payload and Scientific experiment developed by Tel Aviv University and Israel Space Agency;
- Launch and operationalisation of GSAT-8 satellite by Ariane launch vehicle GSAT-8 will augment the INSAT system with C and Ku band transponders;
- Assembly, Integration and Testing of Resourcesat-2, GSAT-5/INSAT-4D and RISAT-1 satellites and progress towards launch from Sriharikota. Resourcesat-2 with enhanced imaging capabilities will provide data for crop applications, vegetation dynamics and natural resource census and will eventually provide continuity of data hitherto provided by Resourcesat-1. GSAT-5/ INSAT-4D will augment the INSAT capacity with additional C band Transponders. RISAT-1 will enhance ISRO's capability in earth observation with microwave remote sensing;
- Initiate/progress work on Human Space flight programme, Semi cryogenic Engine development, GSLV Mk-III, Advanced Communication Satellite, Chandrayaan-2 and other ongoing space missions and application programmes.

The Government has drawn-up a long-term plan 'Vision 2025' for Space Research Programme identifying the goals, programme, directions and technology requirements upto 2025. The programme encompasses development of advanced launch vehicle systems including critical technologies for re-usable launch vehicles and Human Space Flight Programme, developing capabilities in Space communications towards meeting the developmental needs in the areas of education and literacy, health-care, rural development and disaster management support, introduction of satellite navigation based positioning services, augmenting earth observation systems with enhanced imaging capabilities for natural resource management applications and undertake front ranking research in the areas of space science, astronomy and planetary exploration.

# 5. Overview of the space

## Introduction

The investment in space industry has produced good returns, directly in the form of telecommunications and remote sensing capabilities, and indirectly in the form of technological spin-offs, national prestige and scientific knowledge. However, research on the use of solar energy and mineral raw materials in space shows that the space industry has a still untapped potential for major industrial growth. In order for the space industry to fulfil this potential, it must provide a commercial return, when it will attract commercial capital investment.

### 5.1 Overview of Global Space

Amidst a widespread international economic crisis, the space industry proved resilient, demonstrating growth and expansion through 2009 and into 2010. While other leading industries suffered dramatically, the space industry defied the upheaval and broadened its fields of endeavor. This is due in large part to the space industry's robust array of products and services, which enables it to respond rapidly to changes in global demand.

There has been an increasing role for the private sector through the development of commercial space markets and the spinoff of space technology into non-space industries. Governments around the world have taken a pragmatic approach to challenging economic times by focusing on practical, close to home projects while rethinking a long term, high-cost strategic and visionary programs. As more nations realise the strategic impact and economic potential of space, motivations for national space activity are not only about the fulfilment of State-sponsored ambitions but also about the development of an industry that can compete in a global market place.

A list of leading Space Agencies of the World is given below:

**Table 1: Leading Space Agencies of the world**

| Country | Agency |
|---|---|
| Australia | ASRI (The Australian Space Research Institute |
| Belgium | BISA (Belgian Institute for Space Aeronomy) |
| Brazil | AEB (Brazilian Space Agency) |
| Canada | CSA (Canadian Space Agency) |
| China | CNSA (China National Space Administration) |
| Europe | ESA (European Space Agency) |
| France | CNES (French Space Agency) |
| Germany | DLR (German Aerospace Center) |
| India | ISRO (Indian Space Research Organisation) |
| Iran | ISA (Iranian Space Agency) |
| Italy | ASI (Italian Space Agency) |
| Japan | JAXA (Japan Aerospace Exploration Agency) |
| Netherlands | SRON (Netherlands Institute for Space Research) |
| Russia | RKA (Russian Federal Space Agency) |
| South Korea | KARI (Korea Aerospace Research Institute) |
| Spain | INTA (Instituto Nacional de Tecnica Aeroespacial |
| Sweden | SNSB (Swedish National Space Board) |
| Switzerland | SSO (Swiss Space Office) |
| Ukraine | NSAU (National Space Agency of Ukraine) |
| UnitedKingdom | UKSA (UK Space Agency) |
| Unites States | NASA (National Aeronautics and Space Administration) |

The table below describes some of the other countries that are shining in the space sector.

**Table 2: List of the other countries that are shining in the space sector**

| Country | Current Scenario |
|---|---|
| Australia | ASRI came about in the early 1990s as the result of a merger between the AUSROC Launch Vehicle Development Group at Monash University in Melbourne and the Australian Space Engineering Research Association (ASERA).<br>The Institute is a non-profit organisation run entirely by volunteers. Most of the work at ASRI is done in collaboration with Australian universities such as the Royal Melbourne Institute of Technology, Queensland University of Technology and the University of Technology, Sydney. ASRI is developing a vision for the future of Australia's space community, including industry. Unlike space agencies in most industrialised countries, ASRI does not receive any direct government funding. |
| Europe | ESA is Europe's gateway to space. Its mission is to shape the development of Europe's space capability and ensure that investment in space continues to deliver benefits to the citizens of Europe and the world.<br>ESA is an international organisation with 18 Member States. By coordinating the financial and intellectual resources of its members, it can undertake programmes and activities far beyond the scope of any single European country. |
| United States | NASA grew out of the National Advisory Committee on Aeronautics (NACA), which had been researching flight technology for more than 40 years.NASA conducts its work in four principal organizations, called mission directorates:<br>1. Aeronautics: pioneers and proves new flight technologies that improve our ability to explore and which have practical applications on Earth.<br>2. Exploration Systems: creates capabilities for sustainable human and robotic exploration.<br>3. Science: explores the Earth, solar system and universe beyond; charts the best route of discovery; and reaps the benefits of Earth and space exploration for society.<br>4. Space Operations: provides critical enabling technologies for much of the rest of NASA through the space shuttle, the International Space Station and flight support. |
| China | Aims to snatch 20 percent of the world's space business by 2015. China has launched 36 commercial satellites since 1990, when it started the program. It has signed five satellite export contracts with foreign countries since 2007 and two satellites have entered into orbit. |
| Europe | For increasing its share in the global space market Russia will spend around $14 billion building the Vostochny space center in its Far Eastern Amur Region. Russia currently uses two launch sites for space carrier rockets and ballistic missile tests: the Baikonur space center in the Central Asian Republic of Kazakhstan, which it has leased since the collapse of the Soviet Union, and the Plesetsk space center in northwest Russia.The first launch from the new center is scheduled for 2015 and the first piloted spacecraft are intended to blast off in 2018. |
| South Korea | South Korea first gained experience with missiles provided by the United States to counter North Korea. KARI began in 1990 to develop its own rockets. It produced the KSR-I and KSR-II, one and two-stage rockets in the early 1990s.<br>In December 1997 it began development of a LOX/kerosene rocket engine. KARI is now developing the Korea Space Launch Vehicle, whose first-stage is based on the Angara rocket. Russia is also helping to build the Korea Space Center, a spaceport in Goheung County. |
| Japan | On October 1, 2003, the Institute of Space and Astronautical Science (ISAS), the National Aerospace Laboratory of Japan (NAL) and the National Space Development Agency of Japan (NASDA) were merged into one independent administrative institution called JAXA. As space development and utilization, and aviation research and development are steps to achieve the nation's policy objectives, contribution to problem solving is an important mission for JAXA and has proposed its long-term vision, "JAXA2025". |

### Space Products and Services

As the space industry becomes a vital part of the general consumer economy with GPS receivers and satellite televisions, it becomes more susceptible to general economic downturns. Space products and services have become integrated into the global economy and their significance continues to increase. A detailed note is given in section 8 below.

### 5.2 Overview of Indian Space programme

*The Objective*

The Indian Space programme is characterized by a vision to use space technology for national development. The primary objective of the space programme is to establish operational space services in a self-reliant manner in the thrust areas of satellite communication, satellite based resource survey/management and satellite meteorological applications. The indigenous development of satellites, launch vehicles and associated ground segment for providing these services is integral to those objectives.

*The Organisation*

The Space Commission and Department of Space were set up in 1972 to formulate and implement space policies and programmes in the country. The Space programme is executed through the Indian Space Research Organisation and the four Grant-in-aid institutions viz.,

- National Remote Sensing Agency (NRSA) ,
- Physical Research Laboratory (PRL),
- National Atmospheric Research Laboratory (NARL) and
- North-Eastern Space Applications Centre (NE-SAC).

Besides these, the administrative control of Semiconductors Complex Limited (SCL) at Chandigarh has been transferred from Department of IT to Department of Space w.e.f 1st March 2005. SCL has now been registered as an R and D Society and redesignated as Semiconductors Laboratory (SCL) with the approval of the Cabinet. The Antrix Corporation as a government owned company markets the space products and services. The establishment of space systems and their utilization are coordinated by national level committees namely the INSAT Co-ordination committee (ICC), Planning Committee of National Natural Resource Management System (PC-NNRMS) and Advisory committee on Space Sciences (ADCOS). Five Regional Remote Sensing Service Centre (RRSSC) help in undertaking remote sensing applications projects relevant to the region.

*Overview of Indian Space Programme*

- The major areas of focus of the Indian space program include:
  - Satellite communications for telephony, television broadcast, radio broadcast, mobile communications, distance education, satellite-aided search and rescue, meteorology, etc.
  - Remote sensing for resources survey and management, environment monitoring and meteorological services, and
  - Development and operation of indigenous satellites launch vehicle and ground systems for providing these services.
- India has successfully launched, operated and utilized several generations of its two indigenously developed satellite systems:
  - INSAT (Indian National Satellite) multipurpose satellite system for telecommunications, television and radio broadcasting, tele-education, tele-health, meteorology and disaster warning; and
  - IRS (Indian Remote Sensing) satellite system for earth observation applications, mainly resource monitoring and management.
- ISRO has demonstrated world-class capabilities

in successfully and repeatedly launching multiple classes of expendable launch vehicles (ELV). The PSLV and GSLV are the latest ELV workhorses. The Polar Satellite Launch vehicle (PSLV) is used for launching IRS satellites and the Geosynchronous Satellite launch vehicle (GSLV), is used for launching the INSAT class of satellites.

- Front ranking scientific investigations are being carried out in the fields of astronomy, atmospheric sciences and long term climatic research using satellites, balloons, sounding rockets and ground instruments. India's first Lunar Mission Chandrayaan-1 and the multi-wavelength X-ray observatory satellite ASTROSAT are two important initiatives of the recent past in space science research.
- The Indian Space programme has enabled a significant role for national industries in realisation of space systems. A strong bond with academic institutions exists through extensive research partnership. Unique organizational systems have been evolved in the national space programme for fulfilling diverse functions like development, operations and applications of complex space systems. The space programme has enabled significant technology growth in multiple disciplines as spin-off benefits.
- The launch of EDUSAT, India's first exclusively educational satellite, is an example of India's continued focus on the social and developmental applications of space technology. ISRO continues to stress human security projects, such as mass education, weather forecasting, disaster management, communications and navigation. EDUSAT supports an interactive satellite based distance education system which connects urban educational institutions, such as the Indian Institute of Technology (IIT), with rural and semi-urban educational institutions that lack proper resources. EDUSAT consists of more than 45 broadcast and interactive networks, which cover 30,000 classrooms in 20 states across the nation.
- Today, ISRO is complementing development oriented projects like EDUSAT with commercial ventures. ISRO anticipates new revenues from the highly lucrative satellite industry, which includes broadband Internet Protocol (IP) services, defense and military applications, and leasing options to telecommunication providers. Although ISRO, a relative newcomer to space exploration, has a much shorter list of commercial ventures than its counterparts in the United States and Europe, it has made impressive strides. In April 2007, the PSLV conducted its first commercial launch of a foreign satellite for the Italian Space Agency, AGILE, for US $11 million. Then, in January 2008, the PSLV launched an Israeli satellite, TECSAR, followed by another successful launch in April 2008 of ten satellites on the same launch vehicle. April's launch broke the record of maximum satellites launched simultaneously by any international space program; a record previously held by Russia at eight satellites in a single launch.
- Under Ground segment, ISRO Telemetry, tracking and command network (ISTRAC) provides mission support to low-earth orbit (LEO) satellites as well as launch vehicle missions. It has a network of ground stations at various locations in India and overseas. It's activities are organized into network operations, network augmentation, mission operation and spacecraft health monitoring, communications and computers and control centre facilities and development projects. In addition, Master Control facility monitors and controls all the geo-stationary satellites.
- Antrix, ISRO's marketing arm, has been selling Indian products and services to global customers, thereby increasing ISRO's market share in space services.

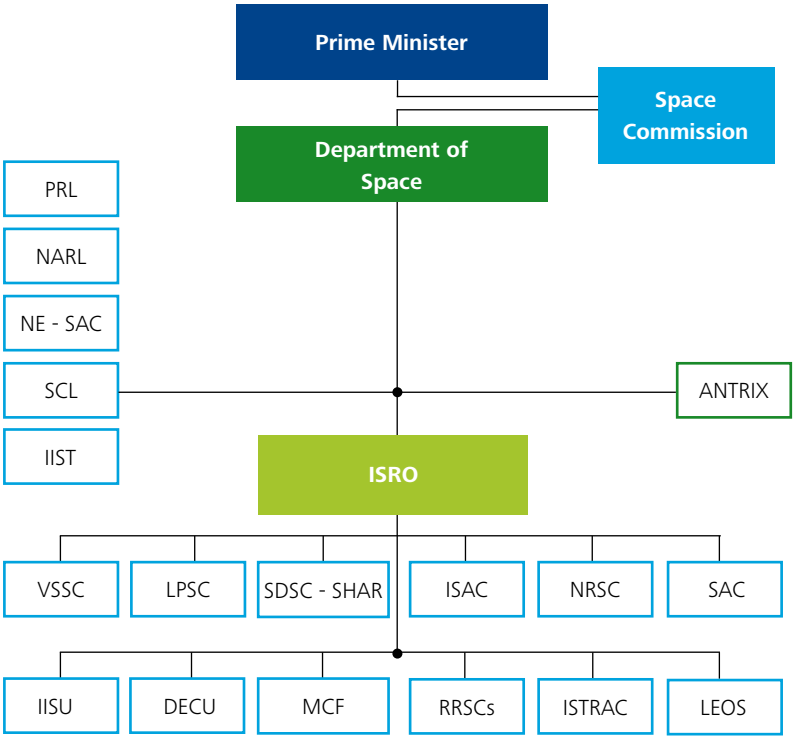
Indian capabilities in space thus represent a wide spectrum of expertise ranging from the conceptual design to building and operating of a variety of space systems, which are matched only by a few nations in the world. In view of these multiple dimensions and capabilities, India is recognized as a leader in space applications that have a wide impact on society. The end-to-end capability in space for vital application in communications, broadcasting, meteorology and natural resource information, which are of direct relevance for national development, has secured India a unique place in the international community. The diverse roles of space technology/services in various fronts – social, commercial, economic and strategic have made the space systems an important component of our national infrastructure.[6]

6 Annual Report 2009-10 of Department of Space, Government of India and Report of the working group on "Space" on 11th five year proposal 2007-12 for Indian Space Programme, ISRO, Department of Space

# 6. Role of Department of Space in India

## Introduction

Exhibit 1 : Structure of Department of Space




**NRSC:** National Remote Sensing Centre, **PRL**: Physical Research Laboratory, **NARL:** National Atmospheric Research Laboratory, **NE-SAC:** North Eastern Space Applications Centre, **SCL:** Semi-Conductor Laboratory, **ISRO:** Indian Space Research Organisation, **Antrix:** Antrix Corporation Limited, **VSSC:** Vikram Sarabahi Space Centre, **LPSC:** Liquid Propulsion Systems Centre, **SDSC:** Satish Dhawan Space Centre, **ISAC:** ISRO Satellite Centre, **SAC:** Space Applications Centre, **IISU:** ISRO Inertial Systems Unit, **DECU:** Development and Educational Communication Unit, **MSF:** Master Control Facility, **RRSSCs:** Regional Remote Sensing Service Centres, **ISTRAC:**ISRO Telemetry, Tracking and Command network, **LEOS**: Laboratory for Electro-optic systems, **IIST:** Indian Institute of Space Science and Technology

**Source: Organisation Structure, http://www.isro.org/scripts/Aboutus.aspx**

### Organisational Setup

The space activities in the country were initiated with the setting up of Indian National Committee for Space Research (INCOSPAR) in 1962 with Dr Vikram Sarabhai[7] as his Chairman. In the same year, the work on Thumba Equatorial Rocket Launching Station (TERLS) near Thiruvananthapuram was also started. The Indian space programme was institutionalised in November 1969 with the formation of Indian Space Research Organisation (ISRO). The Government of India constituted the Space Commission and established the Department of Space (DOS) in June 1972 and brought ISRO under DOS in September 1972.

The Space Commission formulates the policies and oversees the implementation of the Indian space programme to promote the development and application of space science and technology for the socio-economic benefit of the country. DOS implements these programmes mainly through :

- Indian Space Research Organisation (ISRO),
- Physical Research Laboratory (PRL),
- National Atmospheric Research Laboratory (NARL),
- North Eastern-Space Applications Centre (NE-SAC) and
- Semi-Conductor Laboratory (SCL).
- The Antrix Corporation, established in 1992 as a government owned company, markets the space products and services.

### 6.1 Key Objectives and Responsibilities

The Department of Space is committed to

- Carrying out research and development in high end of technologies required for satellites and launch vehicles with a goal to achieve self-reliance

7 Considered as the Father of the Indian Space program

- Provide national space infrastructure for the telecommunication needs of the country
- Provide satellite imagery required for undertaking natural resources survey and security needs of the country
- Provide satellite based services required for weather forecasting/ monitoring and climate related studies
- Provide accurate and timely navigation signals for Indian Regional Navigational Satellite system
- Provide space based services required for developmental purposes to the Central Government, State Governments, Quasi Governmental Organisations, NGOs and the private sector
- Undertake proof of concept demonstration of applications programmes using space-based systems
- Promote research and development in space sciences and planetary exploration[8]

While operationalising the above mentioned objectives, Department of Space will

- Create space based assets for national development
- Provide required satellite transponders and facilities to meet the communication, television broadcasting and security requirements of our country
- Provide adequate earth observation capability in multiple spectral, spatial and temporal resolutions
- Provide launch services to meet national requirements and commercial needs
- Provide its products and services in a prompt and efficient manner to all the users/clients[9]

### 6.2 Role of Indian Space Research Organisation (ISRO)

The objective of ISRO is to develop space technology and its application to various national tasks. ISRO has established two major space systems,

- INSAT for communication, television broadcasting and meteorological services, and
- Indian Remote Sensing Satellites (IRS) system for resources monitoring and management.

ISRO has developed two satellite launch vehicles, PSLV and GSLV, to place INSAT and IRS satellites in the required orbits.

The major establishments of DOS/ISRO and their area of activities are given in the following table:

8 ISRO Annual Report (2008-2009)

9 Ibid

Table 3 : Establishments of DOS//ISRO and their area of activities

| DoS Establishments | Key Work Areas |
|---|---|
| Vikram Sarabhai Space Centre (VSSC) | VSSC at Thiruvananthapuram is the lead centre for the development of satellite launch vehicles and associated technologies. The centre pursues research and development in the fields of aeronautics; avionics; composites; computer and information; control, guidance and simulation; launch vehicle design; mechanical engineering; mechanisms, vehicle integration and testing; propellants, polymers, chemicals and materials; propulsion, propellants and space ordnance; and systems reliability. |
| ISRO Satellite Centre (ISAC) | ISAC at Bangalore is engaged in developing satellite technology and implementation of satellite systems for scientific, technological and application missions. ISAC is functionally organised into five major areas: mechanical systems area including structures, thermal systems and spacecraft mechanisms; digital and communications area including digital systems and communication systems; integration and power area comprising spacecraft checkout, systems integration and power systems; controls and mission area consisting of control system, mission development and computer and information; and facilities. |
| Satish Dhawan Space Centre (SDSC) SHAR | SDSC SHAR, with two launch pads, is the main launch centre of ISRO and has newly established world class facilities for solid propellant processing, static testing of solid motors, launch vehicle integration and launch operations, range operations comprising telemetry, tracking and command network and mission control centre. Management service group, advanced engineering group, reliability and Sriharikota Common Facilities support the centre. |

| DoS Establishments | Key Work Areas |
|---|---|
| Liquid Propulsion Systems Centre (LPSC) | LPSC is the lead centre in the development of liquid and cryogenic propulsion for launch vehicles and satellites. The activities are spread across Thiruvananthapuram, Mahendragiri and Bangalore. LPSC at Thiruvananthapuram carries out design and system engineering of earth storable and cryogenic engines and stages for launch vehicles, design and development of bipropellant thrusters and electric propulsion thrusters for spacecraft, control components and control systems. LPSC, Mahendragiri carries out assembly, integration and testing of earth storable and cryogenic engines and stages, high altitude testing of upper stage engine and spacecraft thrusters, as well as testing of subsystems. This centre also has facilities for storage of earth storable and cryogenic propellants including an Integrated Liquid Hydrogen Plant. LPSC at Bangalore carries out design, development and testing of propulsion systems for spacecraft. It also carries out transducer design and development. |
| Space Applications Centre (SAC) | SAC at Ahmedabad is engaged in the development of payloads for communication, meteorological and remote sensing satellites. SAC also carries out research and development on various space applications programmes. The activities are grouped under microwave systems, satellite communication applications, sensor developments, image and information processing and remote sensing applications. Programme planning group, systems reliability group and library and documentation group support the centre. SAC also operates Delhi Earth Station (DES) for satellite communication. |
| Development and Educational Communication Unit (DECU) | DECU at Ahmedabad is involved in the conceptualisation, definition, planning, implementation and socio-economic evaluation of space applications. The major activities of DECU at present include: EDUSAT projects, their implementation and utilisation; Training and Development Communication Channel (TDCC), Village Resource Centres (VRC), tele-medicine, science channel and new satellite communication development and applications. |
| ISRO Telemetry, Tracking and Command Network (ISTRAC) | ISTRAC provides mission support to low-earth orbit satellites as well as launch vehicle mission.ISTRAC activities are organised into network operations, network augmentation, mission operation and spacecraft health monitoring, communications and computers and control centre facilities and development projects. Programme planning and reliability groups support ISTRAC activities. |
| The Indian Deep Space Network (IDSN), | Consisting of two large parabolic antennas – one with 18 m diameter and the other 32 m diameter was commissioned during the year at Byalalu village near Bangalore. The 18 m antenna is capable of supporting Chandrayaan-1 mission, while the 32 m antenna can support spacecraft missions well beyond Moon |
| ISRO Radar Development Unit (ISRAD) | ISRO Radar Development Unit (ISRAD) at Bangalore, working under the overall umbrella of ISAC has been integrated with ISTRAC. Research and development in the area of radar systems needed for space programme like tracking radars, wind profile radar and weather radars needed for meteorological applications are being undertaken. |
| Master Control Facility (MCF) | MCF at Hassan in Karnataka and Bhopal in Madhya Pradesh monitors and controls all the geostationary satellites of ISRO. MCF carries out operations related to initial orbit raising of satellites, in-orbit payload testing, and on-orbit operations throughout the life of these satellites. |
| ISRO Inertial Systems Unit (IISU) | IISU at Thiruvananthapuram carries out research and development in inertial sensors and systems and allied satellite elements. IISU is organised into research and development groups in the areas of launch vehicle inertial systems, spacecraft inertial systems, inertial system production and reliability and quality assurance. It has facilities for precision fabrication, assembly, clean room and integration and testing. |
| Laboratory for Electro-Optic Systems (LEOS) | LEOS at Bangalore carries out research and development in the field of electro-optic sensors and cameras required for satellites and launch vehicles. |
| National Remote Sensing Centre (NRSC) | NRSC at Hyderabad has been converted into a full-fledged centre of ISRO since September 1, 2008. NRSC was an autonomous body earlier, called National Remote Sensing Agency (NRSA) under Department of Space (DOS). The Centre is responsible for remote sensing satellite data acquisition and processing, data dissemination, aerial remote sensing and decision support for disaster management. |

| DoS Establishments | Key Work Areas |
|---|---|
| North Eastern-Space Applications Centre (NE-SAC) | NE-SAC, located at Shillong, is a joint initiative of DOS and North Eastern Council to provide support to the North Eastern region in using space science and technology for development. The centre has the mandate to develop high technology infrastructure support to enable NE states to adopt space technology inputs for their development. At present, NE-SAC is providing developmental support by undertaking specific projects, utilising space technology inputs – remote sensing, satellite communication and space science. |
| Antrix Corporation Limited | The Antrix Corporation Limited, Bangalore is the marketing agency under DOS with access to resources of DOS as well as Indian space industries. Antrix markets subsystems and components for satellites, undertakes contracts for building satellites to user specifications, provides launch services and tracking facilities and organises training of manpower and software design. |
| Semi-Conductor Laboratory (SCL) | The administrative control of Semi-Conductor Complex Limited, Chandigarh, a public sector undertaking under Ministry of Communications and Information Technology (MCIT) was transferred to Department of Space during March 2005. SCL is entrusted with design and development of Very Large Scale Integration (VLSI) devices and development of systems for telecommunication and space sectors. |
| Indian Institute of Remote Sensing | Indian Institute of Remote Sensing at Dehra Dun, which conducts training courses in remote sensing for user agency personnel at different levels, functions under NRSC. IIRS also hosts and supports the Centre for Space Science and Technology Education (UN centre) in Asia Pacific. |
| Physical Research Laboratory | PRL at Ahmedabad, is an autonomous institution supported mainly by DOS. It is a premier institute engaged in basic research in experimental and theoretical physics, astronomy and astrophysics, earth, planetary and atmospheric sciences. |
| National Atmospheric Research Laboratory (NARL) | NARL at Gadanki near Tirupati is an autonomous society supported by DOS. It is a centre for atmospheric research with facilities like mesosphere stratosphere-troposphere radar, LIDAR, lower atmospheric wind profiler, disdrometer, optical rain gauge and automatic weather station along with associated facilities. NARL is available for national and international scientists to conduct atmospheric research. |

Source: Isro Annual Report (2008-2009), Department-Related Parliamentary Standing Committee On Science and Technology, Environment and Forests

### 6.3 Role of Antrix

Antrix Corporation Limited is a wholly owned Government of India Company under the administrative control of the Department of Space, Government of India. Antrix Corporation Limited was incorporated as a private limited company owned by Government of India, in September 1992 as a Marketing arm of Indian Space Research Organization (ISRO) for promotion and commercial exploitation of space products, technical consultancy services and transfer of technologies developed by ISRO. Another major objective is to facilitate development of space related industrial capabilities in India. Antrix is also providing Space products and services to international customers worldwide, such as EADS Astrium, Intelsat, Avanti Group, etc.[10]

Antrix, has been awarded the "Miniratna" status by the Government of India in 2008. With fully equipped state-of-the-art facilities, Antrix is a one-stop-shop for any of the space products, ranging from supply of hardware and software including simple subsystems to a complex spacecraft, for varied applications covering communications, earth observation, scientific missions; space related service including remote sensing data series, transponders provision; launch services through the operational launch vehicles (PSLV and GSLV); mission support services; and a host of consultancy and training services.

### 6.4 Workforce

ISRO's successes are backed by vision of Dr. Vikram Sarabhai, strong and continued political support from the Indian Government and a high-caliber technical workforce 40% of whom are doctorates, post-graduates and graduates. As per annual report 2008-09, the total approved strength of department is on April 1, 2009 is 17,681 out of which 12,231 are in scientific categories and 5,468 in administrative categories. About 19% of personnel in the Department are women. The commitment, dedication, knowledge and skills of DOS personnel have played a key role in the achievements of Indian space program.[11]

10 ISRO, http://www.isro.org/scripts/antrix.aspx (acessed online21 April 2010)

11 Annual Report 2008-09

# 7. The Space Economy

## 7.1 Budgets and Revenue

While the global economic crisis grabbed the headlines daily in 2009, the global space industry experienced steady growth throughout the year. Estimated space industry revenue and government budgets increased by 7%, to $261.61 billion. This amounts to 40% growth during the previous five years for the global space economy. The commercial satellite services increased by 8%, reaching an estimated market value of $90.58 billion during 2009 and representing 35% of the space economy. Space infrastructure, which comprises spacecraft manufacturing, launch services, in-space platforms, and ground equipment, constitutes the second-largest segment, accounting for $83.63 billion, or 32% of the total market value.[12]

### 7.1.1 Global space budget

Government space budgets increased considerably from 2008, demonstrating an aggregate growth rate of 16%. During 2009, governments spent an estimated $86.17 billion, accounting for 33% of the space economy. This funding supports military, civilian, and commercial space programs covering a broad variety of activities such as national security, scientific research, technology development, and social welfare that target health, rural communications, and emergency services. International government budgets that were counted in both 2008 and 2009 increased by 22% to reach $19.97 billion. With the addition of international budgets this total becomes $21.75 billion.

Meanwhile, two smaller market segments also experienced revenue growth in 2009. Infrastructure support industries and space commercial transportation services were valued at $1.15 billion and $80 million, respectively. With growth in both the commercial sector and government spending, 2009 financial data highlights the merits of investing in space and its future prospects for generating value.[13]

*International Government Space Budgets*

International space spending numbers were derived from the most recent budgetary information available for each country, though not all governments operate under the same fiscal year cycle. The table below provides global space activity budgets.

12 The space report 2010, space foundation

13 Ibid

Table 4: Global Space Budgets, 2009

| Agency | 2009($B) |
|---|---|
| U.S. Government Space Budgets | **$64.42** |
| Department of Defence (DoD) Space | $26.53 |
| National Reconnaissance Office (NRO) | $15.00 |
| National Geospatial-Intelligence Agency(NGA) | $2.00 |
| National Aeronautics and Space Agency(NASA) | $18.78 |
| National Oceanic and Atmospheric Administration(NOAA) | $1.25 |
| Department of Energy (DoE) | $0.04 |
| Federal Aviation Administration(FAA) | $0.01 |
| National Science Foundation(NSF) | $0.80 |
| International Government Space Budgets | **$21.75** |
| European Space Agency(ESA) | $5,16 |
| European Union | $1.56 |
| Argentina | $0.07 |
| Brazil | $0.19 |
| Canada | $0.33 |
| Chile | $0.01 |

| Agency | 2009($B) |
|---|---|
| China | $1.79 |
| France | $1.06 |
| Germany | $0.77 |
| India | $1.06 |
| Israel | $0.01 |
| Italy | $0.47 |
| Japan | $3.72 |
| Nigeria | $0.02 |
| Russia | $2.90 |
| South Africa | $0.08 |
| South Korea | $0.23 |
| Spain | $0.06 |
| United Kingdom | $0.10 |
| Non-U.S. Military Space | $2.18 |
| **TOTAL** | **$86.17** |

Source: www.spacefoundation.org/Introduction to Space Activities

The table below provides spending on civil space as a percentage of gross domestic product.

**Exhibit 2: Civil Space Spending as a percentage of Gross Domestic Product (GDP)**

| Country | 2008 GDP (Constant Prices) | 2009 Civil Space Spending | %GDP Spent on Civil Space |
|---|---|---|---|
| France | €1.645 trillion | €1.454 billion | 0.09% |
| Germany | €2.270 trillion | €1.2 billion | 0.05% |
| India | ₹35.66 trillion | ₹49.6 billion | 0.14% |
| Italy | €1.277 trillion | €699.5 million | 0.06% |
| Japan | ¥557.22 trillion | ¥344.8 billion | 0.06% |
| Russia | R34.965 trillion | R87.9 billion | 0.25% |
| United Kingdom | £1.275 trillion | £302.6 million | 0.02% |
| United States | $11.651 trillion | $20.89 billion | 0.18% |
| | | Average %GDP Spent on Civil Space | 0.11% |

Source: International Monetary Fund, World Economic Outlook Database, April 2009

### 7.1.2 Indian space budget

*Responsible agencies:*

The budget formulation process of the Department has been evolved over the years with emphasis on reviewing the resource requirements with reference to the criteria of Zero Base Budgeting approach. Multi-level budget reviews are carried out at the DOS/ ISRO Centres/Units and Project Management Boards/ Management Councils consistent with the programmatic and financial guidelines of the Department.

The essentiality of each item, the schedule-budget linkages and cash flow requirements are critically analysed while formulating the budget.[14]

***Space expenditure: Key Definitions and areas of focus***

The 2010-2011 budget for space spending in India in ₹57.78 billion or US $1.26 billion, which will account for about 0.14 percent of GDP.[15] [16]

14 Outcome of Budget, department of Space 2009-2010

15 At an exchange rate of ₹ 46 to $US 1

16 One crore is a Hindi measurement equivalent to 10 million

**Exhibit 3: Indian Space Budget 2010-11 break-up (₹crore)**

| Department/ Project | Secretarial-Economic Services | Space Technology | Space Applications | Space Sciences | Direction and Administration | INSAT Operational | TOTAL |
|---|---|---|---|---|---|---|---|
| ISRO | 8.00 | | | | | | |
| GSLV MK III Development | | 152.96 | | | | | |
| PSLV Project | | 250.00 | | | | | |
| GSLV Operational Project | | 250.00 | | | | | |
| Space Capsule Recovery Experiment | | 4.93 | | | | | |
| Manned Mission/Human Space Flight Programme | | 150.00 | | | | | |
| Radar Imaging Satellite | | 3.50 | | | | | |
| Advanced Communication Satellite | | 125.00 | | | | | |

| Department/ Project | Secretarial-Economic Services | Space Technology | Space Applications | Space Sciences | Direction and Administration | INSAT Operational | TOTAL |
|---|---|---|---|---|---|---|---|
| Earth Observation(Cartosat-3, SARAL, TES Hyperspectral, DMSAR-1 | | 75.50 | | | | | |
| Earth Observation Application | | | 2.31 | | | | |
| RESPOND | | | | 15.00 | | | |
| Megha Tropiques Project | | | | 10.00 | | | |
| Aditya and Astrostat- 1 and 2 | | | | 50.00 | | | |
| Indian Lunar Mission Chandryan-1 and 2 | | | | 100.00 | | | |
| ISRO Geosphere Biosphere Programme | | | | 28.96 | | | |
| Other Schemes | | | | 15.70 | | | |
| Special Indigenisation/Advance Ordering | | | | 231.79 | | | |
| Others | | | | | 130.13 | | |
| INSAT- 3 satellites | | | | | | 77.60 | |
| INSAT -4 satellites | | | | | | 574.30 | |
| Vikram Sarabhai Space Center | | 583.66 | | | | | |
| ISRO- Inertial systems Unit | | 28.78 | | | | | |
| Liquid Propulsion Systems Center | | 303.54 | | | | | |
| Cryogenic Upper Stage Project | | 0.10 | | | | | |
| Semi Cryogenic Engine Development | | 250.00 | | | | | |
| Indian Institute of Space Science and Technology | | 140.00 | | | | | |
| ISRO Satellite Centre (ISAC) | | 420.19 | | | | | |
| Laboratory for Electro-Optics System | | 40.14 | | | | | |
| Semi Conductor Laboratory | | 53.85 | | | | | |
| Satish Dhawan Space Centre SHAR (SDSC-SHAR) | | 386.90 | | 10.00 | | | |
| ISRO Telemetry, Tracking and Command Network | | 88.01 | | | | | |
| Space Applications Centre | | | 297.41 | 16.00 | | | |
| Development and Educational Communication Unit | | | 83.02 | | | | |
| National Natural Resources Management System | | | 87.62 | | | | |
| Regional Remote Sensing Service Centers | | | 38.62 | | | | |

| Department/ Project | Secretarial-Economic Services | Space Technology | Space Applications | Space Sciences | Direction and Administration | INSAT Operational | TOTAL |
|---|---|---|---|---|---|---|---|
| National Remote Sensing Center | | | 230.15 | | | | |
| Oceansat-2 and 3 | | 1.60 | | | | | |
| Resourcesat- 2and 3 | | 22.00 | | | | | |
| North Eastern Space Applications Centre | | | 8.00 | | | | |
| Physical Research Laboratory | | | | 71.70 | | | |
| Atmospheric Science Programmes | | | | 28.45 | | | |
| National Atmospheric Research Laboratory | | | | 15.45 | | | |
| Master Control Facility | | | | | | 55.03 | |
| Indian Regional Navigational Satellite System | | 262.10 | | | | | |
| TOTAL | 8.00 | 3592.76 | 747.13 | 361.26 | 361.92 | 706.93 | 5778 |

Source: Expenditure Budget 2010-11 Volume2, Department of Space, Government of India

**Exhibit 4: Budget Breakup in percentage**

It may be seen from the above exhibit that 39 percent investment is on launch vehicles, 19 percent on satellite technology, 9 percent on launch support, tracking network an range facility, 14 percent for space applications, 7 percent on space sciences and the balance on other items. About three-fourth of the total expenditure is incurred towards development of technology in the case of launch vehicles, whereas in the case of satellite communications, meterology and earth observations, three-fourth of the investment is for building operational systems based in service needs of the country. The table below is giving definitions used in the expenditure budget.

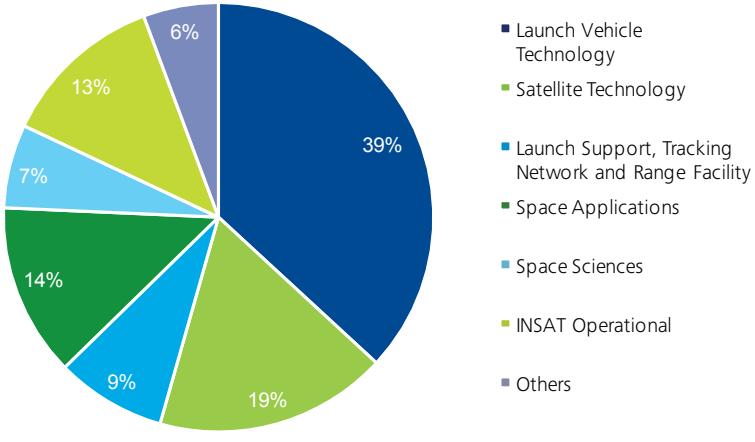


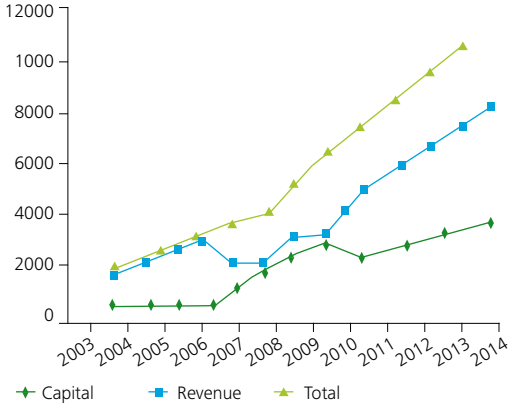
Table 5: Space Specific definitions (Department of Space, Government of India)

| Expenditure Type | Definition |
|---|---|
| | **General budget terms** |
| Budget | The budget for the space is prepared prior to each financial year and estimates the capital and revenue expenditure that will occur in that year. |
| Revised Estimates Budget | The Revised Estimates Budget is calculated at the end of the year and captures the actual revenue and capital expenditure spent during the financial year. |
| Plan Expenditure | Plan Expenditure is expenditure requirements identified and discussed by respective ministers or departments and discussed with the Ministry of Finance. Indian Government Plan Expenditure includes health and education. It comprises 34% of the total Central Government budget. |
| Non-Plan Expenditure | Non-Plan Expenditure is a generic term, which is used to cover all expenditure of Government not included in the Plan. It may either be revenue expenditure or capital expenditure. This expenditure includes salaries of employees, loans to private enterprises, States, Union Territories, Local and Foreign governments, tax collection and social services. It comprises 66% of the total Central Government budget. |
| | **Categories of spending** |
| Capital Expenditure | The Capital Expenditure Budget is primarily used to construct infrastructure, space stations, buildings and procure land, Assets, vehicles and other equipments required. |
| Revenue Expenditure | The Revenue Expenditure includes everyday operating expenses i.e. expenses incurred for the normal day-to-day running of the department. |
| Space Technology | Application of Space Technology in Tele-education, Telemedicine and Village Resource Centres. It comprises of three parts i.e. Launch Vehicle Technology, Satellite Technology and Launch Support, Tracking Network and Range Facility. |
| Space Application | Space Applications in Disaster Management Support– Decision Support Centre, Virtual Private Network, Mapping Support, Emergency Communication Support and Data base support.<br>Space Applications in Natural Resource Management- National Drinking Water Mission, Waste Land Mapping, Natural Resources Census, PFZ estimation, Land use / Land Cover mapping, Bio-diversity characterization.<br>Space applications in Remote Sensing- Flood Management Information System, Aerial Remote Sensing, Radio Remote Sensing. |
| Space Sciences | Space Science initiatives – Chandrayaan, ASTROSAT, Megha-Tropiques, Life science experiments using balloon flights, aerosol measurement campaign and Middle atmospheric studies using Sounding rocket flights and basic research in experimental and theoretical physics, astronomy and astrophysics, earth, planetary and atmospheric sciences. |
| | **INSAT Operational[17]** |
| Master Control Facility | Carrying out initial phase operations and regular on-orbit monitoring and control of all Geostationary satellites of ISRO namely INSATs, METSATs and GSATs. |
| INSAT-3 satellites (including launch services) | Development and launch of third generation INSAT-3 satellites (INSAT-3A to 3E) to augment the capacity of INSAT system. |
| INSAT-4 Satellites (including launch services) | Development and launch of fourth generation INSAT-4 satellites to augment the INSAT system capacity. (Currently, INSAT-4A to 4G and GSAT-9 and GSAT-12 have been approved). |

Source: Expenditure Budget 2010-11 Government of India Volume 1, Outcome Budget of the Department of Space Government of India 2009-10, Report of the working group on "SPACE" on the 11th five year plan proposals 2007-12 for Indian Space Programme, ISRO Department of Space, Bangalore

Looking at the past spending of DOS, the budgeted expenditure has increased from ₹23.68 billion (USD 0.51 billion) to ₹57.78 billion (USD 1.26 billion) from 2003 to 2010 showing an increase of 143.995%. Further taking the average of past seven years, the expenditure for next four years is estimated to be increased at 14.8% annually as shown in Exhibit 5 below.

**Exhibit 5: Budgeted Space Expenditure forecast**




Source: Union Budget of India. Available at: www.indiabudget.nic.in , Deloitte Analysis

## 7.2 Outlook of Space Sector

Space is not merely a destination; it is an economic engine that has become increasingly more critical to economic growth and our way of life. America's investment in space has already brought the benefits of satellite television, global-weather-warning systems, advanced composite materials, medical devices and search-and-rescue tracking tools like GPS that have become so vital to rescue efforts in natural disasters like Hurricanes Katrina, Rita and like. NASA has always partnered with the private sector to achieve its missions. The growth of the private space economy has resulted in significant cost savings to all future government-sponsored space activities, and help develop promising new markets for the economy, The Indian Space Programme aims to establish operational space services in a self reliant manner in the thrust areas of satellite communication, satellite based resource survey management and satellite meteorological applications. It has enabled a significant role for national industries in realization of space systems. Indian capabilities represent a wide spectrum of expertise ranging from the conceptual design to building and operating of a variety of space systems which are matched only by a few nations in the world.[18]

### Space Activity in India

The trend of globalization in space activity continues with nations entering agreements to use each other's infrastructure and space assets. Two decades ago only the United States, the Soviet Union, Europe and China regularly launched and deployed satellites and other missions to space. Today, almost twice as many nations conduct regular reliable launches.

Indian space programme has made phenomenal progress in its quest towards mastering critical technologies and witnessed several major accomplishments. The major event of the year was the successful launch of India's first mission to Moon, Chandrayaan-1, on PSLV and putting the spacecraft in the lunar orbit and placing the Indian tricolour on the surface of the moon. Indian space programme recorded another major success during the year with the launching of 10 satellites on PSLV from Sriharikota that included India's advanced remote sensing satellite CARTOSAT-2A, Indian Mini Satellite (IMS-1) and eight nano satellites for international customers. Some of the other important developments included successful flight acceptance testing of the indigenously developed cryogenic engine on December 18, 2008. A state of the art communication satellite, W2M, built by Antrix/ISRO on a commercial basis in partnership with EADS-Astrium of Europe for a European customer, was successfully launched on December 21, 2008. Substantial progress was made in establishing various facilities for the realisation of the more powerful version of GSLV, namely GSLV-Mark III, which can launch spacecraft of about four tonnes into Geosynchronous Transfer Orbit. A solid propellant production plant capable of producing about 900 tonnes of propellant per year was successfully commissioned thus crossing a major milestone in GSLV-MK III development.

The continuing expansion of space applications programmes like Village Resources Centres, telemedicine, tele-education, disaster management support and outreach through Direct-To-Home television, reiterates the increasing role played by

17 Outcome Budget 2009-10, page 62

18 Report of the working group on "Space" on the 11th five year plan proposals 2007-12 for Indian Space Programme, ISRO Department of Space, Bangalore

## Following the success of Chandrayaan-1, India is working on Chandrayaan-2, second unmanned lunar exploration mission likely to be launched in 2012-13.

the Indian space systems in providing direct benefits to the society. Thus Indian space programme continues to pursue successful goals on all fronts in meeting the objective of achieving self-reliance in space technology and its applications for national development.[19]

**Lunar exploration**

Beyond the ISS, exploration of the Moon shows signs of emerging as the next area of collaboration, and possibly competition, among space faring nations. A number of nations, including the United States, Europe, China, Japan, and India, conducted or participated in lunar missions in 2008.

A highly visible example of collaborative lunar exploration is India's Chandrayaan-1 Moon Probe , a low-cost program with multinational funding and support. Chandrayaan-1 launched on October 22, 2008, from Sriharikota in southern Andhra Pradesh. The Indian lunar initiative bore a number of unique characteristics, among them, low launch cost and indigenous development of the scientific payload within a collaborative context. The cost of launching Chandrayaan-1 was estimated to be US$83 million, approximately half the cost of China's lunar spacecraft launch a year earlier.[20] Both NASA and ESA contributed to the science mission, as Chandrayaan-1 carried two instruments built in the United States and four instruments from various European nations.[21]

Following the success of Chandrayaan-1, the Country's first moon mission, ISRO is planning a series of further lunar missions in the next decade, including a manned mission which is stated to take place in 2020. Chandrayaan-2 is the second unmanned lunar exploration mission proposed by ISRO at a projected cost of ₹4.25 billion (US$90 million). The mission includes a lunar orbiter and a lander/rover.

***Space Tourism***

[22] Space tourism encapsulates the notion that passengers will have the opportunity to travel beyond Earth's atmosphere and experience orbital flights, prolonged stays in rotating space hotels and may participae in research, entertainment and even sport.

Space tourism connotes a provision of services for humans to access and experience space for adventure and recreation. Essentially space tourism can be divided into two categories: i.e. suborbital and orbital.

**Suborbital Tourism**

Suborbital flight, is a flight short of orbit altitude. Currently priced at around US$ 100,000 a suborbital flight would take a tourist to an altitude of about 100 Km above the Earth on a trajectories path, at the peak of which one would experience zero gravity and can see the Earth's curvature and the hollow black space around.

**Orbital Tourism**

A vertical launch to the orbit on a Russian made Soyuz rocket or a reusable launch vehicle (RLV), attached to it like the space shuttle Columbia, where one would dock into the International Space Station (ISS) and stay there for a week or more. So far only a handful of tourists have been to the ISS paying a price of about US$ 20 Million. The orbital experience is totally different from that of suborbital in the sense that one would experience zero gravity throughout the stay, orbit the Earth and see the sunrise every 90 Minutes.

On April 28, 2001, Dennis Tito became the first "fee-paying" space tourist when he visited the International Space Station (ISS) for seven days. He was followed in 2002 by South African computer millionaire Mark Shuttleworth. The third was Gregory Olsen in 2005, who was trained as a scientist and whose company produced specialist high-sensitivity cameras. The first three participants called as 'Spaceflight Participant' paid in excess of $20 million (USD) each for their 10-day visit to the ISS.
As of 2009, space tourism opportunities have been

19 Annual Report 2009-10 of Department of Space, Government of India

20 Peter B. de Selding, "ATV docking with space station occurs flawlessly," SpaceNews, April 7, 2008

21 Emily Shanklin, "SpaceX adds two DragonLab missions to manifest," SpaceX Press Release, December 11, 2008, http://www.spacex.com/press.php?page=20081202 (accessed January 23, 2009).

22 Abstract from the report on Space tourism in India by McGill University, Canada and University of Petroleum and Energy Studies, Dehradun

limited and expensive, with the Russian Space Agency providing this facility. The price for a flight brokered by Space Adventures to the International Space Station aboard a Soyuz spacecraft is $20-35 million. Space tourists usually sign contracts with third parties to conduct certain research while in orbit. This helps minimise their own expenses.

Space tourism is something where India can play a niche role with its affordable solutions. However, this will take some time. ISRO was allocated a plan for India's human space flight programme amounting to ₹50 billion. Isro scientists have started work to reach Mars, put an orbiter there by using the capabilities of its workhorse launch vehicles like PSLV (Polar Satellite Launch Vehicle), GSLV (Geosynchronous Satellite Launch Vehicle) and GSLV Mark 3.

Roskosmos currently charges about $35 million for a ten day tourist flight to the International Space Station. Moscow and New Delhi signed a space agreement last year, under which Russia will help ISRO in training Indian astronauts and provide technical backup enabling India to build its own manned spacecraft. ISRO already has launch vehicles under development which could carry the Soyuz craft into orbit.

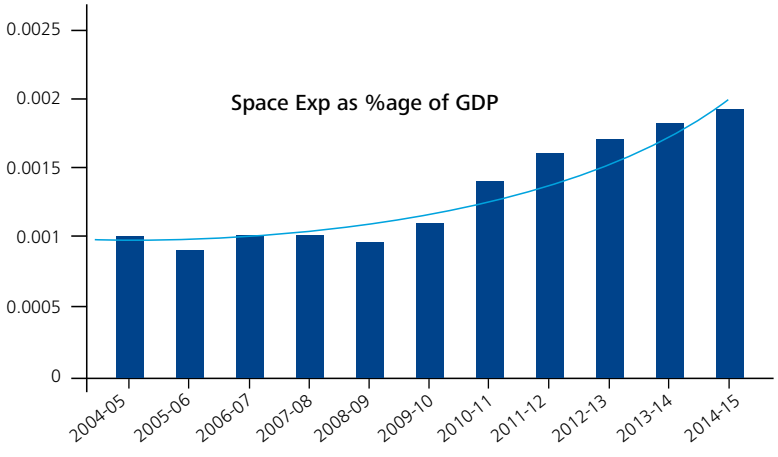
India has become one of the major space powers in the world, particularly after the successful launch of the Chandrayaan –I. Indian space sector is being opened up for private participants and has begun commercializing certain technologies and services internationally. In India, the privatization and commercialization of space technologies make it imperative for the Government to legislate appropriate national space laws and regulations.

### 7.3 Role/Benefits Of Space On Indian Economy

ISRO prepared to zoom into higher orbit following a nearly 35% hike in its budget. In 2009, ISRO's budgetary allocation was ₹ 41.67 billion (USD 0.91 billion). This year (2010-11) it has jumped to ₹ 57.78 billion (USD 1.26 billion). The spending for 2010-11 accounts for about 0.14 percent of GDP[23] [24]. The space expenditure as a percentage of GDP over the years is shown in Exhibit 6.

Positive Impact of Space on Indian Economy:

**Exhibit 6: Space Expenditure as percentage of Indian GDP**




Source: IMF World Economic Database- October 2009, indiabudget.nic.in, Deloitte Analysis

1. **In the short run: Spin-off Benefits**
   A space program generally involves the development of cutting edge technologies. Even if something has been done before, it can be done in a more efficient manner. ISRO had received 150 patents (not all international) and equally importantly had transferred 268 technologies to industry.

   The aim of Space should be to reach the standards of the best in the world, and aggressively seek to commercialize spin-off effects and rake in the royalties to make the research self-sustaining, eventually.

2. **In the medium run: Strategic Advantage**
   India's current space ambitions are something we would not have realistically thought likely even 10 years ago. If our ambitions are remarkable then they are so by our own standards. In the United States, which is the leading space faring nation right now, these achievements have become so mundane that private industry is aiming to commercialize them. While Virgin will take customers to space, Bigelow Industries already has a prototype (unmanned but with living organisms) space station in orbit. Google is sponsoring a competition for organizations to land a spacecraft on the moon, with little or no government assistance.

23 India's government expenditure budget

24 At an exchange rate of ₹46 to $US 1

That takes a lot of the glory out of the achievements but it does raise another important point: commercial exploitation of space technologies is becoming the newest frontier for business and the sky is literally the limit here. We do not know at this stage how big this business is going to be in the near term, so there is no urgency for India Inc to jump in immediately. But as ISRO builds these technologies for the future, it should ensure our domestic economic are not denied an edge that could be crucial.

3. **In the long run: Necessity**

Predicting future trends beyond a few years is always wrought with danger. Based on current trends there are two resources for which human civilization should eventually have to look to space for: solar power and mineral resources.

In view of our dwindling mineral resources and growing environmental concerns we are likely to look to space to meet our requirements. A time when mineral resources from the moon or the asteroids is comparable in cost to those from earth is very far. But when that time arrives the space faring nations will beat a huge advantage.

## 7.4 Space Infrastructure

[25] Space infrastructure is designed, built, used, launched, and operated by the space industry. It is the critical ingredient in all of the space products and services used by governments, businesses, scientists, entrepreneurs, and individuals around the world.

Getting the most out of each launch is a key practice of today's space industry. In 2008, 26 types of launch vehicles were used for 69 launches carrying 106 different payloads into space. Much of this was for government-funded and government-operated programs, but private ventures are gaining an increasingly high profile.

The World revenue in 2009 for commercial space infrastructure, including launch vehicles, satellites, in-space platforms, ground equipment, and infrastructure support industries totalled $83.63 billion.

[26] India has established a strong infrastructure for executing its space programme. They include facilities for the development of satellites and launch vehicles and their testing; launch infrastructure for sounding rockets and satellite launch vehicles; telemetry, tracking and command network; data reception and processing systems for remote sensing.

SDSC SHAR has the necessary infrastructure for launching satellite into low earth orbit, polar orbit and geostationary transfer orbit. The launch complexes inter-alia provide complete support for vehicle assembly, fuelling, checkout and launch operations.

ISRO ISTRAC provides mission support to low-earth orbit satellites as well as launch vehicle missions. It has a network of ground stations in India and at overseas locations. IDSN forms the ground segment for providing deep space support for India's prestigious and first Lunar mission, the Chandrayaan-1.The technical facilities in IDSN include a 32 metre Deep Space Antenna, an 18 metre Antenna Terminal, an 11 metre Antenna Terminal, Indian Space Science Data Centre (ISSDC) and a Technical Services complex. National Remote Sensing Centre (NRSC) is responsible for remote sensing satellite data acquisition and processing, data dissemination, aerial remote sensing and decision support for disaster management. DSC is a single window information provider on major natural disasters like Floods, Agricultural Drought, Forest fires, Cyclones, Earthquakes and Landslides.

Master Control facility (MCF) is for carrying out initial phase operations and regular on - orbit monitoring and control of all geostationary satellites of ISRO namely INSATs, METSATs and GSATs.

Several areas of application such as Agriculture, Soil, Bio-resources and Environment, Ocean Resources, Water Resources, Rural Development, Urban Development, and Disaster Management etc., which are of direct relevance to the nation are executed by ISRO/DOS centers. These centres have sophisticated computer facilities for image analysis and GIS to cater to the users needs and participate actively in areas like disaster management, software development, agro-climatic planning, national drinking water mission, national resources census, large scale mapping, etc,

25 The Space Report 2009, Space Foundation

26 www.isro.gov.in

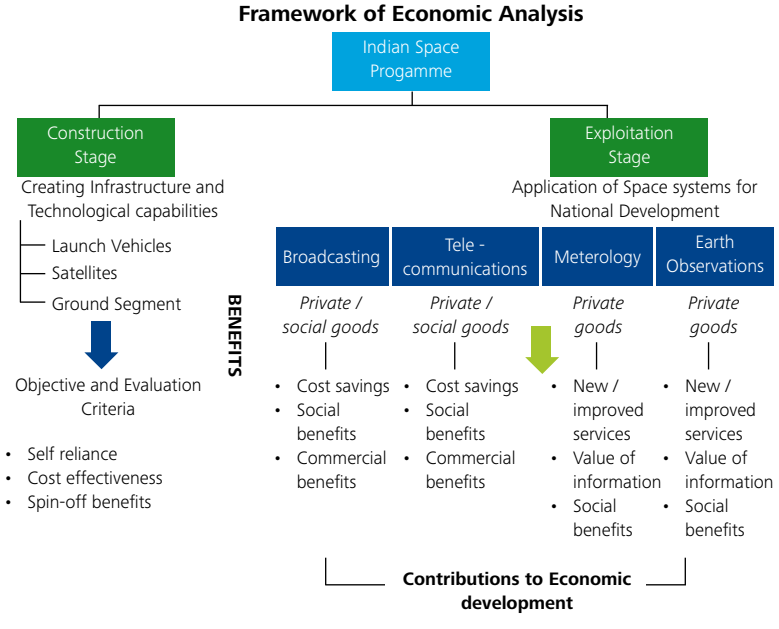
besides taking up projects for various ministries and departments.

### 7.5 Demand Drivers and Growth Areas

The primary industries using space-based products and services involve Earth-orbiting satellites[27]. used for communication; remote sensing and Earth observation; and position, navigation, and timing. An emerging sector of in-space products and services now includes personal spaceflight and private space research. Companies in this sector also support defence and civil government in-space programs.

[28]For the purposes of economic analysis, it is useful to classify space activities into two stages, namely, (i) design, development, testing, manufacturing and launch of spacecrafts into desired orbital slots (construction stage), and (ii) applications of satellite services to different uses (exploitation stage). The methodology adopted for the two stages, category-wise, is given in Exhibit 7.

Exhibit 7: Framework of Economic Analysis




For measurement of the benefits, the role of satellite technology is considered under three different categories: (a) where the technology is unique, (b) where the technology is a substitute to existing technologies, and (c) where the technology is complementary to existing technologies.

Communication satellites connect distant locations, including extremely remote areas, an attribute particularly apparent in the broadcasting and mobile services arenas. Satellites are used to broadcast content to many locations simultaneously with a single transmission, referred to as point-to-multipoint broadcasts.

**Broadcasting**

The INSAT system has played a key role in augmenting Broadcasting, Telecommunications and Meteorological services in the country and has contributed immensely to economic and social development. Satellite communication technologies are terrain and distance independent and they enable governments to achieve goals such as the development of backward and remote areas at low costs and in a short time and thereby achieve technological leapfrogging.

**Television**

INSAT has been a major catalyst for the expansion of television coverage in India. The terrestrial coverage is over 65 percent of the Indian land mass and over 90 percent of the population. There has also been an increase in the number of channels, remote area coverage, satellite news gathering, dissemination of weather and cyclone warning and use of TV as a media for training and education.

For enhancing the population coverage further from 90 to 100 per cent with the distribution of a bouquet of 20 DD channels by the public broadcaster Doordarshan, the capital cost and annual operating cost through terrestrial technology is ₹34.56 billion and ₹5.18 billion respectively while a satellite based solution with direct reception at homes, would involve a capital cost of ₹6.38 billion and annual operating cost of ₹357 million. Thus, given the unique physiographical feature of India, the satellite communications is the least-cost option for achieving 100 per cent population coverage.

The growth of satellite TV has also aided in the emergence of new economic activities. The advent of satellite TV contributed to the growth of several industries like the manufacturing of TV sets, cables, receiving antenna and other equipment and program production. There are about 100,000 cable TV operators and about 35 million cable TV households

27 Space Report 2009

28 Article on Economic aspects of India's space program published in epress.com

Bhuvan opens the door to graphic visualization of digital geospatial India allowing individuals to experience the fully interactive terrain viewing capabilities.

in the country. The gross earnings of cable TV operators is nearing ₹10 billion.

### Telecommunications

Remote area communication is an important objective of public policy. There is considerable cost savings due to use of satellite technology compared with the alternative of optical fiber cable network in remote area communication. The cost of connecting 393 remote areas, currently served by INSAT, by optical fibre cable would be ₹23.58 billion while the comparable cost for satellite technology would be ₹10.46 billion. It may be noted that there are 30,000 remote villages of similar nature needing connectivity. The other uses of satellite technology are: alternative media back up for terrestrial services, business communications, portable terminals for disaster management, Tele-medicine and Satellite Aided Search and Rescue.

Apart from the cost saving, there are many external benefits which are diffused economy-wide. In case of Andaman and Nicobar (AN), rapid expansion of telecom since the mid-nineties facilitated the integration of AN with the mainland thereby boosting the growth of industry, trade and tourism and raising the growth rate of gross state domestic product to more than 8 per cent.

### Meterology

Satellites have made significant contributions to the generation of meteorological information by extending observation to oceans and remote areas on land, enabling generation of new types of observations, facilitating new concepts of data assimilation into models, reducing costs of a few types of observations and enhancing the reliability of certain types of data.

Meteorological services are recognized as public goods. The major contributions of satellite technology are in the areas of weather technology (cloud motion vector, wind-sea surface temperature and outgoing long wave radiation) and tropical cyclone (identification of genesis and current position, intensity of change and transmission of cyclone warnings).

### Remote Sensing

Remote sensing products and services provide a unique perspective of the Earth, its land masses, nations, and communities. Growing access to these products and services has expanded our understanding of landforms and structures, made it easier to identify change in natural and man-made formations, and assisted in rural and urban planning. More than 80% of commercial remote sensing data is produced and purchased by governments with national security as the primary application. [29] A wide range of private companies analyze and integrate imagery with other information such as road maps, store locations, pollution maps, census data, and crime statistics. Demand for imagery is driven by an increasing mix of military, civil government, and consumer interests. Global change, including climate change, human impact, and natural disasters such as the 2008 earthquake in China, floods in Asia and North America, and hurricanes and tsunamis, increasingly drive demand for remote sensing and Earth observation. Innovative services such as Google Earth and Microsoft Virtual Earth, among others, are streamlining and enhancing the use of remote sensing products and services by consumers for such tasks as locating retail stores, gas stations, and restaurants, and getting directions to an office or other destination.

Bhuvan is an initiative of ISRO to showcase distinctiveness of Indian imaging capabilities including the thematic information derived from such imagery which could be of vital importance to common man with a focus on Indian region. Bhuvan takes Indian images and thematic information in multiple spatial resolutions to people through a web portal through easy access to information on basic natural resources in the geospatial domain. It displays satellite images of varying resolution of India's surface, allowing users to visually see things like cities and important places of

29 NASA, "FY 2009 Budget Request," NASA Budget Information, http://www.nasa.gov/news/budget/index.html (accessed January 29, 2009).

30 Space Investment Outlook Space Report 2009,page 116

interest looking perpendicularly down or at an oblique angle, with different perspectives and can navigate through 3D viewing environment. The degree of resolution showcased is based on the points of interest and popularity, but most of the Indian terrain is covered upto at least 5.8 meters of resolution with the least spatial resolution being 55 meters from AWifs Sensor. With such rich content, Bhuvan opens the door to graphic visualisation of digital geospatial India allowing individuals to experience the fully interactive terrain viewing capabilities.

Apart from the major benefits enumerated above, the policy of self-reliance has also enabled internal competence building and technology development and spin-offs to non-space sectors. For example, the spin-off outputs include 224 Technology Transfers, 165 patents, 10 trademarks and 17 copyrights. ISRO has nurtured a symbiotic partnership with more than 500 Indian firms. The flow of funds to industry currently is about 40 per cent of the space budget. This partnership has generated significant spin-off effects to the industries in terms of improved manufacturing processes, quality control and management practices.

The estimated benefits of remote sensing are cost saving due to increase in success rate, mapping returns from Antrix through access fee and royalty, sale of satellite data, etc.

### 7.6 Space Investment Outlook

Despite the bleak state of the economy[30] at the end of 2008, companies in the space industry throughout the year made effective use of available capital and transactional opportunity. Mergers and acquisitions (M & A) of companies remained a common tool for an industry that reshaped itself through dramatic consolidation in the 1990s. As in recent years, M & A activity in 2008 was large in volume but small in individual transaction size. The flow of money into the industry was dramatically constrained by the tightening of credit and declines in corporate valuations brought on by the stock market decline. In the face of these constraints, interested acquirers tapped their own reserves to bring proposed deals to fruition.

### Mergers and Acquisitions

Space companies of all shapes and sizes have used MandA to accelerate growth and execute business strategies. In recent years the volume and valuation have been sustained by a large diversity of buyers. Transactions were by no means limited to the big acquiring the small. Notable transactions in 2008 ranged from acquisitions by small companies of space-related product lines of Honeywell and L-3, to EADS' acquisition of European small satellite prime contractor Surrey Satellite Technology Limited, to the consolidation of International Launch Services under the ownership of Russia's Khrunichev State Research and Production Space Centre.

These buyers are diversified as well as diverse, involved not solely in space-related lines of business but in other markets, particularly military. This diversity is helping to produce consistent, predictable cash flow. As government spending and commercial success have allowed them to build strong balance sheets, they are motivated to invest these positive balances into a broader array of business lines that offer the potential for returns that their investors have come to expect.

The majority of transactions suggest that buyers are using mergers and acquisitions as a rapid way to fill gaps and incorporate promising technical or market niches into existing business lines. The average deal size in the pure space-related arena was well under $100 million, similar to the overall trend in the aerospace/defense/government industry, where the average size of acquisitions in 2008 was approximately $160 million.

### Near-Term Investment Outlook

It is unknown if the prominent political and economic transitions in early 2009 will have an impact on the steady development of the space industry's financial support and activity. Certainly much of the next few years' progress depends on the course taken by President Obama on such important issues as the Space Shuttle Program, missile defense, and commercial space transportation. Much also depends on the pace of economic and capital market recovery.

With the ambitious plans of ISRO for doubling the number of missions-satellites and launch vehicles, there is a need for fully assembled stages and systems which can directly go into the satellite or rocket systems.

Acquisition activity will continue, driven by a number of factors. The financial strength of the space industry leaves companies in a position to sources invest, and the budget pressures felt by both government and commercial customers create incentives to acquire new sources of revenue.

The ongoing internationalization of the space industry will continue to include partnerships of all kinds between companies, including mergers and acquisitions. Investment in space, whether in the form of public stock price or early-stage venture capital, will rise or fall based on the ability of each industry participant to convince customers and investors of the productivity and profit that can be realized from space. Valuation will follow accordingly.

With the ambitious plans of ISRO for doubling the number of missions-satellites and launch vehicles, there is a need for fully assembled stages and systems which can directly go into the satellite or rocket systems. The companies like Godrej and MTAR Technologies jointly work for liquid propulsion systems, could form consortia and supply full systems for spacecraft, launch vehicles, ground systems among others. Thus, there is a need for Indian industry to invest in the industry to a greater extent and join hands with each other to grow this industry.

# 8. Space Products and Services- Commercial Perspective

## Introduction

Space products and services that depend upon space platforms drive innovation and discovery while providing economic and environmental benefits in such spheres as communications, Earth observation, global positioning, and navigation. The design, development, and deployment of these services form a key economic pillar in several national economies, supporting and sustaining high-paying jobs, cutting-edge education, and strong economic growth. Beyond the commercial sphere, satellites support national defence, promote understanding of the universe, and extend human presence further into space.[31]

US operates around half of all military satellites and spends $~20 billion per year on military space activities. Russia owns around 85 military satellites and next to the US has the biggest military presence in space. 45 countries had launched a satellite, with Iran being the 45th. India and China's programmes are developing fast.[32]

## 8.1 Satellite Related Products and Services

A satellite is an object which has been placed into orbit by human endeavour. Such objects are sometimes called artificial satellites to distinguish them from natural satellites such as the Moon. Satellites are used for a large number of purposes. Common types include military and civilian Earth observation satellites, communications satellites, navigation satellites, weather satellites, and research satellites. Space stations and human spacecraft in orbit are also satellites. Satellite orbits vary greatly, depending on the purpose of the satellite, and are classified in a number of ways. Well-known (overlapping) classes include low Earth orbit, polar orbit, and geostationary orbit. Satellites are usually semi-independent computer-controlled systems. Satellite subsystems attend many tasks, such as power generation, thermal control, telemetry, attitude control and orbit control.

ISRO has launched more than 50 satellites for various scientific and technological applications like mobile communications, Direct-to-Home services, meteorological observations, telemedicine, tele-education, disaster warning, radio networking, search and rescue operations, remote sensing and scientific studies of the space.[33]

### 8.1.1 Communication

Communications satellites provide links between ground stations, end users, and other in-space platforms. Satellites can operate as part of a larger communications network or they can provide services directly to the end user. Communications satellites can transmit any kind of data, voice, or video in a variety of formats and radio frequency bands.[34]

ISRO has established the Indian National Satellite System (INSAT) series for communication, television broadcasting and meteorological services which is Geo-Stationary Satellites. India, as of now, has one of the largest domestic communication satellite systems with a total of 199 communication transponders on ten satellites INSAT-2E, INSAT-3A, 3B, 3C, 3E, GSAT-2, Edusat (GSAT-3), INSAT-4A, 4 B and Kalpana providing a variety of communication and meteorological services to the country. Twelve more transponders will soon be added to the tally with the commissioning of INSAT 4C-R, which was launched recently on September 02, 2007, after completion of in-orbit tests.[35]

INSAT system is the largest domestic satcom infrastructure in South East Asia, providing a wide variety of services in various sectors of the economy – TV and telecom, VSAT based business communications, rural / remote area communications, mobile communications, emergency communications and radio networking. Importantly, INSAT meets social needs of the country in the area of health (Tele-medicine), education (Tele-education) and rural development (Village Resource Centres). The spectrum of users of INSAT system includes Government, Private as well as NGOs / VOs.[36]

ISRO has launched more than 50 satellites for various scientific and technological applications like mobile communications, remote sensing and scientific studies of the space.

31 Space Report 2009, Pg 36

32 http://www.parliament.uk/documents/post/postpn273.pdf

33 Satellite ISRO, http://www.isro.gov.in

34 The Space Report 2009, Pg 37

35 Application for Space Communication, current science, vol. 93, no. 12, 25 December 2007, http://www.ias.ac.in/currsci/dec252007/1737.pdf (accessed online 27 April 2010)

36 Eleventh five Year Plan Proposals, 2007-12 for Indian Space programme, Satellite Communications and Navigation Programme, Pg 15

Table 6: Communication satellites of India

| No. | Spacecraft | Launch date | Launched | Mass (kg) | Position | Major payloads | Status |
|---|---|---|---|---|---|---|---|
| 1 | APPLE | June 19, 1981 | Ariane-1 | 670 | GSO 102°E | 2-C-Band | Mission completed |
| 2 | INSAT-1A* | April 10,1982 | Delta | 1150 | GSO 74°E | 12-C, 1-S, VHRR, IR 8 km., 2.5 km | Failed after 5 months |
| 3 | INSAT-1B* | August 30 1983 | Space shuttle | 1190 | GSO 74°E | 12-C, 1-S, VHRR, IR 8 km, 2.5 km | Mission Completed |
| 4 | INSAT-1C* | July 21, 1988 | Ariane-4 | 1190 | GSO 93.5°E | 12-C, 1-S, VHRR, IR 8 km, 2.5 km | Failed after 2.5 Years |
| 5 | INSAT-1D* | June 12,1990 | Delta | 1292 | GSO 83° | E 12-C, 1-S, VHRR, IR 8 km, 2.5 km | Mission Completed |
| 6 | INSAT-2A | July 10,1992 | Ariane-4 | 1905 | GSO 76˚ | E 12-C, 6-Ext.C, 2-S, VHRR, DRT, SASR | Mission Completed |
| 7 | INSAT-2B | July 23,1993 | Ariane-4 | 1932 | GSO 93.5° | E 12-C, 6-Ext.C, 2-S, VHRR, DRT, SASR | Mission Completed |
| 8 | INSAT-2C | December 7,1995 | Ariane-4 | 2020 | GSO 93.5° | E 12-C, 6-Ext.C, 1-S, MSS, 3-Ku | Mission Completed |
| 9 | INSAT-2D | June 4,1997 | Ariane-4 | 2070 | GSO 74° | E 12-C, 6-Ext.C, 1-S, MSS, 3-Ku | Failed after 4 Months |
| 10 | INSAT-2E | April 3,1999 | Ariane-4 | 2550 | GSO 83˚ | E-12-C, 5-Ext.C,VHRR, CCD | In Operation |
| 11 | INSAT-3B | March 22,2000 | Ariane-5 | 2070 | GSO 83˚ | E 12-Ext.C, 3-Ku, MSS | In operation |
| 12 | GSAT-1 | Apri 18,2001 | GSLV-D1 | 1540 | Inclined orbit | 2-C, 2-S, 1-C steerable | Mission completed |
| 13 | INSAT-3C | January 24,2002 | Ariane-4 | 2650 | GSO 74° | E 24 -C, 6-Ext.C, 2-BSS, MSS | In operation |
| 14 | KALPANA-1 | September 12,2002 | PSLV-C4 | 1060 | GSO | VHRR, DRT | In operation |
| 15 | INSAT-3A | April 4,2003 | Ariane-5 | 2950 | GSO | 12-C, 6-Ku, VHRR, CCD, DRT, SASR | In operation |
| 16 | GSAT-2 | September 28,2003 | GSLV-D2 | 1540 | GSO | 4-C, 2-Ku, MSS | In operation |
| 17 | INSAT-3E | September 28,2003 | Ariane-5 | 2775 | GSO | 24 -C, 12-Ext.C | In operation |
| 18 | EDUSAT | September 20 2004 | GSLV-F1 | 1950 | GSO 74° | E 6-Ku, 6-Ext.C | In operation |
| 19 | HAMSAT | May 5,2005 | PSLV-C6 | 42.5 | SSO 97.8° | | Mission completed |
| 20 | INSAT-4A | December 22,2005 | Ariane-5 | 3086 | GSO | 12-Ku, 12-C | In operation |
| 21 | INSAT-4C | July 10,2006 | GSLV-F2 | - | GSO | - | Mission Launch Failed |
| 22 | INSAT-4B | March 12,2007 | Ariane-5 | 3025 | GSO | 12-Ku, 12-C | In operation |
| 23 | INSAT-4CR | September 2,2007 | GSLV-F4 | 2130 | GSO | 74°E 12-Ku | To be declared operational |
| 24 | GSAT-4 | April 15,2010 | GSLV-D3 | 2220 | | - | GSAT-4 was not placed in orbit as GSLV-D3 could not complete the mission. |

* Satellites procured form outside India, in this case from Ford Aerospace Communication Corporation, USA

**Source: Application for Space Communication, current science, vol. 93, no. 12, 25 December 2007, http://www.ias.ac.in/currsci/dec252007/1737.pdf (accessed online 27 April 2010) and updated information from Geo-Stationary Satellites, ISRO, http://www.isro.org/satellites/geostationary.aspx (accessed online 27 April 2010)**

## INSAT Applications

### *EDUSAT Programme*

EDUSAT has been providing a wide range of educational delivery modes including one-way TV broadcast, interactive TV, video conferencing, computer conferencing and web-based instructions.

### *Transponder requirement under Tele- Education*

Considering the interest shown by the States and users of the network, it is expected that the utilisation of the Edusat is likely to expand during 11th Plan (2007-2012) . Majority of the institutions have shown interest in utilising the network for on-line examination, on-line admissions, Intranet activities etc.

### *Telemedicine*

The power of satellite communication has been very well adopted for the unique requirement of Healthcare in the form of providing digital connectivity between a Remote Rural District/Medical College/Mobile hospital on one side and the Speciality hospital located in a town or a city on the other side. Presently Telemedicine Network consists of 176 Hospitals – 142 Remote/Rural/District Hospitals/Health Centres connected to 34 Speciality Hospitals located in major cities.[37]

### *Television*

INSAT has been a major catalyst for the expansion of television coverage in India. Satellite television now covers 100 percent area and 100 percent population. The terrestrial coverage is over 65 percent of the Indian land mass and over 90 percent of the population. At present, over 40 Doordarshan TV channels including news uplinks are operating through C-band transponders onboard INSAT as well as leased ones.

All these Satellite TV channels are digitised. As on Dec 2009, 1416 transmitters of Doordarshan are working in INSAT system out of which 1136 transmitters [130 High Power Transmitters (HPT), 728 Low Power Transmitters (LPT), 260 Very Low Power Transmitters (VLPT) and 18 Transposers] are working in the DD-1 network and 168 TV Transmitters 73 HPTs, 78 LPTs and 17 VLPTs) are working in the DD-News network. 108 Regional service transmitters (6 HPTs, 8 LPTs and 94 VLPTs) and 4 HPTs with digital transmissions are also operational in the Doordarshan Network. Out of these 4 transmitters, one located at Delhi is carrying 16 mobile TV services for experimental purpose. 57 DD and Private TV channels are operational through DTH service ("DD Direct+"). A 10 c channel DTH planned in C-band for Andaman and Nicobar islands has been commissioned in September 2009.

### *Satellite News Gathering and Dissemination*

Satellite News Gathering using INSAT system enables on the spot real-time news coverage and important events at different locations for transmission to a Central Station at Delhi or to State Capitals for rebroadcast over respective DD channels.

### *Radio Networking*

Radio Networking (RN) through INSAT provides a reliable high-fidelity programme channels for national as well as regional networking. At present, 235 All India Radio (AIR) stations have been equipped with S-band receive terminals out of which around 200 AIR stations have been equipped to receive C-band Analogue and Digital RN carriers. At present, AIR has 21 radio channels on DTH platform in Ku-band uplinks with TV carriers from Todapur, New Delhi on INSAT-4B.

### *Telecommunications*

A total of 651 Earth stations and 1,18,675 VSATs telecommunication terminals of various sizes and capabilities (excluding NICNET, and VSAT micro terminals) are operating in INSAT telecommunications network providing 9603 two-way speech circuits and providing transmission backhaul point to point connectivities. These include 101 BSNL, 181 Earth stations and 434 Vsats for government users and 270 Earth stations and 118152 Vsats Closed User Group (CUG)/Commercial VSAT operators earth stations. 48 Multi Channel per Carrier (MCPC) VSATs and 4000 Ku band VSATs under HVNET are working with BSNL. A total of 1,18,675 CUG VSATs are operating through INSAT.

### *Meteorology*

The meteorological data of INSAT system is processed and disseminated by INSAT Meteorological Data Processing System (IMDPS) of India Meteorological Department (IMD). The products derived from the satellite data include: cloud images in Visible, Infra-red and Water Vapour Channel, cloud motion vectors, Water Vapour Winds, etc. are used for weather

37 ibid

forecasting, both synoptic and numerical weather prediction.

***Satellite Aided Search and Rescue (SASandR)***

India is a member of the international COSPAS-SARSAT programme for providing distress alert and position location service through LEOSAR (Low Earth Orbit Search And Rescue) satellite system, under which India has established two Local User Terminals (LUTs), at Lucknow and Bangalore.

***Standard Time and Frequency Signal Dissemination Services***

A Standard Time and Frequency Signal Dissemination Service using a Radio Networking (RN) type CxS carrier on INSAT-3C is being operated by the National Physical Laboratory. This service is available round-the-clock in a broadcast mode at a downlink frequency in S-band and is receivable on a set up consisting of a 2.4 m diameter antenna, a front-end converter, an FM demodulator and a microprocessor controlled signal decoder. The time has a precision of better than one microsecond and accuracy of better than 20 microseconds.

***Disaster Management Support (DMS)***

The Disaster Management Support (DMS) Programme of ISRO, commits to providing timely support and services from aero-space systems, both imaging and communications, for strengthening the resolves of disaster management in the country. These include creation of digital data base for facilitating hazard zonation, damage assessment, etc., monitoring of major natural disasters using satellite and aerial data; development of appropriate techniques and tools for decision support, establishing satellite based reliable communication network, deployment of emergency communication equipments and RandD towards early warning of disasters.[38]

***Thrust areas in Communication [39] (11th plan 2007-2012)***

The major emphasis during formulation of 11th five year plan has been towards meeting the growing demand for transponders, ensuring continuity of quality services, protection of space systems, efficient spectrum management and continuous improvement in technology. The thrust areas of Satellite communications for 11th five year plan include:

- Build INSAT system capacity in C, Ext-C, Ku and BSS/MSS bands for Government, social sectors and private TV and telecom service providers and maintain continuity of services with adequate spare capacity.
- Development of high power Ka band satellites and ground systems for pointto- point connectivity.
- Development of cost-effective 4T-12KW bus with capacity of more than 50 transponders and flexible enough to accommodate wide range of payloads.
- Expansion and growth of tele-education, telemedicine and village resource centers, strategies for operationalisation and institutionalisation with the involvement of Central Government Ministries / Departments, State Governments and NGOs, self-sustenance and large scale training.
- Communication support for space based disaster management system and address critical strategic requirements.
- New communication services including multimedia broadcast, broadband services, high definition TV, Satellite based Tele-surgery and innovative communication media for education and training, and mobile communications.
- R and D in satellite communication technologies such as multiple spot beam communication payloads, multiple beam frequency reuse, reconfigurable beams, onboard data regeneration, etc.,
- Development of low cost indigenous ground systems including hand held communication system for voice and data communications for strategic users, low cost least maintenance Tele-medicine equipments and software, ground systems compatible for MEO SAR payloads.
- Progress towards financial self-sustenance of INSAT/GSAT system and corporatise the services with partial dependence on government funding.
- System level planning and management including efficient spectrum management and frequency interference management.

***Transponder Requirements***

The INSAT system currently has more than 150 transponders. The additional transponders projected for the 11th plan period stands at 260, out of which

38 Annual report ISRO-2009-2010

39 11th 5 year plan proposal, pg-16 to 24

192 Transponders (~75% of the demand) is from Government agencies and societal applications. Therefore, by end of 11th plan, it is estimated that India would need over 400 transponders in various frequency bands. Keeping in mind the growing demand and the need to maintain on-orbit spares, it would be prudent to create transponder capacity of about 500 by end of 11th plan period.

*Village Resource Centres*

Village Resource Centres (VRCs), an initiative of 10th plan period, are intended to provide space based services such as Tele-medicine, Tele-education, agricultural advisories, weather advisories and natural resource data base services in an integrated manner at the door steps of rural mass. From the modest beginning of 3 VRCs and 1 Expert Centre in association with MS Swaminathan Research Foundation (MSSRF), Chennai in October, 2004; today about over 450 VRCs have been set up in the various States. The programmes conducted cover a wide gamut, including agriculture, adult and computer literacy, alternate livelihood related vocational training, marketing of agro-products, micro-finance/ enterprises, livestock management, healthcare and disaster relief measures.

Besides the above, the other satellite communication services planned during the 11th plan period includes mobile communications, multi-media broadcast supporting an exclusive science channel, search and rescue services, real time hydro meteorological data relay services, rural / remote area communications and emergency communications support for disaster management. [40]

### 8.1.2 Remote Sensing

Remote sensing satellites process into images light waves reflected or emitted from Earth. Remote sensing satellites can be passive or active; that is, they only receive light or they emit a signal and measure its properties when it returns.[41]

Satellite remote sensing is an evolving technology with the potential for contributing to studies of the human dimensions of global environmental change by making globally comprehensive evaluations of many human actions possible. Satellite image data enable direct observation of the land surface at repetitive intervals and therefore allow mapping of the extent--and monitoring of the changes--in land cover. Evaluation of the static attributes of land cover (types, amount, and arrangement) and the dynamic attributes (types and rates of change) on satellite image data may allow the types of change to be regionalized and the proximate sources of change to be identified or inferred.

*Remote Sensing Applications*

Remote sensing application[43] projects at national, regional and local levels are being carried out through NRSC (Hyderabad), SAC (Ahmedabad), five RRSSC located at Bangalore, Dehradun, Jodhpur, Kharagpur, and Nagpur as well as North-Eastern Space Application Centre (NE-SAC), Shillong. State and central government departments, state remote sensing centres and others are also associating in the execution of these projects. Some of the major application projects carried out during the year are highlighted in the following paragraphs.

*Groundwater Prospects Mapping*

Under Rajiv Gandhi National Drinking Water Mission, funded by the Department of Drinking Water Supply of the Ministry of Rural Development, ground water prospects mapping on 1:50,000 scale and generation of digital data base pertaining to ground water prospecting such as lithology, geomorphology, geological structures and hydrology was taken up in phases

40 ibid

41 The space report 2009, pg 37

42 Outcome Budget 2009-10, page 9

43 Annual Report 2008-09, pages 39 to 45

# India has successfully launched 17 remote sensing satellites and 24 geostationary satellites since 1975.

***Biodiversity Characterisation***
Initiated by DOS jointly with the Department of Biotechnology (DBT), biodiversity characterisation at landscape level covers four main biodiversity rich regions of the country - NE Region, Western Himalayas, Western Ghats and Andaman and Nicobar Islands.

***National Wastelands Monitoring***
At the behest of Department of Land Resources (DoLR) of Ministry of Rural Development, identification and inventorying of wastelands using satellite data on 1:50,000 scale was initiated in 1986 and completed under 5 different phases.

***Natural Resources Census***
The Natural Resources (NR) census taken up as part of Natural Resources Repository (NRR) is aimed to provide a snap-shot of the status of natural resources of the country. The project uses IRS data to prepare a systematic spatial database of natural resources information such as land use/land cover, soil, geomorphology, vegetation, snow/glacier, land degradation, wetlands at 1:50,000 scale and land use/land cover both at 1:50,000 and 1:250,000 scale for periodic monitoring of natural resources.

***BHOOSAMPADA (Web enabled land use/land cover information system)***
For effective utilisation and to enhance the outreach of generated land use/land cover at 1:250,000 scale using AWiFS data, a web enabled information system, namely, BHOOSAMPADA has been developed in Internet GIS domain

***Topographic Mapping of Indian Coast***
Digital terrain model (DTM) are very much useful for many applications, such as topographic mapping, watershed management, disaster applications, etc. To meet the immediate requirements of disaster applications, Cartosat-1 data has been used to generate the DTM for the entire coast (~7600 line km, except Andaman and Nicobar islands) with a minimum of 20 km inland buffer from the coast covering approximately 1.5 lakh sq km.

***Flood Management Information System***
At the behest of Flood Management Information System Cell, Govt. of Bihar, a Flood Management Information System (FMIS) has been designed and developed as a desktop based application using COTS software with different modules for data access and updation, analysis, generation of maps and reports.

***Natural Resources Census***
The Natural Resources (NR) census taken up as part of Natural Resources Repository (NRR) is aimed to provide a snap-shot of the status of natural resources of the country.

***Aerial Remote Sensing***
The aerial remote sensing facility of NRSA offers value-added services like aerial photography and digital mapping, infrastructure planning, scanner surveys, aeromagnetic surveys, large scale base map, topographic and cadastral mapping, etc.

***Radio Remote Sensing*** [44]
Propagation studies on earth-space path at Ku-band have been carried out using transmissions from the geostationary satellite NSS-6 (95 E).

44 Annual Report 2008-09,page 62

*Remote Sensing Satellites*

The Table below provides details of satellites launched and in service

**Table 7: List of Remote Sensing Satellites**

| Serial No. | Satellite | Date of Launch | Launch Vehicle | Status |
|---|---|---|---|---|
| 1 | IRS 1A | 17 March 1988 | Vostok, USSR | Mission Completed |
| 2 | IRS 1B | 29 August 1991 | Vostok, USSR | Mission Completed |
| 3 | IRS P1 (also IE) | 20 September 1993 | PSLV-D1 | Crashed, due to launch failure of PSLV |
| 4 | IRS P2 | 15 October 1994 | PSLV-D2 | Mission Completed |
| 5 | IRS 1C | 28 December 1995 | Molniya, Russia | Mission Completed |
| 6 | IRS P3 | 21 March 1996 | PSLV-D3 | Mission Completed |
| 7 | IRS 1D | 29 September 1997 | PSLV-C1 | In Service |
| 8 | IRS P4 (Oceansat-1) | 27 May 1999 | PSLV-C2 | In Service |
| 9 | Technology Experiment Satellite (TES) | 22 October 2001 | PSLV-C3 | In Service |
| 10 | IRS P6 (Resourcesat 1) | 17 October 2003 | PSLV-C5 | In Service |
| 11 | IRS P5 (Cartosat 1) | 5 May 2005 | PSLV-C6 | In Service |
| 12 | Cartosat 2 (IRS P7) | 10 January 2007 | PSLV-C7 | In Service |
| 13 | Cartosat 2A | 28 April 2008 | PSLV-C9 | In Service |
| 14 | IMS 1 | 28 April 2008 | PSLV-C9 | In Service |
| 15 | RISAT-2 | 20 April 2009 | PSLV-CA | Mission Completed |
| 16 | Oceansat-2 | 23 September 2009 | PSLV-C14 | In Service |
| 17 | Cartosat-2B | 12 July 2010 | PSLV-C15 | In Service |

*Future IRS launches*

Following are the remote sensing satellites planned by ISRO to be launched next strengthening the fleet of IRS satellites and widening their applications.

- RISAT (Radar Imaging Satellite): A microwave remote sensing mission with Synthetic Aperture Radar (SAR) operating in C-band and having a 6 x 2 meter planar active array antenna based on trans-receiver module architecture. SAR is an all weather-imaging sensor capable of taking images in cloudy and snow covered regions and also both during day and night. RISAT weighs 1,750 kg.
- RESOURCESAT-2: It will have imaging sensors similar to RESOURCESAT-1. Payload electronics have been miniaturised to reduce the overall weight. RESOURCESAT-2 is planned for launch by PSLV in 2010.
- RESEOURCESAT-3: A follow on to Resourcesat-2, it will carry more advanced LISS-III-WS (Wide Swath) Sensor having similar swath and revisit capability as Advanced Wide Field Sensor (AWiFS), thus overcoming any spatial resolution limitation of AWiFS. Satellite would also carry Atmospheric Correction Sensor (ACS) for quantitative interpretation and geophysical parameter retrieval. It slated to be launched during 2011-12.
- CARTOSAT-3: A continuation of Cartosat series , it will have a resolution 30 cm and 6 km swath suitable for cadastre and infrastructure mapping and analysis. It would also enhance disaster monitoring and damage assessment. It is slated to be launched during 2011-12.
- OCEANSAT-3: Oceasat-3 would carry Thermal IR Sensor, 12 channel Ocean Color Monitor,

Scatterometer and Passive Microwave Radiometer. IR Sensor and Ocean Color Monitor would be used in the analysis for operational Potential Fishing Zones. Satellite is mainly for Ocean biology and sea state applications. It is slated to the launched aboard PSLV in 2012-13.

### 8.1.3 Position, Navigation and Timing

The U.S. Navigation Signal Timing and Ranging Global Positioning System[45] (NAVSTAR GPS or GPS) is the only fully operational satellite-based navigation network. Best known from its widespread commercial applications, the network was deployed and is operated by the U.S. Air Force.

The European Union continues to develop the 30-satellite Galileo constellation, expected to be launched in 2010.Funding has been approved for the project, and in April 2008 the second GIOVE (Galileo In-Orbit Validation Element) test satellite was launched. China is planning to supplement its Compass satellite network already in development. Other systems in various stages of development include Japan's Quasi-Zenith Satellite System, which will supplement GPS coverage over areas of Japan that prove difficult with GPS alone[46]. The Indian Regional Navigational Satellite System is under development by the ISRO. The introduction of these competing systems, with newer spacecraft and stronger signals, should improve global coverage, accuracy, and reliability.

**Satellite Navigation**[47] is emerging as a vital area not only for civil aviation but in many other areas such as mobile telephones, surface transport, intelligent highway system, maritime transport, rail, oil and gas, precision, agriculture, fisheries, survey and marine engineering, science, electricity networks and leisure. Besides completing the ground augmentation system GAGAN (GPS And GEO Augmented Navigation), a major target for 11th plan is to establish Indian Regional Navigational Satellite System with a constellation of 7 satellites. Co-operation and participation in global navigational systems will also be pursued.

### 8.1.4 Exploration

**Space exploration** is the use of astronomy and space technology to explore outer space. Physical exploration of space is conducted both by human spaceflights and by robotic spacecraft. While the observation of objects in space, known as astronomy, predates reliablerecorded history, it was the development of large liquid-fueled rocket engines during the early 20th century that allowed physical space exploration to become a reality. Common rationales for exploring space include advancing scientific research, uniting different nations, ensuring the future survival of humanity and developing military and strategic advantages against other countries. Various criticisms of space exploration are sometimes made.

China initiated a successful manned spaceflight program, while the European Union, Japan, and India have also planned future manned space missions. The United States has committed to return to the Moon by 2018 and later Mars. China, Russia, Japan, and India have advocated manned missions to the Moon during the 21st century, while the European Union has advocated manned missions to both the Moon and Mars during the 21st century[48].

#### Space Exploration in India

ISRO plans to launch Chandrayaan -2 on an indigenous cryogenic engine. The current version of India's geo-synchronous satellite launch vehicle will be used to loft the new craft into space.

ISRO is designing a 100 kg solar probe called Aditya. This is a mini-satellite designed to study the dynamic solar corona, the outer most region of the sun. It is planned to be launched in 2012.

ISRO is also working towards launching Astrosat - a dedicated astronomy satellite. This will be launched on PSLV, likely to be in 2011.

## 8.2 In-Space Activities Related Products and Services[49]

Science and research performed on in-space platforms rely for their funding primarily on national space agencies, military agencies, and other government organizations.

### 8.2.1 In Space Platform Services[50]

In 2008, India launched the Chandrayaan-1 lunar probe which carried five instruments built by India, four instruments from European countries, and two from the United States. India's portion of the mission,

45 Space Report 2009,page 77

46 Inside GNSS, "QZSS Progress Spurs Spirent Simulator Capability," Inside GNSS, November 20, 2008. http://www.insidegnss.com/node/925 (accessed January 28, 2009).

47 Outcome Budget 2009-10,page 19 and 20

48 Russia proposes manned Mars mission by 2015 - 08 July 2002 - New Scientist

49 Space Report 2009,page 21

50 Space Report 2009,page 16

including development of the satellite, five of the 11 payloads, and launch and operations, totaled ` 3.8 billion (US$77.2 million). The multinational nature of this lunar probe and its low cost development made the mission unique. NASA, the largest contributor, allocated $1.81 billion for the space station in fiscal year (FY) 2008 and requested $2.06 billion for FY 2009. During 2008, two major modules were added to the ISS: the Japanese Kibo, which cost approximately $3 billion to develop; and the European Space Agency's (ESA) Columbus, which cost €880 million (US$1.24 billion) .ESA's Automated Transfer Vehicle successfully completed its first mission in 2008; development costs were approximately €1.3 billion (US$1.83 billion).

### 8.2.2 In Space Transportation Services[51]

The Indian Space Programme started in a humble way with the launch of modest Rohini sounding rockets from Thumba near Thiruvananthapuram in the early 1960s. Initially, these sounding rocket launches were aimed at conducting scientific investigations over the geomagnetic equator passing over Thumba. Since then, India has made rapid strides in launch vehicle technology to achieve self reliance in satellite launch vehicle programme with the operationalisation of Polar Satellite Launch Vehicle (PSLV) and Geosynchronous Satellite Launch Vehicle (GSLV).

In its fourteenth flight conducted from Satish Dhawan Space Centre (SDSC) SHAR, Sriharikota on October 22, 2008, the Indian Space Research Organisation's (ISRO's) Polar Satellite Launch Vehicle, PSLV-C11, successfully launched the 1380 kg Chandrayaan-1 spacecraft into a transfer orbit with a perigee (nearest point to Earth) of 255 km and an apogee (farthest point to Earth) of 22,860 km, inclined at an angle of 17.9 deg to the equator.

## 8.3 Launch Vehicles

Most launch vehicles[52] are liquid-fueled rockets capable of delivering the thrust needed to overcome the Earth's gravity and enter space. Of the two broad categories of launch vehicle, orbital and suborbital, orbital launch vehicles play the larger role in space infrastructure. Their greater size and thrust allow them to reach altitudes well beyond a commonly-accepted boundary between Earth's atmosphere and space, known as the Karman line, 100 kilometers (62 miles) above Earth.This allows orbital launch vehicles to circle the planet and conduct operations such as deploying satellites, cargoes, or crew that will operate and remain in space. Suborbital vehicles are generally smaller, less advanced rockets,some of them solid-fueled.

Governments, businesses, and individuals seeking access to space have a number of options to get there. In addition to the 26 varieties of orbital vehicles sent into orbit in 2008, other orbital launchers remain in service for the future. The array of operational launchers is complemented by a number of vehicles in design and testing. Most of this activity reflects government-funded efforts to develop more advanced vehicles capable of carrying payloads not fully served by existing incountry vehicle inventories.

The United States and Russia together accounted for 41 of the 69 orbital launches in 2008. The other 28 missions were carried out by other nations or entities, including: Europe, under the auspices of its multinational civil space agency, ESA; China; Japan; India; Iran; and the Sea Launch Company, a multinational commercial launch service provider. Together, orbital missions carried out by these international participants represented two-fifths of the world total in 2008. This proportion, a record high, continues a five-year trend in which the share of launches performed by countries other than Russia and the United States rose from 30% to 41%.

### India's Launch Vehicles[53]

***Landmark achievements in ISRO's Launch Vehicle Development[54]***

| | |
|---|---|
| 1 | PSLV has 16 consecutively successful flights out of 17 launches. |
| 2 | PSLV used for launching a total of 25 satellites for foreign customers under commercial agreements, demonstrating its multi-satellite launch capability |
| 3 | PSLV used to launch Space capsule Recovery Experiment (SRE-1), Chandrayaan-1 and ISRO's exclusive meteorological satellite, KALPANA-1, proving its versatility |
| 4 | GSLV with four successful flights of five launches can launch 2 to 2.5 tonne satellite into GTO |
| 5 | Successful testing of indigenously developed cryogenic upper stage on November 15, 2007. |

51 Annual Report 2008-09,pages 46 to 52

52 Space Report 2009,page 55

53 en.wikipedia.org

54 www.antrix.gov.in/

*ISRO's Launch Fleet at a Glance*[55]

| | |
|---|---|
| 1 | ISRO developed two experimental satellite launch vehicles, SLV-3 and ASLV |
| 2 | Polar Satellite Launch Vehicle(PSLV) commissioned in 1997 |
| 3 | Geosynchronous Satellite Launch Vehicle (GSLV-Mk I) commissioned after second successful flight in May 2003 |
| 4 | GSLV-MK II will use indigenously developed cryogenic Upper Stage |
| 5 | GSLV-MK III is under development |

## 8.4 Ground Systems

Launch vehicles, spacecraft, and other space platforms receive operational, logistical, and navigational instructions from ground stations[56] . Individual ground stations are usually spread across a wide geographic, and sometimes international, expanse to maximize the reach of the network as it uploads instructions to and downloads communications from space hardware. Governments of countries participating in space activity typically own and operate ground stations. Most major commercial satellite operators have their own facilities which they use to monitor and control their fleets, often providing similar services to other operators for a fee. Earth-based mission control centres and tracking systems are also assisted by in-space assets. For example, the satellite-enabled global positioning system (GPS)aids in geolocation of orbiting space vehicles, while space situational awareness systems such as the U.S.- operated Space Surveillance Network monitor space debris in order to avoid collisions.

### Ground Equipment

The ground equipment[57] sector combines network infrastructure and consumer terminals. The global estimated revenue of $74.4 billion includes network facilities such as satellite operations and control stations, very small aperture terminals (VSATs) for private networks, and broadcast video head-end stations. It also includes end-user equipment such as satellite TV receiver dishes, satellite radios, satellite phones, and stand-alone GPS devices.

The term "ground equipment" can also refer to end-user devices that incorporate satellite signals, such as satellite dishes, GPS receivers, or satellite phones.

### Ground control station

ISTRAC provides mission support to low-earth orbit (LEO), Satellites as well as launch vehicle missions. It's activities are organised into network operations, network augmentation, mission operation and spacecraft health monitoring, communication and computers and control centre facilities and development projects.

MCF is for carrying out initial phase operations and regular on-orbit monitoring and control of all Geostationary satellites of ISRO namely INSATs, METSATs and GSATs.

## 8.5 Support of Space Products and services to various sectors

Some of the ways in which space products and services support various sectors of the greater economy are given below:

### Education and infrastructure

Satellite provide a range of local services as diverse as customs and border control, city planning, distance learning, disaster relief and search and rescue, in the form of tele-education, disaster management, civil planning, natural disaster tracking and monitoring, student experiments, etc.

### Science, Biotechnology and health care

Some notable discoveries have been made in the past year in science and medicine through the use of space transportation, satellite imagery and microgravity research. Few such discoveries are tele-medicine, bone loss/osteoporosis research, vaccine research, energy research, disease prediction and monitoring, etc.

### Travel and Entertainment

Space products and services play an important role in the travel and the entertainment industries, such as direct-to-home television, television content, distribution to hotels, computer reservation services, satellite radio, digital movies, digital content to cell phones, GPS services, spaceflights.

55 www.antrix.gov.in/

56 Space Report 2009,page 74

57 Space Report 2009,page 17

**Energy resources and environment management**
Remote sensing satellites provide a wide perspective view of earth that enables applications to local and regional levels in the energy resources and environmental management sectors. Few instances are weather monitoring and forecasting, tele-exploration, resource exploration and exploitation, etc.

**Transportation, logistics and manufacturing**
It span wide range of industries from shipping to airlines to public transportation on the ground. These sectors utilize several space technology associated with satellite imagery, space exploration and GPS. Some such services include air traffic control. Inventory control, package tracking, warehouse inventory management, etc.

**Retail, finance and corporate services**
This sector includes businesses engaged in sales, financial transactions, manufacturing and other enterprises requiring connections among distributed locations. The examples of such benefits are direct to home internet, video conferencing, tele-training, e-commerce, video surveillance, etc.

**Homeland Security, defence and intelligence**
Communications satellites transmit critical data to and from military forces around the globe. Some such use is in cyber warefare, sensor monitoring, border protection, missile launch monitoring, etc.

# 9. Opportunities in The Indian Space Sector

### 9.1 Opportunities For Indian Companies

The relationship between ISRO and private sector goes back a long way. Private firms have been supplying satellite components and ground equipments to ISRO since the initial stages of it's developing satellite launch vehicle in the early 1970s.

Industry involvement in space programme has not only been through the development and fabrication of a variety of hardware for satellites and launch vehicles, but also for creating required ground infrastructure, development, testing, transportation and utilisation of space hardware, either independently or through a consortium. Industries have been augmenting their facilities to suit the space programme requirements. DOS continues to source its requirement of hardware, structural subassemblies, light alloy structures, thermal control systems for satellites, optics, rocket propellants- solid and liquid – oxidizer for the liquid stages of PSLV and INSAT propulsion system and other materials like carbon cloth, etc., through industries. Industry participation in the production of inertial systems for launch vehicle and spacecraft programme has been increasing, especially in precision machining, precision assembly, fabrication and integration of electronic packages, calibration, test and evaluation. After the success of India's maiden unmanned moon mission ('Chandrayaan-I'), ISRO is ready to outsource more high-end work to private companies – everything from building more complicated systems to assembling it.

The commercial-aerospace industry is now eager to play a larger role in the space missions and tap the outsourcing work offered by ISRO, which has an annual budget of ₹ 57.78 billion ($1.26 billion) for 2010-11. It has a spending blueprint of ₹ 124 billion ($3 billion) for its manned space exploration and around ₹ 4.25 billion will be spent for the second unmanned lunar mission – Chandrayaan-2. It also has huge spending plans for missions to Mars and various domestic and international satellite launches.

Firms such as Larsen and Toubro (L&T) and Godrej have been associated with the space agency for a number of years. L&T has worked on all the generations of satellite launch vehicles- SLV, ASLV, PSLV, GSLV. Today, L&T makes rocket casings, has a facility to manufacture advanced composites, honeycomb deck panels and is installing a special radar system at Sriharikota which has a 4000 km tracking range. Similarly Godrej began with components for satellites and then graduated to the sub-system level. Now they make critical liquid propulsion engines for launch vehicles as well as parts of the engines fitted directly to the satellite. Similarly, ISRO has increased outsourcing to the Indian Industry with more critical work, for instance, Astra Microwave which makes critical hardware components that were outsourced by ISRO.

DOS has nurtured a strong partnership with Indian Industries in realizing the objectives of the Space Programme. More than 500 small, medium and large scale Industries participate in the programme in the form of hardware development and supply, software and other services. Almost 60% of a launch vehicle cost flows to Indian Industries. In the recently developed applications, almost 100% of the ground segment equipments/ services for Tele-education and Tele-medicine have been formed out to Indian Industries. The Industry participation policy of the Department has adopted several aggressive measures to promote the participation of Industries in the Space Programme. The DOS, so far, has developed and transferred 289 technologies to Industries in the fields of electronic and computer based systems, speciality polymer chemicals and materials, electro optical instruments, mechanical equipments and ground systems related to satellite communications, broadcasting and meteorology.

Industries in the large, medium and small scale sectors have largely been beneficiaries of the technology transfer scheme. ISRO has executed over 270 consultancy projects in high technology areas to provide support to various industries. ISRO has been investing in developing a patent portfolio, which now consists of 254 patents, 35 copyrights and 10 trademarks.[58]

It is heartening to note that this partnership with Industries has enabled the DOS to meet the growing challenges of advanced technology, handling complex manufacturing jobs and increasing demand for space services without any significant increase in in-house manpower. [59]

58 ISRO Technology Transfer Group, www.isro.org/ttg/

59 Outcome Budget of the Department of Space, Government of India 2009-10

For satellites, most of the R&D takes place within ISRO; around 20 to 25 percent of the hardware is contracted out to industries. Given below is a sample of selected industries that supply hardware and software to support India's space program. As ISRO goes in for bigger better satellites and launch vehicles to meet the growing demand, a survey for the next 10 years have estimated that these projects will need some 1.6 lakhs mechanical components and 20 lakhs electronic, 600 transponders, 650 solar panels and 80 batteries.

We have conducted a research of some of the Indian companies who are playing a key role in Indian space industry and contributing for Indian space program. The Table below shows deep involvement of these companies under five segments-satellite technology, launch vehicles, ground systems, space applications and navigation.

The commercial-aerospace industry is now eager to play a larger role in the space missions and tap the outsourcing work offered by ISRO, which has an annual budget of ₹57.78 billion ($ 1.26 billion) for 2010-11

Table 8: Illustrative List of Indian companies

| Sl no | Company Name | Location | Products | Satellite Technology | Launch Vehicle | Ground System | Space Application | Navigation |
|---|---|---|---|---|---|---|---|---|
| 1. | Accord Electronics | Mumbai | Satellite equipments, cable TV equipments and cyclone warning systems | ✓ | | ✓ | | |
| 2. | Advanced Micronic Devices Limited/ Symmetricon Inc | Bangalore | GPS and time code Instrumentation, time and frequency distribution, precision frequency references, network time server, Bus level phase noise and Allan seviation test Sets, space defense and Avionics components | | ✓ | | | ✓ |
| 3. | Advancetech Controls Pvt Limited | Bangalore | Industrial Computer, display Single Board computers in VME,VPX,CPCI,ATCA platforms, rugged systems | | ✓ | | | ✓ |
| 4. | Altair Engineering India Private Limited | Bangalore | Altair Hyperworks, PBS Grid works,Altair Product Design and Hi Qube | | | | ✓ | |
| 5. | Analog Systems | New Delhi | RF/IF Components, Sensors, Fibre Optic, Isolators | | | ✓ | | |

| Sl no | Company Name | Location | Products | Satellite Technology | Launch Vehicle | Ground System | Space Application | Navigation |
|---|---|---|---|---|---|---|---|---|
| 6. | Andhra Electronics Limited | Kakinanda (Andhra Pradesh) | Quartz Crystals, Crystal Clock Oscillation,VCXO,TC XO,OCXO,Filters,Rubidium Clocks,RFandMicrowave Components | ✓ | | | ✓ | |
| 7. | Ankit Fasteners Private Limited | Bangalore | Cruciform Bolts and Screws, Offset Cruciform Bolts and Screws, Bi-Hexagonal Bolts and Screws, Large Diameter Bolts, Threaded Inserts and Studs, Aluminium Alloy Rivets , Anchor Nuts and Bolts ,Bi-Hexagonal Nuts, Aerospace Nylock Nuts , Extra Long Fasteners, Micro Encapsulated Fasteners, Special Purpose Fasteners | ✓ | ✓ | ✓ | ✓ | |
| 8. | Apollo Microsoft Systems Private Limited | Hyderabad | Pay Load Checkout Systems, High Speed Elementary Systems,Pcm Telemetry Systems, Radio Altimeters, Embedded Aerospace Products, Data Acquisition Systems, Bit Synchronizers, Time Code Readers And Generators,Decommutor Core Designs, Customized Fpga Based Designs, Firmware Development, Application Software Development | | | | | ✓ |
| 9. | Aaron Tech-Pro Private Limited | New Delhi | Hyperspectral Field Airborne Sensors, UAV Hyperspectral Sensors, Geopdf, Toucan Nvugate, DGPS,GPS | | | | ✓ | |
| 10. | Astra Microwave Products Limited | Hyderabad | Coherent frequency generators, L-band modulators, 8x8 switchable routers for earth station, V/UHF T/R modules for ST radar, Ka-band indoor/ outdoor units | ✓ | | ✓ | ✓ | |

| Sl no | Company Name | Location | Products | Satellite Technology | Launch Vehicle | Ground System | Space Application | Navigation |
|---|---|---|---|---|---|---|---|---|
| 11. | BEML Limited* | Bangalore | Construction and Mining Equipment, Railway Products and Metro Coaches, Defence andAerospace Products | | ✓ | ✓ | | |
| 12. | Bharat Electronics Limited* | Bangalore | Radars,Sonars,Telecom, Opto, Spa electronics | ✓ | ✓ | | ✓ | |
| 13. | BrahMos Aerospace Thiruvananthaouram Limited | Kerala | Aerospace Industry | ✓ | ✓ | ✓ | ✓ | |
| 14. | Broadcast Equipments (India) Ltd | Hyderabad | Routers, Transmitters, Converters, Scalers | | | ✓ | | |
| 15. | Centraline Lubrotech Enginers Private Limited | Bangalore | Lubrication Systems and Equipments for Radars and other Machinery | ✓ | | | | |
| 16. | Centum Electronics Limited | Bangalore | Electronic Moduls and Sub Systems,Crystal Oscillators (SPXO,TCXO,VCXO and OCXO), Hybrid Microcircuits | ✓ | | | | |
| 17. | Chithra International | Bangalore | Hi-Rel Wave guide and Ferrite Isolator and Circulators | | | | ✓ | |
| 18. | ComAvia Systems Technologies P Limited | Bangalore | Mi-Std-15538 Card, ARINC429 Card, AFDX Cards, RUGGED Laptop and industrial | | ✓ | | | |
| 19. | Data Patterns (India) Private Limited | Chennai | Automatic Test Equipments Check Systems, On Board Satellite Electronics,Avionic Systems,RF Microwave Designs,Control Systems, Nanigation Packages,Rugg Displays,Hardware and Software Development,Turnkey Solutions | | ✓ | | ✓ | ✓ |

| Sl no | Company Name | Location | Products | Satellite Technology | Launch Vehicle | Ground System | Space Application | Navigation |
|---|---|---|---|---|---|---|---|---|
| 20. | Electronics Corporation of India Limited(ECIL) | Hyderabad | Earth Station Antennae at operating frequencies S,C,Ext.C, Ku andKa Bands, 32 meter DSN Antennae with X and S Band with Beam wave guide optics,Los Antennae 500 MHz to 26 GHz, VSAT Networks ,Ku Band Stabilization Platforms for LCAs, Seekers in Ka Band for Missile applications, Rate Gyros for Space Applications, Actuator Systems | ✓ | ✓ | ✓ | ✓ | ✓ |
| 21. | Embed Technogies Private Limited | Bangalore | Development Tools such as Emulators, Compliers, Debuggers, Data Acquit ion Products | | ✓ | | | |
| 22. | EmWiB Technologies P Limited | Secundrabad | Avionics Bus/DSP Solutions/Test Equipments, RF Test Equipments,WiMAX Wodem, GNSS Receivers | | ✓ | | | |
| 23. | EmWiB Technologies Pvt. Limited | Hyderabad | USB 1553 Bus Simulator , USB ARINC 429 Bus Simulator, Tacan/ DME Tester, Plam RF Power Meter ,RF Power Meter (with frequency), Wimax CPE, Synthesizer for Tacan/DME | | | ✓ | | |

| Sl no | Company Name | Location | Products | Satellite Technology | Launch Vehicle | Ground System | Space Application | Navigation |
|---|---|---|---|---|---|---|---|---|
| 24. | Exalto Communication Technologies Pvt Ltd | Bangalore | System Integrators in the Satellite Communication domain, undertake Turnkey projects in establishing Satellite Uplink / Downlink Earth Stations, Digital TV Teleport, DSNG / OB Van systems, Satellite Communication on The Move' systems, STL links, Contribution links, Content Delivery Networks, VSAT networks, etc. | | | ✓ | | |
| 25. | Godrej and Boyce Mfg. Co. Limited | Mumbai | Launch Vehicle Engines, Satellite Thrusters, Valves, Regulators, Air Frame Sections, Antenna | ✓ | ✓ | | ✓ | |
| 26. | Hindustan * Aeronautics limited | Bangalore | DIA 2Mts/8Mts/3Mts/4Mts/5Mts Riveteo Structures, Tanks and Feedlines for Launch Vehicles PSLV,GSLV,MK andgslv Mkll , Metallic/Composite Structures for IRS/INSAT class satellites, Aircraft-Jaguar/ Hawk MK 132, Aircraft-Sukhoi MK/MIG 27/MIG 21, Helicopter-Dhruv /Cheta/ Cheetah, Aeroengineer-Adour,MK811,Artouse,Dart 533 ORPHEUS 70105 GNOME 1400 Aeroengines-A31FP,R29,R25,Advances Communications/Navigations Equipments,Accessories for Aircraft, Helicopter andAero engines Aluminum Alloy/ Magnesium Alloy/Steel Castings/Forgings Investment Castings andPrecision Forgings, Passenger Aircraft Dornier D0228 Composites for Aerospace Applications | ✓ | ✓ | | ✓ | ✓ |

| Sl no | Company Name | Location | Products | Satellite Technology | Launch Vehicle | Ground System | Space Application | Navigation |
|---|---|---|---|---|---|---|---|---|
| 27. | Hypertac India | Bangalore | PCB Connectors, Rectangular Connectors, Back Plane Connectors, Micro D | ✓ | | | | |
| 28. | Ignis Technology Private Limited | Bangalore | Avionics and Electrical Design and Development, Technical Documentation | | ✓ | | | |
| 29. | Inde Enterprises | Chandigarh | RF and Microwave Cable Assemblies, Fiber Optic Cable Assemblies | | | | ✓ | |
| 30. | Kannan Industries | Kerala | Pyro Systems, Umbillical Systems, Control Components , Cyro Engine Components, Avionics/Integration | | ✓ | | | |
| 31. | Kerala State Electronics Development Corporation Ltd.* | Thiruvananthapuram | Information Technology, Strategic Electronics Products For Defence, Space Electronics, Process Automation systems, Industrial Electronics Systems,Id and Smart Card Solutions,Traffic Management Systems, Consumer Electronics, Components | ✓ | ✓ | | | |
| 32. | Larsen and Tubro | Mumbai | Launcher parts manu-facturing advanced composites, rocket casings ,honeycomb, deck, panels and installing radar systems | ✓ | ✓ | | ✓ | |
| 33. | Lakshmi Electro Controls and Automation | Bangalore | Ac Servo Motors and Drives,Motorized Gher Unit,Position Controller, Cnc Controller Up To 5 Axes Simulation, Digital Readout, Linear /Rotary Transducers, Torque Motors, Safety Wire Stripping Tools and Cutters | | ✓ | | | |

| Sl no | Company Name | Location | Products | Satellite Technology | Launch Vehicle | Ground System | Space Application | Navigation |
|---|---|---|---|---|---|---|---|---|
| 34. | Lakshmi Technology and Engineering Industries Ltd | Coimbatore | High Precision Parts and Assemblies for Aerospace Domain, Transducers,Attitude and Orbit Control System Valves, Hydraulic Pumps,Gas Motors, Actuators, Thrusters, Pressurisation System Modules, Command System Modules, Slip Ring Assembler | | ✓ | | | |
| 35. | Lee Hydraulic and Fasteners P Limited | Hyderabad | Titanium andSpecial Alloy Fasteners | | | | ✓ | |
| 36. | Madras Hardtools P Limited | Chennai | Steel Wire Rope Slings, Lifting Equipments, Steel Wire Ropes, Chain Slongs, WEB/ Round Slings, Crosby Shackles, Yoke Chain/ Wire Slings Terminals, Electric Winches , Poly Propylene 8 Strand and 4 Strand Ropes, Caro Net | ✓ | | ✓ | | |
| 37. | Mechvac Fabricators(I) Private Limited | Navi Mumbai | Metal Mirrors, Optics, Ultra Precision Machining, Precision Machining, Precision Assembly, large Sixe Metal Mirror , Inspection Facilities | | | | ✓ | |
| 38. | Medhani Steel | Vishakhapattanam | Supplies special steel for Launchers | | ✓ | | | |
| 39. | Merlinhawk Aerospace P Limited | Bangalore | Vibration Monitoring Systems, Health and Usage Monitoring Systems,Aircraft Starting Power Packs | ✓ | | ✓ | | |

| Sl no | Company Name | Location | Products | Satellite Technology | Launch Vehicle | Ground System | Space Application | Navigation |
|---|---|---|---|---|---|---|---|---|
| 40. | MFR Electronic Components Pvt Limited | Mumbai | Precision metals Flims Resistors, Metals Flim Resistors, Metal Oxide ResistorsCarbon Flim Resistors,Moulded Resistors,Moulded Radial Resistors, Flameproof Fusible Resistors ,Silicon Coated Axial Wire Wound Resistors, Metal Glaze Resistors,Aluminium Housed Resistors, Lamp Resistors, Jumper Wire ,Zhero Ohm Resistors, High Voltage Metal Glaze Resistors, Power Radial Wire Wound Resistor, Ceramic Encased Wire Wound Resistor | ✓ | | | ✓ | |
| 41 | Prabhakar Products | Chennai | Road transportable carriers for satellite launcher segments and earth station antennas | ✓ | ✓ | ✓ | | |
| 42. | Prapoorna Enterprise Private Limited | Bangalore | RF and Microwave | | | | ✓ | |
| 43. | Saltel Inc | New Delhi | Surge Arrestors | | | | ✓ | |
| 44. | Saraswati Dynamics Private Limited | Roorkee | Electro Dynamic Vibration System, Enviornmental Chamber, Combined and Temperature Vibration System, Climatic Chamber,Squeak andRattle Test System, Automotive Fatigue Test Rigs, Sensor Callibration System, Rubber Mount Test Rigs, EV Drive System | ✓ | | | ✓ | |
| 45. | Satcom Technologies P limited | Hyderabad | Satellite Ground Station Equipment For: remote sensing , meteorology and communications/Instrumentation for antenna testing and telemetry/ all types of antenna systems for fixed ,mobile andairborne applications services: Consultancy for satellite ground stations , Installation, maintenance and training | ✓ | | ✓ | ✓ | |

| Sl no | Company Name | Location | Products | Satellite Technology | Launch Vehicle | Ground System | Space Application | Navigation |
|---|---|---|---|---|---|---|---|---|
| 46. | SenSol Inc | Bangalore | Pressure Transducers, Pressure Sensors, Strain Gages | | ✓ | | | |
| 47. | Shwetha Engineering Works | Bangalore | Pressure Transducers to LPSC,ISRO | | ✓ | | | |
| 48 | SLN Technologies Private limited | Bangalore | Antenna, PXI, PCI, PMC, VME, Automated Test equipments/ simulators | ✓ | | ✓ | | |
| 49. | TATA Advanced Materials Limited | Bangalore | Monolithic, Sandwich Composite Components andToolings for space, Aircraft and Helicopter Applications | | | | ✓ | |
| 50. | Tecsol Marketing/ Chelton Telecom and Microwave | Secundrabad | Diodes andModules ,Ferrite Devices, Isolators andCircula-tors, RF Filters, Waveguides | | | | ✓ | |
| 51. | Tecsol Marketing / Plug IN | Secundrabad | Design and manufacturing of hermetic feedthroughs using epoxy resign, glass or ceramic sealing .Used for ground testing in thermal vaccum space simulation chambers, beam lines of particulars accelerators, research vacuum or pressure equipments, laser experiences, metallization machines and satellite pay loads | | ✓ | ✓ | ✓ | |
| 52 | Unicom Satellite Systems | Bangalore | Installing Satellite | | | ✓ | | |
| 53. | Vajra Rubber Products Limited | Kerala | (Aero Space, Submarine, Helicopter, Defence Related, Oilfield , Automotive) Rubber Products, Bridge Bearing Pads, Underwater Cable Splicing Services, Rubberising of Submarine, Tanks, Pipes | ✓ | | | | |

| Sl no | Company Name | Location | Products | Satellite Technology | Launch Vehicle | Ground System | Space Application | Navigation |
|---|---|---|---|---|---|---|---|---|
| 54. | Walchadnagar Industries Limited | Pune | Rocket Motor Casing, Critical Equipment for Defence , Critical Equipment for Nuclear, Cement Projects, Sugar Projects, Minerala Processing Projects, Marine Processing Projects, Marine Gear Boxes , Industrial Boilers, Oil andGas Projects ,Foundry | ✓ | | | | |
| | Service companies | | | | | | | |
| 55. | A-Set | Noida | Research and development | | | | | |
| 56. | CADES | Bangalore | Aerospace Product Design and Development | | | | | |
| 57. | Dish TV India Limited | Noida | DTH Service Provider | | | | | |
| 58. | Hughes Communication India Limited | Gurgaon | Telecom Services | | | | | |
| 59. | Onward Technologies Limited | Pune | Mastercam Reseller/ Engineering Design Services CAD/ CAM/ CAE/ IT Services | | | | | |
| 60. | Sankhya InfoTech Limited | Secundrabad | Simulation and Training | | | | | |
| 61. | TAAL Technologies Private Limited | Bangalore | Engineering and Technology Solutions | | | | | |
| 62. | Tata Sky Limited | Bangalore | DTH Service Provider | | | | | |
| 63. | Tech Comm | Bangalore | MICE Services for Space Technology | | | | | |

* These companies are public sector undertakings

As per our reviews we got to know future prospects of some of the Indian companies which are described below:

- Aerospace companies like Taneja Aerospace and Aviation (Taal), which counts ISRO among its top customers are moving up the value chain and gearing up to provide avionics and electronics to customers like ISRO.
- Wipro is in discussions with ISRO to provide software and electronics for projects like the Chandrayaan-2 mission to collaborate in the area of robotic design, as they plan to land a motorised rover or robot on the Moon by 2013. They are present in the software, product engineering and R&D spaces and now they are gearing up to be ready in aerospace manufacturing by 2010.
- Technology firms like TCS and Infosys are talking to ISRO to provide their engineering design services.

**Relative advantages of Indian Industry**

India has great market advantages because of high demand, strong domestic manufacturing base, cost advantages, well-educated talent pool, abundant low cost skilled workforce, ability to leverage IT competitiveness, location advantage.

The Government is also giving thrust which is exhibited through large and growing spend on space, Research and development (R&D), liberalization, push for private participation in manufacturing.

Further, as highlighted above, given the current capabilities of Indian industry in space, it makes India as one of the very few nations that has the technological capabilities to fabricate, small, medium and large satellites as well as launch vehicles. This also ranks India among the top six space-faring nations of the world in terms of budget and technological capabilities.

### 9.2 Opportunities For Foreign Companies

The foreign companies have been cooperated with Indian space programme in number of ways. Few such instances are given below:

- Establishment of TERLS, conduct of SITE and STEP, launches of Aryabhata, Bhaskara, APPLE, IRS-IA and IRS-IB/ satellites, manned space mission, etc. involved international cooperation.
- ISRO operates LUT/MCC under the international COSPAS/SARSAT Programme for Search and Rescue.
- Chandrayaan-1 carried scientific payloads from NASA, ESA and the Bulgarian Space Agency.
- The Russian Space Agency is cooperating with India in developing the rover for Chandrayaan-2 and also in the Indian manned mission.
- ISRO bought seven cryogenic engines from Russia and has used five of them. It plans to use the remaining two engines for its upcoming GSLV launches [60].
- Work on ISRO's OCEANSAT-2 has made progress which will also carry an atmospheric sounder called ROSA from Italy as a part of the main payloads namely the ocean color monitor and imaging scatterometer.

Further in a recent article it has been revealed that ISRO has sought assistance from a US major company in four specific areas:

- A launch escape system (LES) to enable astronauts to escape from a rocket that is undergoing catastrophic failure.
- A life support and environmental control system, which creates an environment inside the space capsule in which astronauts can comfortably carry out their functions. This removes carbon dioxide and maintains humidity levels.
- Vehicle Health Monitoring System (VHMS), which keeps a constant check over key systems.
- Reusable space systems and composition cryogenic tanks. These tanks would be used to store fuel for India's cryogenic motors.

In addition, foreign companies can also utilize Indian industry's capabilities and further benefits from low cost base, educated pool,huge supplier base, low cost skilled workforce, technology and IT manpower.

60 http://timesofindia.indiatimes.com/india/Indigenous-engines-bring-down-GSLV/articleshow/5814028.cms

India is giving thrust to Indian Industries which is exhibited through growing spending on space.

# 10. Opportunities In The Global Space Sector

## ISRO/Antrix is expecting around $60 million from manufacturing satellites for other countries.

### 10.1 Opportunities

ISRO/Antrix earns sizeable sum by launching satellite for others. It has also notched up a good returns around time in manufacturing satellites. It could deliver a satellite in approximately 28 months time from the date of placing an order. The global average time schedule is around 30 months. Similarly the cost of manufacturing is also lower in India. India produces 2-ton satellites at a cost of US $40-60 million[61]. ISRO's PSLV launch cost is at no more than US $20 million.

ISRO/Antrix is expecting around $60 million from manufacturing satellites for other countries. At present a huge chunk of ISRO/Antrix's revenue (60%) comes from transponder rentals. The space agency also derives its profit by selling remote sensing data, ground station services, satellite launches and exports of satellite components and other products. [62] [63]Antrix sees revenues surging 20% annually over the next few years. Over the next three years, the space agency plans to launch between six and eight vehicles every year compared to two or three launches earlier. Transponders are channels of a communications satellite through which data is transmitted. The provision of transponders for the video and telecommunications sector accounted for 56% of Antrix's total revenues stood at ₹ 5.92 billion in 2008-09. Other products and services such as marketing of remote sensing data, satellite manufacturing and launch or ground system activities constituted 8%, 15% and 21% of revenues respectively, with revenue from export at ₹ 4.66 billion.

Around 200 transponders on the Insat series satellites provide services to state-run Doordarshan channels and various direct-to-home broadcasters such as Tata-Sky, Sun Direct and Bharti Airtel. Other applications of the Insat series include tele-medicine, tele-education, connecting village resource centres, search and rescue operations and disaster management support.

Meanwhile, Antrix plans to add another 60 transponders in the C and Ku bands later this year through two satellite launches. The satellites GSAT-5P and GSAT-8 would be launched by respective GSLV and Arianespace, the European launch services company. In the launch business, Antrix's order book currently includes 11 launches scheduled during the next two or three years while a few other contracts are in the pipeline, he said.

Last fiscal year, the firm also grew its business of marketing data from remote sensing satellites to include countries such as Sri Lanka, Vietnam and Nepal. It currently has around 22 international ground stations for the remote sensing segment along with 20 resellers worldwide.

Antrix/ ISRO clientele include overseas companies. A list of these companies is given below:

**Table 9: Illustrative List of overseas customers of Antrix/ISRO**

| Sl. No. | Overseas Customers |
|---|---|
| 1 | EADS Astrium |
| 2 | Intelsat |
| 3 | Avanti Group |
| 4 | World Space |
| 5 | Inmarsat |
| 6 | WorldSat |
| 7 | DLR |
| 8 | KARI |
| 9 | Eutelsat |
| 10 | OHB Systems and |
| 11 | Space Institutions in Europe, Middle East and South east Asian Countries |

61 www.domain-b.com

62 www.india-server.com/news/

63 www.financialexpress.com

Although ISRO has set a million dollar target, it has to combat with other satellite manufacturers like Boeing, Lockheed Martin, Mitsubishi and Thales Alenia.

ISRO crossed a new milestone on 12 July, 2010 in launching third party satellites by slinging three foreign satellites into orbit, reaching a total of 25 satellite launches.[64] The international satellites launched so far by ISRO is given in table below:

**Table 10: International Satellites Launched [65] :**

| Sr. No | Satellite Name | Country | Weight in Kg | Date of Launch | Launch Vehicle |
|---|---|---|---|---|---|
| 1 | DLR-TUBSAT | Germany | 45 | 26-05-1999 | PSLV-C2 |
| 2 | KITSAT-3 | Korea | 110 | 26-05-1999 | PSLV-C2 |
| 3 | BIRD | Germany | 92 | 22-10-2001 | PSLV-C3 |
| 4 | PROBA | Belgium | 94 | 22-10-2001 | PSLV-C3 |
| 5 | LAPAN-TUBAT | Indonesia | 56 | 10-01-2007 | PSLV-C7 |
| 6 | PEHUENSAT-1 | Argentina | 6 | 10-01-2007 | PSLV-C7 |
| 7 | AGILA | Italy | 350 | 23-04-2007 | PSLV-C8 |
| 8 | TECSAR | Israel | 300 | 21-01-2008 | PSLV-C10 |
| 9 | CAN-X2 | Canada | 7 | 28-04-2008 | PSLV-C9 |
| 10 | CUTE-1.7 | Japan | 5 | 28-04-2008 | PSLV-C9 |
| 11 | DELFI-C3 | Netherlands | 6.5 | 28-04-2008 | PSLV-C9 |
| 12 | AAUSAT-II | Denmark | 3 | 28-04-2008 | PSLV-C9 |
| 13 | COMPASS-I | Germany | 3 | 28-04-2008 | PSLV-C9 |
| 14 | SEEDS | Japan | 3 | 28-04-2008 | PSLV-C9 |
| 15 | NLS-5 | Canada | 16 | 28-04-2008 | PSLV-C9 |
| 16 | RUBIN-8 | Germany | 8 | 28-04-2008 | PSLV-C9 |
| 17 | UWE-2 | Germany | 1 | 23-09-2009 | PSLV-C14 |
| 18 | BeeSat | Germany | 1 | 23-09-2009 | PSLV-C14 |
| 19 | ITU-pSAT1 | Turkey | 1 | 23-09-2009 | PSLV-C14 |
| 20 | SwissCube | Switzerland | 1 | 23-09-2009 | PSLV-C14 |
| 21 | Rubin-9.1 | Luxemberg | 8 | 23-09-2009 | PSLV-C14 |
| 22 | Rubin-9.2 | Sweeden | 8 | 23-09-2009 | PSLV-C14 |
| 23 | ALSAT-2A | Algeria | 116 | 12-07-2010 | PSLV-C15 |
| 24 | NLS-6.1 (AISSAT-1) | Canada | 6.5 | 12-07-2010 | PSLV-C15 |
| 25 | NLS-6.2 (TISAT–1) | Switzerland | 1 | 12-07-2010 | PSLV-C15 |

64 sify.com/news

65 www.antrix.gov.in/

# ISRO takes great interest in providing expertise and services for helping other developing countries in the applications of space technology.

ISRO recently manufactured and shipped satellites for two major European companies. The first of these is a telecom satellite, W2M, for Paris-based Eutelsat Communications. The order was sub-contracted to India from European Aeronautic Defence and Space Company's subsidiary, EADS Astrium, which builds telecom, military and weather satellites. Another recent contract involves the building of a broadcast satellite for a broadcast company, the UK-based Avanti Screen Media.

### 10.2 Role of International Cooperation

DOS continues to lay importance on bilateral and multilateral relations with space agencies and space related bodies with the aim of taking up new scientific and technological challenges, defining international frameworks for exploitation and utilization of outer space for peaceful purposes, refining space policies and building and strengthening existing ties between countries. ISRO also takes great interest in providing expertise and services for helping other developing countries in the applications of space technology. ISRO and the DOS have signed formal Memorandum of Understanding agreements with a number of foreign political entities, including:-

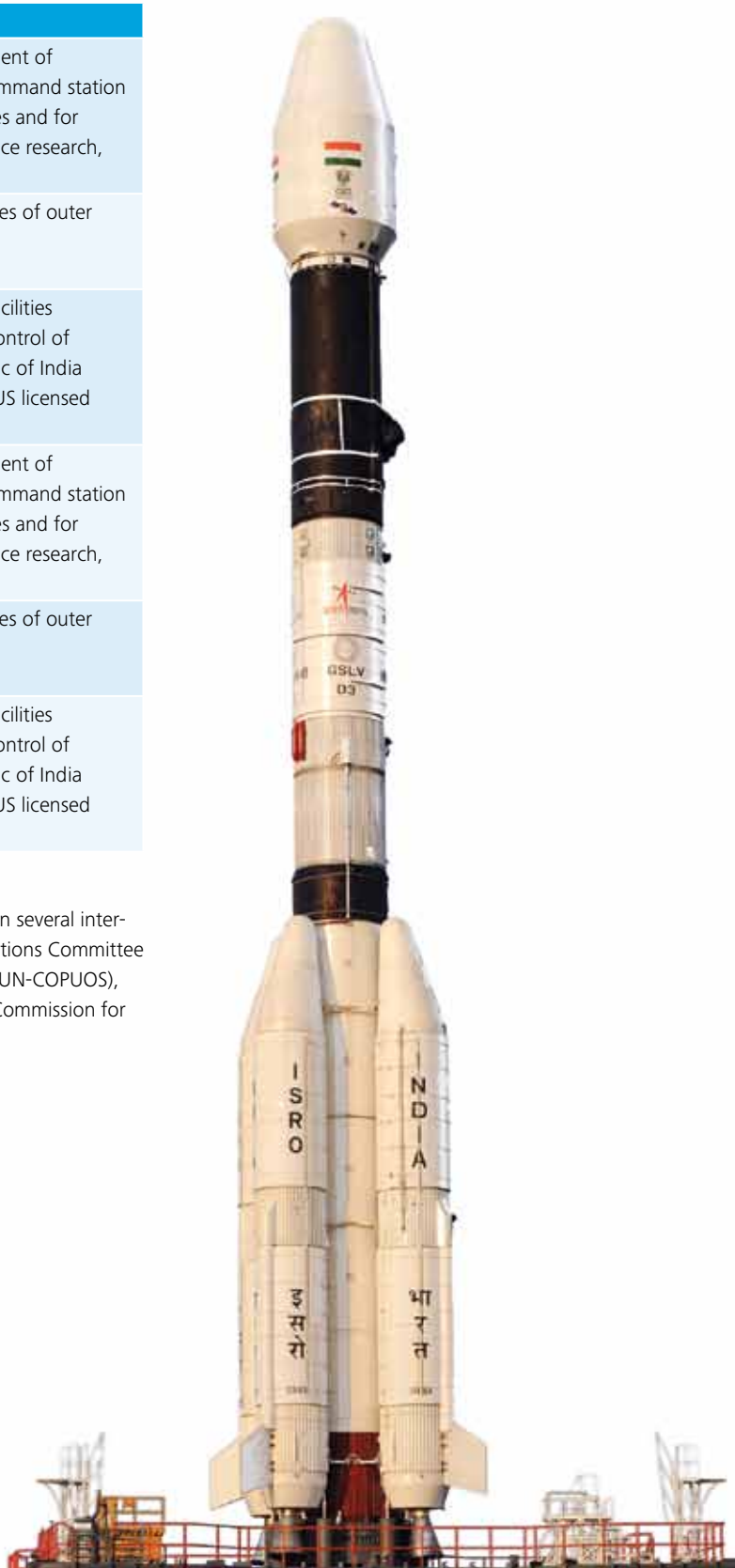
| | |
|---|---|
| Australia | Italy |
| Brazil | Japan |
| China | Kazakhstan |
| Canada | Netherlands |
| Egypt | Norway |
| European Union | Russia |
| France | Sweden |
| Germany | Ukraine |
| Hungary | United Kingdom |
| Israel | United States |

Table 11: List of agreements signed during the year are given below:

| Agreements | Nature |
|---|---|
| Government of India and the Government of Brunei | Co-operation in the operation of telemetry tracking and tele-command station for satellite and launch vehicles and for coopera-tion in the field of space research, science and applications |
| Government of the Republic of India and the Government of the Federative Republic of Brazil | Co-operation in augmentation of a Brazilian earth station for receiving and processing data from IRS Satellites. |
| Government of India and the Government of France | Co-operation In the peaceful Uses Of Outer Space |
| The Japan Aerospace Exploration Agency (JAXA) and ISRO | Co-operation in space X-Ray observations |
| ISRO and The Agenzia Spaziale Italiana | Co-operation In Flying ROSA Instrument on Megha-Tropiques Satellite. |
| ISRO and the Federal Space Agency of Russia | In the Field of Joint Moon Exploration. Earlier cooperation was in the development and use of the Russian GLONASS navigation satellites |
| ISRO and the Canadian Space Agency | Development of the Ultraviolet Imaging Telescope (UVIT) planned on ISRO's multi wavelength astronomy satellite ASTROSAT. |
| Government of the Republic of India and the Government of the Arab Republic of Egypt | Cooperation in the exploration and use of outer space for peaceful purposes |
| ISRO and National Space Agency of the Republic of Kazakhstan | Cooperation in the field of space activities; |
| Government of the Republic of India and the Government of the Republic of Chile | Exploration and utilisation of outer space for peaceful purposes |

| Agreements | Nature |
|---|---|
| Government of the Republic of India and the Government of the Republic of Mauritius | Cooperation for the establishment of telemetry, tracking and tele-command station for satellites and launch vehicles and for cooperation in the fields of space research, science and applications; |
| Government of the Republic of India and the Government of Argentine Republic | Cooperation in the peaceful uses of outer space |
| Agreement between the Government of Republic of India and the Government of the United States of America | Technology Safeguards at all facilities under the jurisdiction and/or control of the Government of the Republic of India associated with the launch of US licensed spacecraft. |
| Government of the Republic of India and the Government of the Republic of Mauritius | Cooperation for the establishment of telemetry, tracking and tele-command station for satellites and launch vehicles and for cooperation in the fields of space research, science and applications; |
| Government of the Republic of India and the Government of Argentine Republic | Cooperation in the peaceful uses of outer space |
| Agreement between the Government of Republic of India and the Government of the United States of America | Technology Safeguards at all facilities under the jurisdiction and/or control of the Government of the Republic of India associated with the launch of US licensed spacecraft. |

In addition, India plays an active role in several international bodies such as the United Nations Committee on the Peaceful Uses of Outer Space (UN-COPUOS), United Nations Economic and Social Commission for Asia and the Pacific (UN-ESCAP), etc



# 11.Regulatory Framework in India

## Agrani, the only ISS in India, has been set up with an objective of establishing, owning and operating a satellite system to provide satellite capacities in and Around the Indian sub-continent.

### 11.1 Existing Policy Guidelines

In the year 1997-1998, the Government of India ("GoI") announced the Satellite Communication Policy Framework ("SatCom Policy") (section of National Telecom Policy under TRAI Act, 1997) and formulated the norms, guidelines, and procedure for registration of Indian satellite systems (ISSs) by private Indian companies and allowed limited use of foreign satellites (i.e., uplink from India) in special circumstances provided the satellites were coordinated with the INSAT satellites. Pursuant to the SatCom Policy, the GoI authorized ISRO to set up a Committee for Authorizing the establishment and operation of Indian Satellite Systems ("CAISS"), with its Secretariat at the Satellite Communication Programs Office at ISRO Headquarters at Bangalore.

In terms of the SatCom Policy, an Indian company incorporated under the laws of India is permitted to register its satellite systems for establishment, operation and maintenance of satellite systems in the Indian orbital spectrum and to offer communication transponder capacities/bandwidth to service providers. Indian orbit spectrum is the orbit-spectrum for which filings are done by WPC with the ITU and informed, notified and coordinated by WPC under the relevant ITU procedures. Satellite Company can consider establishing an ISS in terms of the SatCom Policy. Foreign equity investment upto 74 percent is permitted in the Indian company subject to obtaining the prior foreign investment approval from the Foreign Investment Promotion Board, subject to the sectoral guidelines of Department of Space/ISRO.

The Satellite Company would need to submit an application to the CAISS for setting up the satellite system together with the technical description of the proposed system including intended services and service area; network description and characteristics; and other details. As a condition for grant of authorization, the satellite control and monitoring facility including the telemetry, tracking and control ("TTandC") facility center for the satellite will need to be located in India and all foreign personnel deployed for installation, operation or maintenance of the TTC facility will need to be cleared by the Ministry of Home Affairs, GoI. Additionally, the satellite launched or leased would need to be on an orbital slot that is informed, notified and coordinated by the Wireless planning and coordination wing of the department of Telecommunications (WPC) under the relevant International Telecommunication Union (ITU) procedures for which filings will need to be done by WPC with the ITU.

The system established under the authorization will be accorded the status of an Indian Satellite System for providing satellite based services and transponder capacity/bandwidth on a commercial basis in India and will be eligible for all the preferential treatment accorded to such systems in service provisioning in India prescribed under the SatCom Policy.

There is presently one ISS in India, which is Agrani (Zee Group/Dish TV venture). Agrani has been set up with the objective of establishing, owning and operating a satellite system to provide satellite capacities in and around the Indian sub-continent. Agrani has however so far not been able to set up a satellite system even though it has entered into a long term collaboration with ProtoStar I Ltd. for lease/purchase of transponder capacity. No other application is presently pending before the CAISS for its consideration for setting up an ISS.

A foreign satellite operators ("Satellite Company") can consider two entry options to establish its business presence in India and provide satellite services in the Indian subcontinent.

A. Providing services through ISRO. The Satellite Company can provide bandwidth capacity services to Indian end users (such as DTH and VSAT service providers) through ISRO. For this purpose, the transponder capacity is canalized through ISRO and ISRO's approval may be forthcoming if alternate capacity is not available on INSAT satellites. As the leasing process involves DOS WPC and the concerned Ministry (for instance in the case of DTH, the Ministry of Information and Broadcasting), the process is definitely time consuming and with no clear assurance of achieving approval. The foreign satellite should be coordinated with INSAT satellites in terms of the ITU Radio Regulations as a pre-condition for lease of capacity. A short term lease (usually on a yearly basis) is signed by ISRO or by its commercial arm, i.e., Antrix with the Indian customer, and between Antrix and the Satellite Company. There is no privity of contract between the end customer and the Satellite Company though typically the Indian customer and the Satellite Company agree on the commercial terms prior to approaching ISRO. The lease rentals are generally marked up by ISRO for provision of capacity to the end customer. INSAT reserves the option of not extending the capacity lease for subsequent years and require the end customer to migrate to a INSAT satellite, as and when alternate capacity is available. This indirect route of providing capacity to the Indian market has been adopted by several foreign satellite operators in the past including SES Americom, Asiasat, and New Skies.

Alternatively, collaboration with ISRO to jointly develop, launch and operate a satellite can be also considered by the Satellite Company (similar to the joint development of the Measat system program, proposed to be established under a joint venture company with Antrix).

B. Establishment of an Indian Satellite System. The Satellite Company can alternatively consider to independently set up satellite systems in India. ISSs are satellite networks which are informed, notified and coordinated by WPC under the relevant ITU's Radio Regulations and procedures.[66]

For the purposes of establishing an ISS, the foreign satellite operator and/or domestic Indian company, as the case may be, ("Satellite Company") would need to obtain various approvals and registrations with the Indian regulatory authorities, such as Registrar of Companies, CAISS and Foreign Investment Promotion Board, Ministry of Finance, etc.

Foreign satellites will also allowed to be used in special circumstances for satellite communication services in India. The service licensing departments may allow the use of foreign satellites only in consultation with the Department of Space. If suitable capacity/capability is available in INSAT or Indian Satellite Systems, operations with foreign satellites will not be permitted.

### 11.2 Existing Tax Framework

***Quick overview of taxation for a foreign company***

India has a well-developed tax structure with clearly demarcated authority between the Central and State Governments and local bodies. The Central Government levies taxes on income, customs duties, central excise and service tax, etc. Then there are also levies on taxes such as surcharge and education cess which is the collection by the Government to meet specific objective.

Value Added Tax (VAT), stamp duty, State Excise, land revenue and tax on professions are levied by the State Governments. Local bodies are empowered to levy tax on properties, octroi and for utilities like water supply, drainage etc. Indian taxation system has undergone tremendous reforms during the last 10-15 years. The tax rates have been rationalized and tax laws have been simplified resulting in better compliance, ease of tax payment and better enforcement. The process of rationalization of tax administration is continuing in India with the Government intending to implement New Direct Tax Code (DTC) and new Goods and Services Tax (GST) w.e.f. April 1, 2011.

*Foreign Company*

A foreign company is a company, which is not a domestic company. A domestic company means an Indian company or other company, which declares and pays dividends in India. Generally, a company registered outside India, is regarded as a foreign company.

A foreign enterprise may carry on its business operations in Indian in any of the following manner:

66 http://www.articlealley.com/article_743275_18.html

- Through a Liaison office in India
- Through a branch set up in India
- Through a Project office in India
- Without any physical presence in India

*Liaison Office (LO)*
Prior approval of Reserve Bank of India (RBI) is required for establishing LO. LO is not permitted to carry on commercial activities in India. Its role is usually restricted to collection and dissemination of information on behalf of the foreign entity. Therefore, generally a liaison office is not liable to tax in India.

*Branch Office (BO)*
Prior approval of RBI is required for establishing BO. BO can carry on full-fledged business activities (except not permitted activities viz. manufacturing). However, since a branch office is an extension of its head office, under the tax treaties, a branch would be considered as a Permanent establishment (PE) of the foreign company. Therefore, the business income accruing in India would be taxable at the rate of tax applicable to the foreign companies (i.e. effective tax rate is 42.23%[67] on net profits) which is higher than the rate of tax applicable to companies incorporated in India (effective tax rate is 33.22%[68] on net profits). In computing the income of the branch, there are certain restrictions on allocation of head office expenditure.

*Project Office (PO)*
Although PO does not need prior approval of RBI. A PO can be established to execute a specific project. A project office would not be considered a legal entity separate from its parent company. Therefore, income of a project office would also be taxable at the rate applicable to the foreign companies (effective tax rate is 42.23% on net profits). The computation of the profit of the project office does involve complexities such as the base on which the tax is leviable.

Further, LO/BO/PO needs registration with registrar of companies, income tax department etc. It is also required to fulfil annual compliances with RBI and ROC.

Business Operations without Physical Presence in India
A foreign enterprise may operate in India without any actual physical presence in India. For instance, a foreign company may supply goods, plant and machinery to Indian parties from its home country. A foreign company is taxable in India on the income received or income accrued/arising in India. Where the supply is affected in a manner that no income therefrom is received or accrues in India, then tax liability may not arise in India.

The above would be a case where sale of plant and machinery is affected outside India; the title in goods is transferred in favour of the Indian buyer outside India; and the payment for such supply is received outside India. In such a case, income from such transaction may not be taxable in India. However, where a foreign entity has a 'business connection' in India, tax is payable on the income arising from operations in India.

The normal business income is computed by reducing from the gross business receipts, expenses incurred in earning such income subject to certain restrictions prescribed under the Income-tax Act, 1961 (ITA).

*Joint venture Company (JV)*
The Investment in satellite establishment and operation limited to 74% is to be approved by the Government.

Where a foreign company makes foreign direct investment in a JV in India, the JV is considered as a 'domestic company'. The income of JV is taxable at the rate applicable for domestic companies. The effective rate of tax is 33.22%.

*Remittances*
LO/BO/PO can remit surplus funds to foreign company subject to approvals from RBI and tax department Whereas cash remittance by the JV to the parent company can be made through dividend pay-outs, interest payments, royalty/fee for technical services, exit through transfer of shares, buy-back, capital reduction, capital restructuring.

Automatic approval for remittances under foreign technology agreements has been recently liberalized.

*Supply of Technical Know-How/Services*
Income from supply of technical know-how or technical services to Indian parties is taxable in India

67 For foreign companies- surcharge @ 2.5% (where income exceeds Rs. 10 million) and education cess @2% and secondary and higher education cess @1%). Draft DTC has proposed tax rate at 25% for foreign companies and additional tax of 15% as 'Branch profits tax'.

68 For domestic companies- surcharge @ 7.5% (where income exceeds Rs. 10 million) and education cess @2% and secondary and higher education cess @1%). Draft DTC has proposed tax rate at 25% for domestic companies

either as 'Royalty' or as 'Fee for technical services (FTS)' as defined under the ITA.

The definition of royalty covers payment for the use of or the right to use, industrial commercial or scientific equipments. Under the ITA, royalty is taxable @ 10% on gross payment, plus surcharge and education cess (aggregate to 10.56%) or a lower withholding tax rate under the applicable tax treaty.

FTS is defined to mean consideration for provision of any technical, managerial or consultancy services including supply of technical personnel. Like royalty, FTS is also taxable @ 10% on gross basis in certain cases or a lower withholding tax rate under the applicable tax treaty.

*Interest Income*
Interest Income earned in India is taxable in India at the normal tax rate applicable to foreign entities, viz, 20% (effective rate 21.12%). Under Tax Treaties, generally, the interest income is taxed at the reduced rate of 10% or 15%.

*Capital Gains*
Gain arising from transfer of a capital asset is liable to capital gains tax in India. Most of the tax treaties signed by India provide for taxation of capital gains as per domestic tax laws of the respective countries. Accordingly, capital gains from sale of capital assets/ immovable properties situated in India are generally taxable in India.

*Dividend Distribution Tax (DDT)*
In addition to the normal income tax, a Domestic Company is liable to pay DDT @ 15% on amount distributed as dividends. Thus, the effective rate of tax is 16.61%. On the other hand, receipt of dividend is fully exempt from tax in the hands of the recipient shareholders. Foreign companies are not required to pay DDT.

*Withholding tax*
An Indian resident is obliged to withhold tax while making payment to a foreign party. The withholding tax rates vary depending upon the nature of payments like Royalties, FTS, interest, etc. Generally, under the Tax Treaty mechanism, withholding tax rates are lower as compared to the tax rates under the domestic tax laws of India.

Under the domestic tax laws of India, a mechanism has been provided whereby if the entire income of a non-resident is not believed to be taxable in India, the payer or the payee of the income can obtain a lower rate withholding order from the tax authorities.
A new provision has been inserted recently w.e.f. April 1, 2010, whereby any person whose receipts are subject to withholding tax under the ITA, should furnish PAN to the person responsible for such withholding tax. On failure to furnish PAN, higher of the following to be deducted as tax at source:

- Rate of tax specified in ITA;
- Rates in force as specified under the Finance Act or under relevant tax treaties;
- Rate of tax at 20%

*Minimum Alternate Tax*

Where income tax payable by corporate taxpayers is less than 18% of the book profits, 18% of the book profits is regarded as their tax liability. Book profits mean profits as per profit and loss account prepared in accordance with the Indian Companies Act, subject to certain specified adjustments.

Thus, effective rate of minimum Alternate Tax (MAT) for Domestic companies is 19.93% of the book profits. For Foreign companies, the effective rate of MAT is 19.00% of the book profits.

Further, taxpayers are allowed credit in respect of MAT paid on or after 1 April 2006 to the extent of difference between MAT paid and tax payable on total income computed as per other provisions of the ITA. MAT credit can be set off against the tax payable in the year in which taxpayer is liable to pay tax under normal provisions of the ITA. It can be carried forward for 10 years from the AY it becomes allowable. Draft DTC has proposed MAT to be levied at the specified rate of the book profits.

*Corporate tax Incentives*

- Developers and co-developers of Special Economic Zone (SEZ) entitled to 100% tax holiday.
- Units set up in SEZ eligible for 100% tax holiday on profits on exports for 5 years and 50% tax holiday for the next 10 years.
- Export Oriented Units (EOUs)/Electronic Hardware Technology Parks (EHTPs)/Software Technology Parks (STPs) eligible for deduction of 90% of export profits for 10 years (up to March 31 2011).
- Under the DTC, taxable profits of the business of developing SEZ shall be the gross income from the business carried on during the financial year as reduced by capital and revenue expenditure
- No tax holiday available to units in SEZ/ EOU/ EHTP/ STP under the Code if the unit is commencing operations on or before 31st March 2011.
- Companies manufacturing eligible goods in North Eastern States (up to 31st March 2017) eligible for 100% tax holiday for 10 years and in Himachal Pradesh and Uttaranchal (up to March 2012) eligible for 100% tax holiday available for 5 years and 30% thereafter. Draft DTC does not allow area-based exemptions. Tax holiday available to an undertaking manufacturing eligible goods in specified areas to be discontinued without affecting tax payers currently enjoying such incentives, which will be grandfathered.
- Exemption available on royalty/fees for technical services received by a notified foreign company under an agreement with the Government to provide services in or outside India in projects connected with the security of India.
- Expenditure on Scientific Research is allowed at:
  - 100% deduction for any revenue expenditure on scientific research
  - 100% deduction for capital expenditure (other than land) on scientific research
  - 200% weighted deduction for in-house scientific research available to companies engaged in manufacturing/ production of any goods (except goods such as liquor, tobacco, cosmetics etc.)
  - 125% of deduction on payments for research activities to an approved Indian company in scientific RandD

*Transfer Pricing*

- The Indian transfer pricing regulations require international transactions with associated enterprises to be at arm's length price and further supported with prescribed documentation. There are strict penalties for non-compliance.
- As a measure of simplification, Central Board of Direct Taxes (CBDT) empowered to formulate safe harbour rules. Detailed Safe harbour rules are still to be prescribed.
- In the draft DTC, there is a proposal to introduce advance pricing agreements with regard to the International transactions between associated enterprises.

*Advance Ruling*

- Taxpayers can approach the Authority for Advance Ruling to determine income-tax aspects of any proposed or current transactions with the non-resident.
- India has entered into comprehensive treaties

for avoidance of double taxation with over 70 countries and limited agreements with 18 countries. Tax implications under the domestic laws could be mitigated by resorting to a tax treaty.

*Alternative Dispute Resolution Mechanism (ADRM)*
With a view to encourage the growth of foreign investment in India, a dispute resolution mechanism has been recently introduced to facilitate expeditious resolution of disputes on a fast track basis. Salient features of ADRM are:

- Foreign companies and cases involving transfer pricing disputes eligible for ADRM.
- DRP directions binding on the Assessing officer.
- ADRM mandatory for eligible taxpayers.

*Indirect Tax Overview*

- Customs Laws : Effective rate of customs duty payable by importer on import of goods would be 26.85%, based on peak rate of customs duty. Presently, customs duty exemption is available, subject to the fulfillment of specified conditions, in relation to certain goods, as follows:
  (a) Satellite and payloads
  (b) Scientific and technical instruments, apparatus, equipments (including computers and computer software, accessories, parts, components, spares, tools, mockups and modules, raw material and consumables required for launch vehicles and for satellite and payloads
  (c) Ground equipment brought for testing of (a) above.

In addition to goods specified above, presently, the following goods, forming part of transmission apparatus, are exempted from customs duty:
  (a) VSAT terminals
  (b) Other satellite communication equipment

- Central Excise Laws :
  – Effective excise duty rate on manufacturing activity is 10.3% (inclusive of cess).
  – However, presently, 'spacecraft' (including satellites) and suborbital and spacecraft launch vehicles attract 'nil' rate of excise duty. Further, parts of spacecraft (including satellites) and suborbital and spacecraft launch vehicles are presently unconditionally exempted from payment of excise duty.
- Value Added Tax ('VAT')/ CST Laws
  – Inter-State sale of goods is subject to levy of CST, intra-State sale of goods is subject to levy of VAT.
  – CST rate is 2%, against submission of prescribed statutory form by the purchaser. Otherwise, VAT rate of the originating State would apply. The rate of VAT typically ranges between 4% to 14.5%.
  – No general/ specific exemptions/ concessions available on components/ parts forming part of a satellite. Each State VAT legislation should be examined, in order to ascertain the VAT rate applicable on sale of such components/ parts of satellite in a particular State.

Further, in the context of provision of space segment capacity of transponders attached to satellite on lease by Satellite Companies, it is also pertinent to note a recent development, wherein, the Hon'ble Karnataka High Court has upheld the levy of VAT on 'lease rental charges' of transponders on the premise that the said lease capacity amounts to 'transfer of right to use' the goods in terms of the Article 366(29A)(d) of the Constitution of India, read with the definition of 'sale', in terms of the provisions of the Karnataka VAT Laws.

- Foreign Trade Policy 2009 - 14
  – Export of manufactured goods is subject to Special Chemicals, Organisms, Materials, Equipment and Technologies ('SCOMET') guidelines,etc.
  – The specified SCOMET items inter alia include aerospace systems, equipment, including production and test equipment, related technology and specially designed components and accessories thereof
- Service Tax (including Cenvat Credit) Laws
  – Specified services are subject to service tax and liability to pay the same is typically on the service provider. For few services including services received from outside India, liability to pay service tax shifts to the service recipient located in India.
  – Service tax applicable on input services like payment for technical know-how, licensing of intellectual property rights ('IPRs') in

relation to equipments, drawings etc./ engineering services.
  - Set-off of such service tax paid could be availed against output excise duty.
  - Service tax rate is 10.3% (inclusive of cess).
  - Services transactions between associated enterprises would be subjected to service tax on book entry basis instead of receipt/ payment basis.
- Research and development (R&D) Cess
  - Research and Development (R&D) Cess @ 5% is applicable on import of technology into India by an industrial concern.R&D Cess can be adjusted against service tax liability, in certain cases.
- Entry Tax/ Octroi
  - The States, Local authorities and Municipal corporations also levy other local taxes such as entry tax, octroi, etc. on entry of goods in the designated areas for the purpose of consumption, use or sale.
- Special Economic Zone ('SEZ') Incentives
  - Indirect tax incentives available to SEZ units for their authorized operations. No service tax leviable on services provided to SEZ wholly consumed within the SEZ.
  - The exemption to the taxable services provided to SEZ consumed partially or wholly outside the SEZ, is provided by way of refund.

In light of above-mentioned structure of indirect taxes in India, it could be stated that an appropriate review of the transactions could result in tax-optimization, including in view of certain indirect tax benefits, which may be available.

# 12. Conclusion and Way Forward

Over past four decades Indian space programme has systematically acquired capabilities in space technologies and implemented its programmes with a high level of focus on societal applications. It is developed into a multi-dimensional programme where its strategy is directed towards diverse stake holders and actors such as government, users and beneficiaries including general public, industrial suppliers as well as customers, academia and other space agencies/international organisations.

The strengths of the Indian Space sector are Government focus on civil space sector, increase of year-on-year funding increases and indirect investment via government ownership of space services, highly skilled and motivated human resource base-and a government policy to support education, increasingly world-class technology base and positive track record, strongly articulated linkage between national space goals and economic development, increased domestic market and strong ties with leading space nations.

On the other hand, the opportunities due to Indian capabilities are ability to leverage IT and software development capabilities, abundant low cost skilled workforce, educated talent pool of resources, low cost of production could stimulate exports, strong domestic low cost manufacturing base and strong Indian industry manufacturing base.

It is inevitable that any industry sector has no challenges and barriers. For space industry some of the identified challenges are few proven cutting-edge space applications or technologies, policy need to be eveloved for space based services eg.: satellite radio, consumer broadband ,etc., in absolute terms, ISRO funding is lower than other leading nations and improving nations military space program

Over the next five years, the Indian space programme has charted an ambitious set of policies and programmes that aim to enhance impacts on society. The major task is to enlarge and diversify the services delivered to a large section of population affected by income, connectivity and digital divides. While efficacy of application of space based systems have been proven in several fields such as tele-education, water resources management, environment, improving productivity of land and out reaching quality health services and others, the crux of the problem is to evolve sustainable and scalable delivery mechanisms on a very large scale and extending over large geographical areas. Essentially the problem shifts from being predominately a technology problem to one of a composite of economic, cultural and social problems. Tackling such problems would need renewal of policies (at national and international level co-operation) relating to commercial as well as public service systems.

Major programmatic initiatives are planned in the next five years involving new and upgraded technologies to expand services from space to fill the gaps and to improve economic efficiency. Thrust is also given to science and exploration mission beyond Chandrayaan-1 and some initial steps for the participation in human space flight.

**11th five year plan (FYP) 2007-12**

The major emphasis of the 11th FYP will be to consolidate the themespecific satellites, in order to fill the gaps in observation including those of disaster monitoring and mitigation, and also to develop a synergy with international missions for complementing and supplementing Indian missions. Strengthening ground segment to meet the need for having easily accessible user-specific products for the community of users is also important. The major thrust areas of 11th plan are:

a. Ensure continuity and enhanced services through operational work-horse missions.
b. Newer missions, adapting and assimilating advances in technologies meeting user needs.
c. Understanding the total Earth system and the impacts of natural resources and human-induced changes on the global environment.
d. Innovative technology development both for on-board and ground systems for futuristic missions
e. Develop 'actionable' EO products and services and address issues on access, affordability, timely delivery, user-friendly format and style
f. Develop strategy for HR development and capacity building in user agencies and decision making bodies

69 India planning to launch 10 satellites in a year, http://economictimes.indiatimes.com/news/news-by-industry/et-cetera/India-planning-to-launch-10-satellites-in-a-year/articleshow/5868540.cms (accessed online on May 19, 2010)

g. Encourage Government - Industry - Academia Triad to enable core indigenous competence in critical areas
h. Position appropriate policies and institutional mechanisms.

In addition, ISRO is planning to launch 10 satellites in a year to better communication network and disaster management. The aims and objectives of these satellites include natural resources management, augmenting the communications infrastructure, satellite navigation, disaster management support, space science research and planetary exploration. The action plan of the department in this context will include augmenting the technical infrastructure within ISRO and enhancing the production capabilities in the Indian industry in the 12th Five-Year Plan period (2012-17) to meet projected demand.[69]

Besides expanding its extensive satellite program, India now plans lunar missions and a Reusable Launch Vehicle (RLV) that takes an innovative approach using a scramjet "hyperplane." India's former President APJ Kalam said that India understands that global civilization will deplete earthly fossil fuels in the 21st century. Hence, he said, a "space industrial revolution" will be necessary to exploit the high frontier's resources. Kalam predicted that India will construct giant solar collectors in orbit and on the moon, and will mine helium-3--an incredibly rare fuel on Earth, but one whose unique atomic structure makes power generation from nuclear fusion potentially feasible--from the lunar surface. India's scramjet RLV, will provide the "low-cost, fully reusable space transportation" that has previously "denied mankind the benefit of space solar-power stations in geostationary and other orbits."

India's policy framework presents a curios combination of domestic protection (satellite operations) and openness (launch services) with a stated gold of self - reliance. Yet despite this contradictions, India's space achievements have been impressive and substantive, benefitting from an availabilty of space professionals who are increasingly world clas, and offset somewhat by technical difficulties and protectionism.

The science-fictional objectives of the vision presented by President Kalam, is exactly what is needed to propel India's journey into space to new and bold frontiers. The style, the vision, the sense and sensibility of the pioneers of India's space program, the development and utilization of space technology in ways that is low on hype and high on impact, is unique to India. With more than four decades of experience-n-expertise, a scientific and technological workforce that is dreaming big, as well as cutting-edge commercially exploitable technology assets, the Indian space enterprise is surely poised to rock the world.

# 13. A Brief About CII

CII has been actively partnering with the Ministry of Defence, Armed Forces and DRDO in promoting Industry's participation in Defence production. CII Defence Division has been committed to working in the areas of steering policy formulation, defence market development / trade promotion and formation of international joint ventures / technology transfers.

Space is a rising industry and CII is actively involved in providing support to ISRO and Antrix and working for the development of Indian Space Industry.

CII had formed the Defence Division in 1993 to catalyse change in the Defence sector by pursuing the Government to liberalise Defence Production and by initiating the process of partnering with the Defence establishments in organizing interactive meetings with the end users, i.e. the Armed Forces. Realising the importance of harnessing the technologies developed within the country, CII has also been a pioneer in organising Interactive sessions with the Defence Research and Development Organisation to enlarge the role of Private sector in Defence R&D. A major partnership with the Ministry of Defence has been the organisation of the Defexpo India (Asia's largest Land and Naval Systems exhibition) in 1999, 2002, 2004 and 2006.

CII's Defence Division strives to forge industry initiatives to strengthen the Indian Defence Sector. The objective of this Division is to "Establish a strong partnership between Defence Services & Industry and enlarge the role and scope of Indian Industry in Defence Production for mutual benefit and enhance the National Security".

CII's initiatives in the area of policy reforms really got a boost when, CII had the CEOs meeting with the Ministry of Defence on the 18th June 1998. The meeting provided an opportunity for the Industry to interact with the senior officials of the Ministry of Defence (MoD) and DRDO. As a fall out of this meeting 6 Joint task forces, chaired by serving officers from the armed forces / Ministry of Defence and co-chaired by CII were formed. This was an epoch making event, which had never previously happened in the history of India.

By representing the interests of the Indian Industry both public and private sector as well as the end users – The Armed Forces, CII has been recognised as the voice of Indian Defence Industry by the Government of India. This would bring about competition and help provide quality equipment to the armed forces at the right time and at the right price. This would in turn increase defence exports of the country. CII helps the Indian Defence Industry to promote their contribution in Indian Defence procurement by helping them to identify the opportunities that exist in Defence. CII organizes several sector focussed interactive session with the Armed Forces to enable the industry to identify their requirements.

CII has institutionalised several events with the Armed Forces such as AIP (Army Industry Partnership), NIP (Navy Industry Partnership Meet), DIP (Defence Industry Partnership Meet), DEFCOM (Defence Communications Seminar), Artillery Technology Seminar, Defence IT Convention to name a few.

CII Defence Events provide excellent platforms for Industry to understand the future requirements of the Armed Forces. These events also provide a platform for industry to introduce their capabilities in terms of offering new products and technologies to the Indian Defence.

International Linkages for Technology Cooperation, Joint Ventures and Export CII provides international exposure to Indian Defence Industry by organising inward and outward industry missions. It has organised Defence Industry Mission to USA, UK, South Africa and Israel. It has also received international delegation from USA, UK, Russia, South Africa, Poland, Slovakia etc. The Committee has signed Memorandum of Understanding with the Defence Manufacturers Association of UK (DMA); The United States India Business Council (USIBC); Polish Chamber of National Defence Manufacturers, Association of the Defence Industry of the Slovak Republish (ADISR) and Association of Italian Defence and Aerospace (AIDA).

# 14. A Brief About Deloitte

Deloitte refers to one or more of Deloitte Touche Tohmatsu Limited, a UK private company limited by guarantee and its network of member firms, each of which is a legally separate and independent entity. Please see www.deloitte.com/about for a detailed description of the legal structure of Deloitte Touche Tohmatsu Limited and its member firms. Deloitte provides audit, tax, consulting and financial advisory services to public and private clients spanning multiple industries. With a globally connected network of member firms in more than 140 countries, Deloitte brings world-class capabilities and deep local expertise to help clients succeed wherever they operate. Deloitte's more than 168,000 professionals are committed to becoming the standard of excellence.

Deloitte's professionals are unified by a collaborative culture that fosters integrity, outstanding value to markets and clients, commitment to each other, and strength from cultural diversity. They enjoy an environment of continuous learning, challenging experiences, and enriching career opportunities. Deloitte's professionals are dedicated to strengthening corporate responsibility, building public trust, and making a positive impact in their communities.

The Deloitte Global Aerospace and Defense (A&D) industry group serves all sectors in the A&D industry, including commercial and military aircraft, engines and propulsions systems, guided missiles, space vehicles and shipbuilding.

Deloitte has a strong A&D practice that draws on best practices, experience, Aerospace and defense, manufacturing and our other commercial industry practices.

We focus on the top issues facing the industry, including Supply Chain Strategy, Customer Support and Sustainment (CSS), Program Management, Mid-market ERP Solutions, Corporate Finance, Talent Management, and Tax Strategies

# 15. Abbreviations

| Abbreviations | Expansion |
|---|---|
| AARS | Asian Association of remote Sensing |
| ACS | Atmospheric Correction Sensor |
| A&D | Aerospace and defense |
| ADCOS | Advisory Committee on Space Sciences (constituted by ISRO) |
| ADRM | Alternative Dispute Resolution Mechanism |
| AEB | Agencia ESpacial Brasileira |
| AFDX cards | Avionics full duplex ethernet |
| AGILE | Ilatilian Space Agency |
| AIR | All India Radio |
| AMC | Advanced Mission Computer |
| AN | Andaman and Nicobar |
| ANUSAT | First experimental communication satellite |
| APJ | Avul Pakir Jainulabdeen |
| APPLE | Ariane Passenger Payload Experiment |
| ASAT | Anti Satellite |
| ASERA | Australian Space Engineering Research Association |
| ASI | Italian Space Agencies /Agenzia Spaziale Italiana |
| ASIC | Application Specific Integrator Circuit |
| ASLV | Augmented Satellite Launch Vehicle |
| ASRI | Australian Space Research Institute |
| ATS | Advanced Telemetry System |
| ATROSAT | Astronomy Satellite |
| ATV | Automated Transfer Vehicle |
| AWiFS | Advanced Wide Field Sensor |
| BDS | Boeing Defence,Space and Security |
| BE | Budget Expenditure |
| BEML | Bharat Earth Movers Limited |
| BISA | Belgian Institute for Space Aeronomy |
| BHOOSAMPADA | Web enabled land use/land cover information system |
| BMDS | Ballistic Missile Defence System |
| BNSC | British National Space Centre |
| BO | Branch Office |
| BSNL | Bharat Sanchar Nigam Limited |
| BSS | Broadcast Satellite Services |
| CAD | Computer aided design |
| CAE | Computer aided engineering |

| Abbreviations | Expansion |
|---|---|
| CAISS | Committee for Authorising the establishment and operation of Indian Satellite System |
| CAM | Computer aided machine |
| CARTOSAT | Cartographic Satellite |
| CATV | Cable television/Community Antenna Television |
| CBDT | Central Board of Direct Taxes |
| CCD | Charge Coupled Device |
| CEO | Chief Executive Officer |
| CEOS | Committee on Earth Observation Satellites |
| CFRP | Carbon Fibre Reinforced Plastic |
| CGMS | Coordinating Group on Meteorological Satellite |
| CNES | Central National d'Etudes Spatiales/French Space Agency |
| CNSA | China National Space Agency |
| COPOUS | United Nation Committee on the Peaceful Uses of Outer Space |
| COSPAR | Committee on Space Research |
| COSPAS-SARSAT | Programme for providing distress alert and position location services of Russia |
| COTS | Commercial Orbital Transportation Services |
| CPCI | Computer program configuration item |
| CS | Cryogenic Stage |
| CSA | Canadian Space Agency |
| CS and S | Customer Support and Sustainment |
| CSSTE-AP | Centre for Space Science and Technology in Asia and the Pacific |
| CST | Central Sales Tax |
| CUG | Closer User Group |
| CUS | Cryogenic Upper Stage |
| CUSP | Cryogenic Upper Stage Project |
| DAE | Department for Atomic Energy |
| DBT | Department of biotechnology |
| DD | Doordarsan |
| DDT | Dividend Distribution Tax |
| DECU | Development and Educational Communication Unit |
| DES | Delhi Earth Station |
| DEW | Directed Energy Weapons |
| DGPS | Differential Global Positioning Service |

| Abbreviations | Expansion |
|---|---|
| DLR | German Aerospace Centre/Deutsches Zentrum Fur Luft- und Raumfahrt |
| DMRJ-FTD | Dual Mode Ramjet Flight Test Demonstrator |
| DMS | Disaster Management Support |
| DMSAR | Disaster Management Synthetic Aperture Radar |
| DOD | Department of Ocean Development |
| DOE | Department of Energy |
| DoLR | Department of Land Resources |
| DOS | Department of Space |
| DRDO | Defence Research and Development Organization |
| DRP | Design Review Panel |
| DRT | Data Relay Transponder |
| DSC | Decision Support Centre |
| DSNG | Digital Satellite News Gathering |
| DTC | Direct Tax Code |
| DTH | Direct To Home (Television) |
| DTM | Digital Terrain Model |
| EADS | European Aeronautic defence and Space Company |
| ECIL | Electronics Corporation of India Limited |
| ECMWF | European Centre for Medium Range Weather Forecasts |
| EDUSAT | Education Satellite |
| EHTPs | Electronic Hardware Technology Parks |
| ELV | Expendable launch vehicles |
| EMP | Electromagnetic Pulses |
| EO | Earth Observation |
| EOUs | Export Oriented Units |
| ERP | European Recovery Program |
| ECMWF | European Centre for Medium Range Weather Forecasts |
| EHTPs | Electronic Hardware Technology Parks |
| EMP | Electromagnetic Pulses |
| EO | Earth Observation |
| EOUs | Export Oriented Units |
| ERS | European Remote Sensing(satellite) |
| ESA | European Space Agency |
| ESCAP | Economic and social communication for Asia and Pacific |

| Abbreviations | Expansion |
|---|---|
| EUMETSAT | European Organisation of Exploitation of Meteorological Satellites |
| EO | Earth Observation |
| EOUs | Export Oriented Units |
| ERS | European Remote Sensing(satellite) |
| ESA | European Space Agency |
| EUMETSAT | European Organisation of Exploitation of Meteorological Satellites |
| FAA | Federal Aviation Administration |
| FASAL | Forecasting Agricultural output Space Agro-meteorological and Land-based observations |
| FCC | Federal Communications Commissions |
| FNS | Flex Nozzle Control |
| FSS | Fixed Satellite Services |
| FTS | Fee for technical Services |
| FY | Fiscal Year |
| GAGAN | GPS Aided Geo Augmented Navigation |
| GDP | Gross Domestic Product |
| GEO | Geo Synchronous Orbit |
| GIOVE | Galileo In-Orbit Validation Element |
| GIS | Geographic Information System |
| GLONASS | Russian Global Navigation Satellite System |
| GNSS | Global Navigation Satellite System |
| GOI | Government of India |
| GPS | Global Positioning System |
| GRT | Ground Resonance Test |
| GSLV | Geosynchronous Satellite Launch Vehicle |
| GSO | Geostationary Orbit |
| GST | Goods and Service Tax |
| GTO | Geostationary Transfer Orbit |
| GUI | Graphical User Interface |
| HAL | Hindustan Aeronautics Limited |
| HDTV | High Definition Television |
| HEX | High Energy X-Ray Spectrometer |
| HPT | High Power Transmitter |
| HTV | H-II Transfer Vehicle |
| HVNET | High speed satellite based VSAT network of department of telecom services |
| HYLAS | Highly Adoptable Satellite |
| IAF | International Astronautical Federation |

| | Expansion |
|---|---|
| IADC | Inter Agency Debris Coordinating Committee |
| ICBM | InterContinental Ballistic Missiles |
| ICC | INSAT Coordination committee |
| IDSA | Institute for Defence Studies and Analysis |
| IDSN | Indian Deep Space Network |
| IFA | Independent financial adviser |
| IGDMP | Integrated Guided Missile Programme |
| IGS | Inertial Guidance System |
| IGOS | International Global Observing Strategy |
| IISU | ISRO Inertial System Unit |
| IIRS | Indian Institute of Remote Sensing |
| IIT | Indian Institute of technology |
| ILN | International Lunar Network |
| IMD | India Meteorological Department |
| IMDPS | INSAT Meteorological Data processing System |
| IMS | Indian Mini Satellite |
| INCOIS | Indian National Center for Ocean Information Services |
| INCOSPAR | Indian National Committee for Space Research |
| INMCC | Indian Mission Control Centre |
| INSAT | Indian National Satellite |
| INSAT/GSAT | Indian National Satellite/Geo - Synchronus Satellite |
| INTA | Instituto Nacional de Tecnica Aeroespacial |
| INTELSAT | International Telecommunication Satellite organisation |
| IOC | Indian Oil Corporation |
| IP | Internet Protocol |
| IPR | Intellectual Property Right |
| IR | Infra Red |
| IRBM | Intermediate range ballistic missile |
| INMCC | Indian Mission Control Centre |
| INSAT | Indian National Satellite |
| INTA | Instituto Nacional de Tecnica Aeroespacial |
| INTELSAT | International Telecommunication Satellite organisation |
| IOC | Indian Oil Corporation |
| IP | Internet Protocol |
| IPR | Intellectual Property Right |
| IR | Infra Red |

| Abbreviations | Expansion |
|---|---|
| IR&D | Independent Research and Development |
| IRS | Indian Remote Sensing Satellite |
| IRS | Indian Remote Sensing Satellite |
| ISA | Israel space Agency |
| ISAC | ISRO Satellite Centre |
| ISP | Internet Service Provider |
| ISPRS | International Security for Photogrammetery and Remote Sensing |
| ISRAD | ISRO Radar Development unit |
| ISRO | Indian Space Research Organisation |
| ISS | Indian Satellite System |
| ISSDC | Indian Space Science Data Centre |
| ISTRAC | ISRO Telemetry,Tracking and Command Network |
| ISU | International Space University |
| IT | Information Technology |
| ITA | Income Tax Act |
| ITU | International Telecommunication Union |
| JAXA | Japan aerospace Exploration Agency |
| JV | Joint Venture Company |
| KALPANA | Meterological Satellite |
| KARI | Korea Aerospace Research Institute |
| KEW | Kinetic Energy Weapons |
| KSR | Stage rockets |
| LEO | Low Earth Orbit |
| LES | Launch escape System |
| LEOSAR | Low Earth Orbit Search and Rescue |
| LFDC | Large Format Digital Camera |
| LIDAR | Light Detection and Ranging |
| LH2 | Liquid Hydrogen |
| LO | Liaison Office |
| LOD | Launch-on –demand |
| LOX | Liquid Oxygen |
| LPT | Low Power Transmitter |
| LPSC | Liquid Propulsion Systems Centre |
| LUT | Local User Terminal |
| L&T | Larsen and toubro |
| MandA | Mergers and Acquisitions |

| Abbreviations | Expansion |
|---|---|
| MADRAS | Microwave Analysis and Detection of Rain and Atmospheric Structures |
| MAT | Minimum Alternate Tax |
| MCC | Mission Control Center |
| MCF | Master Control Facility |
| MCIT | Ministry of Communication and Information Technology |
| MCPC | Multi Channel Per Carrier |
| MADRAS | Microwave Analysis and Detection of Rain and Atmospheric Structures |
| MAT | Minimum Alternate Tax |
| MCC | Mission Control Center |
| MCF | Master Control Facility |
| MCIT | Ministry of Communication and Information Technology |
| MCPC | Multi Channel Per Carrier |
| MDDC | Meteorological Data Dissemination Centre |
| MEO | Medium Earth Orbit |
| MCPC | Multi Channel Per Carrier |
| MDDC | Meteorological Data Dissemination Centre |
| MEO | Medium Earth Orbit |
| METSAT | ISRO's meteorological ,geostationary satellite |
| MHA | Ministry of Home Affairs |
| MOU | Memoranda of Understanding |
| MSAS | MTSAT Satellite –based Augmentation System |
| MSL | Mean sea level |
| MSS | Mobile Satellite Services |
| MSSRF | MS Swaminathan Research Foundation |
| MTAR | Moving Target Acquisition Radar |
| NACA | National Advisory Committee on Aeronautics |
| NAL | National Aerospace Laboratory of Japan |
| NARL | National Atmospheric Research Laboratory |
| NASA | National Aeronautics and Space Administration |
| NASDA | National space Development agency of Japan |
| NAVSTAR | Navigation Signal Timing and Ranging |
| NDEM | National Database for Emergency Managemant |
| NDT | Non destructive testing |
| NE-SAC | North Eastern Space Application Centre |
| NGA | National Geospatial-Intelligence Agency |
| NGO | Non governmental Organisation |

| Abbreviations | Expansion |
|---|---|
| NIC | National Institute of Corrections |
| NICNET | National Informatics Centre Network |
| NMD | National Missile Defense |
| NNRMS | National Natural Resources Management System |
| NOAA | National Oceanographic and Atmospheric Administration |
| NR | Natural Resources |
| NRDB | Natural Resources Data base |
| NRO | National Reconnaissance Office |
| NRR | Natural Resource Repository |
| NRSA | National Remote Sensing Agency |
| NRSC | National Remote Sensing Centre |
| NSA | Net Sown Area |
| NSAU | National Space Agency of Ukraine |
| NSF | National Science Foundation |
| NSP | National Space Policy |
| NSS | Geostationary satellite |
| NTP | National Telecom Policy |
| OCEANSAT | Ocean and Coastal Satellite |
| OCXO | Oven controlled crystal oscillator |
| OEM | Original Equipment Manufacturer |
| OHB systems | Space flight of OHB-technology |
| OOSA | Office for Outer Space Affairs |
| PAN | Panchromatic Camera(of IRIS) |
| PCB connectors | Payload control board |
| PCI | Peripheral Component interconnect |
| PC-NNRMS | Planning Committee of NNRMS |
| PE | Permanent Establishment |
| PFZ | Potential Fishing Zone |
| PLM | Product lifecycle management |
| PMC | Payload monitoring and control |
| PO | Project Office |
| PRL | Physical research Laboratory |
| PSF | Propellant Servicing Facilities |
| PSLV | Polar satellite Launch Vehicle |
| PXI | PCI Extensions for instrumentation |
| RBI | Reserve Bank of India |
| RandD | Research and Development |

| Abbreviations | Expansion |
|---|---|
| RESOEOURCESAT | Imaging sensor satellite |
| RESPOND | Research Sponsored by ISRO |
| RF | Ratio of Fronts |
| RH | Rohini |
| RICS | Range Instrumentation and Computer Systems |
| RISAT | Radar Imaging satellite |
| RKA | Russian Federal Space Agency |
| RLV | Reusable Launch Vehicle |
| RN | Radio Networking |
| ROC | Registrar of Companies |
| ROSA | Atmospheric sounder carried by OCEANSAT-2 |
| RRSSC | Regional Remote Sensing Service Centre |
| SAC | Space Application centre |
| SAR | Synthetic Aperture Radar |
| SARAL | Satellite with ARGOS and ALTIKA |
| SAS & R | Satellite aided Search and Rescue |
| SATCOM | Satellite Communication |
| SC | Space Commission |
| SCARAB | Scanner for Radiation Budget Management |
| SCED | Semi Cryogenic Engine Development |
| SCL | Semi- Conductor Laboratory |
| SCOMET | Special chemicals, organisms, material, equipment and technologies |
| SCSG | Southern California Selene Group |
| SDSC | Satish Dhawan Space Centre |
| SELENE | SELenological and Engineering Explorer |
| SEZ | Special Economic Zones |
| SFCG | Space Frequency Coordination Group |
| SHARES | Sharing of Experience in Space |
| SIA | Satellite Industry Association |
| SIGNIT | Signals Intelligence |
| SIS | Signal In Space |
| SITE | Satellite Instructional Television Experiment |
| SLV | Satellite Launch Vehicle |
| SNRMS | Sustainable Natural Resource Management |
| SNSB | Swedish National Space Board |
| SPP | Solid Propellant Plant |
| SRE | Space Capsule Recovery Experiment |

| Abbreviations | Expansion |
|---|---|
| SRON | Netherlands Institute for Space Research |
| SSO | Sun Synchronous Orbit |
| STEP | Satellite Telecommunication Experiments Project |
| STPs | Software Technology Parks |
| STS | Space Transportation System |
| SSO | Sun Synchronous Orbit |
| STEP | Satellite Telecommunication Experiments Project |
| STPs | Software Technology Parks |
| STS | Space Transportation System |
| SSO | Sun Synchronous Orbit |
| STEP | Satellite Telecommunication Experiments Project |
| STPs | Software Technology Parks |
| STS | Space Transportation System |
| TAAL | Taneja Aerospace and Aviation |
| TALIS | Teaching and learning international survey |
| TAUVEX | Telescope for scientific and technical interfaces for flying |
| TCXO | Temperature compensated crystal oscillators |
| TDCC | Training and development Communications Channel (INSAT) |
| TDS | Technology Demonstration System |
| TDSAT | Telecom Dispute Settlement and Appellate Tribunal |
| TECSAR | Israeli Satellite to feature Synthetic Aperture Radar |
| TERLS | Thumba Equatorial Rocket Launching Station |
| TES | Technology Experimental Satellite |
| TRAI | Telecom Regulatory Authority of India |
| TSTO | Two Stage to Orbit |
| TTC | Telemetry, Tracking and Command |
| TUBSAT | Indonesia's first remote sensing satellite |
| TV | Television |
| USSR | Union of Soviet Socialist Republic |
| UAV | Unmanned Aerial Vehicle |
| UKSA | UK Space Agency |
| ULV | Unified Launch Vehicle |
| U.S. | United States |
| USA | United states of America |
| USSR | Union of Soviet Socialist Republic |

| Abbreviations | Expansion |
|---|---|
| UVIT | Ultra Violet Imaging Telescope |
| VAT | Value Added Tax |
| VATF | Vehicle Assembly and Test Facilities |
| VCXO | Voltage Controlled Crystal Oscillator |
| VHMS | Vehicle Health Monitoring System |
| VHRR | Very high Resolution Radiometer |
| VLF | Very low frequency |
| VLPT | Very Low Power Transmitter |
| VLSI | Very Large Scale Integration |
| VME | Virtual memory environment |
| VOs | Village Officers |

| Abbreviations | Expansion |
|---|---|
| VPX | Virtual Path cross connect |
| VRC | Village Resource Centre |
| VSAT | Very Small Aperture Terminal |
| VSSC | Vikram Sarabhai Space Centre |
| WEB | West Early Bird (ASTRIUM Satellite,UK) |
| WiFi | Wireless Fedility |
| W2M | W series European Communications Satellite |
| WMD | Weapons of mass destruction |
| WPC | Wireless Planning and Co-ordinating |
| WS | Wide Swath |
| XSAT | Xtreme Satellite Communication |

# 16. Exhibits & Tables

# 17. Acknowledgement

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