बजट परिणाम

OUTCOME BUDGET
2016-2017

भारत सरकार
अन्तरिक्ष विभाग

GOVERNMENT OF INDIA
DEPARTMENT OF SPACE

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OF THE
DEPARTMENT OF SPACE
GOVERNMENT OF INDIA
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EXECUTIVE SUMMARY

1. The primary objective of the Indian Space Programme is to achieve self-reliance in Space Technology and to evolve application programme to meet the developmental needs of the country. Towards meeting this objective, two major operational space systems have been established – the Indian National Satellite (INSAT) for telecommunication, television broadcasting and meteorological service and the Indian Remote Sensing Satellite (IRS) for natural resource monitoring and management. Two operational launch vehicles, Polar Satellite Launch Vehicle (PSLV) and Geosynchronous Satellite Launch Vehicle (GSLV) provide self reliance in launching IRS & INSAT Satellites respectively.

2. The Department of Space (DOS) and the Space Commission was set up in 1972 to formulate and implement Space policies and programmes in the country. The Indian Space Research Organisation (ISRO) is the research and development wing of the Department of Space and is responsible for executing the programmes and schemes of the Department in accordance with the directives and policies laid down by the Space Commission and the DOS. The Space programme is executed through the ISRO Centre/Units and the Grant-in-aid Institutions.

3. The overall thrust of the Space programme envisaged during 12th plan period has been towards sustaining and strengthening the already established space based services in the areas of Earth Observation, Satellite Communication, Disaster Management Support and Societal applications such as Tele-medicine, Tele-education and Village Resource Centres and to undertake advanced space missions including Aditya-1 and Chandrayaan-2. The details of the programmes envisaged during the 12th Plan period are dealt in para 4 of Chapter 1.

4. The Budget proposals for the Department of Space for 2016-2017 have been formulated under the framework of Twelfth Five Year Plan (2012-2017). The BE 2016-2017 for Department of Space stands at ₹**7,509.14 Crores** comprising of ₹**6000.00 Crores** 'Plan' outlay and ₹**1509.14 Crores** 'Non-plan' outlay. The outlay has been arrived at taking into account the programmatic targets set for 2016-2017.

5. The Department has prepared **"Outcome Budget 2016-2017"** as per the extant guidelines issued by the Ministry of Finance, Department of Expenditure. The Table 2.1 annexed to Chapter II gives the Outcome Budget for 2016-2017 in the prescribed format.

6. The Department of Space is largely project and mission oriented. The nature of Outcome of the Space Programmes will be mainly in the form of (a) Indigenous capability to develop and realise complex space systems such as satellites and launch vehicles; (b) Creating infrastructure in Space by launching and operationalisation of satellites including Space operations, which are utilised by various user agencies for national development; (c) Capacity building in terms of critical technologies and ground technical infrastructure of relevance for future and (d) Benefits to the society arising from application of space technology/systems such as IRS satellites, INSAT satellites in various fronts. These have been appropriately reflected in the Table 2.1, Chapter II of the Outcome budget against various programmes/schemes.

7. The major programmatic targets for 2016-2017 are the following:-

- Launch and operationalisation of Resourcesat-2A remote Sensing satellite, on-board Polar Satellite Launch Vehicle, for natural resources management.
- Launch and operationlisation of two of the Cartosat-2 series satellites, on-board Polar Satellite Launch Vehicle for cartographic applications.
- Launch and operationalisation of Scatsat with scatterometer on-board for oceanographic and weather studies.
- Launch of communication satellites GSAT-17 and GSAT-18 using procured launch services.
- Launch of GSAT-9 communication satellite on-board GSLV-F-09.
- Completion of cryogenic C25 stage hot test and preparation towards first developmental flight of GSLV Mk III Launch Vehicle.
- Pad Abort Test of crew escape system as part of critical technologies for future Human Spaceflight.
- On-going work on Earth Observation and Space Science missions (Cartosat-3, Oceansat-3, RISAT-1A, Chandrayaan-2 and Aditya etc)

8. The Department has five Grant-in-aid Institutions under its fold viz., Physical Research Laboratory, National Atmospheric Research Laboratory, Semi-conductor Laboratory, North-East Space Applications Centre and Indian Institute of Space Science and Technology. A review of the performance of these institutions is presented in Chapter VI.

9. The Department has taken several policy initiatives and pro-active measures to enhance the effectiveness and outreach of the Space programme. The Policy framework of the Department encompasses the areas of Satellite Communications, Remote Sensing Data distribution, Industry participation, Commercialization, Human Resource Development, Extra-mural research, International Co-operation, effective user participation and continuous upgradation of technological capabilities. Societal applications has been a thrust area of the Space programme and the Department has initiated several programmes such as Tele-education, Tele-medicine, Village Resource Centres to take the benefits of space technology to the door-steps of common man.

10. Periodical review of the physical and financial performance of all the projects/schemes is an integral part of the planning and implementation strategy in DOS/ISRO. Quarterly targets are fixed for each major project/scheme during the beginning of the year and Additional Secretary & FA of the Department takes a rigorous review of the expenditure/commitment status on a monthly basis to ensure that the financial and programmatic targets are realized. With this, the Department has been able to meet most of the programmatic and financial targets.

11. The Indian Space Programme, 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 is poised to play a pivotal role in the national development in the coming years.

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INTRODUCTION

1.1 The Indian Space Programme had a modest beginning with the launch of the first sounding rockets in November 1963 from the Thumba Equatorial Rocket Launching Station (TERLS), 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). ISRO was also brought under the newly formed DOS in September 1972. Since then, over the last five decades, the ever challenging task of space technology development and utilisation, has not only graduated from experimental and demonstration phases to an operation era, but also provided its potential to address the national needs. Notable progress has been made in the design, development and operation of space systems, as well as, using them for vital services like telecommunications, television broadcasting, meteorology, disaster management support and natural resources survey and management including climate variability and change. The space programme has become largely self-reliant with capability to design and build satellites for providing space services and to launch them using indigenously designed and developed launch vehicles. The end-to-end capability in space for vital applications in communications, broadcasting, meteorology and natural resource information are of direct relevance for national development. The diverse roles of space technology & services in various fronts – social, economic, commercial and strategic have made the space systems an important component of our national infrastructure.

1.2 The primary objective of the Indian Space Programme has been to establish and operationalise space services in a self reliant manner in the thrust areas of Satellite Communication and Satellite based information for management of national services and Satellite Meterological applications. The indigenous development of Satellites, launch vehicles and associated ground segment for providing these services, is integral to these objectives. With the establishment of the two major operational space systems – the Indian National Satellite (INSAT) for telecommunication, television broadcasting and meteorological services and management and the Indian Remote Sensing Satellite (IRS) for resource monitoring and management. With the establishment of these two major operational space systems, the Indian Space Programme has been providing operational services to the user community in the country. Two operational launch vehicles, Polar Satellite Launch Vehicle (PSLV) and Geo-synchronous Satellite Launch Vehicle (GSLV) provide self reliance in launching IRS and INSAT Satellites respectively.

2. Organisational Set-up

2.1 The Indian Space Programme has its genesis in the Indian National Committee for Space Research (INCOSPAR) that was formed by the Department of Atomic Energy in 1962. The Indian Space Research Organisation (ISRO) was established under the Department of Atomic Energy in August 1969. The Government of India passed a resolution in 1972 for setting up Space Commission and the Department of Space (DOS) to formulate and implement space policies in the country and brought the Indian Space Research Organisation (ISRO) under the Department of Space in September 1972.

2.2 The primary objective of DOS is to promote the development and application of Space Science and Technology for socio-economic benefit of the nation. The Indian Space Research Organisation (ISRO) is the research and development wing of the Department of Space and is responsible for executing the research and development programmes and schemes of the Department in accordance with the directives and policies laid down by the Space Commission and the DOS. The Space programme is executed through the ISRO Centre/Units and its Grant-in-aid Institutions i.e., the Physical Research Laboratory (PRL), the National Atmospheric Research Laboratory (NARL), the North-Eastern Space Applications Centre (NE-SAC) and Semi-conductor Laboratory (SCL). The Antrix Corporation Limited (ACL), a wholly-owned Government Company established in 1992, is the apex marketing agency under DOS with access to resources of DOS as well as Indian Space industries. The establishment of space systems and their utilization are co-ordinated by national Committees, namely the INSAT Co-ordination Committee (ICC), the Planning Committee of National Natural Resources Management System (PC-NNRMS) and the Advisory Committee on Space Sciences (ADCOS). The ISRO Headquarters co-ordinates the overall programmes like launch vehicle, satellite communication, earth observation, space science, atmospheric science, space-industry development, disaster management support, international co-operation etc.

2.3 Following are the major Centres/Units of DOS/ISRO responsible for carrying out research and development activities as well as for undertaking the various projects and programmes:-

A. Vikram Sarabhai Space Centre (VSSC)

The Vikram Sarabhai Space Centre (VSSC) at Thumba, near Thiruvananthapuram, is the lead Centre for the development of satellite launch vehicles, sounding rockets and associated technologies. The Centre has developed expertise in aeronautics covering aerodynamics, flight mechanics, thermal analysis and structural engineering; mechanical engineering covering manufacturing technology, production and computer aided design; avionics covering control and guidance, TTC systems and on-board computers; propellants, polymers, chemicals, materials and metallurgy; propulsion and space ordnance; launch vehicle mechanism and launch vehicle design; composite materials and systems reliability. The Programme planning & evaluation, technology transfer & industrial co-ordination, human resources development, safety & personnel and general administration groups support the Centre. The Space Physics Laboratory (SPL) at VSSC carries out research in atmospheric and related space sciences. Apart from this, the Construction & Maintenance Group (CMG) carries out planning, execution and maintenance of all civil works related to the Centre.

VSSC has extension Centres at Valiamala, housing the major facilities of the Polar Satellite Launch Vehicle (PSLV) and the Geo-Synchronous Satellite Launch Vehicle (GSLV) Projects and at Vattiyoorkavu for the development of reinforced plastics and composites (Reinforced Plastics Facility). An Ammonium Perchlorate Experimental Plant (APEP) has been set up by VSSC at Aluva near Kochi. VSSC also supports the (i) Thumba Equatorial Rocket Launching Station (TERLS), the International sounding rocket range (ii) Rohini Sounding Rocket (RSR) Programme.

The major programmes at VSSC include: Polar Satellite Launch Vehicle (PSLV), Geosynchronous Satellite Launch Vehicle (GSLV), Rohini Sounding Rocket, Space-capsule Recovery Experiment, Reusable Launch Vehicles, Air Breathing Propulsion, Geo-Synchronous Satellite Launch Vehicle (GSLV) MK-III Development and development of critical technologies for Human Space Flight.

B. Liquid Propulsion Systems Centre (LPSC)

The Liquid Propulsion System Centre (LPSC) with its facilities located at Thiruvananthapuram (Valiamala) and Bengaluru is the lead Centre in the development of liquid and cryogenic propulsion stages for launch vehicles and satellites. In LPSC, Valiamala, Thiruvananthapuram management of system projects, design activities in the area of storable, cryogenic and semi cryogenic liquid propulsion systems, electric propulsion systems, flow control components and modules and spacecraft thrusters are carried out. In LPSC, Bengaluru, spacecraft propulsion systems design, realization and integration, monopropellant thruster and component design, spacecraft propellant tank design and realization, managing production of propellant tank and structures for launch vehicles development and production of transducers are carried out.

C. ISRO Propulsion Complex (IPRC)

The status of erstwhile LPSC, Mahendragiri has been elevated as "ISRO Propulsion Complex (IPRC)" with effect from February 1, 2014. IPRC has the responsibility for assembly, integration and testing of storable and cryogenic liquid rocket engines and stages, spacecraft thrusters testing in sea level and high altitude conditions, storage of liquid and cryogenic propellants and production of liquid hydrogen etc.

D. Satish Dhawan Space Centre-SHAR (SDSC-SHAR)

The Satish Dhawan Space Centre (SDSC-SHAR) located at Sriharikota, is the principal operational Centre for launching Sounding Rockets and Satellite Launch Vehicles. This Centre has the 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. Apart from this, the Construction & Maintenance Division (CMD) takes care of planning, execution and maintenance of all civil works of the Centre. The Centre has two launch pads from where the rocket launching operations on PSLV & GSLV are carried out.

E. ISRO Satellite Centre (ISAC)

The ISRO Satellite Centre (ISAC) at Bengaluru is engaged in developing satellite technology and implementation of satellite systems for scientific, technological and application missions. ISAC is functionally organised into six major areas: Mechanical Systems Areas, Digital & Communications Area, Integration & checkout area, Power Systems & Avionics Production area, Control & Mission Area and Reliability & Components Area. The Construction & Maintenance Division (CMD) of the Centre is responsible for planning, execution and maintenance of all civil works related to the Centre.

Four project management teams co-ordinate the implementation of Projects. Space astronomy and instrumentation division is engaged in space science activities. A new facility, ISRO Satellite Integration and Test Establishment (ISITE) including a Comprehensive Assembly, Test and Thermo-vacuum Chamber (CATVAC) has been set up recently.

F. Laboratory for Electro-Optics Systems (LEOS)

The Laboratory for Electro-Optics Systems (LEOS) at Bengaluru is responsible for design, development and production of electro-optic sensors like earth sensors, star sensors, sun sensors, magnetic sensors, temperature sensors and optical gyros for spacecraft use. LEOS is also responsible

for the fabrication of various types of optics for satellite cameras & radiometers and development of indigenous detectors for spacecraft. LEOS is also involved in the development of miniature sensors Micro Electro Mechanical Sensors (MEMS) devices, development of Charge Coupled Devices (CCD), Time Delay Integration (TDI) devices with external participation.

G. Space Applications Centre (SAC)

The Space Applications Centre (SAC) at Ahmedabad is responsible for the development, realization and qualification of communication, navigation, earth observation & meteorological payloads & related data processing and ground systems. The Centre carries out development of ground systems and application activities in the areas of communications, broadcasting, earth observations for remote sensing of natural resources, weather and environmental studies, disaster monitoring/mitigation, etc. SAC plays an important role in harnessing space technology for a wide variety of applications for societal benefits. The activities of SAC 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 & documentation group support the Centre. The Construction & Maintenance Division (CMD) takes care of planning, execution and maintenance of all civil works related to the Centre.

The facilities of this Centre include the Ahmedabad Earth Station, Delhi Earth Station, Portable & Mobile Earth Stations, Laboratories for remote sensing & communication activities, fabrication & environmental test facilities for development & qualification of space and ground hardware.

H. Development and Educational Communication Unit (DECU)

The Development and Educational Communication Unit (DECU) at Ahmedabad is involved in the conceptualisation, definition, planning, implementation and socio-economic evaluation of innovative developmental communications in space applications. The major current activities of DECU include: Training and Development Communication Channel (TDCC), Village Resource Centres (VRC), Tele-Health (TH), Tele-Education (TE) mission and new satellite communication development and applications.

I. National Remote Sensing Centre (NRSC)

National Remote Sensing Centre (NRSC) located at Hyderabad is responsible for satellite data acquisition, processing and dissemination of aerials and remote sensing data. NRSC has set up data reception station at Shadnagar near Hyderabad for acquiring data from Indian remote sensing satellites as well as others. The Centre is also engaged in executing remote sensing application projects in collaboration with the users.

J. Indian Institute of Remote Sensing (IIRS)

Indian Institute of Remote Sensing (IIRS), Dehra Dun is a premier training and educational Institute set up for developing trained professional in the field of Remote Sensing, Geoinformatics and GPS Technology for Natural Resources, Environmental and Disaster Management.

The main area of the function of the Institute is capacity building through technology transfer among user community, education at post-graduate level in the application of Remote Sensing & Geoinformatics for Natural Resources Management and promote research in Remote Sensing & Geoinformatics. The Institute provides value-added services in the field of natural resources management, remote sensing,

GIS and GPS technology. Earlier, IIRS, Dehradun, was functioning under NRSC. With effect from April 30, 2011, IIRS has been re-organised as a separate Unit of ISRO.

K. ISRO Telemetry, Tracking & Command Network (ISTRAC)

The ISRO Telemetry, Tracking & Command Network (ISTRAC) at Bengaluru provides mission support to low-earth orbit satellites as well as for launch vehicle missions. ISTRAC has its headquarters and a multi-mission Spacecraft Control Centre at Bengaluru. It has a network of ground stations at Bengaluru, Lucknow, Sriharikota, Port Blair and Thiruvananthapuram in India besides stations at Mauritius, Bearslake (Russia), Brunei and Biak (Indonesia). ISTRAC activities are organised into network operations, network augmentation, mission operation and spacecraft health monitoring, communications & computers & control centre facilities and development projects. Programme planning and reliability groups support ISTRAC activities. ISTRAC also operates the Local User Terminal/ Mission Control Centre (LUT/MCC) under the international programme for satellite aided search and rescue. An Indian Deep Space Tracking Network station at Byalalu near Bengaluru for India's mission to moon, Chandrayaan-1, has been recently established by ISTRAC.

L. Master Control Facility (MCF)

The Master Control Facility (MCF) located at Hassan in Karnataka and Bhopal in Madhya Pradesh monitors and controls all the geo-stationary satellites of ISRO. MCF carries out operations related to initial orbit raising of satellites, in-orbit payload testing and on-orbit operations through out the life of the satellites. The operations involve continuous tracking, telemetry and commanding, special operations like eclipse management, station-keeping maneuvers and recovery in case of contingencies. MCF interacts with the user agencies for effective utilisation of the satellite payloads and to minimize the service disturbances during special operations.

M. ISRO Inertial Systems Unit (IISU)

The ISRO Inertial Systems Unit (IISU) situated at Vattiyoorkavu, Thiruvananthapuram carries out research and development in inertial sensors, inertial systems, navigational software, actuators & mechanisms and to realize the flight units of these system for the launch vehicle & satellite programmes and allied satellite elements. IISU is organised into research and development divisions in the areas of launch vehicle inertial systems, spacecraft inertial systems, inertial system production and reliability & quality assurance. It has facilities for precision fabrication, assembly, clean room and integration & testing.

2.4 A National Natural Resources Management System (NNRMS) with the Department of Space (DOS) as the nodal agency has been established to ensure optimal management/utilisation of natural resources using remote sensing data in conjunction with conventional techniques.

2.5 Following are the Grant-in-aid institutions of DOS: -

A. Physical Research Laboratory (PRL)

The Physical Research Laboratory (PRL) at Ahmedabad, is an autonomous Institution funded by DOS through grant-in-aid. It is a premier Institute engaged in basic research in experimental & theoretical physics and earth sciences. PRL is also responsible for the administration of the Udaipur Solar Observatory. Research activities in the area of infrared astronomy, solar and plasma astrophysics, solar and galactic astronomy, geo-cosmo physics, planetary atmosphere, solar-terrestrial physics,

laboratory astrophysics, theoretical physics and archaeology & hydrology are carried out at PRL. PRL is also involved in conducting extensive academic programmes for Doctoral and Post Doctoral research and also has an Associateship programme for University Teachers.

B. National Atmospheric Research Laboratory (NARL)

The National Atmospheric Research Laboratory (NARL) at Gadanki near Tirupati is an autonomous research laboratory fully funded by DOS. The main objectives of NARL are (i) Basic research in atmospheric science (ii) Indigenous technology development for probing the atmosphere and (iii) Application of Weather and Climate research for short and long term weather prediction. NARL has a variety of state-of-the art equipments such as the Mesosphere-Stratosphere-Troposphere (MST) Radar, different types of LIDARs, regular GPS sonde balloon launches, automatic weather station etc. NARL is available for national and international scientists to conduct research in atmospheric & space sciences and related disciplines.

C. North-Eastern Space Applications Centre (NE-SAC)

The North-Eastern Space Applications Centre (NE-SAC) located at Shillong set up as an autonomous society, jointly with the North- Eastern Council, is supporting the North-Eastern Region by providing information on natural resources utilisation & monitoring, infrastructure developmental planning & interactive training using space technology inputs of remote sensing & satellite communication. 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 in remote sensing, satellite communication and space science.

D. Semi-conductor Laboratory (SCL)

The SCL at Chandigarh, is engaged in the design, development and manufacture of Very Large Scale Integrated Circuits (VLSIs) and development of systems for telecommunication & space sectors Board Level Products. The SCL has an Integrated Facility comprising class 10, 6” Wafer Fabrication Plant, Design Facility, Test & Assembly, Quality Assurance & Reliability and system Level Assembly Facility. Development & Manufacture of ASICs for Strategic Sector is the major thrust.

E. Indian Institute of Space Science & Technology (IIST)

The Indian Institute of Space Science and Technology (IIST) is an autonomous body under DOS formed with the primary objective of creating world class Institution in the area of advanced Space Science and Technology education and generating high quality human resources to meet the quality human resource requirements of DOS/ISRO. The Institute has undergraduate, postgraduate and doctoral programmes in the area of space science technology and applications. The Institute offers graduate, post-graduate and doctoral programmes in the area of Space Science and Technology. The Institute has started functioning from the academic year 2007-2008, around the existing infrastructure adjacent to VSSC, Thiruvananthapuram. It started functioning from its own new campus at Valiamala w.e.f August 15, 2010. The annual intake of the Institute is about 150-200 students.

2.6 Apart from this, the RESPOND programme of ISRO supports sponsored research activity in Space Science, Space Applications and Space Technology in various national academic/research institutions and Space Technology Cells in premier technological institutes of the country through grants-in-aid. The RESPOND Programme is aimed at promoting space research activities and to

develop a large research based trained manpower and infrastructure facilities for specific activities of interest to the space programme in the country.

2.7 Antrix Corporation Limited (ACL)

The Antrix Corporation Limited, Bengaluru 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 organizes training of manpower and software development.

3. Major projects/programmes of Department of Space

3.1 The Department of Space (DOS) has the primary objective of promoting development and application of Space Science and Technology to assist in all-round development of the nation. Towards this, the Department has evolved the following programmes:-

(a) Launch Vehicle programme having indigenous capability for launching spacecrafts;

(b) INSAT Programme for telecommunications, broadcasting, meteorology, development of education etc;

(c) Satellite Navigation Programme for providing positional services in the country;

(d) Remote Sensing Programme for application of satellite imagery for various developmental purposes; and

(e) Research and Development in Space Science, Technology for subserving the end of applying them for national development.

3.2 Over the years, India has established two operational Space Systems - the Indian National Satellite (INSAT) System providing services for telecommunications, TV broadcasting and meteorology including disaster warning support and the Indian Remote Sensing Satellite (IRS) System for natural resource monitoring and management. The Polar Satellite Launch Vehicle (PSLV) is well proven through Thirty Two successive successful flights and has emerged as a reliable cost-effective launch vehicle. Two successful flights of Geo-Synchronous Satellite Launch Vehicle (GSLV), with Indian Cryogenic Engine, achieved on January 5, 2014 and August 27, 2015 are landmark achievements in India's technological progress. India is one among the six countries in the world to demonstrate capabilities for geo-stationary satellite launch using cryogenic technology. GSLV has the capability of launching 2 Ton class of communication satellites into Geo-Synchronous Transfer Orbit. Apart from these two launches, GSLV had seven earlier launches. Procured cryogenic stages from Russia have been used for the upper stage in six missions of GSLV.

3.3 Indian Earth Observation satellite system is one of the largest constellations of remote sensing and meteorological satellites in operation in the world today. With currently thirteen operational satellites in orbit providing data in a variety of spatial, spectral and temporal resolutions, serving as main stay of the National Natural Resources Management System (NNRMS) besides providing data worldwide. Vital applications such as identifying zones which could yield ground water, suitable locations for recharging water, monitoring command areas, estimating crop areas and yields, assessing deforestation, mapping urban areas for planning purposes, delineating ocean areas with higher fish catch potential, monitoring of environment and scene specific spot imagery are being pursued actively by users with the space based data. The data from IRS Satellites is received worldwide through a network of International

ground stations under commercial agreement with M/s. Antrix Corpration Limited.

3.4 INSAT contributes significantly to a variety of services in telecommunications and television broadcasting including meteorological observations, disaster communications, Tele-education and Tele-health services. Indian National Satellite (INSAT) system is a joint venture of the Department of Space, Department of Telecommunications, India Meteorological Department, All India Radio and Doordarshan. Established in 1983, INSAT is the largest domestic communication satellite systems in the Asia Pacific Region with thirteen operational satellites. The overall coordination and management of INSAT system rests with the INSAT Coordination Committee (ICC).

3.5 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 & 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 world wide scientists. ASTROSAT satellite, India's first dedicated astronomy satellite was successfully launched on September 28, 2015. ASTROSAT enables simultaneous multi-wavelength (Ultraviolet to X-Ray) observations to study Stars and Galaxies. It will also provide opportunity to task observations for the scientific community. India's second mission to moon, Chandrayaan-2 and Aditya-L1 missions have also been taken up.

3.6 India's first Mission to Planet Mars, Mars Orbiter Mission was successfully launched on November 05, 2013. Subsequently, the Mars Obiter Spacecraft was successfully inserted into an elliptical orbit around planet Mars on September 24, 2014. With this successful Mars Orbit Insertion operation, ISRO has become the fourth space agency to successfully send a spacecraft to Mars orbit and India became the first country in the world to do so in its first attempt. The Mars Orbiter has completed one year around Mars orbit on Septembr 24, 2015 and accomplished its planned mission objectives. Mars Orbiter through its scientific payloads continues to provide valuable data of Mars surface and its atmosphere.

3.7 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 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.

3.8 Indian capabilities in space thus 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 recognised as a leader in space applications that have a wide impact on society.

4. Overview of Twelfth Five Year Plan 2012-2017

4.1 During the 12th Plan, the thrust of the space programme has been on augmentation of INSAT/GSAT capacity to meet demand for transponders, establishment of the Indian Regional Navigational Satellite System over Indian region, continuation of established services with improved capabilities with thematic series of Indian EO satellites, expansion of satellite based applications including societal

applications, strengthening of Polar satellite Launch Vehicle (PSLV) and Geo-synchronous Launch Vehicle (GSLV) as the workhorse vehicles, Realisation of developmental flights of next generation launch vehicle (GSLV MK III) capable of launching 4T class INSAT satellites; pursuance of semi-cryo engine development, undertaking space science and planetary exploration; strengthening space-based Disaster Management Support and developing critical technologies for the human spaceflight programme.

4.2 In the area of **Satellite Communications**, it has been planned to augment the INSAT capacity to bridge the gap between the demand and supply of the transponders for meeting all the requirements of the country and also to maintain sufficient spares capacity to meet contingencies. Development of state-of-the-art technologies and latest applications areas shall also be pursued.

4.3 In order to meet the emerging demand for operational transponder, 14 communication satellites are planned to be realised during the 12th Plan period for (a) increasing the transponder capacity (b) introducing new generation broadband VSAT systems (c) introduction of Ka band systems (d) building high power S-band satellite mobile communications and (e) introduction of new generation geo-imaging satellite

4.4 **Satellite based Navigation** service is an emerging satellite based system with commercial and applications. Establishment of an independent Indian Regional Navigation Satellite System (IRNSS) over Indian region with a constellation of 7 satellites was planned to be realised during the 11th Plan. Considerable progress has been achieved in realizing the various subsystems of these satellites and the constellation shall be completed during the 12th Plan. Implementation of the final operational phase for satellite based augmentation system (SBAS) GAGAN (GPS Aided Geo Augmented Navigation) over the Indian Airspace is also an important targets for 12th Plan. Formulation of Indian Satellite Navigation Policy to facilitate growth of Satellite based navigation application will also be pursued. Work towards augmentation of IRNSS system with 4 additional satellites shall also be initiated during the 12th Plan.

4.5 The thrust areas of **Earth Observation and Atmospheric Sciences Programme** for the 12th Plan will be in continuation of established services with improved capabilities with three thematic series of Indian EO satellites i.e. Natural resources, Cartography and Ocean & Atmosphere, including all-weather capability; development of newer state-of-the-art capabilities to meet specific user requirements; augmentation of ground segments for effective utilization of the various sensors; and special emphasis application missions in the areas of agriculture, environment, large scale mapping, infrastructure planning, oceanography, climate and atmospheric studies. To achieve the above, 8 Earth Observation missions are planned during the 12th Five Year Plan period. With the realization of these missions, there would be significant improvements in the areas of short term weather and ocean state forecasting, natural resources management, high resolution cartography, large scale mapping, space based Essential Climate Variables (ECVs) with enhanced spatial, spectral, radiometric and temporal resolution.

4.6 **The Disaster Management Support (DMS) Programme** of ISRO is intended to provide near real time information support and services from imaging and communication satellites towards efficient management of disasters in the country. Major programmatic targets of DMS programme during 12th Five Year Plan period will be Operationalization of National Database for Emergency Management (NDEM), Continuation of impact mapping and monitoring of natural disasters with improved turnaround time and with newer capabilities, acquisition of close contour data through ALTM, extension of the

communication network to the District Emergency Operation centres, geo-location based services such as Search & Rescue and distress alerts, operational dissemination of the information and products directly to the affected areas, Operational utilization of early warning systems and extension of the Hydro-meteorological network.

4.7 The main focus of the **Space Transportation Systems** during 12th plan period will be towards achieving self-sufficiency in launching our satellites, developing launch vehicles for enhanced payload capability, adopting appropriate outsourcing strategies for assuring productionisation of launch vehicles, enhancement of infrastructure for launch vehicles and developing advanced technologies for the future. Towards this, enhancement of level of production of PSLV Vehicle systems with vigorous industry participation, completion of qualification of indigenous Cryogenic Upper Stage (CUS), proving GSLV with indigenous cryogenic stage, as a reliable workhorse launch vehicle, completion of development and qualification of C25 Engine & Stage, completion of one development flight of GSLV Mk III with 4.0 T GTO capability, progress on the development of Semi cryogenic engine with the establishment of test facilities, augmentation spaceport infrastructure to meet the launch vehicle requirements shall be pursued. During the 12th Plan period, 17 PSLV missions, 6 GSLV MK-II missions and 2 GSLV MK-III missions (including one experimental mission) are planned to be accomplished.

4.8 **Space Sciences & Planetary Exploration** missions contribute significantly towards understanding the mysteries of the universe, our existence and provide an opportunity towards development of cutting edge technologies. Through space science investigations, we seek to understand the processes governing solar radiation, evolution of planetary system, formation of galaxies, evolution of stellar systems and the universe. Missions initiated during the 11th Plan such as Chandrayaan-2, Astrosat-1 and Aditya-1 will be realised in 12th plan. Undertaking India's First Mission to Mars, Mars Orbiter Mission will be an important milestone during the 12th Plan. In addition, an X-Ray polarimeter (POLIX) to study the x-ray polarization from bright x-ray emitting objects shall also be pursued.

4.9 Technological advancement, which is essential to maintain competitive relevance, will be an important thrust area for future space endeavors. The current level of technologies have to be upgraded to a higher magnitude and novel concepts have to be developed in order to achieve a much better and reliable space system. New technologies acquired will be the driving force for futuristic space missions. Towards this the following technological development activities are planned during the 12th plan period.

4.10 In the area of Launch Vehicle technology development, critical technology initiatives such as composite segmented booster case for large solid motors, elastic memory composites and carbon-carbon technology demonstrators including optimization studies of carbon-carbon processing through CVI furnace, Robotics for planetary missions, Nano materials and composite, lunar soft lander etc., shall be pursued. Similarly, in the area of Satellite Technology development of Green House Gases and Trace gases sensors using hyperfine and ultrafine spectrometers, Field based multi-frequency microwave Ground Penetrating Radar, Reflective Optics with large diameter mirrors, Advance SiC Mirror technology for 2 to 2.5 M Optics, CFRP and composite based telescope/antenna structures, higher capacity Lithium ion batteries, Electric propulsion along with chemical propulsion, miniaturization – MMICs, ASICs, FPGAs, HMCs, BGAs based systems, I-6K Unified bus with modular design, multi EV panels and scalable structure (Bus module & payload module), Inter-satellite communication links, Multi-channel Waveguide Rotary Joint, Development of Portable Ku-band Tele-medicine Terminal, Satcom based Automatic Identification System (AIS), development of Indigenous Space qualified atomic clocks & On-board time synchronization technology shall be initiated.

4.11 In order to demonstrate emerging new technology developments, a series of experimental satellites have been planned. One of the major missions being the technology demonstration related to Docking and Rendezvous. These satellites will be flown on the PSLV missions as auxiliary or co-passenger satellites.

4.12 In addition, policy initiatives such as New Satcom Policy, Space Legislation, Space Navigation policy etc., shall be put in place to facilitate the growth and development of Space Science and Technology in the country.

4.13 Few specialized technical facilities for supporting the development, fabrication, integration and testing of the satellite systems and launch vehicles systems as well as launch and mission management have been planned during the 12th Plan period. The critical facilities considered amongst others during the 12th plan include establishment of Third Launch Pad at Sriharikota to support the increased launch frequency of PSLV, GSLV, Multiple Object Tracking Radar for tracking the space debris to safeguard our space assets, Second Vehicle Assembly Building to improve the launch turn around, Second Cryogenic Main Engine and Stage Test facility at IPRC, Mahendragiri, solar cell production facility to minimizing the dependency for solar cell from foreign sources and setting up of Space Technology Parks at different locations to facilitate industry participation in Indian Space Programme.

4.14 Overall, 58 missions are planned for realisation during 12th Plan period which includes 33 Satellite missions and 25 Launch Vehicle missions.

4.15 The Plan Outlay for the missions planned for the 12th Plan period as well as the advance investments required for the missions planned for the early phase of 12th Plan, has been indicated to be ₹ 39,750.00 Cr. The Non-plan budgetary support during 12th Plan is expected to be ₹7,500 crores approx.

4.16 The Indian Space Programme 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 is poised to play a pivotal role in the national development in the forthcoming decade.

5. Mandate of the Department of Space

5.1 The Department of Space is committed to:-

(i) provide national space infrastructure for the telecommunication needs of the country, including the required transponders and associated ground systems;

(ii) provide satellite data required for weather forecasting, monitoring etc;

(iii) provide satellite imagery and specific products and services required for application of space technology for natural resource management/developmental purposes to the Central Government, State Governments, Quasi Governmental Organisations, NGOs and the private sector;

(iv) Promote Research & Development in space sciences and technology;

6. Policy framework of Department of Space

6.1 The Indian Space Programme is directed towards development and utilization of space science and technology in a self-reliant manner for the social-economic development of the country. Taking cognizance of the global space competitiveness, the policy framework of the Space programme envisages:

(a) **Industry Participation Policy** to promote participation of Indian Industries in the national space endeavors – higher levels of aggregates in system/stage level supply from the industry, use of ISRO facilities by Industry, technology transfer to the industry and technical consultancy services of ISRO expertise.

(b) **Commercialisation Policy** to extend the outreach of Indian Space assets, products and services to the global market through Antrix Corporation, Dissemination of IRS data through International ground stations on commercial basis, Leasing of INSAT transponders to private users, launching of foreign satellites by Indian Launch Vehicles (PSLV/GSLV), TTC support for foreign satellites, design and development of communication satellite for International customers.

(c) **Remote Sensing Data Policy** for acquisition and distribution of satellite remote sensing data from Indian and foreign satellites for civilian users in India.

(d) **Satcom Policy to enable use of INSAT** satellites by non-government sectors and to establish and operate private communication satellite.

(e) **International Co-operation Policy** for mutual benefit – bilateral and multilateral co-operative programmes, payloads of opportunity to be flown onboard Indian satellites and participation in international forums.

(f) **Human Resource Development Policy** oriented to retain the critical mass, training and development programmes, rewards and incentives, flexibility in career growth prospects, sabbatical opportunities and capacity creation in the academia through sponsored research.

(g) **Effective user participation** in the space systems planning and utilization – establishment of inter-departmental/inter-ministerial co-ordination mechanisms viz., INSAT Co-ordination Committee (ICC), Planning Committee of National Natural Resource Management System (PC-NNRMS) and Advisory Committee on Space Sciences (ADCOS).

(h) **Upgrading the technological capabilities** to realise state- of-the-art cost effective space systems viz., satellites, launch vehicles and associated ground systems for providing national space services.

The above policy framework has paved the way for creating cost effective space infrastructure for the country in a self reliant manner, its efficient utilisation for national development, enabled a significant role for Indian Industries and technology growth in multiple disciplines as spinoff benefits.

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OUTCOME BUDGET 2016-17

1.1 The Budget proposals for the Department of Space have been formulated under the framework of Decade Profile 2010-2020 and the missions planned for Twelfth Five Year plan (2012-2017). The BE 2016-17 for Department of Space stands at ₹**7509.14** crore comprising of ₹**6000.00** crore 'Plan' outlay and ₹**1509.14** crore 'Non-plan' outlay. The outlay has been arrived at taking into account the Programmatic targets set for 2016-2017.

1.2 The Department has prepared **"Outcome Budget 2016-17"** based on the guidelines contained on the subject in the Department of Expenditure, Ministry of Finance Office Memorandum No. 10(2)/E.Cord/2015 dated January 29, 2015. The Table 2.1 annexed to this Chapter, gives the Outcome Budget for 2016-2017.

1.3 Table 2.1 has been organised as per the Statement of Budget Estimates (SBE) submitted by the Department, which is prepared as per MoF approved Rationalised Central Sector Schemes of Department of Space.

2. Projects / Mission Mode Working

The Department of Space is largely project and mission oriented. The Department undertakes specific projects and programmes (viz., development of Satellites, launch vehicles and applications) based on demand for space services and executes them in a time-bound manner. Once the objectives of the project are achieved, the project is closed and the resources are re-deployed for other ongoing projects. The Missions and Projects are executed by the Centres and Units of ISRO under matrix management structure to ensure optimum utilization of resources. The Centres and Units are fixed entities and are the custodians of resources in terms of technology, infrastructure and human resources required for execution of the project.

3. Intermediate Outputs :

The implementation of projects on development of satellites, launch vehicles and the associated ground systems is a multi-disciplinary and multi-institutional endeavour. The ISRO Centres/Units are organised based on their areas of specialisation/expertise. For launch vehicle projects, Vikram Sarabhai Space Centre is the lead centre while for Satellite Projects, ISRO Satellite Centre is the lead centre. The lead centre of the project will have the primary responsibility for overall design, subsystem interface specifications, project management and co-ordination in addition to development of subsystems for which the lead centre has specialisation. The other Centres/Units of ISRO will have the responsibility to realise specific subsystems/ sub-assemblies for the project in the area of their expertise /specialisation. Therefore, the output of the ISRO Centres/Units (other than the lead centre), related to realisation of sub-systems for satellites and launch vehicles, are of intermediate products in nature, which will get integrated with the work of lead Centre. This has been suitably reflected in the Outcome budget.

4. Partial Outcome :

The gestation period for Space Projects i.e., Development of Satellites, Launch vehicles and associated ground segments is generally 3 to 5 years, while in some complex Projects, it could extend up to 8 – 10 years also. In the course of the development, the Project goes through various phases such as finalisation of configuration and detailed design, engineering & proto models development and qualification testing, fabrication of flight subsystem units and testing, assembly, integration and testing leading to launching of the satellite into orbit. The Output and Outcome of a Satellite or launch vehicle Project during a year is a result of accumulated expenditure on the Projects during the previous years. Similarly, the outlay of a Satellite or launch vehicle Project during a year does not necessarily result in output or outcome in the same year. While the deliverables and physical outputs are targeted and specified for each year for every project based on the development /realisation plans, the final outcome will accrue only upon the launch and operationalisation of the Satellite. The time frame for such final outcomes are also specified in the Outcome budget. Therefore, for the Projects which are in initial or intermediate stage, the partial outcome can be viewed as almost same as the Physical Output. However, the time frame for the final outcome is also specified in the Outcome budget.

5. Converting Outputs to Outcomes:

The Outcome of a programme is largely dependent on the objectives of the Programme. The primary objective of Space Programme is to develop the Space Technology (comprising of development of Satellites, Launch Vehicles and associated Ground segments), establish operational space systems in a self-reliant manner and demonstrate through pilot projects the potential applications of Space systems for national development in the areas such as Natural Resource Management, Tele-communications, TV broadcasting, developmental communications, rural communications, Tele-education, Tele-medicine and Disaster Management support. Therefore, the nature of Outcome of the Space Programmes will be in the form of (a) Indigenous capability to develop and realise complex space systems such as satellites and launch vehicles (b) Creating infrastructure in Space by launching and operationalisation of satellites including Space operations, which are utilised by various user agencies for national development (c) Capacity building in terms of critical technologies and ground technical infrastructure of relevance for future and (d) Benefits to the society arising from application of space technology/systems such as IRS satellites, INSAT satellites in various fronts. These have been appropriately reflected in the Outcome budget against various programmes/schemes.

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Department of Space

TABLE-2.1

OUTCOME BUDGET 2016-2017

(₹ in Crores)

Sl. No.	Name of the Scheme / Program	Objective / Outcome	Total Sanctioned Cost (In respect of Projects)	Outlay 2016-17			Quantifiable Deliverables / Physical Outputs	Projected Outcome	Processes / Timelines	Remarks
				Non-Plan	Plan	CEBR				
	SECRETARIAT - ECONOMIC SERVICES									
	DOS Secretariat			28.15						
	SPACE RESEARCH									
	SPACE TECHNOLOGY									
1	Vikram Sarabhai Space Centre (VSSC) & its Projects									
2	Vikram Sarabhai Space Centre (VSSC)	To develop critical and advanced technologies related to satellite launch vehicles including Reusable Launch Vehicles (RLV), Sounding rockets and allied satellite subsystems and provide infrastructure support for development and fabrication / testing of Indian launch vehicles.	N.A	381.32	750.00	---	"Realisation of subsystems for five PSLV missions (PSLV-C32 to C-36), one GSLV mission (GSLV- F05), Re-usable Launch Vehicle (RLV HEX 01) and ATV D02.Commissioning of HIPIC, Optical structure facy.,Advanced Detonics Research Lab, CVI furnace for CMSE, etc. Activities to strengthen Tech Development and Productionisation efforts in the area of avionics, aeronautics, advanced materials, propulsion systems, mechanisms, control & guidance and manufacturing technology for increased launch requirements."	Technology development initiatives and hardware development and realisation lead to state-of-art launch vehicles for Indian Space Programme.	Continuing efforts in technology and hardware development to remain state of the art in launch vehicle and satellite technology for Indian space programme.	

Sl. No.	Name of the Scheme / Program	Objective / Outcome	Total Sanctioned Cost (In respect of Projects)	Outlay 2016-17			Quantifiable Deliverables / Physical Outputs	Projected Outcome	Processes / Timelines	Remarks
				Non-Plan	Plan	CEBR				
3	GSLV Operational	To fabricate 16 operational GSLV launch vehicles (GSLV F1 - F16) and take advance procurement actions for additional vehicles and launch communication satellites.	3550.96	---	180.00	---	"Realisation and integration of stages of GSLV-F05 & GSLV-F09 flight."	Augmenting INSAT system with additional transponders to meet the communication requirements.	Launch of GSLV-F05 & GSLV-F09 with indegenous Cryo stages planned in 2016-17.J19	
4	GSLV Mk III Development	To develop a Geosynchronous satellite launch vehicle capable of launching 4Ton class INSAT type of satellites to GTO.		---	100.00	---	"Readiness of S200 systems for D1 flight. Readiness of L110 flight stage for D1 flight Readiness of C25 stage for D1 flight.C25 stage development hot test.CE20 Engine development test. C25 stage propellant mock up. LVM3-D1 mission. Hardware delivery for D2 flight. "	"Partial outcome: Readiness of all systems for LVM3-D1 flight & launch of LVM3-D1. The project is currently in intermediate stage. The final outcome of achieving self reliance in launching 4T class of INSAT satellites will accrue upon successful flight of GSLV Mk III D2 vehicle. "	"Launch of LVM3-D1 in December 2016."	"GSLV MK III will have the capability to launch 4T class of communication satellite into Geosynchronous Transfer Orbit. "

Sl. No.	Name of the Scheme / Program	Objective / Outcome	Total Sanctioned Cost (In respect of Projects)	Outlay 2016-17			Quantifiable Deliverables / Physical Outputs	Projected Outcome	Processes / Timelines	Remarks
				Non-Plan	Plan	CEBR				
5	PSLV-Continuation Project	To fabricate Operational Polar Satellite Launch Vehicles (PSLVs) for launching Remote Sensing and Scientific satellites.	5953.52	---	400.00	---	Mission planning, subassembly preparation, final integration & testing of Launch Vehicle and Launch of PSLV-C34, C35, C36, C37 & C38.	"Launch of 5 PSLV flights."	"1) PSLV-34/ Cartosat-2C Mission in April 2016. 2) PSLV-C35/ Scatsat Mission in June 2016. 3) PSLV-C36/ Resourcesat-2A Mission in September 2016. 4) PSLV-C37/ EMIsat Mission in December 2016. 5) PSLV-C38/ Cartosat-2D Mission in March 2017."	"PSLV had so far 31 successive successful flights and has emerged as a versatile, reliable and cost-effective launch vehicle. Its launch capability has been progressively enhanced from 850 kgs to 1750 kg through continous improvements in the launch vehicle."

Sl. No.	Name of the Scheme / Program	Objective / Outcome	Total Sanctioned Cost (In respect of Projects)	Outlay 2016-17			Quantifiable Deliverables / Physical Outputs	Projected Outcome	Processes / Timelines	Remarks
				Non-Plan	Plan	CEBR				
6	Manned Mission Initiative/Human Space Flight Program	Development of critical technologies for human spaceflight like Crew Module (CM) system, Environmental Control and Life Support System (ECLSS), Flight suit (FS) and Crew Escape System (CES).		---	12.00	---	"Realisation of Crew Module Systems for Pad Abort Test (PAT) flight. Realisation of solid motors, fairing, structures, separation systems and mechanism and avionics for PAT flight. Realisation of sub-systems for ECLSS and integrated tests with Crew Module "	"Technologies leading to manned mission would be able to demonstrate "	"Static tests of CES solid motors are planned by December 2015 / March 2016. Readiness of Crew Module is expected by December 2015 for further integration activities. PAT flight is targeted by fourth quarter of 2016 Integrated test of ECLSS is targeted by December 2016 "	
7	Trisonic Wind Tunnel Project	To provide test facilities for furture launch vehicle developments in Aero-dynamic characterisation in subsonic, transsonic and supersonic mach number.		---	0.10	---	"Approval of the project report."	To provide Aero-dynamic test facilities for future launch vehicles.	The project report of Trisonic wind tunnel project is expected to be approved in 2016.	

Sl. No.	Name of the Scheme / Program	Objective / Outcome	Total Sanctioned Cost (In respect of Projects)	Outlay 2016-17			Quantifiable Deliverables / Physical Outputs	Projected Outcome	Processes / Timelines	Remarks
				Non-Plan	Plan	CEBR				
8	Development of Space Materials & Components	Indigenous development of space grade components and materials required for Satellites and Launch Vehicles		---	12.00	---	Qualification of metallic and non-metallic materials, chemicals and electronic components	Self-reliance and import substitution in few areas by developing indigenous materials and components.	Development of space grade components and materials is a continuous process to remain state of the art in launch vehicle and satellite technology.	
9	ISRO Inertial Systems Unit. (IISU)	Research, Development and realisation of inertial sensors and systems for launch vehicles and allied satellite elements.		---	60.00	---	"Delivery of flight and flight standby systems of RGP,RESINS and GAINS for six PSLVs and one GSLV and one LVM3 missions. Realisation of inertial systems for 8 satellite missions. Procurement of major equipment such as Angular Motion Simulator, Gyro theodolite, Precision Centrifuge, commissioning of Integration Test Complex."	"Realisation of tested and qualified Inertial Navigation systems, Momentum Wheels, Reaction Wheels, Solar Array Drive Assembly, inertial reference units, scan mechanisms etc., for Launch Vehicles and Satellites Inertial Systems are intermediate products/sub systems used in satellites and launch vehicles."	Technology development, improvement and scaling up is a continuous process to remain state-of-the-art in satellite and launch vehicle technology and to achieve maximum self-reliance in this strategic area.	

Sl. No.	Name of the Scheme / Program	Objective / Outcome	Total Sanctioned Cost (In respect of Projects)	Outlay 2016-17			Quantifiable Deliverables / Physical Outputs	Projected Outcome	Processes / Timelines	Remarks
				Non-Plan	Plan	CEBR				
10	Liquid Propulsion Systems Unit (LPSC) & its Projects									
11	Liquid Propulsion Systems Unit (LPSC)	Development of earth storable liquid propulsion and cryogenic propulsion technology/ systems for launch vehicles and satellites.		91.75	220.00		"Delivery of integrated propulsion system for satellite missions. Integration & delivery of flight worthy cryogenic upper stages for GSLV Mk2 mission. Integration of C25 Stage and completion of development hot test. Hardware realisation and delivery of PS2, PS4 stages and control power plants for PSLV. Realisation of GS2 stages, L40 stages and CUS for GSLV."	"Realisation of tested and qualified (a) liquid and cryogenic stages for PSLV and GSLV and (b) Reaction control systems for IRS and GEOSAT Satellites. Liquid and Cryogenic propulsion systems are intermediate products / subsystems used in satellites and launch vehicles. "	"Realisation of tested and qualified (a) liquid and cryogenic stages for PSLV and GSLV and (b) Reaction control systems for IRS and GEOSAT Satellites. Liquid and Cryogenic propulsion systems are intermediate products / subsystems used in satellites and launch vehicles."	Liquid Propulsion Systems Centre is the lead centre for development of liquid and cryogenic propulsion systems and has established unique technical infrastructure (test and fabrication facilities) at Mahendragiri, Valiamala and Bengaluru.

Sl. No.	Name of the Scheme / Program	Objective / Outcome	Total Sanctioned Cost (In respect of Projects)	Outlay 2016-17			Quantifiable Deliverables / Physical Outputs	Projected Outcome	Processes / Timelines	Remarks
				Non-Plan	Plan	CEBR				
12	Semi-cryo-genic Engine Deveopment	Developing a higher thrust semi-cryogenic core stage for the unified modular launch vehicle.		---	160.00	---	"Engine sub-systems realization. Commissioning of facilities at IPRC, Mahendragiri. Commencement of integration of engine subsystems for development test."	The project is in initial stages. The final outcome, in terms of availability of higher thrust semi-cryogenic stage.	Availability of high thrust semi cryo engine is expected by 2018.	Semicryogenic engine is cost effective and eco-friendly technology which is expected to ensure low cost access to space.
13	ISRO Propulsion Complex (IPRC)	Assembly and Testing of storable and cryogenic and liquid Rocket Engines and stages, Space-craft Thrust-ers, Storage of Liquid and Cryogeninc propellants and production of liquid hydro-gen.	NA	58.00	275.00		"Realisation of Vikas Engines, PS2 Stag-es, PS4 stages and testing of systems & subsystems for PSLV. Realisation of Vikas Engines, Cryogenic engines, GS2 Stag-es, Cryogenic Upper Stages and testing of systems & sub-systems for GSLV."	"Realisation of tested and qualified earth storable and Cryogenic stages of PSLV, GSLV and GSLV MkIII. Realisation of tested and qualified systems and subsystems of Semi Cryogenic engine. Liquid and Cryogenic propulsion systems are intermediate products/ subsystems used in satellites and launch vehicles."	Technology development, improvement and scaling up is a continuous process to remain state-of-art in satellite and launch vehicle technology and to achieve maximum self-reliance in this strategic area.	

Sl. No.	Name of the Scheme / Program	Objective / Outcome	Total Sanctioned Cost (In respect of Projects)	Outlay 2016-17			Quantifiable Deliverables / Physical Outputs	Projected Outcome	Processes / Timelines	Remarks
				Non-Plan	Plan	CEBR				
14	ISRO Satellite Centre (ISAC) & its Projects									
15	ISRO Satellite Centre (ISAC)	Developing Satellite Technology and implementation of satellite systems for scientific, technological and application missions.	NA	118.00	300.00	---	"Technology Development initiatives - High Power High Throughput Satellite Platform and 6Ton class, Space Docking experiment. Assembly, integration and testing of Satellites for launch. (Cartosat-2C/2D, Scatsat, Resourcesat-2A, GSAT-17/18, GSAT-11) Establishment of major facilities like AIT-2, Spacecraft Transportaion Systems, Ambient Pressure Thermal Cycling Facility, etc."	Technology development initiatives and spacecraft hardware development and realisation lead to state-of-the-art satellites for Indian Space Programme.	"Technology development, improvement and scaling up is a continuous process to remain state-of-the-art in satellite technology and to achieve maximum self-reliance in this strategic area. "	The ISRO Satellite Centre (ISAC) is the lead centre for Satellite Technology. A new facility, ISRO Satellite Integration and Test Establishment (ISITE) including a Comprehensive Assembly, Test and Thermo-Vaccum Chamber (CATVAC) has been set up recently.

Sl. No.	Name of the Scheme / Program	Objective / Outcome	Total Sanctioned Cost (In respect of Projects)	Outlay 2016-17			Quantifiable Deliverables / Physical Outputs	Projected Outcome	Processes / Timelines	Remarks
				Non-Plan	Plan	CEBR				
16	Oceansat-3 & 3A	Development and Launch of Oceansat-3 & 3A satellite for ceanographic applications. This will be a continuation mission to Oceansat-1 and Oceansat-2.	797.17	--	30.00	--	"Priliminary design review. Initiation of procurement actions for electronic components, materials etc."	"Partial Outcome: Completion of preliminary design reviews."	Completion of preliminary design reviews is planned during 2016-17.	Oceansat-3 & 3A will provide continuity of data for already established services in the area of Oceanographic applications.
17	Resourcesat-2A	Develop and Launch Resoucesat-2A satellite to provide continuity of data in the area of Natural Resources Management.	200.00	---	75.00	---	"Realisation of various subsystems of Resourcesat-2A. Completion of satellite integration and testing. "	"Full Outcome: Launch of Resourcesat-2A satellite"	Launch of Resourcesat-2A is planned during second half of 2016.	Resoucesat-2A is a follow-on mission to Resourcesat-2 satellite which was launched on 2011.
18	Resourcesat-3 Series (3S &3SA)	Develop and launch two remote sensing satellites viz. Resourcesat-3S & 3SA to provide continuity of data for natural resources management.	697.22	---	20.00	---	"Priliminary design review. Initiation of procurement actions for electronic components, materials etc."	"Partial Outcome: Completion of preliminary design reviews."	Completion of preliminary design reviews is planned during 2016-17.	

Sl. No.	Name of the Scheme / Program	Objective / Outcome	Total Sanctioned Cost (In respect of Projects)	Outlay 2016-17			Quantifiable Deliverables / Physical Outputs	Projected Outcome	Processes / Timelines	Remarks
				Non-Plan	Plan	CEBR				
19	Cartosat-3	Develop and Launch an advanced remote sensing satellite with enhanced resolution of 0.25m for cartographic applications and high resolution mapping.	351.16	---	30.00	---	"Finalisation of configuration of Cartosat-3 satellite. Initiation of procurment process for long lead items"	Partial Outcome: Completion of preliminary design reviews	Cartosat-3 satellite is expected to be ready in a period of 4 years.	Cartosat-3 is designed as an advanced Cartographic satellite with a spatial resolution of 0.25m.
20	Scattsat	Develop and Launch a Remote Sensing Satellite with pencil beam Ku-band scatterometer and milimeter wave sounder .	80.00	---	35.00	---	"Realisation of various subsystems of Scattsat. Completion of satellite integration and testing. "	"Full Outcome: Launch of Scattsat satellite"	Launch of Scatsatt is planned during 2016.	Scattsat will provide data for measurement of wind vector and vertical temperature profile of atmosphere useful for atmospheric & Oceanographic studies.
21	RISAT-1A	Develop and Launch a Microwave Remote Sensing Satellite with C-band Synthetic Aperture Radar for Flood Management and Agricultural Applications	490.00	---	35.00	---	"Priliminary design review. Initiation of procurement actions for electronic components, materials etc."	"Partial Outcome: Completion of preliminary design reviews."	completion of preliminary design reviews is planned during 2016-17.	RISAT-1A is a follow-on mission to RISAT-1 with C-band multi-polarised Synthetic Aperture Radar having capability of imaging under all weather conditions.

Sl. No.	Name of the Scheme / Program	Objective / Outcome	Total Sanctioned Cost (In respect of Projects)	Outlay 2016-17			Quantifiable Deliverables / Physical Outputs	Projected Outcome	Processes / Timelines	Remarks
				Non-Plan	Plan	CEBR				
22	Cartosat-2E	Develop and launch a high resolution remote sensing satellite with improved resolution of 0.65 meter panchromatic band alongwith imaging capacity multi-sepectral band for Cartographic application and high resolution mapping	160.00	0.00	50.00		"Realisation of sub-systems of the spacecraft commencement of integration and testing actibities"	"Partial Outcome: integration and testing activities"	Cartosat-2E is expected to be ready for launch by 2017.	
23	RISAT-3	Develop and launch a Radar Imaging Satellite with all weather day and night imaging capability.	(Project not yet approved)	---	0.10	---	"Finalisation of project report for RISAT-3 and processing the same for approval of the Government."	Partial Outcome: Approval of Project Report for RISAT-3	Government approval for RISAT-3 is expected during 2016-17.	RISAT-3 is a microwave remote sensing satellite for disaster management and agriculture applications.

Sl. No.	Name of the Scheme / Program	Objective / Outcome	Total Sanctioned Cost (In respect of Projects)	Outlay 2016-17			Quantifiable Deliverables / Physical Outputs	Projected Outcome	Processes / Timelines	Remarks
				Non-Plan	Plan	CEBR				
24	GEO-Imaging Satellite (GISAT)	To Develop a geosynchro-nous satellite capable of imaging in visible and thermal band with 50m resolution for continuous observation of Indian Sub-conti-nent for quick monitoring of disasters, natual calamities and episodic events.	392.00	--	70.00	--	Finalisation of subsystem level configuration.	Partial Outcome: Completion of spacecraft level design reviews expected during 2016-17.	GISAT was approved in 2009.	
25	Indian Regional Navigational Satellite System	To develop a constellation of Indian Regional navigational satellite system (IRNSS) for providing positioning services.	1420.00	---	80.00	---	"Establishment of Ground elements."	"Full Outcome: Realisation of constellation of seven IRNNS Satellites"	IRNSS is a constellation of 7 satellites is expected to be completed during 2016-17.	Satellite Navigation is strategically an important area of Space technology applications.

Sl. No.	Name of the Scheme / Program	Objective / Outcome	Total Sanctioned Cost (In respect of Projects)	Outlay 2016-17			Quantifiable Deliverables / Physical Outputs	Projected Outcome	Processes / Timelines	Remarks
				Non-Plan	Plan	CEBR				
26	NASA-ISRO Synthentic Apperture Radar Mission	Design, develop and launch dual frequency (L&S band) radar imaging satellite in collaboration with JPL, NASA.	153.00	---	100.00	---	"Priliminary design review. Initiation of procurement actions for electronic components, materials etc."	"Partial Outcome: Completion of preliminary design reviews."	Completion of preliminary design reviews is planned during 2016-17.	
27	Advance Ordering	To maintain minimum credible stock of lang-lead items.	NA	---	5.00	---				
28	Laboratory for Electro-optics Systems. (LEOS)	Research and Development in the field of electro-optics systems required for satellites.	NA	---	45.00	---	"Satellite integration level testing of sensors for IRNSS-1G/1H, GSAT-19, CARTOSAT-2C, GSAT-17, GSAT-9, GSAT-11, RESOURCESAT-2A, SCATSAT, EMISAT and INSAT-3DR . Development of Sensors and Optics for INSAT-3DS, GISAT-1, GSAT-6A, CARTOSAT-2E and CARTOSAT-3."	"Realisation of tested and qualified electro-optical sensors such as earth sensor, sun sensor, star sensor, magnetometer and sensor electronics for satellites. Electro-optic sensors are intermediate products used in satellites."	Technology development, improvement and scaling up is a continuous process to remain state-of-the-art in Electro-optics sensors technology and to achieve maximum self-reliance in this strategic area.	LEOS have developed unique techno-logical capa-bility in the field of optics fabrication and Micro Elec-tro-Mechan-ical Systems (MEMS) for space applica-tions.

Sl. No.	Name of the Scheme / Program	Objective / Outcome	Total Sanctioned Cost (In respect of Projects)	Outlay 2016-17			Quantifiable Deliverables / Physical Outputs	Projected Outcome	Processes / Timelines	Remarks
				Non-Plan	Plan	CEBR				
29	"Satish Dhawan Space Centre - SHAR. (SDSC-SHAR) & its Projects"									
30	"Satish Dhawan Space Centre - SHAR. (SDSC-SHAR)"	To build, maintain and operate state-of-the-art launch infrastructure for assembly and launching of rockets, solid propellant preparation and auxiliary support facilities.	NA	173.00	425.00	---	"Preparation of Launch vehicle segments, Integration, propellant servicing, and launch of PSLV flights. Preparation of L40 strap-ons, GS2 and cryo stages. launch support to GSLV launches. Production of S200 segments for GSLV MK III. Commissioning of Second casting facility, PSOM XL facility, LINAC facility."	"Realisation of tested and qualified solid motors for PSLV and GSLV. Solid propellant motors and Launch complex facilities are intermediate stages for launching of rockets. "	"Launch support for PSLV C34, C35, C36, C37 and C38, GSLV-F05 &F09 and GSLV Mk III D1 flights are planned to be completed in 2015-16"	
31	Realisation Second vehicle Assembly Building	To establish Second Vehicle Assembly Building at Sriharkota. To Provide infrastructural support for enhanced launch of PSLV and GSLV.	363.95	0.00	245.00	---	"Completion of civil building, electrical & A/C works. Completion of MLC track foundation works."	To support enhanced launch frequency of PSLV & GSLV.	Realisation Second vehicle Assembly Building is approved in 2013.	

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				Non-Plan	Plan	CEBR				
32	ISRO Telemetry, Tracking and Command Network. (ISTRAC)	To provide mission support (Telemetry, tracking and command) for low earth orbit satellites as well as launch vehicle missions through a network of ground stations.	NA	60.00	110.00	---	"On-orbit operation and maintenance of all Indian Remote Sensing satellites. Launch and downrange tracking support for PSLV C34, C35, C36, C37 and C38. Operationalisation of of IRNSS Ground Segment."	Enabling operational services of remote sensing and scientific satellites.	On-orbit operation and maintenance of satellites is a continuous round-the-clock process.	"ISTRAC is an operational centre responsible for onorbit maintenance and operations of all low earth orbit satellites (like IRS) and planetary missions (like Chandrayaan-1, Mars Orbiter Mission). ISTRAC has established a Special Deep Space Network at Bylalu near Bengaluru for Chandrayaan-1 with a 18 m dia and 32 m dia Antenna realised through Indian Industries. "
33	ISRO Headquarters	To provide organisational level infrastructure in the areas of Communication and Information Technology.		92.66	44.75					

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				Non-Plan	Plan	CEBR				
34	Internatonal Co-operation	To enable bilateral and multi-lateral co-operation between India and other space faring nations		---	4.00	---				
35	Master Control Facility	To carryout continuous Monitoring & Control of Geo-Station-ary Satellites of India – during initial orbit raising and regu-lar On-orbit phases of various Satel-lite Missions	NA	45.00	63.00	---	"On orbit operations and maintenance of INSATs, GSATs and METSATs. Launch and Early Orbit Phase (LEOP) Operations of GSAT -11, 17 & 18, GSAT-19E, GSAT-9 & INSAT-3DR. Commissioning of Satellite Control Centre for IRNSS Missions Establishment of Adjacent Satellite Interference Monitoring System"	Providing oper-ational services of Geostation-ary satellites for the users in the area of telecommuni-cations, broad-casting and meteorological data.	On orbit op-eration and maintenance of satellites is a continu-ous (round-the-clock) process.	MCF has set up an Earth Station in Bhopal, Madhya Pradesh to augment the tracking, telemetry and communi-cation infra-structure for GSO satel-lites.

Sl. No.	Name of the Scheme / Program	Objective / Outcome	Total Sanctioned Cost (In respect of Projects)	Outlay 2016-17			Quantifiable Deliverables / Physical Outputs	Projected Outcome	Processes / Timelines	Remarks
				Non-Plan	Plan	CEBR				
	SPACE APPLICATIONS									
36	Space Applications Centre (SAC)	Design and development of payloads for communication, meteorological and remote sensing satellites and conduct space applications research and development.	NA	198.39	380.00	---	"Delivery of payloads for GSAT-11, GSAT-17. Development of payloads for Scatsat, GSAT-18, GSAT-19, , GSAT-7A, Chandrayaan-2, GISAT, INSAT-3DR, Cartsat - 2C and Resourcesat-2A. Development of technology for Attomic clocks, Optical polarisation imaging sensor etc. Campus development work in Bopal, Ahemdabad"	"The payloads are intermediate products required for building satellites. Technology development initiatives and experiments lead to realisation of state-of-the-art payloads."	Technology development, improvement and scaling up is a continuous process to remain state-of-the-art in payload sensors, communication transponders and space applications technology and to achieve maximum self-reliance in this strategic area.	

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				Non-Plan	Plan	CEBR				
37	Development and Educational Communication Unit (DECU)	Conceptualisation, definition, planning, implementation and socio-economic evaluation of the developmental applications of space technology.		8.00	14.00		"Upgrade existing Telemedicine (TM) network with new technology; Establish new TM nodes & mobile vans as per requirement from users & ISRO policy approval; Minimum one Continuing Medical Education programme per month. Establish new nodes based on acceptance and approval of Integrated Services demonstration; Remigration of Ku-band networks. Video programme production related to ISRO & Space Science and for EDUSAT users. 04 social research & evaluation studies for Tele-Education and SATCOM applications. Incorporate tech facilities like workstations, Non-Linear Editing (NLE) systems, storage system for NLE, multi-channel audio post production."	The Tele-education, Tele-medicine and VRCs provide satellite connectivity for various development programmes implemented by State/ Central agencies and NGOs. The benefit of these programmes is augmentation of the Education and healthcare infrastructure in the country for National development.	The application of space technology for developmental communication and education is a continuous process.	The user ministries concerned for EDUSAT network, Tele-medicine network and VRCs are Ministry of HRD, Ministry of Health and Family Welfare and Rural Development respectively.

Sl. No.	Name of the Scheme / Program	Objective / Outcome	Total Sanctioned Cost (In respect of Projects)	Outlay 2016-17			Quantifiable Deliverables / Physical Outputs	Projected Outcome	Processes / Timelines	Remarks
				Non-Plan	Plan	CEBR				
38	ISRO Space Application Programmes									
39	National Natural Resources Management System (NNRMS)	To ensure optimal management/ utilisation of natural resources of the country by integrating information derived from remote sensing data.		---	35.00	---				
40	Earth Observation Application Mission	To evolve newer applications / R&D programmes, guiding remote sensing application programme with the user agencies.	NA	---	5.00	---	"Earth Observation application projects - Satellite-based value added Agro-Met products for early warning to farmers, Assessment of Spatial and Temporal Variation of Water Quality in River Ganga with the aid of Space Technology, Snow melt Runoff forecasting for Indian Himalayas using satellite derived products, Development of Near-real time Hydrologic Modelling system for India based on ensemble of SWAT model simulations, Monitoring Progression of Kharif Cropped area using RISAT-1 SAR Data."		Application of Earth Observation data for developmental activities is a continuous process.	

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				Non-Plan	Plan	CEBR				
41	Disaster Management Support	Providing space technology inputs and services on a reliable and timely manner for the disaster management system in the country.	NA	---	22.00	---	"Response to Major Food Disasters. Emergency communication support towards major disasters. In season daily Forest the monitoring during pre-monsoon (1st Feb to 30 June)."	Strengthening of Disaster Management System in the country.		The Virtual Private Network connects Ministry of Home Affairs with State Emergency Operations Centre for real time exchange of critical information and digital data for Disaster Management.
42	National Remote Sensing Centre (NRSC)	Acquisition, processing, distribution of data from Indian Remote Sensing Satellites and research, development and executing remote sensing application projects in collaboration with users.	NA	112.00	200.00	---	"NRSC shall continue to support all services and development works for various natural disasters. Upscaling of Bhuvan infrastructure for geo-spatial applications. Major Infrastructure planned during the year includes Retrofit of Avionics, Bhuvan Scaleup, implementation of security measures as per IB norms, instrumentation for carryout the NICES Programme etc."	Availability of processed IRS satellite data and value added products of remote sensing technology / methods for use by various Ministries in Government, private entrepreneurs and NGOs.	Reception, processing and distribution of IRS data is a continuing activity.	IRS data are used by Ministry of Urban Development, Ministry of Agriculture, Ministry of Water Resources, Ministry of Earth Sciences, Ministry of Rural Development, Ministry of Environment and Forests, Ministry of Science and Technology and State development agencies for various natural resource management applications.

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				Non-Plan	Plan	CEBR				
43	Indian Institute of Remote Sensing (IIRS)	To Develop trained professional in the field of Remote Sensing, Geoinformatics and GPS Technology for Natural Resources, Environmental and Disaster Management.	NA	7.00	38.00	--	"Conduct various courses for the Academic year 2016. Continuation of research activities in "Monitoring & Assessment of Ecosystem Processes" in North-West Himalayas. Theme specific customised short term courses for user departments in recent technological and applications such as microwave and hyperspectral remote sensing, advanced GIS techniques and modelling."	Capacity Building in the Area of Remote Sensing, Geoinformatics and GPS Technologies.	Completion of Courses as per Academic Calendar 2013	Since April 30,2011, IIRS has been functioning as a Unit of ISRO.

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				Non-Plan	Plan	CEBR				
	SPACE SCIENCES									
44	ISRO Space Science Programmes									
45	Sensor Payload development / Planetary Science Programme	Design and Development of Engineering model of sensors/ scientific instruments for space and planetary science programme.	NA	---	0.50	---	Development of engineering model for payloads required for atomospheric sturdies.			
46	RESPOND	To strengthen the academ-ia interac-tion through collaberative research, educational and scientific activities.	NA	---	24.00	---	Supporting Research and Development projects at academic institutions, universities and Space technology cells at IITs / IISc in the area of Space science, technology and applications.	Development of knowledge-base and human resources in academic institutions in the area of space research.	The Research is a continuous process.	Over 80 Universities / Institutions from different parts of the country participate in the RESPOND programme. Every year, about 150 R & D projects are undertaken under this programme.

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				Non-Plan	Plan	CEBR				
47	Space Science Promotion			---	6.05	---				
48	Climate & Atmospheric Programme	Untertake studies and Research in the areas of climate and atmospheric sciences by utilising satellite data and advanced modelling techniques.		---	35.20	---	"Upgradation or development of instruments ranging from MST Radar, Polarimetric Radar, LIDAR, etc., to probe atmospheric parameters i.e., clouds, aerosols, temperature, humidity, ozone etc." "CAMC of AWS to make AWS data in compliance with WMO standards with majority of AWSs restored to working condition" "Setting up of AWSs, radiosonde stations in the data gap areas as per requests from user agencies or projects" Set up of additional 3 meteorological towers at Hyderabad, Ponmudi and Bengaluru Carrying out simultaneous observations of aerosol chemical, physical and optical properties with CCN at different high altitude sites. "	The Outcome is Intermediate in nature. The development efforts in terms of observational tools and modeling is applied by the operational agencies towards improved capabilities for weather prediction and climate monitoring.	The Research and development in atmospheric science is a continuous process.	

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				Non-Plan	Plan	CEBR				
49	Small Satellites for Atmospheric Studies and Astronomy	To design and develop small satel-lites for study of Earth's near space environment, study of aerosol and gases, inner magneto-sphere and Solar Physics	9.85	---	2.10	---	"Final integration and testing of the spacecraft."	"Partial Outcome: Integration and testing od the spacecraft. Final Outcome: Launch of the satellite"	Spacecraft realisation in 2016-17	Nano satellite for Aerosol monitoring.
50	ADITYA-1	To launch a spacecraft, which will be the first Indian Space based solar coronagraph, which will be available for solar coronal observation to all the Indian researchers in the field of Solar Astronomy.	127.75	--	25.00	--	"Realisation of various subsystems for ADITYA-1 satellite. Configuration finalisation of scientific instruments to be flown in Aditya-1."	Final outcome is to achieve a fundamental understanding of the physical processes that heat the solar corona, accelerate the solar wind and produce Coronal Mass Ejections (CMEs)		

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				Non-Plan	Plan	CEBR				
51	ASTROSAT 1 & 2	Design and development of a satellite for Multi-wavelength studies of a variety of celestial sources and phenomena using X-ray / Gamma ray astronomy instruments and UV telescope.	177.85	---	1.00	---	Post launch operations.	"Full outcome: The ASTROSAT satellite was successfully launched on September 28, 2015"		ASTROSAT is a unique observatory satellite simultaneously covering a range of high energy radiation hitherto not covered from any other global observatory missions.
52	Indian Lunar Mission Chandrayaan-1& 2	The baseline mission objective of Chandrayaan-2 is to soft land at a suitable site on the lunar surface and to carry out in-situ chemical analysis.	811.00	---	80.00	---	"Chandrayaan-2: Realisation of Orbiter and rover systems. Detailed design review of Lander system."	Final outcome is the enhanced understanding of the Moon and its environment from the analysis of the scientific data received from Chandrayaan satellite.		Chandrayaan-1 was successfully launched into earth orbit on October 22, 2008. Subsequently, it was placed in the intended lunar orbit and the Moon Impact Probe was released on to the surface of Moon on November 14, 2008. The scientific instruments onboard Chandrayaan-1 satisfactorily provided a new insight on the Moon's origin and evolution.

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				Non-Plan	Plan	CEBR				
53	X-RAY Polarimeter Mission (XpoSat)	Design, development & launch of small satellite to study xray polairsation.	60.00		5.00		"Priliminary design review. Initiation of procurement actions for electronic components, materials etc."	"Partial Outcome: Completion of preliminary design reviews."	Completion of preliminary design reviews is planned during 2016-17.	
54	Space Docking Experiment Mission	To demonstrate docking of two small satellites in space environment	Yet to be approved		0.10		"Priliminary design review. Initiation of procurement actions for electronic components, materials etc."	"Partial Outcome: Completion of preliminary design reviews."	Completion of preliminary design reviews is planned during 2016-17.	

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				Non-Plan	Plan	CEBR				
	INSAT SATELLITE SYSTEM									
55	INSAT Satellite System									
56	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.	2979.63	---	14.00	---	"Final integration and testing of INSAT-3DR satellite. Launch of INSAT-3DR on board GSLV-F05"	Final outcome: launch and operationalisation of INSAT-3DR satellite.	Launch of INSAT-3DR is projected during 2016.	"Currently, INSAT-3A, INSAT-3D and Kalpana (METSAT-1) are providing the meteorological data to the users for weather forecasting. INSAT-3DR will further augment the materiological services."
57	INSAT-4 Satellites (including launch services)	Development and launch of fourth generation INSAT-4 satellites to augment the INSAT system capacity.	3642.70	---	15.10	---	"Assembly, Integration and Testing of GSAT-9 satellite and its readiness for launch."	Augmentation of INSAT/GSAT transponder capacity.	GSAT-9 satellite are targeted for launch in 2016-17.	"INSAT system currently has 188 Transponders, which is used for Telecommunications, Broadcasting, Business Communications, Rural Area communications, Emergecny communication and developmental communications."

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				Non-Plan	Plan	CEBR				
58	Service Charges for Leasing of INSAT/GSAT Transponders	To facilitate augmentation of transponder capacity of INSAT/GSAT system.	NA	--	75.00	--	Contract Management service for INSAT Capacity utilisation.			Service Charges to be paid to Antrix Corporation for Managing leasing of INSAT/GSAT transponders.
59	GSAT-15 Satellite & Launch Services	To develop a communication satellite with 24 Ku-band transponders and a GAGAN payload	291.50	---	36.00	---	Post launch operations.	Full Outcome: Launch of GSAT-15 spacecraft	GSAT-15 satellite was successfully launched on November 11, 2015.	GSAT-15 will further augment GSAT/ INSAT system with 24 Ku-band transponders.
60	GSAT-16 Satellite	To develop a communication satellite with 24 C-band, 12 Upper Ext-C band and 12 Ku-band transponders.	297.50	---	1.10	---		Full Outcome achieved		On operationalisation, GSAT-16 will further augment GSAT/ INSAT system with 24 C-band, 12 Upper Ext-C band and 12 Ku-band transponders.

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				Non-Plan	Plan	CEBR				
61	GSAT-17 Satellite	To develop a communication satellite with 24 C-band, 12 Upper Ext-C band and 12 Lower Ext-C band, 4 MSS & 1 DRT transponders.	337.71	---	120.00	---	"Realisation of various subsystems of the satellite. Completion of Integration and Testing & readiness of launch."	"Full Outcome: Launch of GSAT-17 is projected during 2016-17"	Approval of GSAT-17 satellite is expected during 2016.	
62	GSAT-17 Satellite - Launch Services	To secure Launch Slots for Future Communication satellites through procured launch services	675.49	---	302.50	---	"Millestones payment of Launch services contract."	To secure a launch slot for GSAT-17 Satellite		
63	GSAT-18 Satellite	To develop a communication satellite with 24 C-band, 12 Upper Ext-C band and 12 Ku-band transponders and 1 Ku-band beacon transmitter	364.51	---	120.00	---	Operationlisation of GSAT-18 satellite.			

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				Non-Plan	Plan	CEBR				
64	GSAT-18 Satellite - Launch Services	To secure Launch Slots for Future Communication satellites through procured launch services	675.49		55.00					
65	GSAT-19 Satellite	To develop a communication satellite with 3 Ka band, 2 normal C-band, 2 MSS transponders	94.00	---	25.00	---	"Realisation of various subsystems of the satellite. Completion of Integration and Testing & readiness of launch."	"Full Outcome: Launch of GSAT-17 is projected during 2016-17"		
67	GSAT-11: Advanced Communication Satellite.	Development and launch of a 4T class communication satellite with advanced communication payloads.	500.00	---	30.00	---	"Qualification of various sub-systems of the satellite. The review of technical details of ground segement Finalisation of procured launch services contract."	Partial Outcome: Qualification of sub-systems of the project	Government have approved the Project in August 2009.	
68	GSAT follow-on Satellite and missions - Launch Services	To develop follow-on communications satellites in order to augment INSAT/GSAT transponder capacity	Yet to be approved	---	0.20	---	Preparation of project reports for GSAT - 11S & 20.	Prepartion of Project report.	Report is expected to be ready in 2016	

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				Non-Plan	Plan	CEBR				
69	Augmentation of Capacity through leasing of transponders from foreign Satellite	Procurement/ hiring of transponder capacity from foreign agency in order to augment INSAT/GSAT Transponder capacity	N.A.	---	1.00	---	RFP preparation for hiring of transponders.	completion of RFP		
70	Procurement of Heavier class satellites.	Procurement of heavier class of communication satellite to augment INSAT/GASAT capacity	Yet to be approved	---	0.10	---	Evaluation of offers.	Augmentation of INSAT capacity.		
71	GSAT-20 Satellite	To develop a communication satellite.		---	1.00	---				
72	Development of a Satellite for SAARC Countries			---	0.10	---				

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				Non-Plan	Plan	CEBR				
73	Assistance to Autonomous Bodies									
74	Indian Institute of Space Science and Technology	To develop high quality manpower required for Space Science, technology and applications programmes.	NA	23.00	50.00	---	"Completion of admissions for the academic year 2016-17. Conduct of the courses for the academic year 2016-17."	The fifth batch of students have been inducted to ISRO Centres/ Units during 2015. 6th batch of graduates expected to be inducted during 2016.	Completion of admissions for new Academic year by July 2016.	IIST has started the courses from the Academic year 2007-08. The annual intake of the Institute is 156 students for three courses in Avionics, Aerospace engg and applied science. The IIST campus is now located in Valiamala.

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				Non-Plan	Plan	CEBR				
75	Semi-conductors Laboratory (SCL)	Design, development and manufacture of Very Large Scale Integrated (VLSI) circuits and system / board level products and leading R & D effort in the area of micro-electronics.	NA	58.37	220.00	---	"Fabrication of in-house designed ASICs/IPs/Test-Circuits to meet the requirements of DOS/ISRO Units and other Strategic Sector Organization like Units of DAE and DRDO. Yield optimization and production ramp-up in the 8” CMOS Wafer Fab. Qualification of 0.18µm CMOS Process on 8” Wafer Fab Line. Establishment of Large Area Silicon Detector Processing Facility and failure analysis facility."	"Realisation of micro electronic devices such as ASICs, MEMS based devices, CCDs, memories, etc, for strategic applications. The output of this unit is an intermediate product used as components / devices in satellites and launch vehicles."	Technology/ process / device development, improvement and scaling up is a continuous process to remain state-of-art in the ares of micro-electronics technology and to achieve maximum self-reliance in this strategic area.	SCL has integrated capability comprising of design, wafer fabrication (up to 0.8 micron technology), testing, packaging, quality assurance and system / board level assembly of micro-electronics devices. It has developed VLSI products, sensing devices and MEMS for strategic orgnisations such as DRDO, DAE and ISRO.

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76	North Eastern Space Applications Centre (NE-SAC)	To support the devel-opmental activities of North-East-ern Region by providing information on natural resources utilisation & monitoring, infrastructure developmen-tal planning & interactive training using space tech-nology inputs of remote sensing & satellite com-munication.		5.50	15.00		"• Preparation of working plan inputs for the States of Arun-achal Pradesh, Assam and Sikkim to be completed in participation with the State Forest Departments • To initiate the second phase of the Project on Applications of Re-mote sensing and GIS in 20 priority districts in NER • Land evaluation for organic crop planning in Assam using RS & GIS techniques"			

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77	Physical Research Laboratory (PRL)	Carryout basic research in the areas of astronomy and astrophysics, solar physics, planetary science, interplanetary science, earth's magnetosphere, ionosphere,atmosphere, earth's surface and interior, theoretical physics, quantum optics / lasers C99	NA	42.20	90.00	---	"Development of payloads for Chandrayaan-2 mission. Design and development of sub-systems for the proposed XpoSat."	"Partial Outcome: Capability to develop complex payloads and analysis of data for space science and planetary exploration. PRL is primarily an R & D institution and the outcome is in the form of expanding our knowledge in the areas of Astronomy & Astrophysics, Solar physics, Planetary science, earth Science, Asmopheric science and related fields."	Space Science Research is a continuous process.	

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78	National Atmospheric Research Laboratory (NARL)	Carryout scientific research in Atmospheric Science and serve as a major national experimental facility for atmospheric research in the country including boundary layer, troposphere, middle atmosphere, thermosphere and ionosphere.	NA	6.80	20.00	---	"Completion of up-gradation of MST Radar into a fully active array system. Calibration and initial test measurements of newly Installed of X-Band radar. Realization of a Tethered Balloon Observation Platform (TBOP) to obtain height profiles of aerosol concentrations, trace gas concentrations, turbulence intensities etc. Development of Digital receiver with Universal software radio peripheral. Development of Chemical Transport Modelling to understand the role of trace gases and aerosols."	NARL is basically a research institute and the outcome of the programme will lead to expanding our understanding of the complex processes of the lower and middle atmosphere.	The Research is a continuous process.	NARL, located at Gadanki, near Tirupati, has established a major state-of-the-art experimental National MST Radar Facility for middle atmospheric research.
	Total			**1509.14**	**6000.00**					

REFORM MEASURES AND POLICY INITIATIVES

1. India has an impressive array of achievements in the area of development of satellites, launch vehicles, associated ground segment and most of relevant societal applications. Some of the recent applications of space technology such as Tele-medicine and Tele-education have had a far reaching impact on national development. These efforts together with conducive policies and reform measures adopted by the Department have yielded rich results.

2. Space Industry Partnership

2.1 The Department of Space 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 farmed 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 Department, so far, has developed and transferred about 310 technologies to Industries for commercialization. It is important to note that this partnership with Industries has enabled the Department 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.

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REVIEW OF PERFORMANCE OF THE MAJOR ONGOING PROJECTS/PROGRAMMES/CENTRES OF DOS/ISRO

1. Vikram Sarabhai Space Centre (VSSC) & its Projects

1(a). Vikram Sarabhai Space Centre (VSSC)

(₹ in crores)

Budget 2015-2016	Revised 2015-2016	Budget 2016-2017
1029.00	1113.15	1131.32

1.1(a) VSSC, located around picturesque Veli Hills near Thiruvananthapuram, is the lead Centre responsible for the design and development of launch vehicle technologies, sounding rockets and associated technologies for the Indian Space Programme. The Centre pursues Research and Development in the fields of Aeronautics, Avionics, Composites, Computer & Information, Control, Guidance & Simulation, Launch Vehicle Design, Mechanical Engineering, Mechanisms, Vehicle Integration and Testing, Propellants, Polymers, Chemicals, Materials, Propulsion, Space Ordinance and System Reliability. Activities like Programme Planning & Evaluation, Construction & Maintenance, Safety, Personnel and General Administration support the Centre's core functions. The mandate for VSSC is:

- Research and Development for ongoing and future space transportation systems of ISRO.
- Multiple missions as per ISRO's launch manifest.
- Ensuring Low cost access to Space.

1 (a).2 Major Achievements during 2015-2016

- Successful launches of PSLV-C28/DMC3 Mission on 10th July 2015, PSLV-C30/Astrosat Mission on 28th September 2015, PSLV-C29/TeLEOS-1 Mission on 16th December 2015 and PSLV-C31/IRNSS-1E on 20th January, 2016. Apart from these 4 Missions, 2 more PSLV Missions are planned during 2015-16 viz. PSLV-C32/IRNSS-1F & PSLV-C33/IRNSS-1G Missions;
- GSLV-D6 with GSAT-6 spacecraft was successfully launched on August 27, 2015 using indigenous cryogenic stage;
- The first experimental flight of GSLV MkIII designated as LVM3-X was launched successfully on 18th December 2014 with CARE (Crew module Atmospheric Re-entry Experiment) as payload. Extensive Post Flight Analyses (PFA) were conducted to assess the performance of the vehicle systems during flight. All objectives of LVM3-X flight were met;
- A series of development hot tests (10 nos) have been completed in CE20-E1 engine including long duration qualification hot test for 800s duration with Mixture Ratio Control (MRC) in closed loop. C25 D stage assembly operations are in progress at C25 assembly hall, IPRC;
- For RLV –TD, flight integration, RCS, SITVC and TPS integration completed;

- A total of fifteen RH200 flights with chaff payload were successfully conducted from TERLS Range for collecting MET data;
- Major facilities established/commissioned include Ammonium perchlorate blending facility in June 2015, Model incidence mechanism for HWT, Advanced Thermo Vacuum Chamber, CVI furnace in PCM, 400 MHz NMR spectrometer, 6-ton shaker, Nozzle & Combustor Test Facility, CVI furnace in CMSE, Hot Isostatic press. Sea surveillance Radar etc. Civil works are in progress towards setting up of Optical Structures facility in CMSE, Vatiyoorkavu.

1(a)**.3 Major Achievements during 2016-2017**

- 5 PSLV missions are scheduled during 2016-17;
- GSLV F06 - Realization of stages, preparation of vehicle systems for the mission, launch operations and launch Integration of stages, launch operations and launch of LVM3 – D1/GSAT -19 E in July 2016;
- Sounding rocket flights planned include 30 Nos. of RH 200, 3 Nos. of RH 300 and 2 Nos. of RH 560;
- Realisation of Pad Abort Test, Integrated tests of ECLSS and Flight suit in Cabin Environment Simulation Chamber;
- Major facilities to be commissioned include new Data Centre and 200 TB central storage system, Dual Energy LINAC, Neutron radiography system, Advanced Detonics Research laboratory, HIPIC furnace, Optical structures facility in CMSE, etc.

1(b) GSLV-Operational Project

(₹ in crores)

Sanctioned Cost	Expenditure to end of March 2015	Budget 2015-2016	Revised 2015-2016	Budget 2016-2017
3550.96	2531.20	195.0	195.00	180.00

1(b).1 In order to meet the launch requirement of 2 tonne class of operational INSAT/GSAT satellites, the GSLV-Operational Project has been conceived. Currently, the approved scope of the Project include realization of 16 launch vehicles (F01-F16).

1(b).2 The first operational flight GSLV-F01 was successfully launched on September 20, 2004 with GSAT-3 (Edusat) onboard. The second operational flight GSLV-F02 launched on July 10, 2006 with INSAT-4C on board was unsuccessful due to malfunctioning of one of the strap-on stages. However, GSLV-F04 carrying INSAT-4CR was successfully launched on September 2, 2007. The GSLV F-06 mission carrying GSAT-5P launched on December 25, 2010 was unsuccessful due to untimely and inadvertent snapping of a group of 10 connectors located at the bottom portion of the Russian Cryogenic Stage.

1(b).3 Considering the successive failures of GSLV D3 and GSLV F06 mission, it has been decided to establish the robustness of GSLV vehicle by having the next two missions i.e. GSLV D5 and GSLV D6 as developmental flights with indigenous cryogenic stages.

1(b).4 Though the initial launch attempt of GSLV-D5 on August 19, 2014 was unsuccessful due to the detection of unexpected leakage of UH25 propellant from GS2 tank, the vehicle successfully placed GSAT-14 satellite in a very precise orbit on January 5, 2014 using indigenous cryogenic stage.

1(b).5 The changes in the vehicle from GSLV-D5 to D6 were discussed in detail by various Technical Committees & MRR and cleared for implementation in D6 mission with GSAT-6 satellite. The changes proposed in the CUS-06 stage in order to improve the payload mass from 1982 kg of GSAT-14 to 2140 kg of GSAT-6 were also approved. There were a total of 55 PFA observations of which 40 were new and 15 were recurring. These were also studied and suitable actions were taken.

1(b).6 GSLV-D6 was successfully launched on August 27, 2015 with indigenous cryogenic stage CUS-06, which placed the spacecraft GSAT-6 weighing 2117 kg in a precise orbit. No major anomalies were seen upon analysis of flight data.

1(b).7 The next mission planned is GSLV-F05/INSAT-3DR mission in July 2016 again with indigenous cryogenic stage CUS-07. Cryo stage CUS-07-A10 engine test stand integration for flight acceptance hot test is in progress at IPRC and the hot test is planned in November 2015. The cryogenic stage CUS-07 is expected to be ready by April 2016. L40-S4 stage is nearing completion at HAL-ASD, Bengaluru and will be despatched to SDSC-SHAR in November, 2015. All solid propellant segments and pyro systems are available. Trajectory design is completed and the F05 vehicle configuration is (4L40H+S139) + L37.5H+CUS12+3.4m dia. PLF with a targeted payload of 2150 kg.

1(b).8 Activities planned till March 31, 2017 include:

- Realization of CUS-07 flight stage, GS2 stage and L40-S3, S2 and S1 stages, L40 ;
- EGC actuators and their integration, all launch vehicle structures and assemblies, all avionics NGC and TTCP packages;
- Realization of flight systems for GSLV-F09, CUS-08 flight stage, lower stages and sub-assemblies;
- Launch of GSLV-F05 and GSLV-F09 from SDSC-SHAR in July, 2016 and March, 2017 respectively.

1(c) GSLV- Mk-III Development

(₹ in crores)

Sanctioned Cost	Expenditure to end of March 2015	Budget 2015-2016	Revised 2015-2016	Budget 2016-2017
2962.78	2568.64	120.00	120.00	100.00

1(c).1 GSLV Mk-III Project is responsible to develop a cost effective heavy lift Launch Vehicle (LVM3) capable of launching 4 tonne class of communication satellites into Geo-synchronous Transfer Orbit (GTO). The major propulsion modules in LVM3 include two S200 solid strap-on stages, L110 core liquid stage and C25 cryogenic upper stage.

1(c).2 The first experimental flight of GSLV MkIII designated as LVM3-X was launched successfully on

18 December 2014 with CARE (Crew module Atmospheric Re-entry Experiment) as its payload. The vehicle was launched from the Second Launch Pad (SLP) located in SDSC-SHAR. The LVM3-X launch vehicle injected the CARE module into the indented altitude of 126 km within five and half minutes after lift-off. The objective of this flight was to validate the complex atmospheric flight regime considering the specific and unique design features of LVM3 that are not yet demonstrated in any of the ISRO launch vehicles so far.

1(c).3 Extensive Post Flight Analyses (PFA) were conducted to assess the performance of the vehicle systems during flight. All objectives of LVM3-X flight were met. For LVM3-D1 mission, further improvements and optimization in vehicle systems were proposed for improved robustness. CFD & wind tunnel tests were conducted for different configuration options.

1(c).4 Major configuration changes recommended for LVM3-D1 mission are the change of payload fairing to Ogive shaped nose conewith reduced cylinder length in lieu of 200 straight nose cone and inclined S200 strapon nose cone in lieu of axi symmetric nose cone. Closure of C25 inter tank structure is also recommended.

1(c).5 S200 Motor Head End Segment grain configuration has been changed to 13 lobed star configuration from 10 lobed slotted configuration to reduce the dynamic pressure in transonic regime. This has been validated through S200 ST03 static test on 14th June 2015.

1(c).6 For LVM3-D1 mission payload identified is GSAT-19E. Space craft mass is 3200 kg. S200 motors casting activities are in progress at SDSC-SHAR. Middle segments are casted and ready for integration. Nozzle End Segment & Head End Segment casting operations are in progress. L110 flight Stage integration activities are also commenced at IPRC, Mahendragiri.

1(c).7 A series of development hot tests (10 nos) have been completed in CE20-E1 engine including long duration qualification hot test for 800s duration with Mixture Ratio Control (MRC) in closed loop. C25 D stage assembly operations are in progress at IPRC, Mahendragiri.

1(d) Polar Satellite Launch Vehicle - Continuation (PSLV-C) Project

(₹ in crores)

Sanctioned Cost	Expenditure to end of March 2015	Budget 2015-2016	Revised 2015-2016	Budget 2016-2017
5953.52	2523.51	312.25	280.39	400.00

1(d).1 The Polar Satellite Launch vehicle (PSLV) is designed and developed during 1982 - 1993 period to cater to the needs of launching satellites in Sun Synchronous and Low Earth Orbits. PSLV is configured as a four stage vehicle with alternate solid and liquid propulsion stages. The booster stage along with the strap-on motors and the third stage are solid motors while the second and fourth stages use liquid engines. The overall length of PSLV is 44.4m and the lift off mass is 320t with core vehicle diameter of 2.8m. The Payload Fairing is of 3.2m diameter. The 1st stage consists of S139 solid motor with 139t propellant and six strap-on motors (S12) each carrying 12.2t propellant. The 2nd stage (PL40) carries 42t Earth storable liquid propellant. The 3rd stage is a composite case Solid motor containing 7.6t propellant. The 4th stage (L2.5) is a twin engine pressure fed liquid stage with 2.5t propellant.

1(d).2 PSLV has the capacity to launch 1700 kg class satellites into 600km Sun Synchronous Polar Orbit (SSPO) and 1425 kg satellites into a Sub-GTO of 284 km × 20650 km. PSLV has the versatility to launch multiple satellites and also has the capability to inject satellites into various orbits. Currently, two versions of PSLV are operational, namely PSLV-XL (with six extended version of Strap-on motors) and the PSLV Core-alone (without Strap-on motors).

1(d).3 Four successful PSLV Missions were carried out during 2014-15 - PSLV-C24/IRNSS-1B Mission on 4thApril 2014, PSLV-C23/SPOT-7 Mission on 30thJune 2014, PSLV- C26/IRNSS-1C Mission on 16th October 2014 and PSLV-C27/IRNSS-1D Mission on 28th March 2015. In 2015-16, 4 PSLV Missions have been executed - PSLV-C28/DMC3 Mission on 10th July 2015, PSLV-C30/Astrosat Mission on 28th September 2015, PSLV-C29/TeLEOS-1 Mission on 16th December 2015 and PSLV-C31/IRNSS-1E on 20th January, 2016. Apart from these 4 Missions, 2 more PSLV Missions are planned during 2015-16 viz. PSLV-C32/IRNSS-1F & PSLV-C33/IRNSS-1G Missions. Five PSLV Missions are planned during 2016-17.

2. ISRO Inertial Systems Unit (IISU)

(₹ in crores)

Sanctioned Cost	Expenditure to end of March 2015	Budget 2015-2016	Revised 2015-2016	Budget 2016-2017
2962.78	2568.64	120.00	120.00	100.00

2.1 The ISRO Inertial Systems Unit (IISU) situated at Thiruvananthapuram is responsible for the design and development of Inertial Systems for Launch Vehicles and Spacecraft Programmes of ISRO. Major systems like Inertial Navigation Systems based on Mechanical gyros and optical gyros, attitude reference systems, Rate Gyro Packages, Accelerometer packages are developed indigenously and used in various missions of ISRO. IISU also designs and develops actuators and mechanisms viz. Solar Array Drive, Reaction Wheel, Momentum Wheel, Scan Mechanisms for Spacecraft and allied applications.

2.2 The unit is organized into Research and Development divisions in the fields of Launch Vehicle Inertial Systems, Spacecraft Inertial Systems, Advanced Inertial system, Bearing and Space Tribology, Inertial System Production and Reliability & Quality Assurance. Many TDP & R&D activities are carried out in the fields of inertial sensors, systems and various spacecraft mechanisms, to reduce size, volume, power, weight, costs and also to increase accuracies, durability, life, redundancy and flexibility in operating environments. IISU is also equipped with facilities for precision fabrication, assembly and clean room, integration and testing of inertial sensors, systems and actuators.

2.3 Major Achievements during 2015-2016

- Delivered Launch Vehicle Inertial Systems (RESINS, RGP and GAINS) for PSLV C28, PSLV C29, PSLV C30, PSLV C31, PSLV C32, PSLV C33, PSLV C34 and GSLV D 6;
- Realisation of Spacecraft Inertial Systems for GSAT-18, GSAT-17, GSAT-9, INSAT-3DR, IRNSS-1E, IRNSS-1F, Scattsat and Resoursat-2A missions;
- Delivery of Flight model of Scatterometer Scan Mechanism for SCATSAT-1.
- Delivery of Accelerometer Measurement Package for ATV-D02 project.

- New wide band dual channel rotary joint realized along with SAC team for Scatterometer Scan Mechanism for SCATSAT-1.
- Delivery of RESINS Mk IVR, HDAS, GAINS, RGP and CSAP for

RLV-TD Mission.

- The following major technological developments have been completed:
    - Engineering Model of Control Moment Gyro for CARTOSAT-3 series;
    - Engineering Model of High resolution absolute optical encoder;
    - Development of NavRx1.0 GPS receiver for RH-200;
    - Development of 'GPS-NavRx-LV' GPS receiver for Launch Vehicles;
    - Engineering Model of Digital ILG (ILG 300);
    - Realisation of Metallic Servo Accelerometer (MSA) for Launch vehicle bending modes;
- Completed civil works for Integrated Test Complex (ITC) building, ISRO Space Tribology Laboratory (ISTL) & Mechanical production storage area;
- Facility augmentation have been completed in respect of the following:
    - Form Measuring Machine;
    - X-ray Fluorescence (XRF) Analyzer;
    - Maskless Laser Lithography Facility;
    - Universal Testing Machine;
    - Horizontal thermo vacuum chamber test facility;
    - Thermal circulator facility for thermo vacuum cycling test of IRU and IRAP for regular spacecraft missions;
    - EDM hole drilling machine;
    - Precision jig boring machine at M/s.CTTC.

2.4 Major Programmes for 2016-2017

- Planned to realize Launch Vehicle Inertial Systems (RESINS, RGP, RGPD and GAINS) for PSLV-C35, PSLV-C36, PSLV-C37, PSLV-C38, GSLV-F05, GSLV Mk-III D1 and GSLV-F09;
- Planned to realize spacecraft Inertial Systems for IRNSS-1G, Resourcesat-2B, IRNSS-1H, GSAT-19E, INSAT-3DS and GSAT-11;
- Planned realization of LIRAP-EM for Chandrayaan-2 Lander;
- Planned realization of Engineering Model of AINS 300;
- Planned realization of new generation bearing unit for Momentum Wheel application;

- Engineering Model of following technology development programmes will be realized:
  - Autonomously Navigating Robot;
  - FPGA based unified SADA electronics;
  - Dual Gimbal DTG;
  - Rotary Transducer;
  - Rate Gyro Package Digital (RGPD 300);
  - Planetary Gear for I-6K SADA;
  - Realisation of Engineering Model of Scatterometer Scan Mechanism for OCEANSAT-3;
  - Planned to develop and realize HRG shell/QM for Control Moment Gyro;
- Planned to develop MEM sensors – proto model;
- Planned realization of subscale facility for atom interferometer based sensors;
- The following major facility augmentation activities are planned during 2016-2017 :-
  - Ultra Nano indenting and surface characterization system;
  - Angular Motion Simulator;
  - Ultra high precision CNC Turning Centre;
  - High Precision CNC EDM Machine;
  - High Precision CNC Machining Centre;
  - Gyro Theodolite;
  - Tribology Laboratory establishment;
  - Advanced Packaging System;
  - Commissioning of Integration and Test Complex;
  - Laser Soldering Machine;
  - UPS system for Integration Test Complex (ITC);

3 Liquid Propulsion Systems Centre (LPSC) & its Projects

3(a) Liquid Propulsion Systems Centre (LPSC)

(₹ in crores)

Budget 2015-2016	Revised 2015-2016	Budget 2016-2017
309.00	278.18	311.75

3(a).1 The Liquid Propulsion Systems Centre (LPSC), with its facilities located at Thiruvananthapuram (Valiamala) and Bengaluru is the lead Centre in the area of liquid propulsion encompassing earth storable and cryogenic propulsion systems for launch vehicle and spacecraft programmes. The launch vehicle engine and stage design activities are carried out at its facilities at Valiamala. Spacecraft propulsion systems

engineering, mono-propellant thruster development and transducer production activities are carried out at its facilities at Bengaluru.

3(a).2 Major Achievements during 2015-2016

- Indigenous Cryogenic Upper Stage (CUS 06) and earth storable stages were delivered for GSLV D6 mission and the propulsion stages performed satisfactorily during the successful GSLV D6 mission on August 27, 2015. Post flight analysis have also been completed;
- In respect of CUS 07, the Main Engine (A10) integration was completed and cold start test of A10 flight main engine conducted. However, the test was called off during chill down. The results have been reviewed and test is rescheduled. Planned to complete integration of main engine, steering engines and propellant tanks and commencement of stage integration;
- Steering Engines (SE 19 & 20) integration for flight acceptance test completed. Fuel Booster Unit (FBU-D14) and Oxidiser Booster Unit (OBU-D11) flight acceptance tested and made ready for stage integration. LH2 propellant tank (T 09) realized. Subsequently, the first Proof Pressure Test, trial integration of tank internals, bonding of wire tunnel/click bond brackets and load testing completed and insulation of shell portion of tank is in progress. LOX Propellant tank (T 09) realization is in progress. Stage structures viz. Lower Stub Adaptor, Inter Tank Truss, Lower Truss Assembly have been realized and made available for stage integration;
- CE20 Integrated Engine (E1) development hot test at sea level conditions were conducted. With this a total of 12 tests (2 cold flow tests & 10 hot tests) were completed for a cumulative duration of 1742s, which includes flight duration hot test for 635s, hot test with Mixture Ratio Controller (MRC) in closed loop and extended duration hot tests with MRC in closed loop for 800s. Thus, the engine development hot test series on E1 engine has been successfully completed and the engine is removed from MET;
- C 25 D-Stage subsystems assembly is in progress for stage development tests. CE20 engine (E2) mechanical integration is completed and leak checks are in progress. LH2 propellant tank is realized, proof pressure tested and insulation completed. Tank internal integration is in progress. Stage structure viz. ASA, FSA & ITSc are realized and made available. Planned to complete integration and acceptance hot test of E2 engine for Stage development hot test, E3 engine integration and commencement of High altitude development testing at TCT HAT facility and completion of C25 development stage (D stage) integration & radiness for Stage hot test;
- Integration of L110 Stage for GSLV Mk III-D1 mission was inaugurated on July 16, 2015. Propellant tanks AA6061, Water tank, stage structures viz. Core Base shroud, Inter-stage-1/2L are realized & positioned for stage integration;
- Integrated Technical Review (ITR) of Semi Cryogenic Engine by the National Expert Panel chaired by Dr.B.N Suresh was conducted. Engine subsystem fabrication orders for six work packages are placed with two parallel work centres. Fabrication process document review for five work packages viz. Booster turbo pump, pre-burner, heat exchanger, turbo pump and mixing head is completed and Thrust chamber process document review is in progress. Cold flow tests of Low Pressure Oxidiser Turbo Pump (LPOT) was conducted at the newly established Cold Flow Test Facility (CFT) at IPRC, Mahendragiri, Semi cryo burner single

element injector hot tests was conducted at APRG/VSSC demonstrating the ignition with hypergolic igniter and flame holding at very high mixture ratios. Design of Sub scale Pre-Burner & Trust Chamber is completed and fabrication is in progress. 21 types of engine control components are to be developed. Out of this, assembly & testing of 16 types have been completed. Assembly & testing of 2 types and fabrication of 3 types are in progress. For Hydraulic Actuation System (HAS), fabrication of 4 types of control components is in progress;

- Propulsion system integration and system level tests completed for GSAT-6. Subsequent to launch, Apogee Motor Firing (AMF) for orbit raising operations were successfully completed;
- Propulsion system integrated and delivered for IRNSS 1D, 1E and Astrosat. In respect of IRNSS 1F and Resourcesat 2A, the propulsion system components delivered and Propulsion system integration is under progress;
- For Chandrayaan-2, Lunar lander propulsion system configuration was finalized and preliminary design reviews at component level and spacecraft level completed. Propulsion system components development and qualification activities are under progress;
- Configured Electric Propulsion Systems (EPS) with 4 Nos. of 18mN SPT for 12K Satellite (GSAT-9). Completed the preliminary design reviews at component level and spacecraft level. Completed the integrated testing of 18mN impored SPT with indigenous Power Processing & Control Unit;
- Finalised the configuration of EPS for 14K Satellite (GSAT-19) with 4 nos. of 75mN indigenous SPT;
- Finalised the modifications for High Thrust Vikas (HTV) engine and initiated engine realization. Successfully conducted the demonstration hot test for 20s;
- Thermal and structural design completed and fabrication of thust chamber is in progress;
- Realised two engines (QE-01 & QE-02) and all major qualification tests completed for both engines. QE-01 with 42V flow control valve for Chandryaan-2 orbiter has been tested and qualified for a cumulative duration of 18627s and QE-02 with 70V flow control valve for GSAT-11 has been tested and qualified for a cumulative duration of 23300s. Flight hardware realization is under progress;
- Profiled coaxial injector developed and cold flow characterization completed;
- Supersonic Film Cooling with Carbon-Carbon Nozzle was demonstrated in hot test with solid motor;
- Fuel feed system stage for Acoustic test at NAL realized & completed the acoustic test. Modification of GH2 module carried out & successfully tested. Realisation of hardware for fluid mock up & flight tests is nearing completion;
- Material Characterisation lab and New creep test facility established at Valiamala. The new integrated chemical cleaning facility was installed and commissioned for the chemical cleaning of all satellites & PS4 propellant tanks. Engine raw material stores established for storing raw materials for 50 Vikas engines, 20 Cryo engines and 6 Semicryo engines. Spin test facility for turbine rotors commissioned at turbo pump bearing and seal lab;

- Production of Vikas engines, PS4/RCT engines, PS4 RCS thrusters, propellant tanks, water tanks, stage interface elements, satellite thruster parts and satellite components parts continued though industries;
- Integrated L40 stage production continued at M/s ASD/HAL. Integrated production of components and modules continued through M/s MTAR and M/s LTE;
- End to End production of 21A pressure transducers and Differential Pressure Transducer continued through industry and initiated for IDLV transducers, MEMS Transducers and Temperature sensors;
- Initiated development of BATL as Second source for Vikas Engine-Contour and establishement of Integrated Cryogenic Components and Modules Assembly and Test Facility (ICMAT) at LPSC, Valiamala;

3(a).3 Major Activities Planned during 2016-2017

- Planned to complete integration & delivery of CUS 08 flight stages for GSLV F09 mission;
- Planned to complete High altitude development testing of E3 engine, C25 development stage (D stage) ground hot test and completion of integration & delivery of C25 development fight stage (D1);
- Planned to complete L110 flight stage integration and delivery for developmental flight – D1 and realization of hardware for second development flight stage;
- Planned to complete Semicryo Turbo pump sub systems development tests, Subscale Thrust chamber & subscale Pre burner hot tests and hardware readiness for bootstrap made tests;
- Planned to continue realization and delivery of PS2, PS4 stages and control Power Plants (CPP) for PSLV continuation programme & launch campaign activities;
- Planned for realization and delivery of GS2 stage and L40 stages (through industry) for GSLV continuation programme & launch campaign activities.;
- Planned for delivery of integrated propulsion systems for satellite mission & launch base support;
- The following R&D/TDPs are planned :
    - Qualification of indigenous 75mN SPT thruster and PPCU;
    - Integration and delivery of indigenous 75mN SPT based EPS for GSAT 19E application;
    - Development of Helium purge seal with hydrodynamic lift and Non-contact face Seal for turbo pumps;
    - Design and development of 5 kW Stationary Plasma Thruster and High Voltage Contractor for SPT;
    - Development of Ultrasonic Flow Meter for satellite propellant gauging;
    - High thrust Vikas engine development testing;
    - 800n throttleable engine development and qualification for lander propulsion;

- 50N thruster development and qualification for lander propulsion;
- Continuation of L40 stage integration. Continuation of production of Vikas Engine, Cryo engine, pressure fed engines, propellant tanks & stage interface elements, feed lines etc through industry. Production of transducers, satellite thruster parts, tankages & feedlines, end to end production of spacecraft propulsion components, satellite pressure vessel parts etc. Integrated production of fluid control components, satellite propulsion components & sensors through industry;
- Augmentation of EBW facility with 30m3 capacity. Establishment of integrated production facility for satellite propulsion components and tanks. Establishment of facilities for satellite thruster production enhancement from 60 to 150 thrusters per year. Establishment of in-house production facilities for Cryogenic control components and modules. Commissioning of augmented facilities for L110 & C 25 tankages at M/s ASD/HAL.

3(b). Semi Cryogenic Engine Development

(₹ in crores)

Sanctioned Cost	Expenditure to end of March 2015	Budget 2015-2016	Revised 2015-2016	Budget 2016-2017
1798.00	324.90	150.00	143.00	160.00

3(b).1 The objective of the Semi Cryogenic Engine Development is to power the future heavy lift Unified Launch Vehicles (ULV) and Reusable Launch Vehicle (RLV) of India. This semi cryogenic engine, which uses a combination of cryogenic as well as earth storable propellants, developing a thrust of 2000 kN, is planned as the booster engine for the Common Liquid Core of ULV. This engine uses Liquid Oxygen and Kerosene as propellants. The engine is planned to be developed and qualified over a span of 6 years. In this, the first four years is planned for subsystem development and the remaining two years will be used for development and qualification of the engine. The facilities needed for testing also has to be made ready in 4 years.

3(b).2 Integrated Technical Review (ITR) of Semi Cryogenic Engine by the National Expert Panel was conducted.

3(b).3 Engine subsystem fabrication orders for six work packages are placed with two parallel work centres. Fabrication process document review for five work packages viz. Booster turbo pump, pre-burner, heat exchanger, turbo pump and mixing head is completed and Thrust chamber process document review is in progress. Cold flow tests of Low Pressure Oxidiser Turbo Pump (LPOT) was conducted at the newly established Cold Flow Test Facility (CFT) at IPRC, Mahendragiri, Semi cryo burner single element injector hot tests was conducted at APRG/VSSC demonstrating the ignition with hypergolic igniter and flame holding at very high mixture ratios. Design of Sub scale Pre-Burner & Trust Chamber is completed and fabrication is in progress. 21 types of engine control components are to be developed. Out of this, assembly & testing of 16 types have been completed. Assembly & testing of 2 types and fabrication of 3 types are in progress. For Hydraulic Actuation System (HAS), fabrication of 4 types of control components is in progress.

4. ISRO Propulsion Complex (IPRC)

(₹ in crores)

Budget 2015-2016	Revised 2015-2016	Budget 2016-2017
238.00	217.30	333.00

4.1 ISRO Propulsion Complex (IPRC), Mahendragiri is equipped with state-of-the-art- facilities necessary for realising the cutting edge technology products for ISRO's space research program. Taking cognizance of the future growth of the space program of our nation and the concomitant expansion, the then LPSC, Mahendragiri was elevated as IPRC with effect from February 01, 2014.

4.2 The main activities carried out at IPRC, Mahendragiri include assembly, integration and testing of earth storable propellant engines, assembly, integration and testing of cryogenic engines and stages for PSLV, GSLV and GSLV MKIII launch vehicles, establishment of facilities for assembly, integration and testing of 2000 kN Semi Cryo engine, assembly, integration and testing of sub-systems for launch vehicles such as turbo pumps, injectors, gas generators, gas bottles, umbilicals etc., high altitude testing of upper stage engines and space craft thrusters, as well as testing of its sub- systems, Production, analysis and supply of Cryogenic propellants & Storable Liquid propellants for launch vehicles, satellites & test facilities, Instrumentation and control system for remote testing of various systems and sub-systems of launch vehicles and satellites, Qualification, acceptance testing and calibration of transducers for all flight stages, QA & QC for assembly & integration, instrumentation & control systems and Test Facilities for earth storable and cryogenic propulsion systems, Metrology, NDT and material testing laboratories for inspection & testing of components and propulsion subsystems, Design, CFD & Thermo-structural analyses of various mechanical and fluid systems and Technology Development Programs towards continual development.

4.3 Major Achievements during 2015-2016

- PS2 & PS4 stages were integrated for PSLV C27, PSLV C28, PSLV C29 & PSLV C30 missions. Vikas engines, PS2 Stages and PS4 stages for respective PSLV missions were realized. Necessary flight acceptance tests were carried out to confirm the flight worthiness of various systems and subsystems;
- Completed assembly & integration of L40 S3 Vikas engine for GSLV F05 flight and delivered to HAL, Bengaluru for integration with L40 Stage;
- The GS2 stage for GSLV-D6 flight was assembled and integrated. Propellant tanks, water tank and subsystems were prepared and functionally integrated. Vikas engine integrated to stage assembly. Stage electrical integration, functional checks, Vikas engine cold gimbal tests and leak checks were carried out;
- As part of realisation of CUS-06 stage for GSLV-D6 mission, integration of external pneumo hydraulic fluid system was carried out. All major modules and components were assembled with stage and circuits were welded with proper sequence resulting in 100% radiography. After the mechanical and electrical integration of the stage, the acceptance tests were carried out. All the cavities, gas bottles and propellant tanks were media substitutes as per specifications. Thermal screen inflation test, stage centre of Gravity and mass measurement were carried

out. The stage was containerized in a special container/trailer and despatched to SDSC-SHAR;

- FBU D14 was integrated and leak checked. It was acceptance tested at SET facility for a duration of 200s. Activities for FBU preparation for stage integration is in progress. OBU D11 for CUS 07 stage was integrated and leak checked. The same was acceptance tested along with CUS A9 Main Engine at MET facility and made ready for integration with stage. Assembly of OBU D12 for CUS 08 stage was completed and mounted at MET facility for acceptance test along with CUS A10 engine;

- The LH2 tank was prepared and proof pressure tested. Shell side of the tank was insulated. Trial and functional integration of internals, manhole cover welding and post welding proof pressure tests are planned;

- Carried out flow characteristic tests for CUS gas generator injector head, CUS Metering Valves, CUS Mixture ratio Controller, CUS Steering engine injector head assembly and Steering engine bottom units with DM water and SST facility. Carried out Cryo Proof Pressure Test of CUS Helium bottles. Carried out Bubble point test of LH2 Propellant Acquisition system net separator;

- The L110 stage integration works initiated for LVM3D1 mission. Propellant tank and other subsystems preparation in progress;

- The first integrated engine E1 was realized with sea level nozzle of area ratio 10. The engine was mounted at engine test bay of Cryo Main Engine and Stage test facility (MET) for conducting ground level developmental tests. Subsequently two cold start tests and two hot tests were carried out. The E1 engine test campaign was successfully completed in September 2015. Subsequently E1 engine was unmounted from MET and positioned at assembly hall;

- C25 D stage assembly qualification test is in progress. LH2 tank external fluid line support brackets were welded on tank. Ambient proof pressure test & post PPT acceptance tests of the tank were completed. LH2 tank insulation viz., Cryo Adhesive Coating, foam application, Vapour Barrier Coating, constructive Wrapping, Heat Shield Coating and Conductive Coating were applied. LH2 tank internal integration is in progress;

- The assembly and integration of CE20 E2 engine for C25 D stage testing is in progress. CE20 E2 engine is a sea level version consisting of subsystems such as Thrust Chamber, LOX & LH2 turbo pumps, Gas Generator, command blocks, pressure & temperature sensors, propellant feed & vent lines and valves. Mechanical integration of CE-20 E2 engine is nearing completion. After mechanical integration, Sensor mounting, electrical harnessing and checkout activities are planned. The assembly and integration of CE20 E3 engine for HAT testing is in progress. Thrust chamber cleaning completed. LOX pump Cold flow assembly and LH2 pump balancing completed;

- Carried out flow characteristic tests of Gas Generator Injector head, CE-20 Gas Generator Assembly, CE-20 LOX Pressure Regulator and Thrust chamber with DM water. Carried out Cryo proof pressure test of C-25 Bimetallic Adaptor and Cryo pressure test at MEOP of C-25 Helium gas bottles. Completed cold flow testing with DM water and evaluated performance characteristics of the LH2 Pump and LOX Pump at Turbo Pump test facility. Completed cold flow testing with GN2 and evaluated performance characteristics of the LH2 Turbine and LOX

Turbine. Carried out proof and qualification level deflection tests of C25 stage polyimide pipes at Cryogenic Subsystem Test facility;

- Carried out Cold Flow tests on LPOT D-1 hardware at de-rated conditions at Semicryo Cold Flow Test Facility;
- Tested 23 ACOS engines to its acceptance level at STTF for GSAT project. LAM engine tested for IRNSS-1D, IE, 1F, GSAT-15 and GSAT-16 missions;
- Realization of facilities for Semi Cryo Engine development in progress. Realization and commissioning of semi Cryo Cold Flow Test facility completed. 60% of IET site leveling and earth excavation work completed. Construction of Test Control Centre under progress;
- Production/procurement, analysis and supply of propellants and fluids for ground testing of engines, launch vehicles and satellites are being carried out;
- The SET facility was augmented and CUS Fuel Booster Turbopump test rig was relocated to cater the parallel testing requirements of CE20 Turbopump and CUS FBTP;
- Completed civil works of Cryo Welding Facility, Main Building, Additional accommodation and VIP suites in Guest House, sub-station for Semi cryo Test Facility, Compound wall between hill and project area, security track between hill and project area, Addiitonal Test bay at PTS – Deflector pit, construction of centralized safety command and additional family & bachelors accommodation for CISF were completed;
- The following Technology Development Programmes are being carried out:
    - Development of high temperature coatings on super alloys;
    - Studies of Hydrogen embrittlement sensitivity on Inconel 718;
    - Studies on solidification of ferrous & non ferrous alloys;
    - Development of activated TIG welding process for nickel based super alloy material;
    - Development of electro spray thrusters;
    - Concept demonstration of wind tunnel experiments in HAT facility;
    - Development of LOX/Ethyl alcohol steam generator;
    - Development of Annular ejectors;
    - Development of LAM Side Thrust measurement system;
    - Development of Robotic system for cylinder surface cleaning;
    - Development of Signal conditioner for hydrogen sensors

4.4 Major Achievements during 2016-2017

- Planned to complete realization of Vikas engines, PS2 stages and PS4 stages for PSLV continuation programme and launch campaign activities to meet the launch targets;
- Planned to complete assembly & integration of Vikas engines for L40 and GS2 stages for GSLV missions to meet the launch targets;

- Planned to complete GS2 and Cryogenic Upper Stage (CUS) realization for GSLV missions to meet the launch targets;
- Planned to complete CE20 Integrated Turbopump Development Hot Tests (Phase-3) in bootstrap mode at Subscale Engine Test facility (SET);
- Planned to complete assembly, integration and acceptance testing of CE20 E2 & E3 Engines;
- Planned to complete assembly, integration and development tests of C25 D stage;
- C25 main and auxiliary umbilical qualification and static separation tests are planned at Cryo Subsystems Test facility (CST);
- Planned to complete Vikas engine assembly for L110 D1 Stage;
- Planned to complete realization of L110 stage assembly for GSLV MkIII development flight;
- Planned to complete TCT facility augmentation for testing Semi Cryo Subscale engine;
- Planned to complete establishment of Isrosene storage facility and LOX bulk storage facility;
- Continual Testing of LAM and AOCS engines for future satellite programs. LAM 800 N test is planned for Chandrayan-II mission;
- TDP activities such as development of LOX-Methane thrusters, development of Bunched Passage Bernoulli Obstruction Flow Meter, New scrubbing system for N2O4 and MON-3 fumes, Fuel additives for Isrosene for performance improvisation, Fire detection system based on multisource information fusion, design of photoelectric smoke detector with multiple detection angles and development of dynamic pressure sensor are planned;
- Production of earth storable & cryogenic propellants to meet the requirements of ground tests, launch vehicle and satellite programme. Establishment of Second N2O4 plant with 3 MT per day capacity. Establishment of new Isrosene plant with 2.4 MT per day capacity at IPRC, to meet the requirements of Semi Cryo engine development. Commissioning of lab to analyze the raw material/intermediate/product requirements of Hydrazine plant, which is being established at IPRC;
- Activities for establishment of New facilities and Augmentation of existing facilities are planned. Initiation of activities for realizing PS4 engine test facility and LAM test facility, establishment of new effluent treatment plant, establishment and commissioning of PTS additional Vikas engine test bay, realization of Vikas Engine Assembly & Integration facility, augmentation of Thrust Chamber Test facility, introduction of LH2 purification plant at Second Liquid Hydrogen Production plant, Design and tendering for realization of New Cryo Turbo Pump Test Facility (CTPT) and Integrated Cryo Engine Test Facility (ICET) are planned.
- Planned to complete civil works for realization of Hardware Preparation & Storage Building, PS2/GS2 stage Integration Building, Structural Test Bay, New Gas Cylinder Test Facility, Bulk storage facility, Vikas Engine Integration Building, V Construction of Integrated Stage Storage building, Coertical extension to TCT-CTR, Construction of Hydrazine plant lab, additional family & bachelors accommodation for CISF and Thrust Chamber Preparation and coating facility;
- Planned to complete civil works for amenities such as new canteen building and auditorium.

5. ISRO Satellite Centre (ISAC) & its Projects

5(a) ISRO Satellite Centre (ISAC)

(₹ in crores)

Budget 2015-2016	Revised 2015-2016	Budget 2016-2017
238.00	217.30	333.00

5(a).1 The ISRO Satellite Centre (ISAC) at Bengaluru is the lead Centre for Satellite Technology. ISAC is carrying out conceptualization, design, fabrication, testing and integration and in-orbit commissioning of satellite systems through time bound projects. ISAC is functionally organised into six major areas: Mechanical Systems Area, Digital & Communication Area, Integration & Checkout Area, Power Systems & Avionics Production Area, Controls & Missions Area and Reliability & Components Area. Electronic and Mechanical fabrication facilities, Environmental test facilities support the centre in fabrication and testing activities. Programme Planning and Evaluation Group is responsible for all planning and acts as the central coordinating agency and technical Secretariat of Director of the Centre. Space Astronomy Group has been involved in optical, X-ray and Gamma ray astronomy research with strong emphasis on instrumentation. Computer and Information Group is responsible for establishment and management of centralised IT infrastructure in ISAC. Avionics Production Division is the nodal agency for production of standardized electronic packages. Three Programme Management Offices coordinate the implementation of the INSAT, IRS & Small satellites and Navigation Programmes. CMD is responsible for planning, execution and maintenance of all civil works related to Centre.

5(a).2 ISRO Satellite Integration and Test Establishment (ISITE) functioning under ISAC is equipped with state-of-the-art clean room facilities for spacecraft integration and test facilities including 6.5M Thermo-Vacuum Chamber, 29T vibration facility and Compact Antenna Test Facility under one roof. Assembly Integration and Testing of all communication & Navigation Spacecraft is carried out at ISITE. A dedicated facility for productionisation of standardized sub-systems has been established at ISITE.

5(a).3 Major Achievements during 2015-2016

- Spacecraft integration activities initiated for Resourcesat-2A. BDH & SSR subsystem fabrication activities are in progress. Spacecraft readiness is planned during June 2016;
- In respect of SCATSAT, the Mainframe & payload system fabrication and testing in progress. Payload integration and dis-assembled mode IST planned to be completed;
- CARTOSAT-2E Project approval received and subsystems realization initiated;
- CARTOSAT-3 Project approval received. Configuration finalized. Development activities are in progress;
- In respect of CHANDRAYAAN-2, the detailed design of structural elements of orbiter and lander in view of revised configuration is in progress. Towards orbiter craft, mainframe electrical ICD Preparation in progress of orbiter craft in progress. Payload Electrical ICD Completed. Towards lander craft, 800N Engine Plume analysis in progress. Lander Imager Electrical Interface, RF Systems DC-DC Converter finalized and Propulsion

elements accommodation study finalized/completed. Rover craft: Six wheel rover configuration assembly completed and fabrication is in progress. Tests on development model of rover is in progress;

- Realization of Lab model electronics for Aditya-L1 in progress. Thermal analysis of HEL1OS payload and Fabrication of Mechanical Housing of SoLEX initiated. Fabrication of electrostatic analyzer for PAPA payload planned to be initiated;
- Payload testing and Critical Design Review (CDR) of major sub-systems and payloads completed for Astrosat. Spacecraft level assembly, integration and testing activities completed and the spacecraft successfully launched onboard PSLV – 30 on September 28, 2015;
- After spacecraft level assembly, integration and test activities, the GSAT-6 spacecraft was launched onboard GSLV – D6 on August 27, 2015. This spacecraft carried indigenously developed 6.0m unfurlable antenna;
- After completion of spacecraft level assembly, integration and testing activities, the GSAT-15 spacecraft was shipped on September 26, 2015 for launch onboard Ariane-5 and was successfully launched on November 10, 2015;
- Structure for GSAT-9 delivered to AIT. Power packages - IBT started with Core+BIM, shunt and Distribution packages. IRU delivered for HILS test. Sensors & sensor electronic package delivered for HILS test except Earth sensor -1. TMTC-10/20 packages under environmental tests. EPS related electronics packages are under fabrication;
- Structure and EV panel heat pipes for GSAT-11 delivered to AIT. Sub-systems qualification models are being tested. Flight model subsystems fabrication planned to be initiated. Required test setups being established;
- INSAT-3DR Structure delivered to cleanroom. South panel post bonding and Integrated Power test in progress. Sub system fabrication and testing in progress. Harness fabrication completed for North, East and West panels. The meteorological payloads are ready for delivery to AIT;
- INSAT-3DS configuration finalized. Subsystems fabrication initiated;
- Thermal analysis with EOM and updated heat pipes routing, revised layouts for GISAT completed. Orbital slot, TTC and Payload frequency finalization activities are in progress;
- In respect of IRNSS-1E, the payload integration and preparation of second phase of dis-assembled mode IST completed. Spacecraft level assembly, integration and testing activities completed and PSR completed on September 30, 2015. The satellite was successfully launched onboard PSLV- C31 on January 20, 2016;
- In respect of IRNSS-1F, the propulsion system thrusters thermal Implementation completed. CCRR support structure, Star Sensor, Reaction Wheels, Thruster & CASS brackets are delivered to Integration. TTC-RF Test and Evaluation completed and delivered to AIT. Integration tests are in progress. Payload panels and payload systems integration tests in progress. AOCS, Sensors, Inertial Systems integration

tests completed. Dis-assembled mode IST activities are in progress. Spacecraft level assembly, integration and testing activities planned to be completed;

- In respect of IRNSS-1G, Heat Pipes are available and North & South panel fabrication is in progress. Power package rework completed and delivered to AIT. AOCE Package tests in progress. Solar panels thermovac cycling in progress. North & South panel fabrication completed. Thermal implementation in progress;
- Financial approval for GSAT-19E received. Satellite planned to be launched onboard GSLV-MKIII during 3rd quarter of 2016-17;
- Technology development programs for future missions like I-6K Modular Structure, Deployable thermal radiators (DTR) with reservoir embedded loop heat pipe (RELHP) to cater higher thermal dissipation, 12 m Unfurlable Antenna (G20)18 m Unfurlable Antenna, 6 m wrapped rib type UFA (IDRSS), Deployment of 7 solar panels per wing, Thermal cutter based deployment of solar panels, Synthesized programmable TT&C system, Coding and anti jamming features for strategic users, Advanced compression techniques (DWT ASIC based) for lossless/lossy compression, etc., are being taken up;
- Towards campus expansion, construction activities for HDI facility, Space Park Clean Room and Battery and solar panel fabrication facilities are nearing completion. Mechanical Systems Area Building and refurbishment of existing CATF are in progress;
- Multi Junction solar cell fabrication facility proposal was reviewed by SPAC. RFP preparation in progress for industry and technology partner identification;
- In respect of the IRNSS Ground Segment, the INC-II & IRNWT-II at ISTRAC-Lucknow, 5 IRIMS stations (Mauritius, Biak, Gaggal, Kavaratti, Pune), TTC stations at MCF-Bhopal, SATCOM Link etc are planned to be completed.

5(a).4 Major Programmes for 2016-2017

- Assembly Integration & Testing of GSAT-18, SCATSAT-1, INSAT-3DR, RESOURCESAT-2A, GSAT-19E and GSAT-9. The launch of these spacecraft is planned in the FY 2016 – 2017;
- Sub-system fabrication for GSAT-11, GSAT-17, GSAT-6A, GISAT-1, INSAT – 3DS, Cartosat – 2E, Cartosat -3, CHANDRAYAAN-2, IRNSS-1H and ADITYA-L1 spacecraft;
- Realization of technologies for future spacecraft viz., Cartosat-3, I-6K bus development, Interplanetary missions, Docking mission and HSP.

5(b) Geo-Imaging Satellite (GISAT)

(₹ in crores)

Sanctioned Cost	Expenditure to end of March 2015	Budget 2015-2016	Revised 2015-2016	Budget 2016-2017
392.00	120.41	80.00	50.79	70.00

5(b).1 GISAT is a Geo Imaging Satellite at Geostationary orbit with a high temporal resolution. It has a multispectral imager operating in Visible, Near Infra Red and Thermal Infra Red bands and Hyper Spectral imager operating visible, near infra red and short wave infra red bands. The satellite is primarily meant for near real time imaging of natural resources and disaster management. The spacecraft platform is a derived version of I-1K bus with a power handling capability of around 1.6W with a lift of mass of 850 kg. Subsystem configuration finalisation is in progress. Thermal analysis with EOM and updated heat pipes routing, revised layouts completed. Orbital slot, TTC and Payload frequency finalization activities are in progress.

5(c) Resourcesat-2A

(₹ in crores)

Sanctioned Cost	Expenditure to end of March 2015	Budget 2015-2016	Revised 2015-2016	Budget 2016-2017
200.00	51.07	50.00	49.88	75.00

5(c).1 Resourcesat-2A has been approved with an estimated cost of ₹200.00 Cr. Resourcesat-2A is conceived as a follow-on mission to Resourcesat-2 intended to provide continuity of data to the users. The configuration is similar to Resourcesat-2 and carries three payloads LISS-IV, LISS-III & AWiFS with new SWIR band detector. The spacecraft mass is around 1200 kg with a power generation capacity of 1250W and mission life is of 5 years. Most of the mainframe sub-systems fabrication and testing completed and Spacecraft level integration and testing initiated. BDH & SSR subsystem fabrication activities are in progress. Spacecraft readiness planned during June 2016.

5(d) Cartosat-3

(₹ in crores)

Sanctioned Cost	Expenditure to end of March 2015	Budget 2015-2016	Revised 2015-2016	Budget 2016-2017
351.16	0.00	50.00	18.30	30.00

5(d).1 Cartosat-3 is an advanced agile satellite to obtain imageries with spatial resolution of 0.25m in panchromatic, 1m in multi spectral for advanced cartographic applications with an operational life of 5 years. The spacecraft will be built around payload with a mass of 1500 kg and capable of generating around 1900W of power. The spacecraft will be placed in the sun synchronous polar orbit of 450 km. Many new technologies are being developed for the mission which includes highly agile structural and payload platform, data handling & transmission systems, advanced onboard computer, new power electronics dual gimbal antenna etc. Development and qualification activities are in progress.

5(e) Scattsat

(₹ in crores)

Sanctioned Cost	Expenditure to end of March 2015	Budget 2015-2016	Revised 2015-2016	Budget 2016-2017
80.00	0.00	30.00	11.00	35.00

5(e).1 Scatsat-1 is a continuity mission for Oceansat-2 Scatterometer to provide Oceanographic services to users. The spacecraft shall be built around IMS-2 bus with a power generation capability of 900W and mass of around 370 kg. Sub-system fabrication is in progress. RCS activity on the main frame is under progress. Some of the main frame systems are delivered to clean room.

5(f) RISAT-1A

(₹ in crores)

Sanctioned Cost	Expenditure to end of March 2015	Budget 2015-2016	Revised 2015-2016	Budget 2016-2017
490.00	0.00	2.00	10.20	35.00

5(f).1 RISAT-1A is conceived as a follow-on mission to RISAT-1 satellite. RISAT-1A will have a Synthetic Aperture Radar operating in C-band capable of imaging in day-night all-weather conditions.

5(g) Oceansat – 3 & 3A

(₹ in crores)

Sanctioned Cost	Expenditure to end of March 2015	Budget 2015-2016	Revised 2015-2016	Budget 2016-2017
797.17	0.00	25.00	14.70	30.00

5(g).1 Oceansat-3 is an advanced remote sensing satellite with for oceanographic applications. This will carry an Ocean Color Monitor (OCM-3) with 13 bands and a Ku-band pencil beam scatterometer.

5(h) Cartosat-2E

(₹ in crores)

Sanctioned Cost	Expenditure to end of March 2015	Budget 2015-2016	Revised 2015-2016	Budget 2016-2017
160.00	4.77	45.00	22.53	50.00

5(h).1 Cartosat-2E is a high resolution remote sensing follow on satellite for Cartosat-2 with improvements in payload configuration capable of delivering imageries with spatial resolutions of .64 m and 2 m in Pan band and 4 Band multispectral cameras respectively with swath of 10 km. Procurement of components and flight equipments are in progress. Sub-system fabrication of mainframe systems are in progress.

5(i) Navigational Satellite System

(₹ in crores)

Sanctioned Cost	Expenditure to end of March 2015	Budget 2015-2016	Revised 2015-2016	Budget 2016-2017
1420.00	1102.08	120.00	107.30	80.00

5(i).1 The main objective of the Satellite Navigation program is to establish a regional Indian Satellite Navigation System & explore opportunities for participation in global systems.

5(i).2 IRNSS is a regional navigation system with a constellation of GEO and GSO satellites. The coverage includes the Indian subcontinent and around 1500 Km beyond the Indian geographical area. IRNSS system is targeted to provide the dual frequency user with accuracy better than 20 meters in horizontal & vertical position in the coverage area. The IRNSS system mainly consists of Ground Segment, Space Segment and User Segment.

5(i).3 INC computers and servers installation has been completed. Installation of IRNWT sub-systems is completed at INC, Byalalu. The space segment consists of a constellation of seven GEO satellites.

5(i).4 IRNSS-1A, the first of the seven satellites in the constellation was launched successfully on board PSLV-C22 on July 21st 2013 & IRNSS-1B, the second of the seven satellites in the constellation was successfully launched on 4th April, 2014. It is positioned at 55°E with an inclination of 29° w.r.t equator. The In-orbit Test (IOT) of navigation, ranging payload and TTC transponders has been completed successfully. IRNSS-1B is functioning satisfactorily from its designated geosynchronous orbital position.

5(i).5 IRNSS – 1C is the third of the seven satellites planned for the IRNSS constellation. On the successful completion of assembly, integration and testing activities, spacecraft level PDR was held on October 3, 2014. Subsequently it was shipped to the launch base on September 8, 2014. The spacecraft was launched successfully onboard PSLV-C25 on October 16, 2014.

5(i).6 IRNSS – 1D, is the fourth satellite of the IRNSS Constellation. After spacecraft level assembly, integration and testing activities, the spacecraft was launched successfully onboard PSLV-C27 on March 28, 2015.

5(i).7 Payload integration and preparation of second phase of dis-assembled mode IST completed in respect of IRNSS – 1E. Spacecraft level assembly, integration and testing activities completed and PSR completed on September 30, 2015. IRNSS-1E was launched successfully onboard PSLV- C31 on January 20, 2016.

5(i).8 IRNSS-1F & 1G are scheduled for launch during March-April 2016. With this, the full constellation of 7 satellites will be ready.

5(j) NASA ISRO Synthetic Aperature Radar Mission (NISAR)

(₹ in crores)

Sanctioned Cost	Expenditure to end of March 2015	Budget 2015-2016	Revised 2015-2016	Budget 2016-2017
1420.00	1102.08	120.00	107.30	80.00

5(j) NISAR is a dual frequency radar imaging satellite to be jointly developed by NASA and ISRO to study surface deformation, terrestrial biomass structure, natural resources mapping & monitoring and studies related to dynamics of ice sheets, glaciers, forest fire, oil slick etc.

5(k) Resourcesat-3S & 3SA

(₹ in crores)

Sanctioned Cost	Expenditure to end of March 2015	Budget 2015-2016	Revised 2015-2016	Budget 2016-2017
Not yet approved	0.00	0.00	0.00	20.00

5(k).1 Resourcesat-3S & 3SA are two high resolution remote sensing satellites with improved resolution for advanced land, water resources and large scale stereo mapping applications with two Panchromatic cameras.

6. Laboratory for Electro-Optics Systems (LEOS)

(₹ in crores)

Budget 2015-2016	Revised 2015-2016	Budget 2016-2017
0.00	0.00	20.00

6.1 The Laboratory for Electro-Optics Systems (LEOS) at Bengaluru is responsible for design, development and production of electro-optics sensors like earth sensors, star sensors, sun sensors, magnetic sensors, temperature sensors and optical gyros for spacecraft use. LEOS is also responsible for the fabrication of various types of optics for satellite cameras & radiometers and development of indigenous detectors for spacecraft. LEOS is also involved in the development of miniature sensors Micro Electro Mechanical Sensor (MEMs) devices, development of Charge Coupled Devices (CCD), Time Delay Integration (TDI) devices with industry participation.

6.2 Major Achievements during 2015-2016

- Satellite level integrated testing Pre-launch, launch and post-launch support for sensors and optics were provided for IRNSS-1D, GSAT-6, ASTROSAT, GSAT-15 and IRNSS-1E;

- All sensors for GSAT-15, IRNSS-1E and IRNSS-1F are integrated with Satellite and tested. Test and Evaluation of sensors for SCATSAT-1, RESOURCESAT-2A, IRNSS-1G, GSAT-17 GSAT-18, INSAT-3DR and INSAT-3DS are under progress. Fabrication and testing of sensors and electronics for SRE-II, GSAT-9, GSAT-19, ADITYA-1, CHANDRAYAAN-2, CARTOSAT-3, IRNSS-1H and GISAT spacecrafts have been initiated;

- New development from LEOS namely Bolometer onboard GSAT-6 is working satisfactorily. LEOS developed “mirror assemblies for UVIT Telescopes” designed to produce the images of less than 2 arc second resolution in FUV wavelengths are on board ASTROSAT;

- MEMS based inclinometer, Navigation Camera & LIBS for Chandrayaan-2, Color camera & image storage unit for SRE–II are under development;

- Primary mirror & Secondary mirror of High Resolution Optics (HRC) for CARTOSAT-3 under realization;

- Micro Sun Sensor : qualification completed. Flight model under progress for GSAT-11 and Chandrayaan-2;

- Development & testing of low weight & low power, Active Pixel star tracker (MARK-III) is in progress and it will be flown on GSAT-11 & ADITYA-1.

6.3 Major Programmes planned for 2016-2017

- Satellite integration level testing of sensors and launch of IRNSS-1G / 1H, GSAT-19, GSAT-17, GSAT-9, GSAT-11, RESOURCESAT-2A, SCATSAT and INSAT-3DR are planned during this period;

- Development of Sensors and Optics for INSAT-3DS, GISAT-1, GSAT-6A, CARTOSAT-2E and CARTOSAT-3 are the major tasks ahead;

- Indigenous LASER Source for LIDAR and Laser Induced Breakdown Spectroscope (LIBS) for lunar & interplanetary missions, Silicon Carbide (SiC) optics technology, Navigation Cameras for Lunar Rover (Chandrayaan-II) and Space Grade color Camera and image storage unit for SRE-2, will be developed during this period. Development of solar coronagraph optics for ADITYA-1 is under progress;

- To facilitate the development / production / testing of sensors and optics, new facilities will be established during this period. They include Electron Beam Evaporator, Scanning Electron Microscope, Interferrometer tests setup, High Accuracy Star simulator, Mask Alignment unit, Coating plant for thin film deposition, Refurbishment of SiC fabrication facility and 3-Axis CNC milling machine.

7. Satish Dhawan Space Centre (SDSC-SHAR) & its Projects

7(a) Satish Dhawan Space Centre (SDSC-SHAR)

(₹ in crores)

Budget 2015-2016	Revised 2015-2016	Budget 2016-2017
559.00	592.68	598.00

7(a).1 Satish Dhawan Space Centre-SHAR (SDSC-SHAR) is the principal operational Centre for launching Sounding Rockets and Satellite Launch Vehicles. The activities at SDSC-SHAR are grouped under vehicle assembly & static test operations, range operations, liquid storage & service facilities and solid propellant booster plant. The main facilities in the Centre include those for production of solid propellant rocket boosters, ground and environmental qualification of rocket motors and their sub-systems, integration, check-out and launch of satellite launch vehicles, liquid propellants & cryogenic propellants storage and servicing facilities, tracking & telecommand stations, real-time data processing and range & flight safety.

7(a).2 Major Activities Completed and Planned during 2015-2016

- Completed the preparation and integration activities of Launch vehicles and servicing & launch of PSLV C28, C29, C30, C31 and GSLV D-6 missions;
- Integration, servicing and Launching of PSLV C32 & C33 are also planned. Planned for production of PS0-XL motors for PSLV Vehicles;
- At the S200 Production plant, as part of S200-ST03-Head End Segment processed and planned to deliver two segments for S200-ST03;

7(a).3 Major Activities Planned during 2016-2017

- To meet the increased launch frequency requirements, required facilities augmentation is being carried out right from Solid Motor production, Stage Preparation facilities, Integration facilities, Satellite preparation facilities, Propellant Servicing systems, Range operations systems, etc., for simultaneous preparation and launch of two launch vehicles at any given point of time. This will enable the Centre to meet the increased launch frequency requirements as per DOS/ISRO manifest;
- Major activities/ facilities contemplated for 2016-17 are:-
    - Production of solid motors for PSLV-C34, C35, C36, C37, C38 and GSLV-F08;
    - Production of 12 Nos. of PSOM-XL segments at SPP for PSLV.
    - Stage Preparation, Integration and launch of PSLV-C34, C35, C36, C37, C38 and GSLV-F08 as per launch manifest;
    - Progress on works related to:
        - Civil works for Second Vehicle Assembly Building;

- Facilities for solid motors production like realization of PSOM XL facility, dual energy LINAC, Second Casting, Second Inhibition machining, New 4.5T Vertical Mixer, Autoclave and Vertical facing mill;
- Facilities for propellant servicing like realization of Control system, Bulk storage augmentation and Bulk LN2 storage system;
- Facilities for Integration & static testing;

- Commissioning of Multi Object Tracking radar;
- Environmental test of Retro & Ullage motors of PSLV & GSLV.

7(b) Second Vehicle Assembly Building (SVAB)

(₹ in crores)

Sanctioned Cost	Expenditure to end of March 2015	Budget 2015-2016	Revised 2015-2016	Budget 2016-2017
363.95	3.00	120.00	130.00	245.00

7(b).1 SVAB is planned to be realized at Satish Dhawan Space Centre, Sriharikota. SVAB will provide enhanced launch frequency of PSLV and GSLV. It will also provide redundancy to existing vehicle assembly building for integration of GSLV Mk III.

8. ISRO Telemetry, Tracking and Command Network (ISTRAC)

(₹ in crores)

Budget 2015-2016	Revised 2015-2016	Budget 2016-2017
185.00	159.30	170.00

8.1 ISRO Telemetry, Tracking and Command and (ISTRAC) is entrusted with the primary responsibility to provide spacecraft TTC and mission control services to major launch vehicle and Spacecraft missions of DOS/ISRO. Major objectives that go with the above key responsibility are carrying out mission operations for all operational remote sensing and scientific satellites, providing TTC services from launch vehicle lift-off till injection of satellite into orbit and to estimate its preliminary orbit in space and hardware and software developmental activities that enhance the capabilities of ISTRAC for providing flawless TTC and Space Operations services.

8.2 In order to realize these objectives, ISTRAC has established a network of ground stations at Bengaluru, Lucknow, Mauritius, Sriharikota, Port Blair, Thiruvananthapuram, Brunei and Biak-1 & 2 (Indonesia) and the Deep Space Network Stations at Byalalu near Bengaluru. The Mission Operations Complex located at Bengaluru carries out round-the-clock mission operations for all remote sensing and science satellites. All network stations of ISTRAC are connected to the Mission Operations Complex (MOX) through dedicated high performance satellite/terrestrial communication links. Alternate Spacecraft Control Centres (ASCCs)

established at Lucknow and ISDN provide the capability to switchover spacecraft operations from one location to another, in case of disaster scenarios affecting operations from MOX.ISTRAC has also been mandated to provide space operations support for Deep Missions of ISRO, undertake development of radar systems for launch vehicle tracking and metrological applications, to provide Search & Rescue and Disaster Management Services and maintenance of hub station for 'spacenet' services. Establishment, operation and maintenance of ground segment for the Indian Regional navigational satellite System consisting of IRNSS Navigational Control Centre connected to IRNSS CDMA Ranging/IRNSS Range Integrity Monitoring Stations through dedicated IRNSS Data Communication Network is yet another major responsibility vested in ISTRAC.

8.3 Major Achievements during 2015-2016

- Provided pre-launch simulation, launch and early operations phase support for LVM-3X/CARE, PSLV C26/IRNSS-1C, PSLV C27/IRNSS-1D, PSLV-C28/DMC3, PSLV C30/ASTROSAT and PSLV C31/IRNSS-1E and pre-launch simulation and launch operations for GSAT-16, GSLV-D06/GSAT-06;
- Regular operation and maintenance of TTC Network stations at SHAR, Bengaluru, Lucknow, Thiruvananthapuram, Port Blair, Brunei, Biak and Mauritius. In addition to these ISTRAC maintains two deep space network terminals viz., DSN-18 & DSN-32 operating in S/X band and 2 transporter terminals operating in S Band;
- Provided round-the-clock operations support and payload programming for IRS satellites viz., IRS P6, CARTOSAT-1, CARTOSAT-2 series satellites, RISAT-2, Oceansat-2, RESOURCESAT-2, MEGHA-TROPIQUES, RISAT-1 and SARAL, MOM and ASTROSAT missons;
- Provided round-the-clock operations support to IRNSS-1A, IRNSS-1B, IRNSS-1C and IRNSS-1D;
- Continued operation and maintenance of IRNSS Ground Segment consisting of ISRO Navigation Centre (INC), four CDMA Stations (IRCDR), IRNSS Network Timing (IRNWT) and IRNSS Range & Integrity Monitoring Stations (IRIMS);
- Continued the activities towards establishment of Phase-2 of the ground segment under IRNSS. Completed commissioning of new IRIMS stations at Pune and 2 more stations at Kavaratti and Gaggal expected to be completed during the year;
- Provided operation and maintenance of Space communication Hub services for Spacenet, Tele-medicine, Edusat and VRC;
- Continued support to Disaster Management Charter and Search & Rescue Operations;
- Civil works and procurement actions for the establishment of second ISRO Navigation centre (INC-2) at Lucknow in progress. Realisation of IRNWT time scale system at Lucknow at INC-2 for IRNSS mission support is in progress;
- Will provide pre-launch simulations and launch operations support for TeLEOS, IRNSS-1F and IRNSS-1G missions;
- Integrated C Band DWR transmitter and other subsystems were integrated at TERLS, VSSC and SAT is planned in March 2016;

- Completed S Band DWR System Installation at Cherrapunji. Site Acceptance Test is planned in March 2016;
- Integration and testing of S Band DWR Systems at Gopalpur and Kochi are planned to be completed by March 2016;

8.4 Major Programmes for 2016-2017

- Planned to provide pre-launch simulations and launch operations for Polar and Geo missions;
- Continuation of regular operation and maintenance of TTC Network stations at SDSC-SHAR, Bengaluru, Lucknow, Thiruvananthapuram, Port Blair, Brunei, Biak and Mauritius, two deep space network terminals viz., DSN-18 & DSN-32 operating in S/X band and 2 transporter terminals operating in S Band;
- Continue to provide round-the-clock operations support and payload programming for IRS satellites viz., IRS P6, CARTOSAT-1, CARTOSAT-2, Oceansat-2, RESOURCESAT-2, MEGHA-TROPIQUES, RISAT-1, SARAL, Mars Orbiter Mission and ASTROSAT missions;
- Continued round-the-clock operations support to IRNSS-1A, IRNSS-1B, IRNSS-1C and IRNSS-1D;
- Planned to realize a second S-Band Antenna at Port Blair to assure high availability and support future science missions like Aditya;
- Planned to realize indigenous Transportable terminal;
- Planned to replace Antenna/Reflector/Mount for Mauritius-I TTC station at Mauritius;
- Planned to complete civil works for INC-2 facility and establishment of IRNWT-II at Lucknow;
- Development of X-band feed with Transmit capability planned to be integrated within the existing S-band feed assembly of 11m antenna systems at ISTRAC ground segment;
- Continued operation and maintenance of Space communication Hub services for Spacenet, Tele-medicine, Edusat and VRC;
- Continued support to Disaster Management Charter and Search & Rescue Operations;
- Continuation of activities for implementation of green cover and rain water harvesting for IDSN, Byalalu.

9. Master Control Facility (MCF)

(₹ in crores)

Budget 2015-2016	Revised 2015-2016	Budget 2016-2017
90.00	79.55	108.00

9.1 The Master Control Facility (MCF) located at Hassan in Karnataka is responsible for initial orbit raising, payload testing and in-orbit operation of all geostationary satellites. MCF has integrated facilities comprising satellite control earth stations with associated electronics. The Satellite Control Centre (SCC) is the nerve centre for satellite control operations. A back-up MCF (MCF-B) at Bhopal, Madhya Pradesh with essential facilities to manage the satellite operations has been commissioned.

9.2 Major Achievements during 2015-2016

- Successful completion of In-Orbit Tests of GSAT-16 and LEOP operations of GSAT-6, GSAT-15 and IRNSS-1E missions;
- Dome for the Optical Telescope arrived at Ponmudi site (SPROC Project) and installation started;
- Planned to complete LEOP operations of IRNSS – 1F mission;
- Planned to commission IRNSS Satellite Control Centre in new land;
- Planned to commission SCES #3 at MCF- Bhopal;
- Planned to replace Servo/Feed system of SCES #1/#2;
- Planned to refurbish Hassan Campus Network;
- Planned to complete civil construction works of additional quarters for CISF Staff at Hassan;
- Planned to complete civil works of Optical Telescope Project at Mt. Abu (Civil works being executed by CMG-PRL);
- Planned to complete installation of telescope & commissioning of SPROC facility at Ponmudi;
- Planned to host the Inter-Centre Hindi Technical Seminar in March 2016.

9.3 Major Activities Planned during 2016-2017

- Planned to complete LEOP operations of IRNSS-1G, GSAT-18, GSAT-9 & INSAT-3DR missions;
- Planned to establish C band Earth Station with an 11m, 'high-speed' FMA Terminal at Hassan;
- Planned to establish C/S band Earth Station in the Western Hemisphere and L/S band terminal for IRNSS IOT;
- Planned to establish a wide-C band Earth Station for IRNSS IOT;
- Planned to establish Adjacent Satellite Interference Monitoring system at MCF, Hassan;
- Planned to establish a Ku/DBS- band FMA terminal at Bhopal;
- Readiness for installation of Telescope & Commissioning of SPROC facility at Mt. Abu.;
- Planned to start installation activities for GSAT-11 Ground System elements;
- Construction works of IRNSS GMCC (at Hassan);
- Planned to host Orientation programme for Official Language Staff of DOS/ISRO.

10. Space Applications Centre (SAC)

(₹ in crores)

Budget 2015-2016	Revised 2015-2016	Budget 2016-2017
452.00	524.02	578.39

10.1 The main activities of the Space Applications Centre at Ahmedabad include Research and Development work in various areas of space applications which are primarily aimed at national development and development of payloads for remote sensing and communication satellites. The activities of the Centre are grouped under microwave systems, satellite communication applications, sensor developments, image & information processing and remote sensing applications. The Centre has facilities for mechanical and electronic systems fabrication. The facilities of this Centre include the Ahmedabad Earth Station, Delhi Earth Station, portable and mobile Earth Stations, Laboratories for remote sensing & communication activities, fabrication and environmental test facilities for development & qualification of space and ground hardware. The Centre is responsible for the development, realization and qualification of communication, navigation, earth observation and meteorological payloads & related data processing & ground systems in the areas of communication, broadcasting, earth observations for remote sensing of natural resources, weather and environmental studies, disaster, monitoring/mitigation etc. SAC has also been involving industry and practicing outsourcing & indigenous development of technology and vendors.

10.2 Major Achievements during 2015-2016

- Completed In-orbit test of GSAT-16, GSAT-6 & IRNSS-1E;
- Delivered payload for GSAT-15 and IRNSS-1F;
- GSAT-9 payload was successfully integrated and tested in SAC-CATF;
- In respect of SCATSAT-1, the Thermovac and vibration tests of integrated antenna assembly carried out and antenna is delivered to ISAC. T&E of FM rotary joint integrated with SSM-FM is completed and the integrated unit is delivered to IISU for Integration with reflector antenna and further activities;
- Payloads for GSAT-11, GSAT-18 and INSAT-3DR are under advanced stage of development;
- Completed Subsystem development for GSAT-17, GSAT-19, GSAT-20;
- Mobile Radio (SMR), Reporting Terminal (RT), Portable Multimedia Terminal (PMT) and Broadcast Receiver (BR) are tested in all beams using GSAT-6;
- Integrated testing for all four types of services - Multimedia service, Broadcast service, Reporting service and Voice service - for GSAT-6 Hub baseband system with terminals in all five beams using GSAT-6 satellite was carried out;
- Antennas for broadcast receiver (25nos.) and reporting terminal antennas (Qty- 20 nos.) of GSAT-6 were developed and delivered to the project;
- In respect of GSAT-11ground system applications, the ground system configuration and the RFP is completed. Development of onboard Tracking Rx Qualification Model is completed.

- Installed dual frequency, dual polarization Ka-Band beacon receiver for propagation studies using GSAT-14 at Delhi Earth Station, AES Ahmedabad and SPL, Thiruvananthapuram. The systems are fully operational with 20.2 & 30.5 GHz beacon reception from GSAT-14.
- Atomic Clock Monitoring Unit (ACMU) DVM is developed indigenously and demonstrated. All the results are matching with the procured ACMU;
- MoU signed with 6 academic institutes for IRNSS Receiver field trials;
- LISS-3* payload of Resoursesat-2A (August 17, 2015), Rover Imager Payload of Chandrayan-2 (August 17, 2015)
- Payloads under advanced stage of development: INSAT-3DR, Resourcesat-2A, Chandrayan-2;
- Sub-system development for GISAT, NISAR and Cartosat-3,
- Activity related to the planetary missions Astrosat & Aditya is in progress;
- In respect of NISAR, the S-Band SweepSAR system and sub-system specifications have been finalized and DVM development activities initiated;
- ISRO-JPL collaboration AVRIS-NG Airborne flights will be conducted in February- March 2016;
- Preparation of final GIS database for Desertification Status Maps (DSM) at 1:500,000 using IRS AWiFS data for 18 states for 2011-13 and 2003-05 time frames have been completed. Seamless mosaicing of DSM Maps for 12 states has been completed;
- ISRO is now an Operational CWIC (CEOS WGISS Integrated Catalogue) data partner by virtue of enabling INSAT-3D data search through CEOS catalogue;
- Satellite based nowcasting method developed for heavy rainfall alerts over India and is operational through MOSDAC web portal since onset of monsoon-2015;
- Desertification Status Mapping on 1:500,000 scale using AWiFS for 29 States and the Union Territory of Andaman & Nicobar completed;
- INSAT DP (IMDPS) & Special Products Software: a new web based software RAPID (Real time Analysis of Products and Information Dissemination) was developed for near real-time visualization, analysis and animation of INSAT-3D, Kalpana-1 and INSAT-3A products including Geo-physical parameters at IMD, New Delhi and released during IMD annual day on January 15, 2015;

10.3 Major programmes for 2016-2017

- Planned delivery of Payloads for GSAT-11, GSAT-17, IRNSS-1G, IRNSS spare 1&2;
- Planned development of Sub-systems for GSAT-18, GSAT-19, GSAT-20;
- Planned Antenna development for GISAT, Chandrayan-2, SCATSAT-1, X BAND SPACEBORNE SAR, NISAR, X-band MINISAR, L/S BAND SAR;
- Planned advanced Payloads in Design for Future Missions: Q Band Payload, Flexible Payload, Optical Communications Payload, Ka Band High Throughput Payload;

- Planned antennas for HTS & DVM realization of feeds and tracking coupler;
- Planned RF design and development of UHF band feed for Unfurlable antenna for high power UHF band payloads;
- Planned continuation and further expansion of GSAT-6 applications continuation. Railway related and other new user applications will be expanded for nationwide coverage;
- Planned the development of advanced and miniaturized ground terminals and hub technology for GSAT-17 and GSAT-20;
- Planned establishment of GSAT-11 ground segment;
- Planned for the design and development of antennas for GNSS (GPS and IRNSS), Radio Occultation (RO), Precise and Orbit Determination (POD) applications;
- Planned delivery of Payloads for Resourcesat-2A, Chandrayan-2, INSAT-3DR and GISAT;
- Planned sub-system development for GISAT (Tx, ETM telescope, breadboard models for HYS SWIR and HYS VNIR spectrometers), Aditya-1(EM);
- Planned antenna development for INSAT-3DR (0.9m antenna and DRT antenna), GISAT, Chandrayan-2, SCATSAT-1, X BAND SPACEBORNE SAR, NISAR, X-band MINISAR, L/S BAND SAR;
- Planned development of DVM of L and S-FRAp for NISAR;
- Planned development of light weight antenna for the proposed 2.0kg SAR payload X-BAND MINISAR;
- Planned simulations for TMC, IIRS, OHRC Data Products, design & Development of TMC, IIRS, OHRC Data Products S/W and DEM generation & development of DP software for Chandrayaan-2;
- Planned sweep SAR data simulations for NISAR;
- Science plan for ISRO-NASA joint airborne survey of Hyperspectral Applications;
- Prediction of heavy rainfall events using GAGAN and Other Existing Data and Installation of hybrid GNSS receivers;
- Dissemination of GIS-based tropical cyclone prediction and analysis at MOSDAC portal for post-monsoon cyclone season;
- Developing methods for coastal sediment budgeting;
- Winds and Wave Climatology & validation;
- Investigation of the linkage and path-way for the Arctic teleconnection;
- GIS modelling for deriving site suitability for mangrove plantation/afforestation;
- Planned calibration data study for HYSIS and GISAT Payloads and Atmospheric Sounder mission on IMS-2;
- Planned Multi-Channel Microwave Radiometer-Sounder Mission;

- Radio Occultation and GNSS-Reflectometry sensors on small satellites;
- Planned the design & development of MMIC & RF circuits, SAW, LTCC;
- Thin film characterization system;
- Deposition & Characterization equipments for Nano-electronics technology;
- Design and Fabrication of 14K/16K Dummy spacecraft structure (DSS);
- In-house Fabrication of Waveguide Run (WR-75, WR-51, WR-28, WR-NS) assemblies for GSAT series of communication payloads;
- Realisation of suitable Space components by additive manufacturing for future space flights;
- Development of Visualisation of Earth Data and Archival System (VEDAS);
- Planned Atomic Clock Development;
- Planned development of Terahertz Sub-MmWave & IR Sensors/ Telescope, optical Polarization Imaging Sensor and prototype Light Field imaging camera;
- Planned development, simulation and implementation of target detection algorithms for onboard applications and generic timing and precision phase generator ASIC for CCD detectors.

11. Development and Educational Communication Unit (DECU)

(₹ in crores)

Budget 2015-2016	Revised 2015-2016	Budget 2016-2017
44.41	14.20	22.00

11.1 The Development and Educational Communication Unit (DECU) at Ahmedabad is involved in the conceptualisation, definition, planning, implementation and socio-economic evaluation of developmental space applications. The major current activities of DECU include EDUSAT projects, their implementation action & utilisation, Training and Development Communication Channel (TDCC), Village Resource Centre (VRC), Gramsat Programme (GP), Tele-Health (TH), Tele-Education (TE) mission and new satellite communication development and applications.

11.2 Major Achievements during 2015-2016

- Initiated work related to the establishment of 07 new nodes for Chardhams, Kailash Mansarovar, Amarnath & Ayyappa pilgrimage places and for 08 new nodes on pilot project covering one district each in Himachal Pradesh, Odisha, Arunachal Pradesh and Meghalaya as per request from the Ministry of Health & Family Welfare (MoHFW);
- Sent proposal for setting-up of TM facility for Indo Tibetan Border Police (ITBP) to MoHFW;
- 4 nodes at ESI hospitals will be established as per the request from Ministry of Labour & Employment;

- Conducted 8 Continuing Medical Education (CME) programmes from DECU studio by inviting doctors. Around 1500 medical professionals participated. Planned to carry out at least 1 CME every month;
- Planned to repair & operationalise additional 100 TM nodes in order to take the total number of operational nodes to around 200 nodes;
- Providing tech support to users on-request basis;
- Migrated 4 sites (including 1 mobile) of National Council of Science Museum (NCSM) network and Hub & co-located SIT under INDO-US network from GSAT-3 to GSAT-12;
- TE networks of Rajasthan, Maharashtra, ANSSIRD Mysore and SITs of INDO-US network will be migrated;
- Provided technical consultancy related to the re-activation of nodes, Comprehensive Annual Maintenance Contract (CAMC), etc. on request to PES, IGNOU, CIET, IDSP/NCDC, ANSSIRD, J&K, etc.;
- Providing continuous technical support to NE-SAC related to TE networks in North East states;
- Initiated activities related to the demonstration of single window delivery of integrated services like Telemedicine, Tele-Education, Disaster management, e-Government applications, Jan Dhan Yojana, etc. to the Prime Minister's Office (PMO);
- Produced 42 programmes in categories like ISRO & Space Science, coverage, live transmission, etc.;
- 18 more planned programmes are at various levels of production;
- 2 studies, namely, 'Mapping Communication and Information Practices in Backward Regions of India' and 'Usage of ICT and its Impact on Daily Life: A case of e-Gram Project of Gujarat';
- Completed a telephonic survey in order to understand the operational status of the TE network locations in Odisha;
- Initiated activities related to studies 'An Assessment on Requirement of ISRO Telemedicine Services in Himalayan Regions of India', 'Feedback Study on Odisha TE network' and 'Feedback Study on TE network of Punjab';
- Impact study on Integrated Services Pilot Network at Meghalaya will be undertaken;
- Incorporated HD quality content creation as HD camera & HD recorder were procured;
- Digital archive preservation - Checked around 1300 video programs for quality and archived around 1000 video programs in the Digital Asset Management (DAM) system for long term preservation;
- Technical consultancy/support provided to - ANSSIRD, NKN office at IIT Madras, etc.;
- High performance MMLAB storage system - Being established to enable collaborative working & facilitate reuse of computer generated animations;

- A 3D content creation setup, software upgrades, outdoor DVCAM format cameras and portable Audio/Video Mixer will be procured;
- Launched the in-house developed app at a press conference in Delhi;
- Immensely contributed towards the realisation of many things like tri-lingual video selection system, virtual presenter, augmented reality application, 3D auditorium, 3D auto-stereoscopic display, timeline of ISRO's activities, holo-box, self-illuminating static panels, special attractions for kids like Inter-planetary weighing scale, rocket ride, touch interactive video games, model of Mars colony, LED writing board, photography with astronaut cut-outs, etc.;

11.3 Major Activities Planned during 2016-2017

- Planned to upgrade existing TM network, including Hub, with new technology;
- Planned to establish new TM nodes & mobile vans as per requirement from users & ISRO policy approval;
- Planned to develop monitoring & feedback application for the TM project;
- Minimum one CME programme per month from DECU studio planned;
- National Users' Meet to increase the utilisation planned;
- Planned to establish new nodes based on acceptance and approval of Integrated Services demonstration;
- Planned remigration of Ku-band networks;
- Planned continuous tech support to NE-SAC for maintenance & operation of TE networks in NE states;
- Planned to provide technical consultancy to the existing users of TE networks on need basis;
- At least 65 video productions planned on subjects like ISRO & Space Science related topics, coverage & event recordings, live telecast of launches, CMEs, etc.;
- Planned to conduct 6 video programmes and 6 special video programmes for Sikkim EDUSAT (subject to Content Generation Training happening at Sikkim);
- Planned to conduct 4 studies (1 related to TE & 3 related to SATCOM applications);
- Planned to procure 11 workstations with KVM arrangement for MMLAB, 5 high-end NLE systems, High performance storage system for NLE with 100 TB NAS & Autoloader; Multi-Channel audio post production for 5.1/7.1 content generation;
- Digital archive preservation activity to be continued;
- Planned to provide technical consultancy/support on request basis;
- Existing application upgrade planned.

12. ISRO Space Applications Programmes

12(a) Earth Observation Applications Mission (EOAM)

(₹ in crores)

Budget 2015-2016	Revised 2015-2016	Budget 2016-2017
5.20	3.70	5.00

12(a).1 The thrust of EOAM is mainly (i) evolve newer applications. R&D Programmes based on technology trends – leading to operational applications programmes (ii) guiding remote sensing applications programme with the user community towards implementation of remote sensing based solution and (iii) steering commercial activities of remote sensing involving development of value added services. Under EOAM various R&D and technology development studies like horticultural inventory, fluvial geomorphological mapping, snow and glacier studies, precision farming, water use in agriculture, surface deformation/mapping using differential SAR interferometry, desertification monitoring and assessment, geophysical investigations, etc. Apart from the above, pre-investigation studies of Cartosat are also being carried out. Some of the new remote sensing applications studies planned/taken up under EOAM include hot spot mapping and monitoring, coal pitheads, riverine wetlands, forest ecosystem, working plan for forest management, crop growth monitoring system, etc.

12(a).2 Major Activities Completed/Planned during 2015-2016

- Completed five projects out of twenty six ongoing projects using Optical, Hyperspectral, microwave remote sensing techniques; some of the completed/ ongoing projects are as following:
- Integrated Spatial Farming Systems Analysis Techniques with RS and Ancillary data;
- Experimentation on international crop assessment using EO data;
- Nutrient Cycle in Agricultural Systems at Field and Regional Scales;
- Remote sensing of Inland Fisheries;
- Satellite based Thermal Data Utilization for Crop Condition Assessment;
- Estimation of periodic water balance components and generation of geo-spatial hydrological products at uniform grid-wise at National scale;
- Flood Inundation Modelling for Urban & Riverine Catchments;
- GPS & GAGAN/IRNSS data analysis for Intra-Plate Geodynamic Profiling in Active Seismic Zones;
- Airborne survey for hyper spectral studies in various applications;
- Detecting shallow coastal aquifers through Remote Sensing and geophysical techniques;
- Assessment of Irrigation Potential Utilization (I.P.U) using geospatial Data;
- Agricultural Drought Vulnerability – All India Assessment and Mapping at Sub-district level;

- Mapping, Modeling and Impact Assessment of Land Subsidence in Northern India;
- Monitoring and Assessment of Mountain Ecosystem Processes in North-West Himalayas;
- Precise Terrain Parameter extraction using Low Altitude Platforms data;
- Optimizing parameters from multiple sensors for biomass estimation at ICESat GLAS footprint level using different regression algorithms;
- Crop condition assessment under abiotic stress of few selected major crops of NER using remote sensing technique;
- Land evaluation for organic crop planning in Assam using RS & GIS techniques;
- Hydrological Impact Assessment with Climate & Land Use Change of Loktak Lake, Manipur.

12(a).3 Major activities planned during 2016-2017

- Satellite-based value added Agro-Met products for early warning to farmers;
- Agricultural Resource Information research using remote Sensing;
- Assessment of Spatial and Temporal Variation of Water Quality in River Ganga with the aid of Space Technology;
- Snow melt Runoff forecasting for Indian Himalayas using satellite derived products;
- Development of Near-real time Hydrologic Modelling system for India based on ensemble of SWAT model simulations;
- Monitoring Progression of Kharif Cropped area using RISAT-1 SAR Data;
- Assimilation of in-situ and remotely sensed observations for improving short-range weather forecast with emphasis on mountainous terrain;
- Urban micro-climatic zoning for sustainable smart city planning of Indian cities using geospatial technologies;
- A new algorithm for soil moisture retrieval using RISAT-1 and passive microwave data over Karnataka state;
- Spatio-temporal variation in land-surface and energy balance parameters and its effect on rainfall distribution and crop productivity in NER.

12(b) National Natural Resources Management System (NNRMS)

(₹ in crores)

Budget 2015-2016	Revised 2015-2016	Budget 2016-2017
56.70	50.10	35.00

12(b).1 The National Natural Resources Management System (NNRMS) has the objective of ensuring optimal management/utilisation of natural resources by integrating information derived from remote sensing data with conventional techniques. The NNRMS umbrella includes a large cross-section of Government Departments/Agencies, which are responsible for resources management sectorally and other agencies associated in developmental activities. NNRMS activities are co-ordinated at the National level by the Planning Committee of NNRMS (PC-NNRMS) which frames guidelines for implementation of the systems and oversees the progress of remote sensing applications for natural resources management in the country. Nine Standing Committees are (i) Agriculture & Soils (ii) Bio-resources (iii) Geology & Minerals (iv) Water resources (v) Rural Development (vi) Urban Development (vii) Cartography (viii) Ocean & Meteorology and (ix) Training & Technology. NNRMS, thus, encompasses conceptualisation and implementation of space system with ground-based data reception, processing and interpretation systems and integrating the satellite-based remotely-sensed data with conventional data for resource management applications in various thematic areas.

12(b).2 Considering the changing technological and applications dimensions in the country and elsewhere, the NNRMS currently focuses on (i) user funded projects meeting the objectives/goals of the user Departments/Agencies both at the national and regional/local scale; (ii) proactive applications projects of relevance at the national and regional/local scale and (iii) organising the spatial databases for supporting, planning, implementation and monitoring of a variety of developmental programs.

12(b).3 Major Activities during 2015-2016

- Space based Information System for Decentralised Planning (SIS-DP) Project taken up aims to develop ICT enabled geospatial platform using space based EO systems and engage local bodies for planning and execution of area based developmental activities in a decentralised, speedy and transparent manner. The thematic geo-spatial database is being created at 1:10,000 scale using ortho-rectified high resolution Indian Remote sensing satellite data for the entire country. In addition, digital Village cadastral maps are being overlaid onto ortho-rectified imagery for the five priority States. Thematic mapping for the entire country and cadastral overlay for selected priority States are nearing completion. Bhuvan Panchayat portal which acts as an enabling environment to search, access, visualize, understand and analyze the data sets is operationalised and a large volume of data have been ported on to it. A large number of professionals have been trained in digital photogrammetry, thematic mapping and cadastral overlay apart from data utilisation for decentralized planning;

- Under Natural Resources Census project, 11th cycle (2014-15) Land use/Land cover assessment has been made using semi-automated approach which includes automated processing of AWiFS quadrant data and classification using rule based approach. Water spread as well as snow cover information has been generated though automated process. Rule based data integration of temporal datasets was adopted to derive final Land use/Land cover output. Activities have been initiated for 12th cycle kharif area mapping;

- The 2nd cycle of land use/land cover analysis at 1:50,000 scale using data of 2005-06 for the entire country has been successfully completed and the changes between the 1st cycle of created land use/land cover using data of 2005-06 were also captured in spatial and temporal domain;

- Land use/Land cover trajectory mapping using Indian Remote sensing Satellite LISS IV data at 1:10,000 scale for selected sites across the country essentially for hotspot monitoring is progressing well;

- Under the Project on Forest cover change alert system using IRS multi sensor data remote sensing based technique was developed for automated detection of forest cover loss of an area greater than 2 hectare for rapid annual monitoring. The forest pixels are identified on Resourcesat-2 AWiFS data for 14 States in the country. The automated method for annual forest change detection using AWiFS data has been developed. The study currently covers 8 States (Maharashtra, Madhya Pradesh, Chattisgarh, Karnataka, Goa, Telangana, Andhra Pradesh and Himachal Pradesh) and work is nearing completion;

- GCPL Phase-III Project is planned to densify the Ground Control Points (GCP) for satellite data calibration with a total of 4570 GCPs and 620 Pre-Signalised Points (PSPs) covering South India, North India, Jammu & Kashmir and North Eastern regions. So far, GCP collection and database generation was completed for 4060 GCPs and 580 PSPs covering South India and North India. GCP data collection for 550 points covering Jammu & Kashmir and North Eastern regions is in progress. Also, airborne LFDC data was acquired over Bhind area in Madhya Pradesh with 10cm Ground Sampling Distance for calibration. Aerotriangulation of data and Digital Surface Model (DSM) generation were completed;

- As a follow-up to National Meet on, “Promoting use of Space Technology in Governance and Development” held on September 07, 2015, large number of Projects has been identified across 58 Ministries/Departments including applications in the areas of Remote Sensing & Geospatial Technologies as well as Capacity Building in diversified areas. The activity has been initiated.

- Activities towards conducting State Meet in all the States in the similar lines of National Meet have also been planned and a few States will be conducting the State Meet during the current financial year.

- Extended technical and financial support to various Agencies/Institutes for conducting multitier/multi-theme training courses. Efforts of satellite based distance learning programme in RS&GIS is being continued to cover more number of Universities/academic Institutes;

- Technical support is provided to State Remote Sensing Applications Centres for executing Projects of relevance to development of the States.

12(b).4 Major activities planned during 2016-2017

- Under Space based Information System for Decentralised Planning (SIS-DP) Project, generation of natural resources mapping at 1:10,000 scale for entire country will be completed and will be systematically organized for dissemination. In addition, cadastral overlay for 5 priority States will be completed. Dissemination of information/data will be done through Bhuvan Panchayat Portal. In addition, for effective utilisation of data sets generated, asset mapping and capacity building activities will be carried out;

- Under Natural Resources Census project (i) 12th cycle of Land use/Land Cover mapping at 1:250,000 scale will be carried out and mapping activity for the 13th cycle will be initiated (ii)

2nd cycle of Land degradation mapping and change analysis with respect to 1st cycle for entire country will be initiated and (iii) 3rd cycle of Land use/land cover mapping and change analysis will be initiated for entire country;

- Activities under Land use/Land cover trajectory mapping at 1:10,000 scale for 28 sites will be continued;
- Forest cover change alert system using AWiFS data will be extended for the rest of the country and a National Workshop on sub annual forest monitoring system will be organized;
- Under GCPL Phase-III, all the activities related to collection of GCPs and PSPs will be completed;
- As a follow-up to National Meet on, "Promoting use of Space Technology in Governance and Development", execution of projects identified in the areas of Remote Sensing & Geospatial Technologies and Capacity Building will be continued;
- State meet on 'promoting use of Space Technology in Governance and Development' in all the States will be completed and the user requirement will be consolidated for furthering the activity;
- Planned to continue efforts for providing technical support to State Remote Sensing Applications Centres as well as human resources development in the area of Remote Sensing and GIS.

12(c) Disaster Management Support (DMS)

(₹ in crores)

Budget 2015-2016	Revised 2015-2016	Budget 2016-2017
30.00	35.12	22.00

12(c).1 The Disaster Management Support (DMS) Programme of ISRO provides near real time support and services from aero-space systems, both imaging and communication, towards efficient management of disasters in the country. The DMS programme addresses the natural disaster such as flood, cyclone, drought, forest fire, landslide and earthquake. The major components of the DMS programme include creation of digital database for facilitating hazard zonation, damage assessment, monitoring of major natural disasters using satellites and aerial data, development of appropriate techniques and tools for decision support establishing satellite based reliable communication network, deployment of emergency communication equipment and R&D towards early warning of disasters.

12(c).2 Major activities and achievements during 2015-2016

- During 2015, floods were mapped and monitored in 10 states and more than 105 flood inundation maps were provided in near real-time. Value added flood products were populated on the Bhuvan and NDEM web portals;
- The Indian Forest Fire Response and Assessment System (INFFRAS) provides observations

of active forest fires (Feb-Jun) daily at 1030,1230,1430 and 2230 hrs on a near real time basis. In 2015 fire season, a total of 22539 active fires were observed;

- Landslide on Phuktal River (Zanskar Region), Kargil District, J&K was monitored during Feb-May, 2015 using CARTOSAT data and regular updates on impoundment area, volume of water and possible scenario due to breach was provided to NDMA. The inputs were used by NDMA to assess the threat and clear the blockade;

- The Nepal earthquake in April 2015 caused widespread damage and loss of lives in many parts of Nepal, and some damages and deaths in India. The DMSP responded to this event with planning for quick satellite coverage for acquisition of Indian EO data, activation of the International Charter Space and Major Disasters, building damage assessment in the urban areas like Kathmandu valley and rapid inventory of earthquake induced landslides. More than 5000 landslides have been mapped in the areas affected by earthquake;

- The processed data and information were sent to Ministry of Home Affairs (MHA), National Disaster Management Authority (NDMA) and National Disaster response Force (NDRF), in addition to uploading to Bhuvan and NDEM web portals of ISRO. The information derived from satellite data is shared among various international agencies for unifying the efforts and coordinating rescue operations;

- Medium range flood forecast models developed for the Godavari, and Mahanadi were operationally used in real-time in collaboration with Central Water Commission during 2010 to 2015. The study has been extended to the other major flood prone rivers of the country (Mahanadi, Ghagra, Gandak, Kosi, Brahmani-Baitarani, and Krishna). Web-enabled spatial flood early warning system has been developed for the Godavari and being implemented in real-time during the monsoon period of 2015. The Flood Early Warning System (FLEWS) in Assam has started its second operational phase of three years starting 2015 at the request of the Government of Assam. All flood prone districts of Assam are covered as part of the project;

- An experimental early warning system for rainfall triggered landslides was developed and implemented along the pilgrimage route corridors leading to Gangotri, Badrinath and Kedarnath as well as along the Pithoragarh-Malpa route in Uttarakhand. This experimental early warning system is under validation;

- Experimental early warning for thunderstorms is being carried out for Uttarakhand and Himachal Pradesh regions. Further, a prediction model for heatwaves was developed in 2015. Both the forecasts were made available in MOSDAC and the links were given in Bhuvan and NDEM portals;

- National Database for Emergency Management (NDEM) version 2.0 was launched with improved features and functions on ISRO satellite based Virtual Private Network (VPN). Mobile apps and user manuals were also uploaded in NDEM private & public portals for better utilisation of the services. Simultaneously, NDEM Public portal is hosted on ISRO Bhuvan platform through internet connectivity. Seven regional training programmes for Central/State government departments (150 officers) have been organised across the country for the familiarisation of NDEM private and public portals for enabling the better utilisation of NDEM products and services;

- Close contour flood plain mapping is being carried out using airborne LiDAR / LFDC data for use in flood inundation modeling and flood depth assessment. During the year, Geodatabase generation is completed for Mahanadi river basin covering an extent of 8,177 sq.km;

- S Band DWR System installation has been completed at Cherrapunji and IMD site at Gopalpur, Orissa. C Band DWR transmitter and other subsystems have been integrated at TERLS, VSSC and weather data is being acquired since June 2014. An S-band DWR is being established at IMD site at Kochi;

- The Satellite Aided Search and Rescue system which provides services to 7 neighboring countries has supported rescue of 51 lives out of 7 incidents during the last one year. ISRO has carried out the Lead Role in International Charter Operations during April-October, 2015. During this period ISRO managed 17 activations, published three communications and Universal Access was extended to 5 countries. During 2015, satellite data support (28 scenes) were provided for 10 emergency requests from Vietnam, Pakistan, Indonesia, Bangladesh, Japan, Myanmar, Nepal and Taiwan for floods, oil spill, landslides and typhoon disasters.

12(c).3 Major activities planned during 2016-2017

- Nation-wide Near Real Time Flood Mapping and Monitoring and support during other natural disasters, will be continued. Flood hazard atlas for Orissa and West Bengal is being subjected to ground verification for finalisation and release next year. Experimental early warning for rainfall induced landslides in select Himalayan sectors will be continued and validation studies will be carried out. NDEM services will be continued. In 2016-17 around 200 towns high resolution data will be procured and added to the database;

- ALTM DC data of around 15400 sq. kms acquired during 2015-16 will be processed for generation of 0.25 m MSL DEM, 0.5m contours. Fresh ALTM-DC data acquisition and processing of another 15,000 sq. km is also planned in 2016-17;

- Operation & Maintenance of MSS-Type-D hub, maintenance of Type-D terminals will be carried out. At the behest of the Ministry of Home Affairs, ISRO is in the process of preparing a detailed project report on establishment of National Disaster Management Command Centre (NDMCC). NDMCC is conceived to be having multi-layer connection with disaster prone districts and database support for efficient disaster management. The DPR will be further pursued and the basic framework for NDMCC will be established;

- Operational maintenance of Cherrapunji and TERLS Doppler Weather Radars, establishment of two radars at IMD sites in Gopalpur and Kochi and upgradation of SDSC-SHAR DWR will be carried out;

- Support to Sentinel Asia and International Charter requests will be continued. Authorized User training for Bolivia country under International Charter is planned.

13. National Remote Sensing Centre (NRSC)

(₹ in crores)

Budget 2015-2016	Revised 2015-2016	Budget 2016-2017
305.00	285.00	312.00

13.1 NRSC is one of the Centres of Indian Space Research Organisation, striving to realize the Indian space vision, as a key player in Earth Observation and Disaster Management Support Programmes. NRSC is responsible for acquisition, processing and dissemination of aerials and satellite remote sensing data and is continuously exploring the practical uses of remote sensing technology for multilevel (global to local) applications. It also has a focused programme of creating training manpower through capacity building in remote sensing.

13.2 Major Achievements during 2015-2016

- IMGEOS and AGEOS facilities are being augmented with data reception and processing chains for Landsat-7, SCATSAT-1 and Cartosat series missions;
- Development of Software for Data ordering for disaster incidents from IMGEOS;
- Generation of fused products for ~3500 archaeological sites of India from IRS-1C/1D data. Readiness of Bhuvan regional node at RC-Nagpur;
- Designed a system to generate Vegetation Health Index (VHI) from OCM-2 to monitor and warn drought over Indian sub-continent. Fortnightly VHI products @ 5km resolution are being generated and hosted on BHUVAN. Operationalization of Surface Reflectance products from RS-2 AWiFS data using the automatic atmospheric correction software which is based on the 6S (Second Simulation of the Satellite Signal in the Solar Spectrum) radiative transfer model was attempted. Product thematic accuracy was validated with Landsat-8 data sets and found better than 95%;
- As part of Bhuvan, during 2015, more than 25 new applications and services have been released. The new application services/users include 1m images (over 300 cities of the country), Applications for Forests and Environment ministry, Toll information system, AP Housing Corporation, Islands information system, GIS databases of North East Region (NER), Cultural heritage sites of the country, Virtual 3D city models, Horticulture area mapping, Bhujal database and visualization, GIS for schools, GAIL pipeline monitoring system, crowd sourcing applications etc;
- CartoDEM v3.0 was generated for SAARC countries (India, Bangladesh, Nepal, Bhutan, Pakistan & Afghanistan) and 30m DEM was made available on Bhuvan portal for free download. Generation of country wise CartoDEM for Egypt was completed. Generation for Gulf countries including Iran, Yemen, Saudi Arabia and UAE is in progress;
- During 2015 period, 83,215 data products were disseminated of which 11910 were through data supply chain and 71,305 as free web downloads. In addition, 1,53,58,398 Sq Km high resolution IRS data and 10,78,294 Sq Km of high resolution foreign satellite data was provided to the users;

- During the financial year, both the Aircrafts were flown to the tune of 104 hours to carry out the task for Disaster Management Support Programme, ISRO-GBP studies, GCPL enrichment, Topographic Mapping, sensor validation etc. Planned for Airborne flights in collaboration with JPL-NASA using AVIRIS-NG sensor;

- As part of DSC during 2015, floods were mapped and monitored in 9 States (Assam, Gujarat, J&K, Madhya Pradesh, West Bengal, Odisha, Gujarat, Bihar and Manipur). 69 flood inundation maps were provided in near real-time to the concerned State Relief Commissioners. Value added flood products were populated on the Bhuvan and NDEM web portals. In the 2015 fire season, a total of 22539 active fires were observed. As part of NDEM, version 2.0 was launched with improved features and functions. This portal consists of multi-scale geospatial database covering base, thematic, infrastructure, disaster specific products and satellite imagery along with set of customized decision support tools. Phase 2 NDEM Systems Infrastructure has been positioned and made operational at Shadnagar campus;

- During 2015, satellite data support (28 scenes) were provided for 10 emergency requests from Vietnam, Pakistan, Indonesia, Bangladesh, Japan, Myanmar, Nepal and Taiwan for floods, oil spill, landslides and Typhoon disasters;

- As part of Natural Resources Census (NRC/NNRMS), National Land Use/ Land Cover mapping on (1:250,000 scale) 11th cycle (2014-15) LULC assessment has been made under GCPL Phase-III. During the current year a total of 4570 GCPs and 620 PSPs were planned covering South India, North India, J&K and NE regions. So far, GCP collection and database generation was completed for 4060 GCPs and 580 PSPs covering South India and North India. GCP data collection for 550 points covering J&K and NE regions is in progress which is planned for completion by March 2016;

- National Carbon Project (NCP/IGBP) - Vegetation Carbon Pool (VCP): A study to develop methods for spatial estimates of biomass in the Karnataka Western Ghats was taken up. Spatial estimates were computed for very high phytomass density evergreen National spatial estimates of above ground forest biomass were developed using satellite data and field inventory for the 2009-10 period with microwave (ALOS-PALSAR), forest height (ICESAT-GLAS), phenology (from three years of temporal observation with MODIS) and other spatial predictors;

- As part of Climate studies, Surface Soil moisture for the period July 2002-Sep 2011 has been generated using brightness temperature data from AMSRE on-board Aqua. Now more than 14 years of soil moisture data over Indian subcontinent is available on Bhuvan under NICES portal. Under the NICES Programme 20 geophysical products pertaining to land, ocean, atmosphere and cryosphere are generated and about 15 more products are being processed. Spectra have been collected and analyzed Using FTIR to evaluate columnar concentrations of CH4, and N2O;

- A national level project Coordinated programme on Horticulture Assessment & Management using Geoinformatics (CHAMAN) has been taken up, with major objectives of - area assessment and production forecasting of major horticultural crops in selected districts in India. A national level project Coordinated programme on Horticulture Assessment & Management using Geoinformatics (CHAMAN) has been taken up for area assessment and production forecasting of major horticultural crops in selected districts in India;

- As part of Integrated Watershed Management Programme (IWMP) 2.5 m orthorectified FCC and NCC products were generated for the 50 priority watersheds of the country. Generation of fused products is in progress for the remaining watersheds (~600);
- Two Geoportals (Bhuvan-SRISHTI & Bhuvan-DRISHTI) were developed to support the IWMP users. The SRISHTI geoportal enables image and map display, monitoring tools, summary statistics of all the IWMP watersheds (10 states and 50 identified districts in 28 states) and Bhuvan – DRISHTI is a tool for field data capture of the development activities undertaken for the IWMP Projects and includes a facility to upload photos on to the Bhuvan IWMP Server;
- During 2015, NRSC has conducted eighteen courses viz 2 Regular, 3 Customized, 11 Special Courses and 2 ISRO STPs. About 416 persons were benefited by the conduct of Courses at NRSC;
- Realization of Large Format Digital Camera, Bhuvan Distributed nodes at Regional Centres, Storage rack & NAS, Bhuvan Scaleup etc;

13.3 Major Programmes for 2016-2017

- Proposed to augment IMGEOS and DIPAC stations with data reception and processing requirements for Ku band communication and GISAT mission. Contingency Management Plan for Disaster Recovery for IMGEOS data centre;
- NRSC is responsible for establishment of Ka Band Satellite data reception station to receive data from Cartosat-3 series of Satellites. The receive chain subsystems right from Antenna feed up to the down converter are being developed in-house;
- NRSC planned to establish a second Ground Station at Antarctica with S/Ka-band data reception capability. The Antenna control point locations have been identified and pile foundation work has been completed. Initiated technical proposal for necessary project approvals;
- Proposed to establish a remote sensing Satellite ground station in Canada to facilitate full capacity utilization of all satellites and global data acquisition. The required technical proposal and feasibility study document have been prepared for necessary Departmental approvals. The ground station at North pole will facilitate to acquire data of African continent in real-time which is not covered by AGOES;
- Upgrading International Ground stations for Cartosat-2 and Resourcesat-2 data reception at Algeria, Iran and Sudan Ground stations;
- Planned to continue to operational information support and develop models on flood forecasting and inundation modelling for management of various natural disasters. Planned to forecast seasonal landslide inventory mapping & early warning with methodologies;
- Planned to continue Programmes like, NNRMS, ISRO-GBP, EOA, NICES and TDP and all ongoing User funded National missions;
- Planned to continue Regular, Special and Customized courses to participants from various Government Departments (Central, State and PSU), Private organisations, NGOs

and academic Institutions towards effective utilization of Remote Sensing data in various Applications. Further, two ISRO Structured Training Programs (STP) for ISRO Scientists will be conducted;

- Major Infrastructure planned during the year includes Retrofit of Avionics, Bhuvan Scaleup, implementation of security measures as per IB norms, instrumentation for carryout the NICES Programme etc.

14. Indian Institute of Remote Sensing (IIRS)

(₹ in crores)

Budget 2015-2016	Revised 2015-2016	Budget 2016-2017
44.00	41.47	45.00

14.1 The Indian Institute of Remote Sensing (IIRS) located at Dehradun is responsible for capacity building in the field of Remote Sensing and GIS applications. It has grown manifold and has established itself as an Institute of repute both nationally and internationally. Realizing the potential of Earth Observation System and ISRO's forthcoming initiatives in the areas of natural Resource Survey, Earth & Atmospheric Sciences & Oceanography, IIRS has been reorganized as a separate entity of ISRO w.e.f. April 30, 2011. IIRS will continue its training, education and research programmes with enhanced focus on Microwave Remote Sensing, Hyper-spectral Remote Sensing and Climate studies.

14.2 Major Achievements during 2015-2016

- First-phase of ISRO-NCERT sponsored special course was coordinated by IIRS for conducting a special training on all India level from 25 centers parallelly targeting 500 PGT of KVs, NVs and Pvt CBSE affiliated schools. Similarly other special courses were also undertaken like UAV Remote Sensing, ISPRS Summer School, etc. besides the regular mandates courses;
- In honour of the services being rendered, IIRS received the 'Education Leadership Award' from ABP News National Education Awards on July 23, 2015 at Mumbai. The award is in recognition of leadership, development, marketing, and institute & industry interface;
- Due to aggressive approaches and innovative practices, IIRS has already achieved it's RFD for the year 2015-2016;
- Inclusive in aforesaid, the brief details pertaining to Special/Tailor-made courses were designed and conducted at IIRS for the following national organizations; in addition to regular programmes, and following are the ones organized during current year like Special course on geospatial technologies in Watershed Management (8), IAF: RS& GIS for Personnel of the IAF (13), IIRS/ ISRO: Special course on ISPRS Summer School (81), GB Pant Pantnagar: Application of RS& GIS in Water Resources Mgmt. (11), NCERT/ISRO: Training program on Capacity Building Program for PGT in Geography in the field of RS & GIS (18), Jammu University: Course of RS & GIS in Forestry and Wildlife Research (10), Forest Dept. of West Bengal: Special course on application of GPS & GIS tools of forestry (11), MoEF: Refresher

Training Course for IFS Officers on Forest Working Plan Preparation using Remote Sensing and GIS Technology (20), IMD: Special Course on RS & GIS for Crop Growth Monitoring & Yield Prediction for Officials of IMD (24), ISS: Course on Application of RS&GIS for Natural Resource Management for ISS Officers (20), IIRS/ISRO: Course on UAV RS (23);

- 95 summer trainees of various professional courses (e.g. B.Tech, M.Tech, MCA, etc.) from various University and affiliated Colleges have also benefited by completing Dissertation/ Project-work at IIRS;
- IIRS also received National Award for Excellence in Training on 'EDUSAT Program' and 'e-learning Program' for 2015' for 2015' from DoPT & UNDP;
- Strengthening further the training activities in IIRS with close interaction with the State Department and National Institutions through programmes like IUIMs, interactive meets, etc.;
- IIRS initiated new R&D activities like:
    - Dust storm forecasting;
    - Surface energy balance over Agro-ecosystems using Large Aperture Scintillometry;
    - Soil, vegetation-atmosphere Carbon monitoring and modeling;
    - Nepal Earthquake observations;
    - GAGAn-Geotagging for Joint Swachh Bharat Abhiyaan-2015;
    - Traffic noise modeling using 3D-GIS;
    - Urban Microclimate Modeling;
    - HR Land Surface Parameters (LSP) for Indian Climatological zone;
    - Landslide GIS Mapping;
    - Underwater video Image Mosaicking (with NIOT/MoES);
    - IIRS continued TDP in emerging areas of Remote Sensing, spatial modeling and calibration/validation earth processes modeling and collaborative R&D activities with other DOS/ISRO Centres;
    - The collaborative and focused interdisciplinary research with major National Institutes i.e., WIHG, SASE, NIH, GB Pant Institute, Y.S. Parmar University under EOAM Research Programme on 'Monitoring & Assessment of Mountain Ecosystem Processes in Western Himalayas' were continued and completed;
    - Participated in organizing the recent 'National Meet on Promoting Space Technology based Tools and Applications in Governance and Development' with Hon'ble in the PM at Vigyan-bhavan on September 07, 2015. Besides aforesaid the flyers prepared in consultation with SAC, NRSC, Hqs; were appreciated which also designed and printed at IIRS catering various gamut of activities of ISRO;
    - Contributed as LOC in organizing of the conference on "Satellite for the SAARC region and Space Technology Applications" on June 22, 2015 at New Delhi, India ISRO with active support from Ministry of External Affairs, Government of India wherein all member

countries of SAARC region appreciated this new initiative by Government of India.

- Contributions in other DOS/ISRO research projects like EOAM, IGBP, RISAT-UP, SARAL-ALTIKA-UP, INSAT3D-UP, DMSP, etc were continued;
- Major items planned for procurement includes Statistica Software, Engineering Seismograph, Glacier Trekking Equipment, Rainwater Harvesting, Groundwater Recharge & Monitoring, Broad Band Seismometer (BBS) & Strong Motion Accelerograph (SMA) - (1 set), Trace gas analysers: Ozone analyser, Trace level CO analyser, Multiparameter Water Quality Analyser Procurement of Portable Vacuum pump, Spectrophotometer., Microtop-devices, Hydrological modeling softwares including full Suit Mike modules & visual Mod Flow, Ecosounder with integrated GPS and self-recording facility with Remote control and operation facility, Microsoft Windows OS, Back up & Recovery software and media, Central Data Center Networking & Server Upgrades, Centralized Storage & Computing Facility, Met Package, Image Processing and Photogrammetric software (SocetSet);
- ACS & Video Surveillance is being pursued and is in advance stages of completion;
- Major Civil Works activities proposed were Vertical Extension of GID Building (Completed Works), Slope Protection Works on NE Slopes and Land reclamation; Golden Jubilee Hostel Block in Campus; 60 KWp + 20 KWp Solar Power Plant; Face Lifting of Main Building front elevation at IIRS campus; Security gate complex at IIRS Campus; Additional 06 rooms in GH & upliftment of campus entrance at IIRS; Augmentation of electrical facility at IIRS;

14.3 Major Achievements during 2016-2017

- Continue to conduct various scheduled/planned courses (i.e. Certificate/ Diploma/ M.Tech./M. Sc./ITEC/NNRMS.) as per Academic calendar 2015-2016 and Tailor made user defined courses;
- Planned to customize courses for capacity building of State/Central Govt. Department Officials implementing various national level developmental programs/schemes;
- Planned to support summer training for students of various Universities/Institutes;
- Strengthening of IIRS training activities with close interaction with the State Department and National Institutions;
- Support to CSSTEAP for conducting RS & GIS course and other short programs;
- Plan to continue TDP in emerging areas of Remote Sensing, spatial modeling and calibration/ validation earth processes modeling and collaborative R&D activities with other ISRO/DOS Centres;
- Propose to continue the ongoing collaborative and focused, interdisciplinary research with major National Institutes i.e., WIHG, SASE, NIH, GB Pant Institute, Y.S. Parmar University under EOAM Research Programme on “Monitoring & Assessment of Mountain Ecosystem Processes in Western Himalayas”.

- Expecting continued contributions in other DOS/ISRO research projects like EOAM, IGBP, RISAT-UP, SARAL-ALTIKA-UP, INSAT3D-UP, DMSP, etc.;
- Proposed to have R&D in the field of Ground Magnetic Resonance and Road GIS using Integrated Multi-Sensor Mobile System;
- The major items planned for procurement are Sieving Set for Wet Sieving Apparatus, Portable Pulse Modulated Chlorophyll fluorescence system;
- More emphasis will be given to transfer the Geospatial Technology at school level. ISRO has many national level programmes for societal benefits. Capacity building for Panchayati Raj Institutions is also envisaged in near future;
- As an outcome of the recent 'National Meet on Promoting Space Technology based Tools and Applications in Governance and Development' with Hon'ble in the PM, the video lectures and demonstrations will be developed to cater to the need of larger audience. Special courses as per the need of different Ministries and Departments will be customized and organized in near future Multi-lingual e-Learning programme will also be available to cater the need of common man;
- Rainwater Harvesting, Groundwater Recharge & Monitoring; Broad Band Seismometer (BBS) & Strong Motion Accelerograph; Gamma SAR software with various modules; Field instrumentation- Procurement & installation of Two Nos Multipoint Borehole Extensiometer & VW Piezometers; Robust Direct Shear Machine with vertical stress limit: 100kN/sq. m (Shear Box: 30x30x15cm) and 72 strain rates and accessories; Trace gas analysers; Ecosounder with integrated GPS and self-recording facility with Remote control and operation facility, depth range up to 200 m; Snow Depth Guage (6 Nos.); Video streaming software for distance learning;
- Planned to further augment the Centralized Storage, Computing Facility Network Infrastructure - for Golden jubilee hostel, GID second floor, library etc; procurement of network switches, SFPP modules for core and access switches, network accessories, augmentation of computational and data storage facility (NAS/SAN), backup and recovery software; Central Data Center Networking & Server Upgrades, Gamma SAR software with various modules, etc.
- IIRS will be celebrating Golden Jubilee celebrations next year and in this regards major Civil works are envisaged including the Golden Jubilee Hostel Building - vertical extension, Central dining & recreation facility. Besides aforesaid in Civil Works Budget the major activities proposed includes Construction of Security Gate Complex, Face Lifting of Main Building, Construction of additional 6 Rooms in GH and upliftment of Campus Entrance, Construction of 200 KL OH tank & STP, Augmentation of Electrical Facility, Providing high security fence along with the boundary wall, Additional land and development of land for IIRS, Master Plan Works (Rs.1190 Lakhs), Vertical extension to library building, New 60 rooms Hostel building, Site development works, New Academic block including Auditorium, New 40 rooms hostel building, etc.

15. ISRO Space Science Programme

15(a) Climate and Atmospheric Programme

(₹ in crores)

Budget 2015-2016	Revised 2015-2016	Budget 2016-2017
31.50	29.68	35.20

15(a).1 The Climate and Atmospheric Programme has two components namely 'ISRO Geosphere-Biosphere Programme' and 'Atmospheric Science Programme'.

15(a).2 ISRO GBP focuses its research efforts on understanding the natural rhythms and patterns of the Earth system's self regulation, the extent to which anthropogenic forcing interacts with the natural variability of Earth system in producing climate change, the types, scales and rates of change and the thresholds of changes that threaten sustainable development. The research is done through multi-institutional participation and co-ordinated effort. The programme generates the scientific knowledge for decision making and inputs to international protocols and conventions.

15(a).3 Atmospheric Science Programme (ASP) provide an impetus to studies and research in the critical areas of atmospheric of modeling and a mechanism for interactions with Scientific Department and academia for initiating/taking up suitable projects, leading to operational end user products in different domains. The primary goal of Atmospheric Science Programme will be to adopt a holistic approach towards generation, validation and assimilation of data (ground based, oceanic, atmospheric, satellite, radar data) and develop tailored models with advanced land-ocean-atmosphere process, moisture fluxes, could dynamics for operational applications of socio-economic relevance.

15(a).4 Major Activities during 2015-16

- As part of Aerosol Radiative Forcing over India (ARFI), experiments were conducted to understand the optical properties and Cloud Condensation Nuclei (CCN) activity of aerosols at Himalayan region; Enhancement in Black Carbon radiative forcing due to multiple scattering; Formation of ultra-fine particles and their varying growth rates at contrasting environment;
- Under the Network of Observatories for Boundary Layer Experiments (NOBLE) project, two major experimental campaigns were conducted. The campaign conducted in Shillong, was aimed to investigate diurnal evolution of the vertical structure of ABL, its effect on mesoscale circulation and the role in controlling regional meteorology over a mountainous terrain during the per-monsoon season. The second campaign was conducted at the Indian Antarctic station at Bharati for investigating the ABL characteristics and vertical flux of energy and momentum.;
- As an outcome of the project 'Energy and Mass Exchange in Vegetative Systems', hot-spots of long-term change in evapotranspiration and net primary productivity over India have been diagnosed using satellite data and ground based observations;
- Under Vegetation Carbon Pools (VCP), spatially explicit carbon pool change assessment have been carried out and also permanent observatories were established for long term

regional scale studies on terrestrial carbon cycle. As part of Soil Carbon Pools assessment, organic carbon stock of India has been estimated;

- As part of atmospheric CO2 retrieval and monitoring, data collected during the year 2014-15 at the four stations using precision Greenhouse Gas Analyser (GGA), has been analysed for seasonal trends, diurnal variations and differences across the stations that are set in different geographical and environmental conditions;
- Measurement and analysis of primary productivity and carbon uptake rates; source identification of Dissolved Inorganic Carbon (DIC) in the estuary and the Arabian Sea and N2 fixation rates measurements etc., were carried out for Cochin Estuary and Coastal Arabian Sea, under the project Marine Carbon Nitrogen Cycles.

15(a).5 Major Activities Planned during 2016-2017

- Detailed research will be carried under the projects Aerosol Radiative Forcing over India (ARFI) and Network Observatories for Boundary Layer Experiment (NOBLE) towards elucidating the role of aerosols as Cloud Condensation Nuclei (CCN) and their impact on regional cloudiness. It is also planned to do simultaneous observations of aerosol chemical, physical and optical properties with CCN at different high altitude sites. It is also planned to do high altitude balloon experiment during the month of April-May 2016;
- As part of Network of Observatories for Boundary Layer Experiments (NOBLE) project, it is planned to establish three more stations at Hyderabad, Ponmudi and Bengaluru. Integrated analysis of the ABL parameters at the existing stations will be carried out for consolidation of the scientific results and publications;
- Under the project 'Energy and Mass Exchange in Vegetative Systems' an Eddy Covariance tower with fast response flux measurement systems will be set up in the horticulture eco system for further research;
- As part of Atmospheric Trace Gases Chemistry and Transport Modeling, it is planned to have a land based observation campaign. It is also planned to have all measurements at all places and also conduct Balloon flight campaigns to understand Ozone profiles in the next one year.

15(b) ISRO Sponsored Research Programme (RESPOND)

(₹ in crores)

Budget 2015-2016	Revised 2015-2016	Budget 2016-2017
25.15	24.85	24.00

15(b).1 The ISRO Sponsored Research Programme (RESPOND) supports research and developmental projects and other scientific activities at the academic institutions and R&D laboratories in the country in the areas relevant to the Space Programme. In addition, RESPOND also supports Advanced Technology Research in Space Technology Cells established at premiere Institutions like IIT's and IISc.

15(b).2 The main objective of this programme is to establish strong links with academic institutions in the country to carry out research and developmental projects which are of relevance to space and derive useful outputs of such R&D to support ISRO programmes. RESPOND programme aims to enhance academic base, generate human resources and infrastructure at the academic institutes to support the space programme. The major activity of RESPOND is to provide support to research projects in wide range of topics in space technology, space science and space applications to universities/ institutions. In addition conferences, workshops and publications, which are of relevance to space research, are also being supported.

15(b).3 During the year, 34 New Projects were initiated at 19 academic institutions, 6 IITs & 4 Research Centre and 11 Ongoing Projects have been approved for supporting Space Technology Cells established at IISc Bengaluru, IIT, Madras, Kanpur, Kharagpur & Bombay and Joint Research Programme at University of Pune, and 53 conferences/symposia/publication and other scientific promotional activities have also been approved for supporting and 25 RESPOND projects have been successfully completed.

15(b).4 Projects are being carried out at ISRO established Space Technology Cells at IISc, Bangalore; IIT Madras; IIT Bombay, IIT Kanpur, IIT, Kharagpur and Joint Research Programme at University of Pune.

16. ADITYA

(₹ in crores)

Sanctioned Cost	Expenditure to end of March 2015	Budget 2015-2016	Revised 2015-2016	Budget 2016-2017
378.53	23.80	20.00	14.00	25.00

16.1 The ADITYA-1 Project will be the first Indian Space based solar coronagraph, which will be available for solar coronal observation to all the Indian researchers in the field of Solar Astronomy. The primary objective of Aditya is to study about the Solar corona, dynamics and origin of Coronal Mass Ejections. It carries 7 payloads namely Enhanced Visible Emission Line Coronograph (E-VELC), High Energy L1 Orbiting X-ray Spectrometer (HEL1OS), Plasma Analyser Package, Solar Wind Particle Experiment, Solar Low Energy X-ray Spectrometer (SoLEXS), Solar Ultraviolet Imaging Telescope (SUIT) and Magnetometer. The spacecraft is a 3-axis stabilized sun pointing mission built around IRS Bus with a mass of 1400 Kg capable of generating 1500W. It will be put in Halo orbit about Sun-Earth First Lagrangion Point with a targeted mission life of 5 years.

16.2 The financial sanction for the Project has been issued. Realization of Lab model electronics in progress. Thermal analysis of HEL1OS payload and Fabrication of Mechanical Housing of SoLEX initiated. Fabrication of electrostatic analyzer for PAPA payload planned to be initiated.

17. Indian Lunar Mission – Chandrayaan-2

(₹ in crores)

Sanctioned Cost	Expenditure to end of March 2015	Budget 2015-2016	Revised 2015-2016	Budget 2016-2017
603.00	221.34	40.00	51.50	80.00

17.1 Chandrayaan-2 is the follow-on lunar mission with indigenously developed Lander and Rover. The primary mission objective of the mission is to expand the technologies inherited from Chandrayaan-1 spacecraft and 'Develop & demonstrate' newer technologies for future planetary missions and to design, realize and deploy a Rover to carry out in-situ analysis by to soft landing at a suitable site on the lunar surface and carry out in-situ chemical analysis. Chandrayaan-2 is configured as a two module system comprising of an Orbiter Craft module (OC) and Lander Craft module (LC) carrying the Rover.

17.2 Spacecraft has been re-configured in view of the indigenous Lander and PDR of revised configuration is completed. Orbiter and Rover system realization are under progress. Detailed design of lander in view of revised configuration is in progress.

17.3 Detailed design of structural elements of orbiter and lander in view of revised configuration is in progress. Towards orbiter craft, mainframe electrical ICD Preparation of orbiter craft is in progress. Payload Electrical ICD Completed. Towards lander craft, 800N Engine Plume analysis in progress. Lander Imager Electrical Interface, RF Systems DC-DC Converter finalized and Propulsion elements accommodation study finalized/completed. Rover craft: Six wheel rover configuration assembly completed and fabrication is in progress. Tests on development model of rover is in progress.

18. Astrosat 1&2

(₹ in crores)

Sanctioned Cost	Expenditure to end of March 2015	Budget 2015-2016	Revised 2015-2016	Budget 2016-2017
177.85	172.92	3.00	2.00	1.00

18.1 The Astrosat project is India's first astronomical observatory satellite for study of cosmic sources. It carries five scientific payload instruments namely Large X-Ray Proportional Counter (LAXPC)-TIFR, Soft X-ray Telescope (SXT)-TIFR, Cadmium Zinc Telluride Imager (CZTI)-TIFR, Ultra Violet Imaging Telescope (UVIT)-IIA, Scanning Sky Monitor (SSM)-ISAC and Charge Particle Monitor (CPM)-TIFR, developed by external scientific Institutes to meet the mission goals. The life of the satellite has been configured for a minimum life period of 5 years and the spacecraft is capable of generating 2100 watts of power. Payload testing and Critical Design Review (CDR) of major sub systems and payloads completed. Spacecraft level assembly, integration and testing activities completed and the spacecraft was launched on September 28, 2015 onboard PSLV-C30. Scientific data received from the satellite are being used by researchers from India and abroad.

19. INSAT Satellite System

19(a). INSAT-3 Satellites (including Launch Services)

(₹ in crores)

	Sanctioned Cost	Expenditure to end of March 2015	Budget 2015-2016	Revised 2015-2016	Budget 2016-2017
INSAT-3 Satellites & Launch Services	3594.78	3328.58	17.00	11.08	14.00

19(a).1 The objectives of INSAT-3 Spacecraft Project are to (i) build five INSAT-3 satellites (INSAT-3A to 3E) keeping flexibility for mid-course corrections to accommodate emerging requirements, carry out mission planning, launch campaign & initial phase operations and (ii) establish required programme elements for carrying out the same. INSAT-3B was launched on March 22, 2000, INSAT-3C on January 24, 2002, INSAT-3A on April 10, 2003 and INSAT-3E on September 28, 2003. INSAT-3D is a state-of-art meteorological satellite with 6 channel Imager and 19 channel Sounder payload. The spacecraft is built around 1-2 K platform with lift-off mass of 2050 Kg with a designed mission life of 7 years. The spacecraft will be located at 82¬¬ºE longitude in geostationary orbit. The spacecraft has many new elements like the star sensor micro stepping Solar Array Drive (SADA) and the Bus Management Unit (BMU). INSAT-3D spacecraft level assembly, integration and testing activities are completed. The spacecraft was launched onboard Ariane-5 on July 26th, 2013. The payload performance is satisfactory and the preliminary images received are of good quality.

19(a).2 INSAT-3DR is a metrological spacecraft with configuration indentical to INSAT-3D. It carrier a 6 channel Imager and a 19 channel Sounder payload. In addition to the meterological payload instruments, it also carries Data relay Transponder (DRT) and Satellite Aided Search and rescue (SAS&R) payload to provide continuity to some of the INSAT services. The spacecraft is built around 1-2K platform with a lift-off mass of 2100 Kg, providing a mission life of 7 years. The spacecraft will be located at 740E longtitude in geostationary orbit. Subsystem fabrication activities are in progress.

19(a).3 **INSAT-3DR** structure has been delivered to cleanroom. South panel post bonding and Integrated Power test in progress. Sub system fabrication and testing in progress. Harness fabrication completed for North, East and West panels. The meteorological payloads are ready for delivery to AIT.

19(a).4 In respect of **INSAT-3DS**, the configuration has been finalized and the fabrication of subsystems has been initiated.

19(b). INSAT-4 Satellites (including Launch Services)

(₹ in crores)

	Sanctioned Cost	Expenditure to end of March 2015	Budget 2015-2016	Revised 2015-2016	Budget 2016-2017
INSAT-4 Satellites	3597.70	3248.60	34.00	16.93	15.10

19(b).1 The fourth generation INSAT-4/GSAT Satellite series has been planned to meet the capacity and service requirements in the areas of Satellite Telecommunication Broadcasting, DTH, Emergency Communications & Mobile Multimedia Services. The sanctioned cost of the first two satellites in the INSAT-4 series, INSAT-4A & 4B, approved in March 2004 is ₹453.00 crores for spacecraft development and ₹901.00 crores for Launch Services. The objective of INSAT-4A & 4B Project is to design and develop high power satellites with 12 C-band and 12 Ku-band transponders which will enhance the capacity of the INSAT system considerably. The first satellite in the fourth generation INSAT-4 series, INSAT-4A has been successfully launched on December 22, 2005 from Kourou, French Guyana, which carried 12C-band and 12 Ku-band high power transponders enabling DTH broadcasting. The INSAT-4B has been successfully launched on March 12, 2007 and is identical to INSAT-4A. The replacement satellite INSAT-4CR (cost ₹ 43.20 crores) was realised on fast track mode and launched successfully on September 2, 2007 onboard GSLV-F04.

19(b).2 The sanctioned cost of INSAT-4C satellite, planned for launch onboard GSLV is ₹ 95.75 crores to carry 12 Ku band transponders. INSAT-4D/GSAT-5 was configured to carry 24 C-band transponders & the total sanctioned cost was ₹123.75 crores. The satellite was launched on 25th December 2010. However, GSAT-5P could not be placed in orbit due to the failure of GSLV F-06 mission.

19(b).3 The sanctioned cost of INSAT-4E/GSAT-6, the multi-media satellite is ₹269.00 crores. GSAT-6 is a high power S-band communication satellite configured around 1–2K bus with a lift–off mass of 2140 kg. It carries BSS & MSS payload. This satellite will also provide a platform for developing technologies such as demonstration of 6m S-Band Unfurlable Antenna, handheld ground terminals and network management techniques that could be useful in future satellite based mobile communication applications. After spacecraft level assembly, integration and test activities, the spacecraft was launched onboard GSLV – D6 on August 27, 2015.

19(b).4 GSAT-8/INSAT-4G Communication Satellite is a state-of-art Satellite, which has 24 Ku band transponders and a two channel GPS Aided Geo Augmented Navigation (GAGAN) payload for (a) augmenting the INSAT System Capacity in Ku-band (b) providing a second Geostationary augmentation payload for the operational phase of GAGAN and (c) providing continued and uninterrupted service. The sanctioned cost of GSAT-8/INSAT-4G Communication Satellite is ₹610.00 crores. The satellite was successfully launched on 21st May 2011, from Kourou, French Guyana onboard Airane-5-VA-2012.

19(b).5 GSAT-9 spacecraft, configured to augment the growing need of Ku band transponders carries 12 Ku Band Transponders. The spacecraft employs the standard I-2K structure with the power handling capability of around 3 KW, with a lift off mass of 2195 kg. It is designed for a mission life of more than 12 years. The spacecraft is planned to be positioned at 480 East longitude in the geostationary orbit. Structure delivered to clean room. The subsystem fabrication activities are in progress.

19(b).6 The sanctioned cost of GSAT-10 is ₹735.00 crores. The spacecraft carries 12 Ku-Band, 12 C-Band and 12 Extended C-band transponders. The spacecraft employs the standard 1-3 K structure with the power handling capability of around 6 KW with a lift-off mass of 3400 kgs. GSAT-10 Communication satellite has been successfully launched on September 30, 2012 onboard ARIANE-5 launch vehicle from the Kourou launch base in French Guyana and the spacecraft is working satisfactorily.

19(b).7 GSAT-12, the communication satellite built by ISRO, weighs about 1410 kg at lift-off. GSAT-12 is configured to carry 12 Extended C-band transponders to meet the country's growing demand for transponders in a short turn-around-time. The 12 Extended C-band transponders of GSAT-12, will augment the capacity in the INSAT system for various societal applications like Tele-education, Tele-medicine and Village Resource Centres (VRC). The sanctioned cost of GSAT-12 is ₹ 80.00 crores. GSAT-12 was launched successfully on 15th July 2011, onboard PSLV C-17.

19(c). GSAT-11 (Advanced Communication Satellite)

(₹ in crores)

Sanctioned Cost	Expenditure to end of March 2015	Budget 2015-2016	Revised 2015-2016	Budget 2016-2017
500.00	463.05	31.00	33.40	30.00

19(c).1 The Advanced Communication Satellite is a multi beam communication satellite operating in Ka and Ku bands employing a new I-6K Bus platform. It provides 32 user beams in Ku band and 8 hub beams in Ka band to provide a through put of 10 GBPS. Being a forerunner for next generation DOS/ ISRO 6 Tonne class spacecraft, it serves as a platform for demonstration of new technological elements like modular structure comprising of modules-Bus module, Payload module and propulsion module, a new communication architecture to support various telecom services and VSAT networks, next generation power systems operating at 70V with large solar panels capable of generation of about 18KW power, high power SADA, multi beam technology for efficient utilization of spectrum and frequency re-use etc. With a lift of mass of 5600 Kg, the satellite is being designed to be compatible with both GSLV Mk-III and all commercial launchers. Structure and EV panel heat pipes delivered to AIT. Subsystems qualification models are being tested. Flight model subsystems fabrication planned to be initiated. Required test setups being established.

19(d). GSAT-15 SATELLITE (INCLUDING LAUNCH SERVICES)

(₹ in crores)

Sanctioned Cost	Expenditure to end of March 2015	Budget 2015-2016	Revised 2015-2016	Budget 2016-2017
892.69	659.07	165.00	171.20	36.00

19(d).1 GSAT-15 is a communication satellite planned to be positioned at 93.50E with a lift of mass of about 3150 Kg and 6.5KW power generation capacity. It is designed for a mission life of 12 years. The satellite will carry 24 Ku Band Transponders and two channel GAGAN payload. After completion of spacecraft level assembly, integration and testing activities, spacecraft was launched onboard Ariane-5 on November 10, 2015.

19(e). GSAT-17 SATELLITE (INCLUDING LAUNCH SERVICES)

(₹ in crores)

Sanctioned Cost	Expenditure to end of March 2015	Budget 2015-2016	Revised 2015-2016	Budget 2016-2017
1013.20	0.00	330.00	219.30	422.50

19(e).1 GSAT–17 is a communication satellite configured around I–3K extended bus with a lift off mass of 3425 kg and around 6 KW power generation capacity. The spacecraft carries 24 C, 12 Lower Extended C band and 2 Upper Extended C transponders. The spacecraft also carries 2 channels CxS, SxC MSS transponders as well ad DRT and SAR transponders. Designed with mission life of more than 15 years, the spacecraft is planned to be positioned at 93.5 deg East longitude in the geostationary orbit. Subsystem fabrication activities are in progress.

19(f). GSAT-18 SATELLITE (INCLUDING LAUNCH SERVICES)

(₹ in crores)

Sanctioned Cost	Expenditure to end of March 2015	Budget 2015-2016	Revised 2015-2016	Budget 2016-2017
1013.20	0.00	330.00	219.30	422.50

19(f).1 GSAT–18 is a communication satellite configured around I – 3K extended bus with a nominal lift off mass of 3400 kg and around 6 KW power generation capacity. The spacecraft carries 12 Ku, 24, Normal C & 12 Extended C band transponders. The satellite is designed for a mission life of more than 15 years. The spacecraft is planned to be positioned at 740 East longitude in the geostationary orbit. Most of the electronic packages are ready for delivery. The satellite planned to be launched during first quarter of 2016-17 onboard Ariane-5.

19(g). GSAT-19 SATELLITE

(₹ in crores)

Sanctioned Cost	Expenditure to end of March 2015	Budget 2015-2016	Revised 2015-2016	Budget 2016-2017
94.00	0.00	25.00	5.80	25.00

19(g).1 The spacecraft configured around I-4K bus is planned to be launched onboard GSLV-MkIII development flight. The spacecraft shall be realized using qualification models of GSAT-11 sub systems. It is planned to be launched during the 3rd quarter of 2016-17.

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FINANCIAL REVIEW

1. 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.

2. The Department has evolved a mechanism of reviewing and monitoring the commitment and expenditure status of various programmes/projects approved in the annual budget periodically and take appropriate action, for making financial management more effective. In order to have better expenditure management, the monthly cash flow is also monitored scheme-wise/project-wise by the Additional Secretary & FA of the Department of Space to ensure that the allocated funds are fully utilised. Accordingly, while formulating the Revised Estimates 2015-2016, a critical appraisal of the progress - both physical and financial is carried out consistent with the programmatic requirements. Quarterly targets are fixed for each major project/scheme during the beginning of the year and the Additional Secretary & FA of the Department takes a rigorous review of the expenditure/commitment status on a monthly basis to ensure that the financial and programmatic targets are realized. The project management councils/project management boards of all the major projects constituted at the DOS/ISRO Centre level also review the progress of expenditure/commitment status and initiate necessary follow-up actions keeping in view the programmatic criticalities. Thus, periodical review of the physical and financial performance of all the projects/schemes is an integral part of the planning and implementation strategy of DOS/ISRO

3. The Financial performance of the Department in terms of Budget Estimates, Revised Estimates and Actual expenditure for the last three years viz., 2012-2013, 2013-2014 and 2014-2015 are given below:

Financial performance 2012-2013

(₹ in crores)

	Non-Plan	**Plan**	**Total**
Budget Estimates 2012-2013	1100.00	5615.04	6715.04
Revised Estimates 2012-2013	1080.00	3800.03	4880.03
Actual Expenditure 2012-2013	1073.05	3783.23	4856.28

4. The Revised Estimates 2012-2013 was reduced to ₹**4880.03** crores in compliance with the reduced ceilings fixed by the Ministry of Finance. The actual expenditure during the year was ₹**4856.28** crores which is about **99.51%** budget utilization with respect to RE.

Financial performance 2013-2014

(₹ in crores)

	Non-Plan	Plan	Total
Budget Estimates 2013-2014	1177.00	5615.04	6792.04
Revised Estimates 2013-2014	1172.00	4000.04	5172.04
Actual Expenditure 2013-2014	1170.81	3998.00	5168.81

5. The Revised Estimates 2013-2014 was reduced to ₹**5172.04** crores in compliance with the reduced ceilings fixed by the Ministry of Finance. The actual expenditure during the year was ₹**5168.81** crores which is about **99.94%** budget utilization with respect to RE.

Financial performance 2014-2015

(₹ in crores)

	Non-Plan	Plan	Total
Budget Estimates 2014-2015	1238.00	6000.00	7238.00
Revised Estimates 2014-2015	1326.00	4500.00	5825.10
Actual Expenditure 2014-2015	1325.00	4473.81	5798.81

6. The Revised Estimates 2014-2015 was reduced to ₹**5825.10** crores in compliance with the reduced ceilings fixed by the Ministry of Finance. The actual expenditure during the year was ₹**5798.81** crores which is about **99.55%** budget utilization with respect to RE.

7. The scheme-wise/project-wise details of BE, RE and Actuals for 2014-2015, BE & RE for 2015-2016 and BE for 2016-2017 are given in Table 5.1 enclosed.

8. 1 There are about 234 Utilization Certificates outstanding as on 31.03.2015. Continuous follow-up action is being taken with the grantee institutions for submission of Fund Utilization Certificates duly supported by statement of audited accounts in respect of the above 234 cases.

8.2 In addition to the above, the Department has also evolved effective mechanisms to monitor the physical progress of the sponsored research Projects. The duration of such research Projects is generally 3 to 5 years. Periodical reviews, both physical and financial, are carried out every year by an expert committee to assess the research progress and recommend the grants to be released to such Projects for the following year. The mechanism ensures that the funds released to the Projects are utilized for the intended purposes.

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Department of Space

TABLE-5.1

Scheme-wise/Project-wise details for the period from 2014-2017

(₹ in Crores)

Sl. No.	Programmes/Projects/Centres/Units	Budget 2014-2015	Revised 2014-2015	Actuals 2014-2015	Budget 2015-2016	Revised 2015-2016	Budget 2016-2017
A	**Secretariat - Economic Services**						
1	Department of Space	27.2	21.75	21.70	28.90	26.97	28.15
B	**SPACE RESEARCH**						
	SPACE TECHNOLOGY						
2	**Vikram Sarabhai Space Centre (VSSC) & its Projects**						
2a	Vikram Sarabhai Space Centre (VSSC)	988.67	939.91	947.36	1029	1113.15	1131.32
2b	GSLV – Operational Project (including MK-III Operational)	203.67	175.00	174.87	195.00	195.00	180.00
2c	GSLV Mk-III Development	180.10	107.00	106.97	120.00	120.00	100.00
2d	PSLV-Continuation Project	390.00	71.50	71.50	312.25	280.39	400.00
2e	Space Capsule Recovery Experiment - I & II	0.25	0.11	0.11	0.04	0.00	0.00
2f	Manned Mission Initiatives/Human Space Flight Programme	17.50	13.00	13.00	21.50	12.00	12.00
2g	Trisonic Wind Tunnel Project	10.00	0.00	0.00	1.00	0.00	0.10
2h	Development of Space Materials and Components	0.00	0.00	0.00	0.00	0.00	12.00
3	ISRO Inertial Systems Unit	76.88	65.00	64.96	95.00	63.00	60.00
4	**Liquid Propulsion Systems Centre & its Projects**						
4a	Liquid Propulsion Systems Centre	278.05	267.00	268.95	309.00	278.18	311.75
4b	Cryogenic Upper Stage Project	0.10	0.00	0.00	0.00	0.00	0.00
4c	Semi Cryogenic Engine Development	150.00	105.00	105.00	150.00	143.00	160.00
5	ISRO Propulsion Complex	193.50	172.50	174.45	238.00	217.30	333.00

Sl. No.	Programmes/Projects/Centres/Units	Budget 2014-2015	Revised 2014-2015	Actuals 2014-2015	Budget 2015-2016	Revised 2015-2016	Budget 2016-2017
6	**ISRO Satellite Centre & its Projects**						
6a	ISRO Satellite Centre	369.16	368.25	366.75	386.00	382.55	418.00
6b	Geo-Imaging Satellite (GISAT)	63.00	41.74	42.07	80.00	50.79	70.00
6c	Resourcesat-2A	50.00	31.85	30.65	50.00	49.88	75.00
6d	Cartosat-3	10.00	0.00	0.00	50.00	18.30	30.00
6e	Scattsat	10.00	0.00	0.00	30.00	11.00	35.00
6f	RISAT-1A	1.00	0.00	0.00	2.00	10.20	35.00
6g	Oceansat-3 & 3A	25.00	0.00	0.00	25.00	14.70	30.00
6h	Cartosat-2E	25.00	5.00	4.78	45.00	22.53	50.00
6i	Risat-3	1.00	0.00	0.00	2.00	0.00	0.10
6j	Navigational Satellite System (including IRNSS)	120.00	94.25	95.38	120.00	107.30	80.00
6k	NASA ISRO Synthetic Aperature Radar Mission (NISAR)	0.00	0.00	0.00	50.00	25.98	100.00
6l	Resourcesat-3	0.00	0.00	0.00	0.00	0.00	20.00
6m	Advance Ordering	0.00	0.00	0.00	0.00	0.00	5.00
7	Laboratory for Electro-Optics System	60.13	58.00	58.22	60.00	50.65	45.00
8	**Satish Dhawan Space Centre - SHAR & its Projects**						
	Satish Dhawan Space Centre - SHAR	508.30	524.00	525.75	559.00	592.68	598.00
	Second Vehicle Assembly Building (SVAB)	50.00	3.00	3.00	120.00	130.00	245.00
9	ISRO Telemetry, Tracking and Command Network	157.04	139.50	137.82	185.00	159.30	170.00
10	ISRO Hqs (including Central Management)	121.78	94.44	92.83	124.90	119.56	137.41
11	International Co-operation	4.37	3.32	4.20	4.60	4.60	4.00
12	Master Control Facility	84.07	60.85	61.13	90.00	79.55	108.00
13	Development of Space Materials and Components	24.55	12.20	12.18	26.00	12.00	0.00
14	Advance Ordering	25.00	13.60	13.60	24.00	11.40	0.00
	TOTAL : SPACE TECHNOLOGY	**4198.12**	**3366.02**	**3375.53**	**4504.29**	**4274.99**	**4955.68**
	SPACE SCIENCES						
15	Space Applications Centre	426.03	376.00	377.17	452.00	524.02	578.39
16	Development & Educational Communication Unit	40.80	17.67	17.65	44.41	14.20	22.00
17	**ISRO Space Applications Programmes**						
17a	Earth Observation Applications Mission	4.03	2.71	2.71	5.20	3.70	5.00

Sl. No.	Programmes/Projects/Centres/Units	Budget 2014-2015	Revised 2014-2015	Actuals 2014-2015	Budget 2015-2016	Revised 2015-2016	Budget 2016-2017
17b	National Natural Resources Management System	30.30	20.00	19.95	56.70	50.10	35.00
17c	Disaster Management Support	21.37	22.85	23.30	30.00	35.12	22.00
18	National Remote Sensing Centre	244.09	246.00	244.75	305.00	285.00	312.00
19	Indian Institute of Remote Sensing (IIRS)	40.55	32.07	30.54	44.00	41.47	45.00
	TOTAL : SPACE APPLICATIONS	**807.17**	**717.30**	**716.07**	**937.31**	**953.61**	**1019.39**
	SPACE SCIENCES						
20	ISRO Space Science Programmes						
20a	ISRO Geosphere-Biosphere Programme	20.00	12.63	11.11	20.00	17.30	0.00
20b	Sensor Payload Development/Planetary Science Programme	2.60	0.96	0.96	2.50	0.90	0.50
20c	Sponsored Research (RESPOND)	21.72	18.50	18.50	25.15	24.85	24.00
20d	Atmospheric Science Programme	23.37	11.53	11.51	11.50	12.38	0.00
20e	Small Satellites for Atmospheric Studies & Astronomy	2.60	0.45	0.45	2.40	0.68	2.10
20f	Other Schemes	5.75	3.25	2.47	5.50	20.03	0.00
20g	Space Science Promotion	0.00	0.00	0.00	0.00	0.00	6.05
20h	Climate & Atmospheric Programme	0.00	0.00	0.00	0.00	0.00	35.20
21	ADITYA	27.00	6.90	6.86	20.00	14.00	25.00
22	Indian Lunar Mission-Chandrayaan-1&2	60.00	37.60	35.98	40.00	51.50	80.00
23	Astrosat-1 & 2	4.50	1.50	1.43	3.00	2.00	1.00
24	Mars Orbiter Mission	71.00	87.20	90.83	6.00	6.65	0.00
25	X-RAY Polarimeter Mission (Xposat)	0.00	0.00	0.00	0.00	0.00	5.00
26	Space Docking Experiment Mission	0.00	0.00	0.00	0.00	0.00	0.10
	TOTAL : SPACE SCIENCES	**238.54**	**180.52**	**180.10**	**136.05**	**150.29**	**178.95**
	INSAT SATELLITE SYSTEM						
27	INSAT Satellite System						
27a	INSAT-3 Satellites (including launch services)	10.00	10.55	10.34	17.00	11.08	14.00
27b	INSAT-4 Satellites (including launch services & leasing of Transponders)	37.90	29.72	29.08	34.00	16.93	15.10
27c	Service Charges for Leasing of Transpomders	75.24	79.40	70.50	93.00	72.87	75.00
27d	GSAT-7 Satellites (Launch Services)	1.05	1.55	1.51	0.00	0.00	0.00

Sl. No.	Programmes/Projects/Centres/Units	Budget 2014-2015	Revised 2014-2015	Actuals 2014-2015	Budget 2015-2016	Revised 2015-2016	Budget 2016-2017
27e	Advanced Communication Satellite (GSAT-11 including Launch Services)	164.50	141.00	140.01	31.00	33.40	30.00
27f	INSAT-3D Launch Services	1.15	1.40	1.35	0.00	0.00	0.00
27g	GSAT-15 Satellite	110.00	92.35	92.59	120.00	131.70	34.00
27h	GSAT-15 Satellites-Launch Services	378.00	320.13	320.12	45.00	39.50	2.00
27i	GSAT-16 Satellites	110.00	168.25	167.05	45.00	36.22	1.10
27j	GSAT-16 Satellites-Launch Services	433.00	359.83	359.72	1.00	1.50	0.00
27k	GSAT-17 Satellite	50.00	0.00	0.00	95.00	47.72	120.00
27l	GSAT-17 Satellite- Launch Services	10.00	0.00	0.00	235.00	171.58	302.50
27m	GSAT-18 Satellite	50.00	0.00	0.00	95.00	127.00	120.00
27n	GSAT-18 Satellite- Launch Services	10.00	0.00	0.00	412.00	426.30	55.00
27o	GSAT-19 Satellite	10.00	0.00	0.00	25.00	5.80	25.00
27p	GSAT-20 Satellite	0.00	0.00	0.00	0.00	0.00	1.00
27q	GSAT follow-on Satellites including Launch Services	20.00	0.00	0.00	1.00	0.00	0.20
27r	Augmentation of Capacity through leasing of transponders from foreign Satellite	47.80	0.00	0.00	10.00	0.00	1.00
27s	Procurement of Heavier class of Satellites	10.00	0.00	0.00	1.00	0.00	0.10
27t	Development of a Satellite for SAARC Countries	0.00	0.00	0.00	2.00	0.00	0.10
	TOTAL : INSAT SATELLITE SYSTEM	**1528.64**	**1204.18**	**1192.27**	**1262.00**	**1121.60**	**796.10**
	ASSISTANCE TO AUTONOMOUS BODIES						
28	Indian Institute of Space Science & Technology (IIST)	122.50	80.00	80.00	151.00	76.50	73.00
29	Semi-conductor Laboratory	114.27	112.00	88.91	179.44	194.00	278.37
30	North Eastern Space Applications Centre	21.80	18.90	18.90	25.00	14.02	20.50
31	Physical Research Laboratory	156.80	105.33	105.33	141.00	124.26	132.20
32	National Atmospheric Research Laboratory (NARL)	22.96	20.00	20.00	23.20	23.20	26.80
	TOTAL : ASSISTANCE TO AUTONOMOUS BODIES	**438.33**	**336.23**	**313.14**	**519.64**	**431.98**	**530.87**
	GRAND TOTAL : GROSS	**7238.00**	**5826.00**	**5798.81**	**7388.19**	**6959.44**	**7509.14**
	Deduct Recoveries	0.00	0.00	0.00	0.00	0.00	0.00
	TOTAL : (NET)	**7238.00**	**5826.00**	**5798.81**	**7388.19**	**6959.44**	**7509.14**

AUTONOMOUS BODIES OF DOS/ISRO

1. Physical Research Laboratory (PRL)

(₹in crores)

Budget 2015-2016	Revised 2015-2016	Budget 2016-2017
141.00	124.26	132.20

1.1 The Physical Research Laboratory (PRL) at Ahmedabad is an autonomous Institution supported mainly by the Department of Space. It is a premier Institute engaged in basic research in the fields of Astronomy, Planetary, Space, Atmospheric & Earth Sciences and Theoretical Physics. Academic programmes of PRL also include Doctoral & post-Doctoral research, summer programmes for science & engineering graduate students, Associateship programme for University teachers and outreach activities for high school students and general public.

1.2 Major Achievements Completed and Planned during 2015-2016

- Provided polarimetry algorithm to enable hard X-ray polarimetry, first of its kind, with the Cadmium zinc Telluride Imager (CZTI) on board Astrosat. Caliberation and response matrix were performed. First results have demonstrated capability of the instrument to detect X-ray polarimetry in the X-ray bright sources;
- A study conducted using ground based magetograms from Kitt peak/NSO shows that sun's photospheric magnetic fields are continuously declining since 1995 and trends indicate such phase to continue until 2020, well over one full magnetic cycle;
- Photo-spectroscopic observations from Mt. Abu using near infrared camera demonstrated that Nova Sco 2015 is a symbiotic system containing a giant secondary. It is indicated by the presence of decelerative shock accompanying the passage of the ejecta through giant's wheel;
- Multi-Application Solar Telescope (MAST) operationalized in June 2015. Regular observations in G-band (photosphere) & in H-alpha (chromosphere) are now being taken simultaneously for studies of active solar regions;
- Signatures of flare-induced global oscillations in the Sun were reported using Doppler and intensity measurements from GOLF and VIRGO instruments, respectively;
- Large scale contraction of overlying coronal loops in pre-flare phase as manifestation of localized energy release reported;
- Simulation studies of dynamics of magnetic field lines involving repetitive magnetic reconnection reveal formation of helical structure, resembling tornadoes on the sun;
- Study of the relative signs of chiral and shear components of the electric current in a sunspot supports a monolithic flux-tube model of the sunspot magnetic field;

- Searched presolar silicate and oxide grainsin a section of Isheyevo meteorite, with a focustowards lithic class with extreme nitrogen isotopic composition. Using high spatial resolution (~150 nm) mapping with nanoSIMS, 6 such grains were identified which also have excess/deficit of isotopes 17O and 18O. Four of these grains are formed in envelopes of red giant branch (RGB) or asymptotic giant branch (AGB) stars. A single grain was observed to be highly enriched in the heavy O isotopes and probably formed either in stars with higher-than-solar metallicity or originated in a supernovae;
- Our new study of diamonds from Ureilite (a differentiated primitive group of achondrites) revised solar abundance of 40Ar from 27 to 11 atoms with respect to 106 atoms of Si. It is very difficult rneasurements as in most of the solar system material, 40Ar is mostly radiogenic origin and produced due to decay of 40K;
- A new chromatographic procedure for simultaneous extraction of Si and Mg has been established. This experimental development is a major step in facilitating the simultaneous study of silicon and magnesium isotope systematics of differentiated meteorites to understand core formation process and time scales for formation of planetesimals and planets;
- Similar variations in Ring current intensity and high-latitude electron density provide evidence for high-to-low latitude coupling suggesting that these two independent processes are being controlled by same source of energy dissipation in magnetosphere;
- It is shown that 3 independent magnetosphere-ionosphere coupling mechanisms are operational during a long duration electric field prompt penetration event; Aerosol optical depths simulated by global models are lower than measured aerosol optical depths due to the absence of seasonal cycle in models which is attributed to the lack of proper representation of aerosol emissions and not due to meteorology;
- Inter-correlations among CO2, CH4 and CO show dominance of fossil fuel emissions over Ahmedabad;
- Biogenic sources contribute ~30% to total isoprene, a volatile organic compound, in Ahmedabad;
- Dissolved Fe (DFe), an essential micronutrients in ocean is measured in Arabian Sea onboard Sagar Kanya. Western Arabian Sea has lower DFe with higher N/Fe ratio compared to western part, however western Arabian Sea does not seem to be Fe deficient in October. Shelf region of the Eastern Arabian Sea and oxygen minimum zone has higher concentration DFe acting as source of Fe in the Arabian Sea;
- Enhanced supply of dissolved organic carbon (DOC) from reverence sources controls the DOC budget in the Bay of Bengal;
- Chemical composition of aerosol coupled with thermodynamical model suggest the disequilibrium between gas and particle phase;
- Geochronology and geochemical studies of xenoliths and their host lavas from the subaerial base of Barren Island, the lone active volcano of India, reveal that the volcano had emerged out of the sea at ~1.6 millionyears ago and that the oceanic crust on which it is located is ~106 million years old;

- The Majorana nature of neutrinos (being their own anti-particles) can have a significant impact on particle phenomenology. It can be probed via neutrino less double beta decay experiments as well as at LHC. In specific models, an interplay of correlations between results from neutrino oscillations, Higgs physics and direct searches at LHC have been studied, and new constraints obtained;
- Electric dipole moments of atoms offer a complementary probe to study physics beyond the standard model of particle physics. New improved limits on the couplings and nuclear Schiff moment have been obtained via computationally intensive atomic calculations;
- The vorticity of a light beam has been recovered after scattering through a rough surface. The results can be very useful for free space optical communication using spatial modes of light;
- New experimental schemes for efficient teleportation and quantum key distribution have been proposed using three particle entanglement;
- Developed a high-power (1.06 W), high-repetition-rate (78 MHz), Vb-fiber laser based femtosecond (576 fs) source at 355 nm that will be used for generating a bright source of entangled photons;
- Luminescence of natural BaS04 was examined rigorously and based on this study its use for geochronology (oceanic sediments) and retrospective dosimetry with a minimum detectable dose of 1.5mGy was observed;
- It was demonstrated that it is possible to date past earthquakes using sand dikes. Calculation on heating during grain friction associated with viscous flow during dike injection indicated that heating during dike injection can be >300C suggesting past luminescence was reset and that the dike signal corresponds to the age of its emplacement. Application to a set of 50 samples from Assam suggeststhat it faced four earthquakes of magnitude betweenM 6 to M 7.5 at 110,300, 500 and 1 ka. This works establishes a new methodology for dating past earth quakes;
- The first VUV photoabsorption spectra of carbonic acid and aromatic residue in the ice phase were recorded;
- The VUV spectra of CO2 revealed phase change at lower temperature than previously thought. In addition VUV spectra of irradiated CO2 ice showed oxygen synthesis during warm up phase

1.3 **Major Programmes for 2015-2016**

- PRL is in the process of acquiring a new 2.5m optical telescope. Work on the related facilities and development of the back-end instrument for the new telescope will be major activity for the years to come. Work on developing a faint object spectrograph and camera (MFOSC) is already underway;
- A new program to study line emitting regions in AGNs (BLR and NLR) using multi-wavelength observations is planned which will help in understanding the central engine and physical processes responsible for the emission;
- Studies related to response of chromosphere and corona to the photospheric magnetic fields using the data obtained from MAST in combination with SDO and Hinode;

- Integration and operationalization of spectro-polarimeter for magnetic field measurements;
- Study of scientific issues related to the development of HXR spectrometer in the context of HEIIOS payload on board ADITYA;
- Development of a magnetic field extrapolation code based on non-force-free model of the coronal field and its integration to MAST observations;
- Integration of Adaptive Optics system for MAST to obtain continuous high resolution observations and integration and testing of Narrow band Imager and polarimeter with the MAST telescope;
- Understanding the differentiation of planets using stable and extinct radio isotopes;
- Study of presolar grains in primitive meteorites with aim to constrain the contributions of different stellar spurces to our presolar nebula;
- Interplanetary journey of asteroid using cosmogenic noble gases;
- Laboratory simulation experiment to understand the surface processes of the Moon and Mars;
- A Laser-ablation inductively coupled plasma mass spectrometer is being procured for geochemical investigations of Martian meteorites;
- Proposed to install a VHF All-Sky Momentum flux Meteor Radar system in the Indian latitude region with an objective to study characterization of tides, gravity waves and planetary waves over the ionization crest region;
- Planned to establish an observational setup to characterize natural aerosols, and their hygroscopic growth along with cloud characteristics;
- Planned to establish the experimental setup for trace level (pptv) detection of C2-C6 & C6-C12
- NonMethane Hydrocarbons (NMHCs);
- Plaeoclimate reconstruction at hundred, millennium and million year time scale using terrestrial and marine archives;
- Tracking the contemporary and paleo-ocean circulation and assessing the impact of varying ocean circulation on productivity and climate change of the past;
- New experimental facility to understand shock processing of astrochemical ices and UV
- spectroscopy of the formed ices;
- Study the nonlinear interaction of entangled photons;
- Generation and characterization of quantum sources of light;
- Developing lab for quantum space communication;
- Development of violet stimulated luminescence of Quartz and Feldspars for radiation dosimetry and geochronology.

2. National Atmospheric Research Laboratory (NARL)

(₹ in crores)

Budget 2015-2016	Revised 2015-2016	Budget 2016-2017
23.20	23.20	26.80

2.1 The National Atmospheric Research Laboratory (NARL) at Gadanki near Tirupati in Andhra Pradesh, is an autonomous Institution fully funded by the Department of Space, Government of India. The main activities of NARL are (i) carrying out fundamental research related to Earth's atmosphere using a variety of state-of-the-art equipments such as the Mesosphere-Stratosphere-Troposphere (MST) Radar, lidars, wind profilers, GPS balloon sonde, automatic weather station etc., (ii) research and development of advanced technology for atmospheric studies and transfer of the same to Indian industries and (iii) Modeling and prediction of weather and climate. NARL encourages national and international Institutes and Universities to make use of its facilities for front ranking research in atmospheric science.

2.2 **Major Achievements during 2015-2016**

- Up-gradation of MST Radar into a fully active array system is in the advanced stage of completion. All the T/R modules are installed in the field and integration and tests are in progress. The system will be made fully operational by March 2016;
- Realization of a Tethered Balloon Observation Platform (TBOP) to obtain height profiles of aerosol concentrations, trace gas concentrations, turbulence intensities etc., is at an advanced stage. The first test launch has already been carried out at the TIFR Balloon Facility, Hyderabad. The second test launch is planned in the first quarter of 2016 at NARL, Gadanki;
- Development of a Differential Absorption Lidar (DIAL) for obtaining ozone concentration profile up to stratopause altitude has been initiated. The laboratory space has been identified in the top floor of the newly inaugurated "Green Building". The automatic roof top has been realized;
- A new program for the detailed investigation of the rural boundary layer atmospheric chemistry involving Ozone and volatile organic compounds has been initiated. Procurement of necessary laboratory equipments like Gas Chromotography has been initiated;
- An advanced mesosphere lower thermosphere photometer capable of making OH, O2 and O (1D) airglow emissions from mesosphere and above is successfully developed and installed;
- Brewer/Dobson Spectrophotometer for regular monitoring of the vertical profile of ozone has been successfully installed and commissioned;
- A joint experiment with NASA LaRC Scientists involving simultaneous balloon and lidar experiments from Gadanki was conducted to study the Asian Tropospheric Aerosol Layer;
- Dual Polarization LIDAR [DPL] technology developed at NARL has been transferred to M/s Opel India, Pune and M/s Holmarc, Kochi through the Technology Transfer Group (TTG) of ANTRIX/ISRO.

2.3 **Major Programmes for 2016-2017**

- In-house development of Digital receiver with Universal software radio peripheral;
- Latitudinal and a longitudinal network of stand-alone state of the art GNSS receivers is planned to derive meteorological and ionospheric parameters;
- Detailed study of Martian atmospheric dynamics and the ionosphere using data obtained from various earlier satellite missions launched by US & EU and India's MOM is planned;
- A Hotwire anemometer has been procured. Necessary calibrations and sensitivity analysis will be carried out at NARL. It is planned to test the performance of the anemometer by installing it on 50 m tower close to the ultrasonic anemometer;
- Chemical Transport Modelling will be developed to understand the role of different physical and chemical mechanisms on trace gases and aerosols and to understand the aerosol-feedback mechanism on weather. It will also be used to study the effect of dust and bio-mass burning on Indian megacities;
- Prediction of centennial scale climate using earth system models under different scenario will be made;
- Study of intra-seasonal variability of Indian Summer Monsoon rainfall using satellite data and global climate models and study of role of land surface processes on regional climate forecast;
- Development of satellite earth station for the reception of free to air data from environmental satellites available for numerical weather predictions.

3. North-Eastern Space Application Centre (NE-SAC)

(₹ in crores)

Budget 2015-2016	Revised 2015-2016	Budget 2016-2017
25.00	14.02	20.50

3.1 The North-Eastern Space Applications Centre (NE-SAC) located at Shillong is an autonomous society set up jointly with the North-Eastern Council to support the North-Eastern Region by providing information on natural resources utilisation & monitoring, infrastructure developmental planning & interactive training using space technology inputs of remote sensing & satellite communication. The Centre networks with the State Governments in the North- Eastern Region and the North-Eastern Council for generating solutions for the developmental activities of the Region.

3.2 Major Achievements during 2015-2016

- Preparation of working plan inputs for Meghalaya has been completed and the Project is in progress in the States of Arunachal Pradesh, Assam and Sikkim in participation with the State Forest Departments;

- Rice acreage estimation has been completed in four NE hilly States viz. Arunachal Pradesh, Meghalaya, Mizoram and Tripura under FASAL Programme;
- Potential area mapping for sericulture development completed for 108 districts covering 24 States and Project atlas officially released by the Hon'ble Union Minister of Textiles on Nov 17, 2015;
- Soil and land capability mapping has been completed for major agricultural districts of North Eastern Region;
- NE-SAC is coordinating the Space Based Information Support for Decentralized Planning (SIS-DP) for NER in collaboration with State Centres of NER. Project work for the State of Meghalaya has been carried out by NE-SAC;
- Space Based Information System on North Eastern Region (SBIK-NER) North Eastern District Resources Plan (NEDRP) portals have been established in all NE states;
- Mining area mapping of Meghalaya completed for Jaintia Hills District;
- Development of an Urban Information System for Nongpoh Town in Ri Bhoi district of Meghalaya;
- NE-SAC has handled the ISRO's Tele-education project in North- Eastern States. Executed Comprehensive Annual Maintenance Contract (CAMC), Establishment of Technical Support & Training Centre (TSTC) contract & Hub Operation (HO) contract for overall management of the project in NER;
- Under ISRO-NEC joint Telemedicine Project migrated and re-commissioned various Telemedicine nodes and also initiated the revival process for all non-working nodes by procuring/dispatching spares, troubling shooting, site visit etc.;
- Under Village Resource Program, conducted a Rapid Sample Survey on VRC applications to understand the VRC impact on villagers in the States of Assam, Nagaland and Sikkim submitted the report to ISRO;
- Under Integrated Service Pilot Network Demonstration of ISRO to PMO, conducted all the activities at North East node;
- Participated in the IRNSS+GPS SPS receiver experiment of ISRO at NE-SAC in collaboration with SAC. Equipments commissioned at NE-SAC and data collection/analysis/dissemination is continued;
- SATCOM studio is maintained at operational level. Under Communication Support in Disaster Management (CSDM), ISRO-VPN node, Type D terminals are maintained at operational level; continued group SMS based alert services under FLEWS Project for the flood affected district of Assam;
- Assimilation of the satellite radiance data from Meghatropiques and DWR data into the WRF model to improve the forecast accuracy further;
- Aerosol radiative forcing estimates have been made for Umiam and also for all locations where data were collected during both the land campaigns using Santa Barbara DISORT Atmospheric Radiative Transfer Model;

- The Doppler Weather Radar (DWR) at Cherrapunjee has been installed and sub-system testing is being done in collaboration with ISTRAC, Bengaluru;
- High resolution weather forecasting for NER using both WRF and MM5 model. Experiment to be continued with different physical schemes to identify the one most suitable for NER;
- Establishment of High Power Computing System for numerical weather prediction;
- Extension of the Flood Early Warning System (FLEWS) to all flood prone districts of Assam by integrating inputs from various stakeholders involved in flood management. Emphasis will be given to forecast the extent and level of inundation with larger lead time;
- Under NER-DRR, standard operating procedures (SOP) have been prepared for different disasters. Apart from this geoportal development and dissemination of alert through mobile applications has been initiated;
- Assessment and monitoring of River embankment breach locations in Assam.

3.3 Major Programmes for 2016-2017

- The following remote sensing and GIS application projects will be continued/initiated during 2016-17:
    - Preparation of working plan inputs for the States of Arunachal Pradesh, Assam and Sikkim to be completed in participation with the State Forest Departments;
    - Rice acreage estimation has been completed in the States of Manipur and Sikkim under FASAL Programme;
    - To initiate NER component of the CHAMAN Project under Ministry of Agriculture, Govt. of India;
    - To initiate the second phase of the Project on Applications of Remote sensing and GIS in 20 priority districts in NER;
    - Mapping of suitable areas for Boro rice in Meghalaya;
    - To coordinate activities under under Space Based Information Support for Decentralized Planning (SIS-DP) for NER in collaboration with State Centres of NER;
    - Crop condition assessment under abiotic stress of few selected major crops of NER using remote sensing technique;
    - Land evaluation for organic crop planning in Assam using RS & GIS techniques;
    - Hydrological Impact Assessment with Climate and Land Use Change Dynamics of Loktak Lake, Manipur;
    - Studies on Spatio-temporal variation in land-surface and energy balance parameters and its effect on rainfall distribution and crop productivity in NER.;

- The following SATCOM activities will be continued/ initiated during 2016-17:
    - Handling of ISRO's Tele-education project in North Eastern States including revival of all faulty nodes/HUB and make all the network fully functional;
    - Setting up a new Tele-education network in the State of Manipur;
    - Revival of ISRO-NEC joint Telemedicine Project in NER in association with DECU by procuring/dispatching spares, troubling shooting, site visit, migration etc.;
    - Revival of Village Resource Centre network in NER in association with ISRO HQ.;
    - Conduction of the actual demonstration with PMO under Integrated Service Pilot Network of ISRO and initiate a pilot network;
    - Working for the IRNSS+GPS SPS receiver experiment of ISRO at NESAC in collaboration with SAC;
    - Starting of the ISRO's Ka-band propagation experiments at NESAC in collaboration ONERA, France;
- The following Space Science activities will be continued/initiated during 2016-17:
    - Assimilation of Doppler Weather Radar (DWR) data from all three DWRs (Cherrapunjee, Agartala, and Mohanbari) in NER of India into the WRF model to improve the forecast accuracy further. Implementation of 4D VAR assimilation technique using WRF model;
    - Operationalisation of DWR at Cherrapunjee in association with ISTRAC;
    - Calibration and Validation of the DWR at Cherrapunjee in collaboration with ISTRAC, BEL and IMD;
    - Research on radar backscatter and precipitation (Z-R) relations for NER of India using data from all available DWRs;
    - Thunderstorm nowcasting using DWR and WRF model data;
    - Setting up a aerosol monitoring laboratory at Tawang, Arunachal Pradesh under the Aerosol Radiative Forcing over India (ARFI) project in collaboration with SPL, Thiruvananthapuram;
    - Augmentation of the high performance computing system with more computing system and storage;
- The following Disaster Management Support Programme activities will be continued/initiated during 2016-17:
    - Extension of the Flood Early Warning System (FLEWS) to all flood prone districts of Assam by integrating inputs from various stakeholders involved in flood management. Emphasis will be given to forecast the extent and level of inundation with larger lead time;
    - Under NER-DRR, standard operating procedures (SOP) have been prepared for different disasters. Apart from this geoportal development and dissemination of alert through mobile applications has been initiated;
    - Assessment and monitoring of River embankment breach locations in Assam.

4. Semi-conductor Laboratory (SCL)

(₹ in crores)

Budget 2015-2016	Revised 2015-2016	Budget 2016-2017
179.44	194.00	278.37

4.1 SCL is entrusted with the task of Research & Development in the field of Microelectronics to meet the strategic need of the country in this vital area. SCL is engaged in the design, development, manufacturing, testing & assembly, packaging of CMOS, Imaging and MEMS devices, including development of Process Technology for various strategic applications. It is also involved in Hi-Rel Board fabrication & component screening for ISRO, indigenization of Electronic Boards for Air Force and production of Dr. Pisharoty Radio Sonde Systems for Atmospheric Studies. While the Design, Assembly, Testing, Quality/Reliability Assurance Facilities are already in place, the Manufacturing facility is being upgraded from 0.8µm CMOS 6" Wafer Fabrication to 0.18µm CMOS 8" Wafer Fabrication. The development and manufacture of ASICs for strategic sector is the major thrust area.

4.2 Major Achievements during 2015-2016

- 8" Wafer Fab Line is geared-up for production activities subsequent to completion of Fab Upgradation. Three Multi Product Wafer Lots have been fabed-out during the year with the first set of in-house designs;
- Total twenty eight ASICs/IPs/Test-Chips including QUAD Low Voltage Differential Signaling (LVDS) Transmitter, QUAD LVDS Receiver, Timing Sequencer, Vikram Processor, Video Processor Logic (VPL) ASIC, CCD Analog Signal Processor (CSP) - ADC1410,TDI Timing Sequencer, 32KB SRAM, LVDS Transmitter, Linear Voltage Regulator (LVR), Sigma Delta ADC, S-Band Low Noise Amplifier, CMOS Imager, RADHARD 8 Bit Shift Register, RADHARD 8 Bit Counter, Phase Locked Loop, 16bit Buffer, Standard Cells, CSP ASIC, Transceiver, 8KB SRAM and RADHARD Test Chip, have been fabricated in these Production Lots. All the devices are meeting expected performance and have been given to the respective users;
- Second set of twenty designs, completed in-house, including Programmable Bias Generator, Programmable Low Drop Out Regulator, 16 Bit Transceiver, C-to-D Converter, RS422 Receiver & Transmitter and RS485 Transceiver are under fabrication in the next set of Multi Product Wafer Lots. Another fifteen designs are getting ready for the third set of designs for fabrication;
- Along with device development, Processes for Analog Modules have been validated. These include Burried Well, High Resistance Poly, High Vt, Metal Insulator Metal and Thick Metal. Critical Electrical Parameters are meeting the specifications. Analog Modules have been released for integration into Baseline Process;
- A 5V CMOS Process has been developed for back compatibility. Electrical characterization of Lot for 5V CMOS Process Integration has been done. The parameters are within the target specifications. The process is released for design of 5V CMOS circuits for verification;

- Test Structures of NMOS Edge Less Transistor (ELT) and Ring Oscillator Circuits (with Standard PMOS & NMOS ELT) have been fabricated and characterized for RADHARD Cell Library of SCL Process Design Kit (PDK). Model for NMOS ELT has been validated for design of Digital Circuits in RADHARD. 8 Bit Shift Register and 8 Bit Binary Counter have been tested for Total Ionization Dose (TID) upto 500 Krad (Si). Single Event Effect (SEE) has also been tested upto 50 MeV-cm2/mg. No upset/latch-up is observed. A Cell Library employing RADHARD by Design technique is being developed using ELT. 80 cells have already been designed. The Cell Library development shall continue during the year;
- Four Lots are running under fabrication for Process Evaluation & Imager Test Structures and OCM-3 CCD Detectors. Fabrication of these Lots is at an advance stage and scheduled to be completed by December 2015. Characterization shall be taken-up for these devices;
- Fabrication of Acoustic Sensor and Gyroscope has been completed as part of ongoing MEMS activities. Acoustic Sensor has been given to VSSC for evaluation. Gyroscope devices are being packaged and shall be given to IISU for testing;
- Pressure Sensor has been integrated with heater and its temperature sensitivity has been characterized;
- Activity of indigenization has been taken-up in the area of Ceramic Packages for ASICs in association with VSSC, SAC and LPSC, for bulk chemicals like Ultrapure HCl with VSSC and for Photo Resists & Slurries with IIT-Mandi. Design of 64 pin Quad Flat Package has been completed. Fabrication has been carried-out at SAC. Results are satisfactory. Results of functional tests on Ultrapure HCl prepared at VSSC are comparable with imported chemical. Chemical analysis is in progress;
- Pisharoty Sonde Systems continued to be delivered to various National Institutions engaged in Atmospheric Studies including units of ISRO and other Universities. A total of 820 in 2015-16 (till October'15) have been delivered to these organizations. A total of 1500 Systems are planned to be delivered this year;
- Trial ascents of Pisharoty Sonde System with Humidity Sensors, fabricated at SCL, have been carried-out at Thumba Equatorial Rocket Launching Station (TERLS). Results are comparable to imported sensors. Humidity Sensors have also been given to IIT-Bombay for soil moisture measurements. The results are satisfactory;
- Development of three prototypes of Firemod Kits for Mi-25/35 and Mi17.1V Helicopters has been taken-up for Indian Air Force as a result of continued satisfactory performance of SCL's earlier delivered Firemod Kits for Mi-8 and Mi-17;
- Production of 10000 no. of ASICs for 3-Phase Electric Locomotive of Indian Railways is planned for the year. 6300 no. have been delivered till October'15;
- Assembly & Hi-Rel Fabrication support to other ISRO Units:

o Wiring of 21 cards, 148 connectors, 100 Signal Conditioning Modules (for LPSC) and assembly of 52 Ultrasonic Liquid Level Sensor (USLS) Devices for LPSC subject to Centre's requirements and schedules.

- Screening of total 19400 active and passive devices has been completed till October'15 for various ISRO Units during the year. Screening activity shall continue as per requirements of ISRO Units

4.3 **Major Programmes for 2016-2017**

- Fabrication of in-house designed ASICs/IPs/Test-Circuits shall be taken up as per requirements of DOS/ISRO Units and other Strategic Sector Organization like Units of DAE and DRDO;
- Yield optimization and production ramp-up in the 8” CMOS Wafer Fab;
- Qualification of 0.18µm CMOS Process on 8” Wafer Fab Line;
- 0.18µm CMOS Process Enhancements for RF-Passives Integration (Inductor, Varactor) and LDMOS (10-20V VDD);
- Development of Silicon Photo-multiplier Sensors for BARC;
- Establishment of Large Area Silicon Detector Processing Facility;
- Setting-up of Wafer Reclaim Capability and Chemical Lab Capability for analysis of chemicals used in Wafer Fab;
- Establishment of Failure Analysis (FA) Facility;
- Completion of development of OCM-3 CCD Detector. Development of technology for CCD for 3D Imaging, 12K TDI CCD and CMOS Imager;
- Radhard by Design Cell Library Development;
- Activities of production and indigenization shall continue.

5. Indian Institute of Space Science & Technology (IIST)

(₹ in crores)

Budget 2015-2016	Revised 2015-2016	Budget 2016-2017
151.00	76.50	73.00

5.1 The Indian Institute of Space Science and Technology (IIST), an autonomous body under DOS was established with the primary objective of creating world class Institution in the area of advanced Space Science and Technology education and generating high quality human resources to meet the quality manpower requirements of DOS/ISRO. The Institute has undergraduate, postgraduate and doctoral programmes in the area of Space Science, Space Technology and Space Applications. The Institute has started functioning from the academic year 2007-2008, in the infrastructure provided by the Vikram Sarabhai Space Centre in Thiruvananthapuram. The Institute duly became a Deemed to be University in the year 2008. IIST has started functioning from its own campus at Valiamala, w.e.f. August 15, 2010. The under graduate programmes offered from 2015-16 are B.Tech in Aerospace Engineering and Avionics and a dual degree programme with B.Tech in Engineering Physics and MS I (i) Solid State Physics (ii) Astronomy & Astrophysics (iii) Eath System Sciences and (iv) M Tech in Optical Engineering.

5.2 The Institute has initiated 13 new M.Tech programmes and one new MS Programme 2 ½ years ago. 10 seats are allocated to each of these programmes out of which 4 seats are reserved for Scientists/ Engineers from DOS/ISRO while the remaining 6 seats are to be filled from the open category. The Institute

presently has 105 Ph. D students out of which 05 students have ISRO/IIST high value fellowship. 17 Ph D students have successfully completed their PH D programmes from the Institute. The Institute at present has a faculty strength of 94.

5.3 The infrastructure of the Institute presently consists of 2 academic blocks, 1 Library and 1 Administrative building together with 11 Hostels.

5.4 The Institute has MOU with Caltech, USA in which one B.Tech Aerospace Engineering student from 2009 and 2010 batches underwent MS Programme in Caltech for the year 2013-14 and 2014-15 under Prof. Satish Dhawan Fellowship Programme. One student from B.Tech (Aerospace Engineering), 2011 batch has gone to Caltech in 2015-16. The Institute also has an MoU with University Space Research Association (USRA) in which 5 B.Tech students of 2007 batch underwent their final semester project work during the year 2011 in Lunar Planetary Institute, Houston, USA and University of Texas, Arlington, USA

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