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Indian Space Research Organisation

अन्तरिक्ष भारत
SPACE INDIA

अप्रैल – दिसंबर 2011 April – December 2011

The Indian Space Programme

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

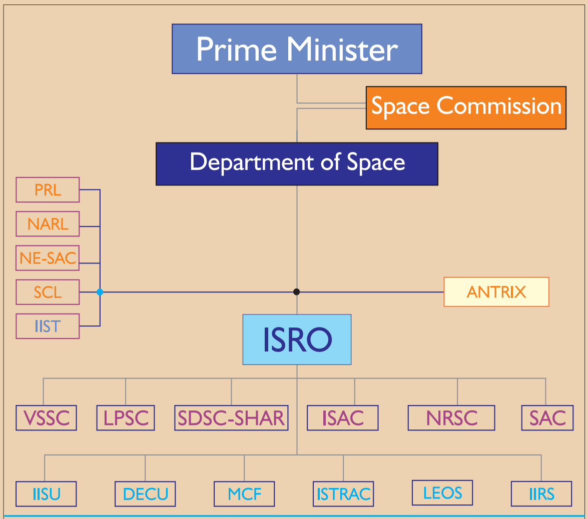
Department of Space (DOS) has the primary responsibility of promoting development of space science, technology and applications towards achieving self reliance and assisting in all round development of the nation. Towards this, DOS has evolved the following programmes:

- Indian National Satellite (INSAT) programme for telecommunications, TV broadcasting, meteorology, developmental education, etc.
- Remote Sensing programme for the application of satellite imagery for various developmental purposes.
- Indigenous capability for design and development of spacecraft and associated technologies for communications, resources survey and space sciences.
- Design and development of launch vehicles with indigenous technology for access to space and orbiting INSAT, IRS spacecraft and space science missions.
- Research and development in space sciences and technologies as well as application programme for national development.

The Space Commission formulates the policies and oversees the implementation of the Indian space programme to promote the development and application of space science and technology for the socio-economic benefit of the country. DOS implements these programmes through, mainly, Indian Space Research Organisation (ISRO), Physical Research Laboratory (PRL), National Atmospheric Research Laboratory (NARL), North Eastern-Space Applications Centre (NE-SAC) and Semi-Conductor Laboratory (SCL). Antrix Corporation, established in 1992 as a government owned company, markets space products and services.

Both the DOS and ISRO Headquarters are located at Bengaluru. The developmental activities are carried out at the Centres and Units spread over the country.

So far, 65 Indian Satellite Missions and 35 Launches from Sriharikota have been conducted.



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

The Centres of Indian Space Programme

अन्तरिक्ष भारत SPACE INDIA

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Cover Page: *Three successes in a row for PSLV in 2011*

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PSLV-C16 Successfully Launches RESOURCESAT-2, YOUTHSAT and X-SAT Satellites

In its seventeenth consecutive successful flight, India's Polar Satellite Launch Vehicle (PSLV-C16) injected three Satellites, viz., RESOURCESAT-2, YOUTHSAT and X-SAT (of Nanyang Technical University, Singapore) into their intended Polar Sun Synchronous orbits on April 20, 2011 from Satish Dhawan Space Centre (SDSC) SHAR, Sriharikota. All the three satellites were placed in the targeted orbits with high precision.

The orbital parameters achieved by PSLV-C16 while injecting the primary Satellite RESOURCESAT-2 were as follows:

Orbital Parameter	Specification Targeted	Achieved by PSLV- C16
Perigee	815 ± 20 km	808.6 km
Apogee	821 ± 20 km	815.6 km
Orbital Inclination	98.72 ± 0.2 degree	98.77 degree

With the precise injection of the RESOURCESAT-2 Satellite, about 20 kg of the fuel allocated for the probable dispersions in injection could be saved. This would help in enhancing the operational life of the Satellite.

RESOURCESAT-2: Immediately after the injection of Resourcesat-2, the two solar panels were deployed. Following this, the three Imaging Cameras were oriented towards Earth. All operations and health checks required prior to switching on the three Imaging Cameras were satisfactorily completed.

PSLV-C16 at the first Launch Pad

Orbital trimming manoeuvre was conducted successfully on April 22, 2011 and RESOURCESAT-2 was placed in the final orbital configuration in a Sun Synchronous polar Orbit with a perigee of 813 km, apogee of 825 km and inclination of 98.78 degree. Operation of the Imaging cameras commenced on April 28, 2011. The first imaging pass covered about 3000 km stretch of Indian landmass from Joshimut (in Uttarakhand) to Kannur (in Kerala).

YOUTHSAT: The health of YOUTHSAT was also found normal. First, the two Indian payloads, viz., Limb Viewing Hyperspectral Imager (LiVHySI) and Radio Beacon for Ionospheric Tomography (RaBIT) and later the Russian payload, Solar Radiation Experiment (SOLRAD), were switched on. Their performance was found satisfactory.

Payload data from YOUTHSAT is processed at the Indian Space Science Data Centre at Byalalu, (near Bangalore).

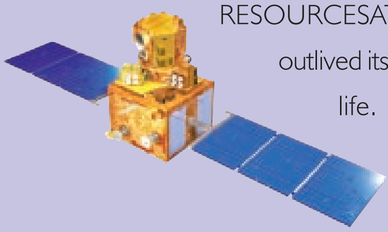
X-SAT: The health of the X-SAT and the performance of the various on-board sub-systems was also normal.

The Tracking, Control and Commanding operations for RESOURCESAT-2 and YOUTHSAT satellites are carried out from ISROs Telemetry Tracking and Command Network Centre (ISTRAC) located at Bangalore, connected to a network of ground stations at Lucknow, Mauritius, Biak (Indonesia) and Svalbard (near North Pole).

RESOURCESAT-2

RESOURCESAT-2 is the eighteenth Remote Sensing satellite built by ISRO and is a follow on mission to RESOURCESAT-1 (launched in 2003).

RESOURCESAT-2 is intended to continue the remote sensing data services to global users provided by RESOURCESAT-1, that has far outlived its designed mission life. Also it provides data with enhanced multispectral and spatial coverage as well.



RESOURCESAT-2 carries Three cameras which are similar to those of RESOURCESAT-1. They are:

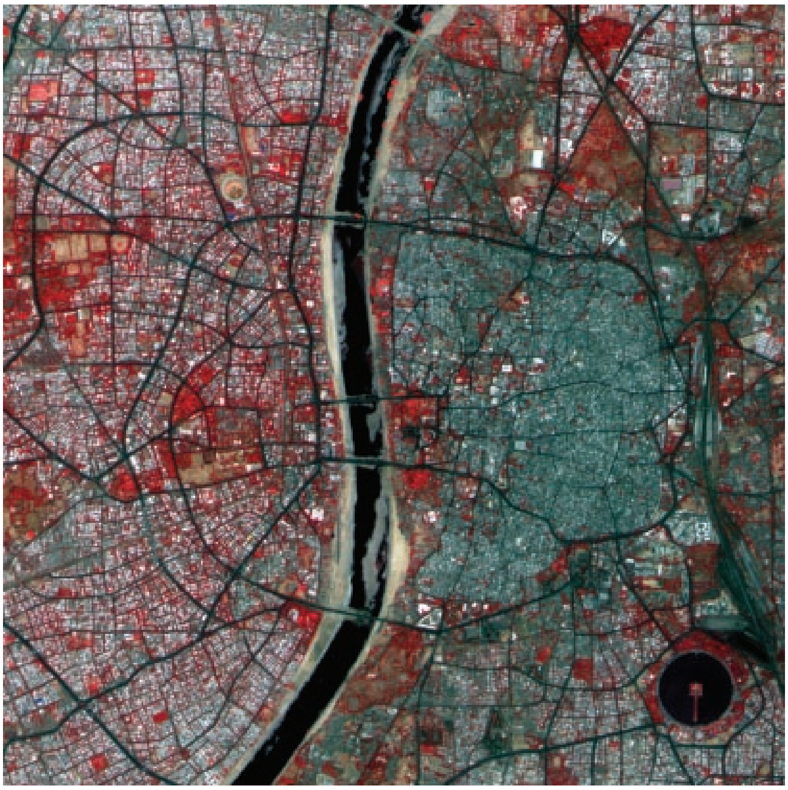
a) A high resolution Linear Imaging Self Scanner (LISS-4) operating in three spectral bands in the Visible and Near Infrared Region (VNIR) with 5.8 m spatial resolution and steerable up to ± 26 deg across track to achieve a five day revisit capability

b) A medium resolution LISS-3 operating in three-spectral bands in VNIR and one in Short Wave Infrared (SWIR) band with 23.5 metre spatial resolution

c) A coarse resolution Advanced Wide Field Sensor (AWiFS) operating in three spectral bands in VNIR and one band in SWIR with 56 metre spatial resolution

Resourcesat-2 undergoing Pre-launch tests

Important changes in RESOURCESAT-2 compared to RESOURCESAT-1 are: Enhancement of LISS-4 multispectral swath from 23 km to 70 km and improved Radiometric accuracy from 7 bits to 10 bits for LISS-3 and LISS-4 and 10 bits to 12 bits for AWIFS. Besides, suitable changes, including miniaturisation in payload electronics, were made in RESOURCESAT-2.



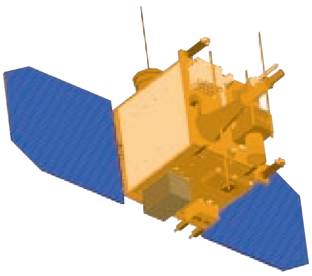
Ahmedabad, as seen by LISS-IV Camera of Resourcesat-2

RESOURCESAT-2 also carries an additional payload known as Automatic Identification System (AIS) from COMDEV, Canada as an experimental payload for ship surveillance in VHF band to derive position, speed and other information about ships.

RESOURCESAT-2 carries two Solid State Recorders with a capacity of 200 Giga Bytes each to store the images taken by its cameras which can be read out later to ground stations.

YOUTHSAT

YOUTHSAT is a joint Indo-Russian satellite for stellar and atmospheric studies with the participation of students from Universities at graduate and post graduate level. With a lift-off mass of 92 kg, Youthsat intends to investigate the relationship between solar variability and thermosphere-



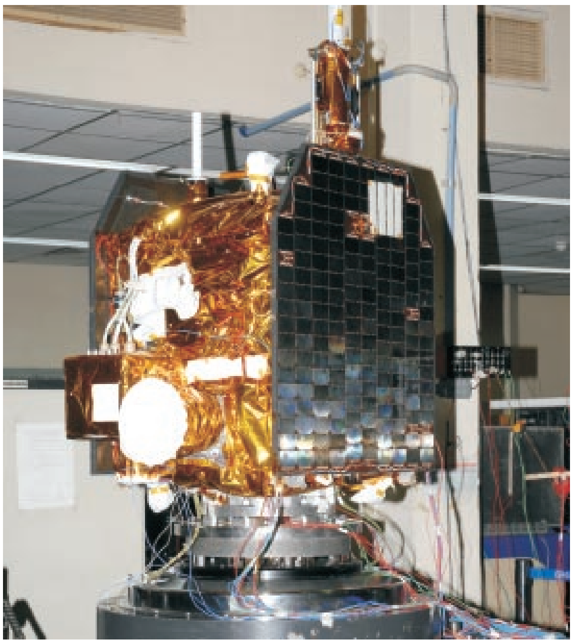
Ionosphere changes. The satellite carries three payloads, of which two are Indian and one Russian. Together, they form a unique and comprehensive package of experiments for the investigation of the composition, energetics and dynamics of earth's upper atmosphere.

The Indian payloads are:

1. RaBIT (Radio Beacon for Ionospheric Tomography), which is a dual frequency beacon payload for mapping Total Electron Content (TEC) of the Ionosphere

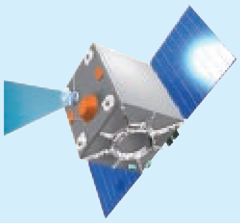
2. LiVHySI (Limb Viewing Hyper Spectral Imager) is designed to perform airglow measurements of the Earth's upper atmosphere (100- 1100 km)

The Russian payload SOLRAD monitors the solar X- and γ ray fluxes and helps to study solar cosmic ray flux parameters and conditions of their penetration in the Earth's magnetosphere.



Youthsat undergoing vibration test at ISRO Satellite Centre

X-SAT



X-SAT, the third payload of PSLV-C16, is Singapore's first satellite. Weighing 106 kg at lift-off, X-SAT is a Mini Satellite with a multispectral camera IRIS as its primary payload. X-SAT mission mainly intends to demonstrate technologies related to satellite based remote sensing and onboard image processing.

PSLV-C16

PSLV-C16 was the eighteenth flight of ISRO's Polar Satellite Launch Vehicle PSLV. In this flight, the standard version of PSLV with six solid strap-on motors was used.

PSLV-C16 placed three satellites with a total payload mass of 1404 kg - RESOURCESAT-2 weighing 1206 kg, the Indo-Russian YOUTHSAT weighing 92 kg and Singapore's X-SAT weighing 106 kg – into an 812 km polar Sun Synchronous Orbit (SSO). PSLV-C16 was launched from the First Launch Pad (FLP) at Satish Dhawan Space Centre SHAR, Sriharikota.

The major changes made in PSLV since its first launch include changes in strap-on motors ignition sequence, increase in the propellant loading of the first stage and strap-on solid propellant motors as well as the second and fourth stage liquid propellant motors, improvement in the performance of the third stage motor by optimising motor case and enhanced propellant loading and employing a carbon composite payload adapter.

PSLV has become a versatile vehicle for launching multiple satellites in polar SSOs as well as Low Earth Orbits (LEO) and Geosynchronous Transfer Orbit (GTO). With sixteen successful launches, PSLV has emerged as the workhorse launch vehicle of ISRO and is offered for launching satellites for international customers also. During October1994-April 2011 period, PSLV launched a total of 47 satellites (including RESOURCESAT-2, YOUTHSAT and X-SAT), of which 26 satellites are from abroad and 21 are Indian satellites.

Reorganisation of Indian Institute of Remote Sensing as a unit of ISRO

Indian Institute of Remote Sensing, Dehradun under NRSC has been responsible for capacity building in the country in Remote Sensing and GIS applications through specialised education and training. Since its inception, IIRS has grown many folds and established itself as an institute of repute, both nationally and internationally, in the areas of remote sensing training and education.

The Earth Observation Systems have to set to grow in the years to come with several thematic satellites in the areas of Natural Resource Survey, Earth and Atmospheric Sciences and Oceanography. Enhanced EO capabilities with microwave remote sensing and hyperspectral imaging are also planned. Efficient utilisation of these systems requires focused efforts in Training and Education in diverse thematic areas.

Considering this imminent need, IIRS was made a Unit of ISRO with effect from April 30, 2011. The activities of IIRS will be guided by a Management Council, headed by Director, Space Application Centre (SAC).

The Management Council will review the IIRS programmes (ongoing and new initiatives), the annual budget proposals, manpower requirements and provide overall direction for the development of the Institute.

ISRO Builds India's Fastest Supercomputer

Indian Space Research Organisation has built a supercomputer, which is to be India's fastest supercomputer in terms of theoretical peak performance of 220 TeraFLOPS (220 Trillion Floating Point Operations per second). The supercomputing facility named as Satish Dhawan Supercomputing Facility is located at Vikram Sarabhai Space Centre (VSSC), Thiruvananthapuram. The new Graphic Processing Unit (GPU) based supercomputer named "SAGA-220" (Supercomputer for Aerospace with GPU Architecture-220 TeraFLOPS) is being used by space scientists for solving complex aerospace problems. The supercomputer SAGA-220 was inaugurated on May 2, 2011 by Dr K Radhakrishnan, Chairman, ISRO at VSSC.

"SAGA-220" Supercomputer is fully designed and built by Vikram Sarabhai Space Centre using commercially available hardware, open source software components and in-house developments. The system uses 400 NVIDIA Tesla 2070 GPUs and 400 Intel Quad Core Xeon CPUs supplied by WIPRO with a high speed interconnect. With each GPU and CPU providing a performance of 500 GigaFLOPS and 50 GigaFLOPS respectively, the theoretical peak performance of the system amounts to 220 TeraFLOPS. The present GPU system offers significant advantage over the conventional CPU based system in terms of cost, power and space requirements. The total cost of this Supercomputer is about ₹ 14 crores. The system is environmentally green and consumes a power of only 150 kW. This system can also be easily scaled to many PetaFLOPS (1000 TeraFLOPS).

SAGA-220 Supercomputer

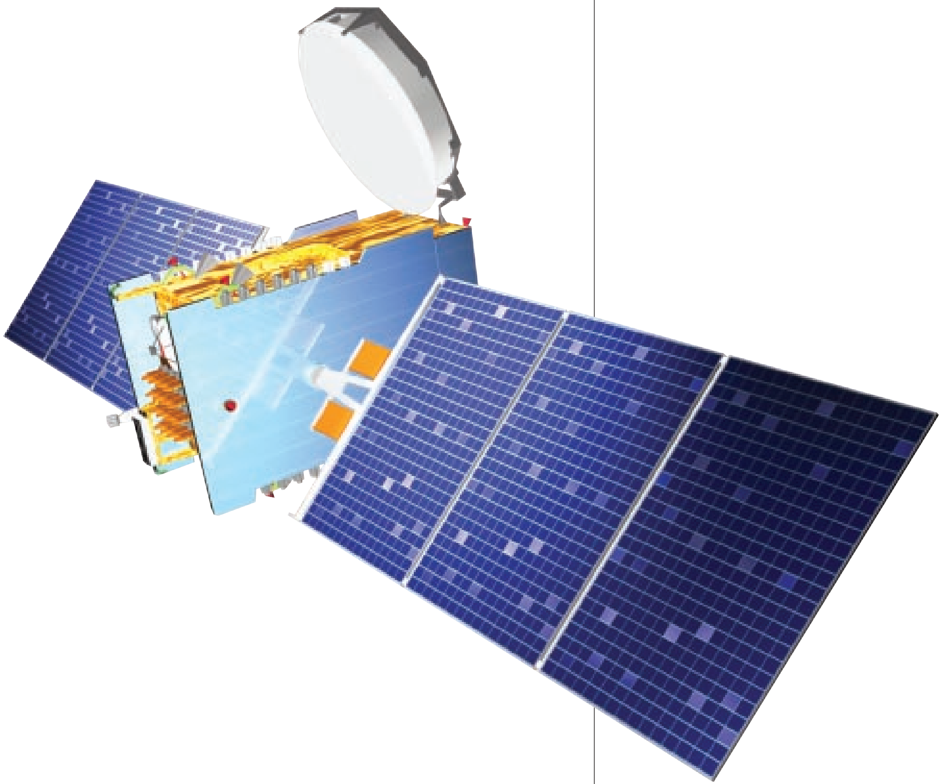
India's Advanced Communication Satellite GSAT-8 Launched Successfully

India's advanced communication satellite, GSAT-8, was successfully launched at 02:08 hrs IST on May 21, 2011 by the Ariane-V launch vehicle of Arianespace from Kourou. French Guiana. Ariane V (VA 202) placed GSAT-8 into the intended Geosynchronous Transfer Orbit (GTO) of 35,861 km apogee (farthest point to earth) and 258 km perigee (closest point to earth), with an orbital inclination of 2.503 deg with respect to equator.

ISRO's Master Control Facility (MCF) at Hassan in Karnataka acquired the signals from GSAT-8 satellite immediately after the injection. Initial checks on the satellite indicated normal health of the satellite. The satellite was captured in three-axis stabilisation mode.

The first critical orbit-raising manoeuvre of GSAT-8 was successfully conducted on May 22, 2011 with the firing of the 440 Newton Liquid Apogee Motor (LAM) on board GSAT-8 for 95 minutes by commanding the satellite from ISRO's MCF at Hassan, Karnataka. The satellite was oriented suitably before the start of LAM operations prior to this critical manoeuvre. With this LAM operation, GSAT-8

GSAT-8 at Kourou prior to its launch



information obtained from GPS Satellites is improved by a network of ground based receivers and made available to the users in the country through the geostationary satellites.

GSAT-8 has reached Geosynchronous orbit on May 21, 2011 with an orbital period of 23 hours 45 minutes. The satellite's orbit had a perigee of 35,543 km, apogee of 35,770 km and an orbital inclination of 0.04 deg with respect to the equatorial plane. The solar arrays on both sides of the satellite were deployed and they started tracking the Sun and generating electrical power. The solar arrays of GSAT-8 are designed to generate 6,240 W of electrical power. Two large dual grid Ku-band antennae were opened and pointed towards the Earth.

perigee was raised to 15,786 km. The apogee remained at 35,768 km and the inclination of the orbit with respect to the equatorial plane was reduced from 2.5 deg at the time of entering into orbit to 0.5 deg. The orbital period became 15 hours 56 minutes. All systems onboard the satellite were functioning normally.

GSAT-8

GSAT-8, India's advanced communication satellite, is a high power communication satellite which is being inducted in the INSAT system. Weighing about 3100 Kg at lift-off, GSAT-8 carries 24 high power transponders in Ku-band and a two-channel GPS Aided Geo Augmented Navigation (GAGAN) payload operating in L1 and L5 bands.

The 24 Ku band transponders are augmenting the capacity in the INSAT system. The GAGAN payload provides the Satellite Based Augmentation System (SBAS), through which the accuracy of the positioning

Following this, the satellite was put into the final orbital configuration pointing towards the Earth continuously. After reaching Geostationary orbit, GSAT-8 was moved towards its final orbital position of 55 deg East where it is now co-located with I NSAT-3E satellite.

In Orbit Testing (IOT) of 24 Ku-band transponders of GSAT-8 followed. Testing of the GAGAN navigational payload was conducted from the new Navigation Control Centre at Kundanahalli near Bangalore.

PSLV-C17 Successfully Launches GSAT-12 Satellite

India's Polar Satellite Launch Vehicle (PSLV-C17) successfully launched GSAT-12 communication satellite on July 15, 2011 from Satish Dhawan Space Centre (SDSC) SHAR, Sriharikota. The launch of PSLV-C17 was the eighteenth successive successful flight of PSLV.

After a smooth countdown of 53 hours, the vehicle lifted-off from the Second Launch Pad at the opening of the launch window at 16:48 hrs (IST). After about 20 minutes of flight time, GSAT-12 was successfully injected into sub-Geosynchronous Transfer Orbit (sub-GTO) with a perigee of 284 km and an apogee of 21,020 km with an orbital inclination of 17.9 deg.

The preliminary flight data indicated that all major flight events involving stage ignition and burnouts, performance of solid and liquid stages, indigenously developed advanced mission computers and telemetry systems performed well.

PSLV-C17 on its Mobile Launch Pedestal

ISRO Telemetry Tracking and Command Network (ISTRAC)'s ground station at Biak, Indonesia acquired the signals from GSAT-12 immediately after the injection of the satellite. The solar panels of the satellite were deployed automatically. Initial checks on the satellite indicated normal health of the satellite.

The critical manoeuvres to raise GSAT-12 Satellite into Geosynchronous Orbit were performed by firing the 440 Newton Liquid Apogee Motor of GSAT-12 Satellite for about 80 minutes in five spells during July 16-20, 2011. The Satellite successfully reached Geosynchronous Orbit with a perigee of 35,684 km, apogee of 35,715 km and an orbital inclination of 0.17 degree with respect to the equatorial plane on July 21, 2011. The Communication antenna onboard the satellite was deployed successfully and the satellite entered its final orbital configuration, pointing towards Earth.

After reaching Geostationary orbit, GSAT-12 was moved to its designated longitude of 83 degree East. In that orbital slot, the Satellite is co-located with INSAT-2E and INSAT-4A Satellites.

After parking the Satellite at this location, the Communication Transponders were switched on followed by In-Orbit Testing.

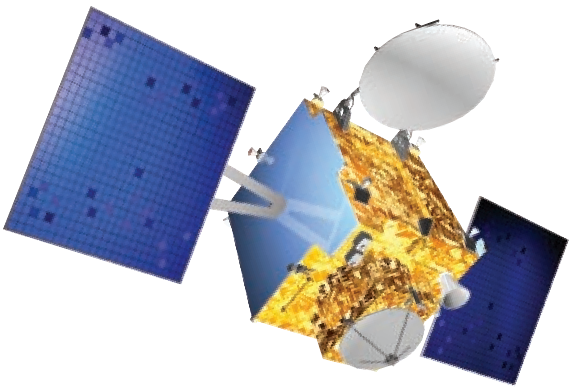
GSAT-12 Communication Satellite

GSAT-12, the latest communication satellite built by ISRO, weighed about 1410 kg at lift-off. It carries 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 are augmenting the capacity in the INSAT system for various communication services like Tele-education, Telemedicine and for Village Resource Centres (VRC).

Polar Satellite Launch Vehicle PSLV-C17

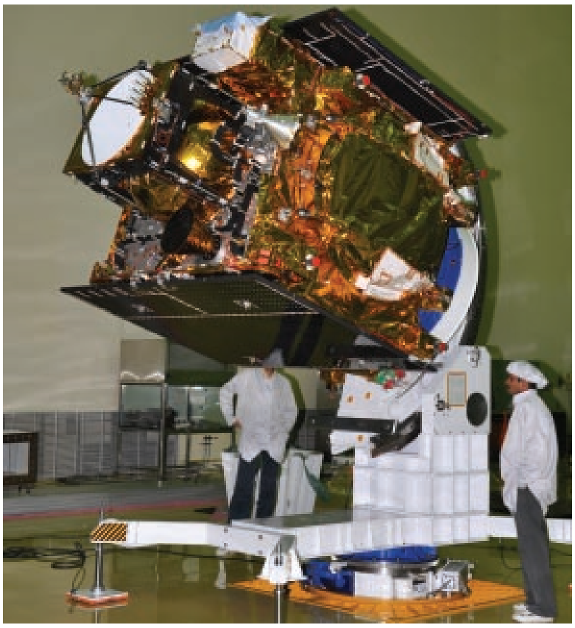
Polar Satellite Launch Vehicle (PSLV-C17), which was the XL version of PSLV and launched India's communication satellite GSAT-12, measured 44.5 m height, with a lift off weight of 320 tonnes with four stages of solid and liquid propulsion systems alternately. In its XL Version, PSLV-XL uses six extended



solid strap-on motors wherein each strap-on carries 12 tonnes of solid propellant. This was the second time such a configuration was flown, earlier one being the PSLV-C11/Chandrayaan-I mission.

Salient features of PSLV-C17/GSAT-12 Mission:

- For the first time, use of indigenously designed and developed On-Board computer (OBC) with Vikram 1601 processor in both primary and redundant chains of the vehicle. The OBC performed the functions of Navigation, Guidance and Control processing for the vehicle.
- Use of extended solid strap-on configuration
- Satellite injection in a sub-Geosynchronous Transfer Orbit (GTO)



GSAT-12 undergoing tests at cleanroom

- Five burn strategy (2 perigee burn and 3 apogee burn) for taking the GSAT-12 satellite from its sub-GTO to Geostationary Orbit

GSAT-12 Salient features

Mission	Communication
Weight	1410 kg (Mass at Lift–off) 559 kg (Dry Mass)
Power	Solar array providing 1430 Watts and one 64 Ah Li-Ion battery
Physical Dimensions	1.485 x 1.480 x 1.446 m cuboid
Propulsion	440 Newton Liquid Apogee Motors (LAM) with Mono Methyl Hydrazine (MMH) as fuel and Mixed oxides of Nitrogen (MON-3) as oxidiser for orbit raising.
Attitude Orbit Control	3-axis body stabilised in orbit using Earth Sensors, Sun Sensors, Momentum and Reaction Wheels, Magnetic Torquers and eight 10 Newton and eight 22 Newton bipropellant thrusters
Antennae	One 0.7 m diameter body mounted parabolic receive antenna and one 1.2 m diameter polarisation sensitive deployable antenna
Mission life	About 8 Years

Second Static Testing of Solid Propellant Booster Rocket Stage S200 for GSLV-Mk III Successfully Conducted

ISRO successfully conducted the second static test of its largest solid booster S200 at Satish Dhawan Space Centre (SDSC), Sriharikota on September 4, 2011.

S200 booster on its test stand

The S200 solid booster will form the strap-on stage for the Geosynchronous Satellite Launch Vehicle Mark III (GSLV-Mk III), which is currently under advanced stage of development for launching 4-ton class of communication satellites.

S200 solid booster contains 200 tonnes of solid propellant in three segments. The motor measures 22 meter long and 3.2 meter in diameter. The design, development and successful realisation of S200 solid booster were a pure indigenous effort involving Vikram Sarabhai Space Centre, Thiruvananthapuram and SDSC at Sriharikota with the participation of Indian Industries. The S200 solid booster derives its heritage from the solid boosters developed earlier for the ISRO launch vehicle programme. The preparation and casting of S200 solid booster segments were carried out at the newly established Solid Propellant Plant (SPP) at SDSC, Sriharikota.

During the test, the S200 booster was fired for about 140 seconds and generated a peak thrust of about 500 tonnes. The performance of the booster was exactly as predicted. Nearly 600 parameters were monitored during the test and the initial data indicated normal performance.

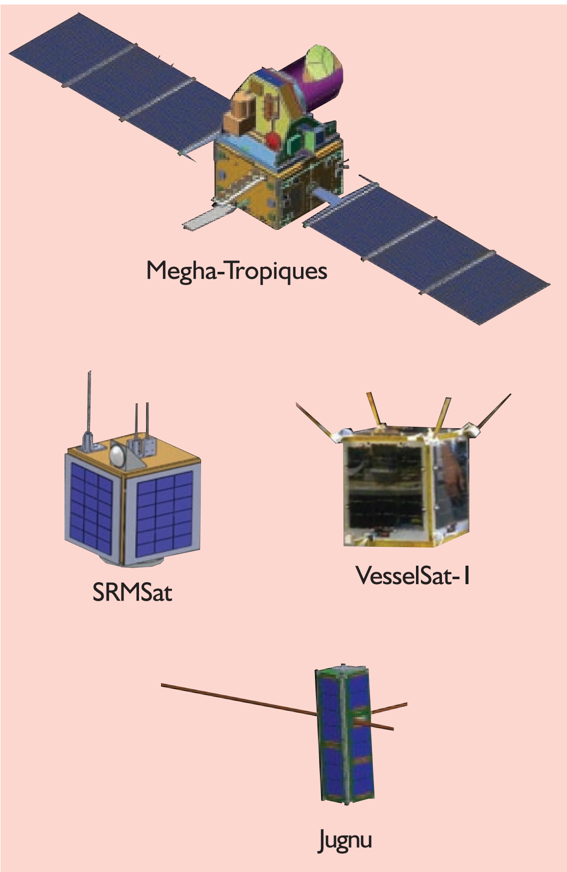
The second successful static test of S200 is a major milestone in the solid rocket motor programme of ISRO and a vital step in the development of GSLV-Mk III. It may be recalled that the first static test of S200 solid booster was conducted on January 24, 2010.

Static test viewed from a distance

PSLV-C18 Successfully Launches MEGHA-TROPIQUES Mission

India's Polar Satellite Launch Vehicle (PSLV-C18) successfully launched the Indo-French MEGHA-TROPIQUES Satellite on October 12, 2011. This was the nineteenth successive successful flight of PSLV.

Three co-passenger Satellites (a) JUGNU from IIT, Kanpur (b) SRMSat from SRM University, Chennai and (c) VesselSat-1 from Luxembourg were also launched by PSLV-C18. The user institutions also confirmed establishing contact with the satellites.



Payloads of PSLV-C18

MEGHA-TROPIQUES Satellite, a joint endeavour of ISRO and the French National Space Agency (CNES), is intended to study the water cycle and energy exchanges in the tropical region covering 20 deg on either side of the Equator.

There are four Science instruments in the MEGHA-TROPIQUES Satellite:

- A Scanning Microwave Imager MADRAS (developed jointly by ISRO and CNES), operating at five frequencies (18, 23, 37, 89 and 157 Giga Hertz) to measure precipitation and cloud properties
- A Scanner ScaRaB (developed by CNES), for measuring Earth Radiation Budget
- A Sounder SAPHIR (developed by CNES) for Atmospheric Profiling of Humidity in the inter-tropical Region
- GPS Radio Occultation Sensor ROSA (procured by ISRO from Italy)

Soon after separation of the MEGHA-TROPIQUES satellite from PSLV, ISRO's Telemetry Tracking and Command Network (ISTRAC), Bangalore took its command and control.

It was later confirmed that the Satellite was placed very precisely into its intended circular orbit, as given belo w:

Orbital Parameter	Target	Achieved at Satellite injection Point
Perigee (km)	865.30 ± 20	864.39
Apogee (km)	867.15 ± 20	865.16
Orbital Inclination (degree)	20.06 ± 0.20	19.99

Megha-Tropiques Satellite under testing at SDSC SHAR

already 21 scientific teams from Australia, Brazil, Italy, Japan, Korea, Niger, Sweden, UK and USA awaiting data from MEGHA-TROPIQUES.

It is pertinent to note that MEGHA-TROPIQUES is only the second mission of this kind globally, next to the Tropical Rainfall Measurement Mission (TRMM) launched in 1997 by USA and Japan. USA and Japan are presently coordinating for establishing a Global Precipitation Measurement Mission with 8-Satellite Constellation.

MEGHA-TROPIQUES Satellite was later put in its final orbital configuration in 3-axis stabilised mode with respect to Sun and Earth. The four Science instruments were energised as follows:

- ROSA payload was switched on October 12, 2011
- SAPHIR payload was switched on October 13, 2011
- MADRAS payload was switched on October 13, 2011
- ScaRaB payload was activated on October 13, 2011

Data from these instruments is expected to enhance scientific knowledge in the field of climate research through study of water cycle and energy exchanges in the tropical region. Other than the scientific community of India and France, there are

MEGHA-TROPIQUES Satellite is a joint contribution from India and France to the global scientific community engaged in research on climate and weather systems that affect the daily life of humankind world over and particularly in the tropical region.

Polar Satellite Launch Vehicle, PSLV-C18

Polar Satellite Launch Vehicle, in its twentieth flight (PSLV-C18) launched Megha-Tropiques satellite along with three auxiliary payloads with a total payload mass of 1047 kg from the first launch pad of Satish Dhawan Space Centre (SDSC SHAR).

PSLV-C18 was the seventh flight of PSLV in 'core-alone' configuration i.e, without solid strap-on motors.

National Conference on Space Transportation Systems

"National Conference on Space Transportation Systems (STS – 2011): Opportunities and Challenges" held during December 16-18 at Vikram Sarabhai Space Centre (VSSC), Thiruvananthapuram, was jointly organised by VSSC/ISRO and Indian National Academy of Engineering (INAE).

The three days of the conference provided a platform for eminent experts in the field of Aerospace and Space Transportation to come together and share their wisdom with the participating engineers, scientists, technocrats, academics and industrialists. Over 1000 people participated in the conference including 680 registered delegates,36 invited speakers and other guests, including experts from NASA, ESA, JAXA and MPDA.

The conference was inaugurated by former President of India Dr A P J Abdul Kalam, preceded by the screening of special video documentaries depicting the strides India has undertaken in the field of Space Technology and Transportation systems.

Dr A P J Abdul Kalam inaugurates the conference by traditionally lighting the lamp as Dr K Radhakrishnan, Chairman, ISRO looks on

Mr P S Veeraraghavan, Director, VSSC and Chairman, Organising Committee welcomed the delegates and guests who thronged the venue of the inaugural function. Dr Baldev Raj, President, INAE made the presidential address. Dr K Radhakrishnan, Chairman, ISRO delivered a special address. Mr S Ramakrishnan, Director, Liquid Propulsion Systems Centre introduced the conference theme and the keynote speaker.

Dr Kalam, in his keynote address, elaborated on World Space Vision 2050, the challenges facing the space community in the decades ahead as well as on the use of space to mitigate the impending global energy crisis. The conference publications were released during the inaugural ceremony by Dr T K Alex, Director, ISRO Satellite Centre. The publications included a souvenir which contained the abstracts of all technical papers selected for the conference, a CD containing the proceedings and anexhibitors' directory. Shri MC Dattan, Director, Satish Dhawan Space Centre offered felicitations. Mrs J Geetha, Organising Secretary, offered a vote of thanks to all the participants.

A host of sessions on wide ranging topics related to Space Transportation Systems were began after the inaugural function. Eleven plenary sessions were organised featuring national and international experts in the field elaborating on the state of the art as well as the challenges and highlighting opportunities in the road ahead.

95 papers were presented in 22 technical sessions organised on specific areas covering the entire gamut of Space Transportation Systems and Technology. Six parallel sessions were conducted at different venues and the best paper in each session was awarded a cash prize and a certificate of merit. Each technical session featured invited talks by eminent experts in the field elaborating on key topics, followed by the presentation of papers. In addition, 75 papers were presented as posters, which were evaluated under five categories and the best posters were also awarded prizes.

Some of the areas focused upon in the technical sessions include Expendable and Reusable Launch Vehicles, Advanced Propulsion Concepts for Launch Vehicles, Spacecraft systems and Planetary Sciences. Emerging technologies in different areas were highlighted including Navigation, Guidance, Control, Space Materials, Avionics Systems, Power Systems, Fabrication, Aerospace Structures, etc. Papers were presented on Human Presence in Space, Launch Space Environment, Life Support Systems, Sensors and Mission Planning. Discussions on Commercialisation of Space and Space Medicine also featured in the sessions.

A major exhibition showcasing the great strides made by the nation in the field of Aeronautics and Space Transportation was also organised at the venue.

The three day Conference was concluded with a panel discussion. The panel was chaired by Dr S C Gupta and the panelists comprised of distinguished experts in different areas of Space Transportation Systems including many of plenary session speakers.

STS-2011 had a rich content in terms of participation, the breadth and depth of discussions and the response from the delegates. The Conference was concluded with the hope that more such events would be organised yearly or biennially to provide a platform for experts in the field of Space Transportation Systems and Space Technology to come together and serve as a catalyst for further advances in the field.

Interview with Dr V Jayaraman
Former Director, NRSC, ISRO

Dr V Jayaraman, who superannuated as Director, NRSC on April 30th, 2011 after a distinguished career of four decades in ISRO, spoke to Mr S Satish, Director, Publications and Public Relations, ISRO. Excerpts:

Dr V Jayaraman

Q.1 As the first Director of National Remote Sensing Centre (NRSC), ISRO, what were your priorities and what was your Vision for NRSC?

Over the years, NRSA, the earlier avatar of NRSC, has served the remote sensing community in the country and abroad in a most distinguished way and has been recognised for its operational delivery of data products and services. With the conversion into a full-fledged Centre under ISRO, NRSC has a well cut responsibility to integrate fully with other ISRO Centres to develop innovative solutions and public good services to the users in a more concerted manner without compromising on efficiency and efficacy. Hence, I envisioned NRSC to strive to position itself as a globally leading knowledge institution towards developing and efficiently delivering affordable, actionable, "niche" geospatial products and services involving industry and academia; and meeting the ever growing public good, strategic and commercial needs of the nation by continuously harnessing the advances in Earth Observation science and technologies.

Accordingly, the priorities were set in defining a mission oriented approach with definite timelines for the following activities:

- Developing a warehouse of accessible, affordable and actionable knowledge products and services. Thus, the immediate step of reducing the prices of IRS satellites' data products by 30-50% earmarked this intention.
- Ensuring a streamlined demand-supply chain with effective delivery mechanisms through real time, web-based services; populating free-ware tools for access to data products and services. BHUVAN, BHOOSAMPADA, and WRIS initiatives exemplified this process.
- Fusing knowledge management and business process re-engineering through operationalisation of Integrated Multi-mission Ground segment for Earth Observation Satellites (IMGEOS) with efficient multi-mission data acquisition and processing mechanism for improved turn-around-time for products delivery.
- Working towards NRSC-ANTRIX axis for coping with global competition and global outreach
- Regenerative skills development and breeding NextGen leaders; Manpower auditing and recruiting bright youngsters in multi-disciplines and training the middle-managers emphasised this approach.
- R&D Initiatives in newer areas, Interface with Academia and Industry, Initiatives in climate change adaptation, early warning of disasters, and
- Capacity building and awareness programmes

Apart from the above, NRSC had immediate challenges of adopting changed governmental accounting procedures and also had to take immediate steps to ensure continued pension for the retirees. Also, operationalisation of COWAA was one more focus in tune with the other ISRO/DOS centres.

The merger into ISRO has facilitated NRSC to effectively deal with various user departments in the Government sector as a full partner towards realising the fullest potential by expanding the public good services both from satellite and aerial platforms. Further, amalgamation of the Regional Remote Sensing Service Centres (RRSSCs) into NRSC was envisaged a system towards strengthening the above efforts to address the specific needs of the respective States and the region in a more focused manner. Finally, this process of Governmentalisation was a win-win situation for all the stake-holders, and I enjoyed every moment of my stay in NRSC.

Q.2 You have all along been associated with Remote Sensing programme such as development of satellite systems and their use under NNRMS. How did you see yourself in the role of a service provider from NRSC?

In my opinion, it was just an extension of the job I was carrying out earlier. With experience in concurrently handling three major programmes as Director of Earth Observations Programme; Director, NNRMS-RRSSC; and Programme Director, ISRO-Geosphere Biosphere Programme (ISRO GBP), I had necessary exposure, be it in the science, technology and application domains, in dealing with the expectations of the user community, covering areas from cartography to climate, both at national and at international levels. I was also closely associated with NRSA through its Governing Society, Governing Board, and Finance Sub-committee activities for more than a decade, besides working closely with the ground segment development of IRS satellites at NRSA as well as in defining the archival and pricing policies. I was also part of many NNRMS user projects and missions as well as capacity building exercises. In fact, my association with NRSA spans over more than 25 years from IRS-1A onwards in various capacities. So when I moved over to NRSC, I found that it was just a logical other side of the table. It enabled me to further understand the nuances of user interactions more closely.

Q.3 Could you tell us something about BHUVAN and the user feedback on the same?

Over the past two decades, ISRO has spearheaded myriad unique applications from a rich repository of images collected from a versatile thematic series of IRS satellites and they have been successfully institutionalised in many important areas of policy making, natural resources management, and disaster support towards enhancing the quality of life across all sections of the society. BHUVAN is an initiative to showcase these distinctive features of Indian imaging capabilities including the thematic information derived thereon in the geospatial domain providing 2D and 3D visualisation products and services through a web portal for easy access. BHUVAN strives to provide the geospatial information on basic natural resources, enabling real time fusion and streaming of massive satellite data and thematic map information on the "fly". Thus, BHUVAN is essentially envisaged as a window to ingress into different services ISRO has been providing to the users.

It was a matter of great satisfaction for me when we launched BHUVAN within a few months after NRSC became an ISRO Centre. Yes, there were brickbats in the initial days and I should congratulate the young inter-centre team which withstood the tremendous societal pressure to bring out a world class product ultimately. Later, we have been receiving very encouraging feedback from the users even as BHUVAN portal started adding more and more features such as map navigation, panning and adding various developers' tools incorporating the features of interoperability as per Open Geospatial Consortium (OGC) Standards. The robust and open API with rich capabilities provided by BHUVAN can be utilised in a wide range of applications by the users. Thus, it was a moment of glory when BHUVAN was found as one of the top-10 most popular Google searched subjects in India during 2009. The crowning glory was when BHUVAN was chosen as the 'Website of the Month' by the Open Geospatial Consortium (OGC) in December 2010.

BHUVAN is constantly getting updated and I am sure, with the recent RSDP 2011, it will have much more focused geospatial contents in the coming days competing with the contemporary services anywhere in the world.

Q.4 Can you elaborate on the new initiative of NRSC namely, the Integrated Multi-mission Ground Segment for Earth Observation Satellites (IMGEOS), and in what way it will be beneficial to the users?

The essential feature of IMGEOS is towards process re-engineering of all the related activities to have an improved near-real time data delivery mechanism in tune with the expectation of the users. It calls for a network-centric approach with a multi-tier storage system and automated processes to clear the data products within a few hours after data reception. As mentioned earlier, ISRO has been planning a thematic series of satellites for land and water resources management; large scale cartographic applications; and weather and climate applications. IMGEOS aims to have a unified system addressing the needs of the new sensors in terms of varying data rates and formats, and when in place, IMGEOS is expected to revolutionise the data delivery services from NRSC in a very significant manner. Obviously, such a unified system should provide a better turn-around-time for the products benefiting the end users. We are planning to process more than 1000 data products per day, and particularly in disaster scenario, the data supply should be within a few hours.

Q.5 Can you briefly tell about the ambitious Master Plan in NRSC Shadnagar Campus initiated by you?

You are aware that NRSC Earth Station is located at Shadnagar around 65 Kms from Hyderabad wherein we have more than 300 acres of land. The current Balanagar Campus is highly congested and located in an industrial area which will not allow any further expansion commensurate with the growing needs of the user community. Even as NRSC is planning to have a dedicated IMGEOS activity and associated infrastructure, it has been considered essential to have a Master Plan for the whole campus, both at Balanagar and Shadnagar, looking ahead towards meeting the needs of the next 20 years including the upcoming infrastructure for National Database for Emergency Management (NDEM) and many other national and international initiatives. The Master Plan envisages developing the total area at Shadnagar into 5 zones – Technical area, Technical support systems area, facilities area, residential area and bio-consideration area. The elevated high-bay area of the campus in the northern part has been identified for locating the antenna terminals and technical activities with the residential and other facilities located at the southern part. The redeeming feature of the Master Plan is the use of Green Technology for building the infrastructure, ensuring all environment friendly technologies. NRSC is aiming to achieve Platinum LEED rating and I hope they succeed as it would be once again a first-of-its-kind effort in ISRO. Towards this, NRSC is planning to have a solar power station providing of 200 KWP, a huge effort, meeting almost 7.5% of the total power from solar energy. I think it is yet another major initiative by NRSC, which will also serve as a bench-mark for taking up similar such projects elsewhere in ISRO.

Q.6 In your long tenure of nearly four decades in ISRO, how do you see the evolution of remote sensing programme in the country?

I have been fortunate to be associated with the Indian Remote Sensing programme starting from the Bhaskara-I and II days till the recent Resourcesat-2 mission in various capacities and have seen a quantum jump in terms of technological capabilities both in the space and ground systems, thanks mainly to the development of high quality electro-optics systems and very high volume data handling capability, essentially due to increasing computing power and broadband networking capability. It is really mind boggling to note the quantum jump we have made just in 20 odd years in terms of spatial resolution from the 1 km in BHASKARA missions to better than 1 metre in TES and Cartosat 2 missions, not to speak of 100 kbps data rate then to near Giga bit now. The advent of multi-frequency, multi-polarisation microwave remote sensing and the emerging advances in hyperspectral imaging, and development of many quantitative products and modelling aspects is yet another facet of remote sensing programme around the world. Meanwhile, remote sensing itself has moved from an era of awe to a common man forte with Google Earth and the like services exploding the myth and reaching larger populace with ease. The world has also seen the concerns for global warming and climate change adaptation, calling for more concerted international cooperation in the Earth Observation initiatives to monitor the Essential Climate Variables (ECVs). ISRO has also emerged as one of the leading players in the world, contributing to its might to the virtual constellation of EO Satellites in the CEOS and GEOSS domains. Correspondingly, there have been enhanced capabilities in image processing, GIS and GPS, once again enabled by convergence of pervasive digital technologies. There have been corresponding developments on the ground segment with emphasis moving towards generating knowledge products and services, and delivering them in real time for many researchers working on modelling, be it on weather or in climate applications. This convergence of technologies in miniaturised devices and instruments, and shrinking of satellite sizes will lead to developments such as sensor web, formation flying, and event triggered missions providing the geospatial information in 3D and 4D domains more operationally not so far in the future. In short, the future will be much more exiting for the remote sensing community, and I am sure, ISRO and NRSC will have a major role in shaping that future.

Parliamentary Standing Committee on Science and Technology, Environment and Forests visits ISRO, Bangalore

The Parliamentary Standing Committee on Science and Technology, Environment and Forests was on a study visit to Department of Space (DOS)/Indian Space Research Organisation (ISRO), Bangalore on October 18, 2011. Dr T Subbarami Reddy, Chairman of the Standing Committee was accompanied by three members from Rajya Sabha and six members from Lok Sabha.

Dr K Radhakrishnan, Chairman, ISRO/Secretary, DOS welcomed the Chairman and Members of the Standing Committee to ISRO. The committee was taken on a tour of ISRO's facilities at ISRO Satellite Integration and Test Establishment (ISITE), Bangalore. The committee witnessed GSAT-6, GSAT-7 and GSAT-14 communication satellites and INSAT-3D meteorological satellite under fabrication and testing. The committee also visited Compact Antenna Test Facility (CATF) and Comprehensive Assembly and Test Vacuum Chamber (CATVAC) facilities at ISITE.

Dr T Subbarami Reddy congratulated the entire ISRO family on the successful launch of PSLV-C18, which launched Megha Tropiques, and three more small satellites on October 12, 2011. He said the country was proud of this achievement.

Highlights of the progress made in the area of space technology and the benefits that have accrued to the country were presented to the committee. A detailed presentation on the activities on communication satellites, navigation satellites, remote sensing satellites, small satellites and space science missions undertaken at ISRO Satellite Centre (ISAC) were also presented.

Dr T Subbarami Reddy, the chairman of the committee and members evinced keen interest in the programmes of ISRO and expressed their appreciation on the progress made by the nation in space science and technology. Members asked wide ranging questions covering drought monitoring, flood relief, glacier inventory, weather forecasting and prediction of earthquakes.

In his concluding remarks, Dr T Subbarami Reddy commended the remarkable achievements of the Indian space scientists and the phenomenal contribution of space systems towards the national development.

Chairman and Members of the visiting Parlimentary Standing Committee with Dr K Radhakrishnan, Chairman, ISRO at Cleanroom

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President of India Inaugurates the New Control Centre at Satish Dhawan Space Centre SHAR, Sriharikota

Mrs Pratibha Devisingh Patil, President of India, unveils the plaque at the New Control Centre

A panoramic view of the New Control Centre Building housing Mission Control Centre as well as Launch Control Centre

Indian Institute of Remote Sensing, Dehradun which has recently become an ISRO Unit