अन्तरिक्ष भारत SPACE INDIA

भारतीय अन्तरिक्ष अनुसंधान संगठन

Indian Space Research Organisation

जुलाई-दिसम्बर 2015 July-December 2015

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.

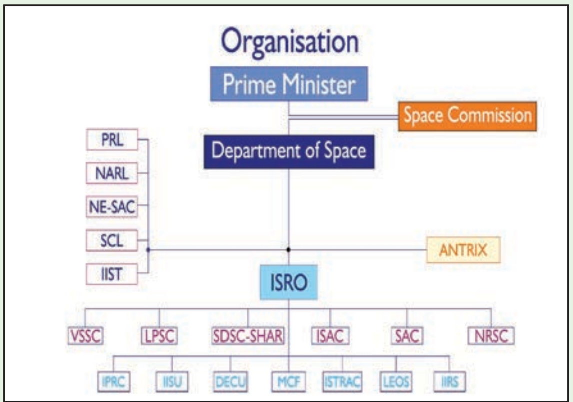
Department of Space has the primary responsibility of promoting development of space science, technology and applications towards achieving self reliance and assisting in all round development of the nation. Towards this, DOS has evolved the following programmes:

- 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, 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, 82 Indian Satellite Missions (including satellites built by students, SRE-1 and CARE Module) and 50 Launches from Sriharikota have been conducted.



PRL: Physical Research Laboratory **NARL:** National Atmospheric Research Laboratory **NE-SAC:** North Eastern Space Applications Centre **SCL:** Semi-Conductor Laboratory **IIST:** Indian Institute of Space Science and Technology **ISRO:** Indian Space Research Organisation **Antrix:** Antrix Corporation Limited **VSSC:** Vikram Sarabhai Space Centre **LPSC:** Liquid Propulsion Systems Centre **IPRC:** ISRO Propulsion Complex **SDSC:** Satish Dhawan Space Centre **ISAC:** ISRO Satellite Centre **SAC:** Space Applications Centre **NRSC:** National Remote Sensing 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 **IIRS:** Indian Institute of Remote Sensing

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PSLV Successfully Launches Five Satellites from UK

ISRO's Polar Satellite Launch Vehicle, PSLV-C28 successfully launches Five Satellites from United Kingdom (UK) in its 30^{th} flight conducted from Satish Dhawan Space Centre (SDSC) SHAR, Sriharikota on July 10, 2015. These satellites were placed into a polar Sun Synchronous Orbit (SSO), very close to the intended orbit of 647 km height. The satellites included three identical DMC3 commercial Earth Observation Satellites and two smaller satellites together weighing about 1440 kg at lift-off.

These five satellites were launched as part of the agreement entered into between DMC International Imaging (DMCii), a wholly owned subsidiary of Surrey Satellite Technology Limited (SSTL), UK and Antrix Corporation Limited, the commercial arm of the Indian Space Research Organisation (ISRO), a Government of India Company under the Department of Space (DOS). This was the 29^{th} consecutively successful flight of PSLV.

PSLV was launched in its heaviest 'XL' version with six strap-on motors of the first stage. This flight was unique since for the first time, the 'XL' version of PSLV was used to launch foreign payloads exclusively. Till now, the lighter 'core alone' version of PSLV has been used to launch foreign payloads exclusively. With this launch of five foreign satellites, PSLV has successfully launched 45 satellites for customers from abroad and further underscores the country's capability in launch vehicle technologies.

Through 29 successful flights during 1994-2015 period, PSLV has launched a total of 77 satellites with a total mass of 32.04 tons, of which 4.64 tons (about 14%) comprises 45 satellites for customers from abroad. The vehicle has repeatedly proved its reliability and versatility by successfully launching satellites into a variety of orbits including polar Sun Synchronous, Geosynchronous Transfer and Low Earth orbits thereby emerging as the workhorse launch vehicle of India.

After a 62.5 hour smooth count down, the 320 ton PSLV-C28 lifted off from the First Launch Pad (FLP) at SDSC SHAR at 2158 hrs (9:58 pm) IST with the ignition of its first stage. The important flight events included the ignition and separation of strap-ons, separation of the first stage, ignition of the second stage, separation of the payload fairing at about 118 km altitude after the vehicle had cleared the dense atmosphere, second stage separation, third stage ignition and third stage separation, fourth stage ignition and fourth stage cut-off.

Once in proper orbit, the three DMC3 satellites were successfully deployed about 18 minutes after lift-off in quick succession. Following this, the 7 kg Nanosatellite De-OrbitSail and the 91kg Microsatellite CBNT-1 were also successfully deployed.

CBNT-1 (left) and three DMC3 Satellites (right) in the clean room at SDSC SHAR

PSLV-C28

PSLV-C28 was 30th flight of the Polar Satellite Launch Vehicle of ISRO and 29th consecutively successful launch. PSLV-C28 launched three identical earth observation satellites (each weighing 447 kg), DMC3, built by Surrey Satellite Technology Limited (SSTL), United Kingdom (UK). In addition, it carried two auxiliary satellites namely, CBNT-1, the technology demonstrator earth observation micro satellite built by SSTL and De-OrbitSail, a technology demonstrator, nano satellite built by Surrey Space Centre. These satellites were launched into a 647 km Sun-Synchronous Orbit (SSO) using the high-end version of PSLV (PSLV-XL) from SDSC-SHAR, Sriharikota, the spaceport of India.

PSLV-C28 was the ninth flight of PSLV in the 'XL' configuration. With the overall lift-off mass of five satellites amounting to 1440 kg, this mission becomes the heaviest commercial mission ever undertaken by Antrix/ISRO.

Accommodating three DMC3 satellites each with an overall height of nearly 3 metre, within the existing payload fairing of PSLV was a challenge. To mount these satellites onto the launcher, a circular Launcher adaptor called as L-adaptor and a triangular deck called Multiple Satellite Adapter-Version 2 (MSA-V2) were newly designed and realised by ISRO for this specific purpose.

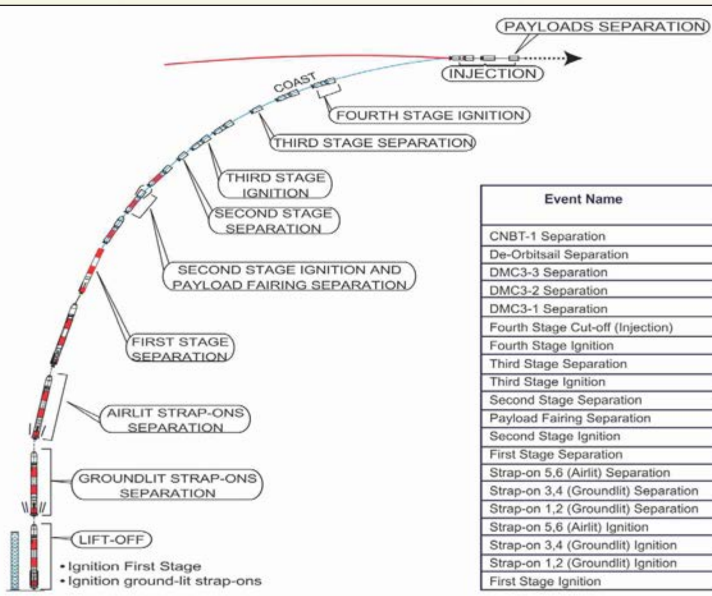
These international customer satellites are being launched under a commercial arrangement entered into between DMC International Imaging (DMCii) a wholly owned subsidiary of SSTL, UK and Antrix corporation limited (Antrix), the commercial arm of Indian Space Research Organisation (ISRO), a Government of India company under Department of Space.

PSLV-C28 at a glance (Vehicle lift-off mass: 320 tonne Height: 44.4 m)

	Stage-1	Stage-2	Stage-3	Stage-4
Nomenclature	Core Stage PS1 + 6 Strap-on Motors	PS2	PS3	PS4
Propellant	Solid (HTPB based)	Liquid (UH25 + N_2O_4)	Solid (HTPB based)	Liquid (MMH + MON-3)
Propellant Mass(T)	138.2 (Core), 6 x 12.2 (Strap-on)	42.0	7.6	2.5
Max Thrust (kn)	4819 (Core), 6 x 716 (Strap-on)	804	240	7.3 x 2
Stage Dia (m)	2.8 (Core), 1 (Strap-on)	2.8	2.0	1.3
Stage Length (m)	20 (Core), 12 (Strap-on)	12.8	3.6	3.0

HTPB: Hydroxyl Terminated Poly Butadiene, UH25: Unsymetical Dimethyl Hydrazine + 25% Hydrazine Hydrate N_2O_4: Nitrogen Tetroxide, MMH: Mono Methyl Hydrazine, MON-3: Mixed Oxides of Nitrogen

PSLV-C28 Typical Flight Profile



Event Name	Time after lift-off	Altitude (kilometre)	Velocity (metre per second)
CNBT-1 Separation	19 min 16.08 sec	654.75	7531.42
De-Orbitsail Separation	18 min 36.08 sec	653.09	7531.81
DMC3-3 Separation	17 min 57.02 sec	653.09	7532.16
DMC3-2 Separation	17 min 56.80 sec	653.09	7532.16
DMC3-1 Separation	17 min 56.58 sec	653.08	7532.16
Fourth Stage Cut-off (Injection)	17 min 19.08 sec	652.34	7527.46
Fourth Stage Ignition	8 min 47.20 sec	514.29	5948.51
Third Stage Separation	8 min 37.20 sec	506.29	5959.77
Third Stage Ignition	4 min 23.32 sec	233.25	4187.50
Second Stage Separation	4 min 22.12 sec	231.85	4190.50
Payload Fairing Separation	2 min 34.68 sec	118.51	2428.63
Second Stage Ignition	1 min 50.38 sec	69.06	2146.66
First Stage Separation	1 min 50.18 sec	68.82	2147.52
Strap-on 5,6 (Airlit) Separation	1 min 32.0 sec	47.47	1868.57
Strap-on 3,4 (Groundlit) Separation	1 min 10.1 sec	26.85	1308.81
Strap-on 1,2 (Groundlit) Separation	1 min 9.90 sec	26.69	1304.21
Strap-on 5,6 (Airlit) Ignition	25.0 sec	2.68	570.51
Strap-on 3,4 (Groundlit) Ignition	0.62 sec	0.024	451.89
Strap-on 1,2 (Groundlit) Ignition	0.42 sec	0.024	451.89
First Stage Ignition	0 sec	0.024	451.89

Indigenously Developed High Thrust Cryogenic Rocket Engine Successfully Ground Tested

India's first indigenously designed and developed high thrust cryogenic rocket engine generating a nominal thrust of 19 tonnes was successfully endurance hot tested for a duration of 800 seconds on July 16, 2015 at ISRO Propulsion Complex (IPRC), Mahendragiri. This duration is approximately 25% more than the engine burn duration in flight. The engine will be used for powering the Cryogenic stage (C25), the upper stage of the next generation GSLV Mk-III launch vehicle of ISRO, capable of launching four tonne class satellites.

This cryogenic engine of C25 Stage operates on Gas Generator Cycle using extremely low temperature propellants – Liquid Hydrogen (LH2) at 20 Kelvin (-253 deg C) and Liquid Oxygen (LOX) at 80K (-193 deg C). The various subsystems of the engine are – re-generatively cooled Thrust Chamber, Gas Generator, LOX and LH2 high speed turbo pump systems, flow control components, close loop mixture ratio control system, Pyrogen igniters, fluid systems, etc. The turbo pump system rotates at a speed of 36,000 rpm with a power level of 2 MW.

This high performance cryogenic engine was conceived, configured and realised by Liquid Propulsion Systems Centre (LPSC). The engine design was totally in-house effort with experts from different fields like fluid dynamics, combustion, thermal, structural, metallurgy, fabrication, rotor dynamics, control components, etc., working together. The fabrication of major subsystems of the engine was carried out through Indian industries, while assembly and integration of the engine and testing were carried out at IPRC.

LPSC has also developed a cryogenic upper stage of 12.5 tonne propellant loading and successfully flight tested it in GSLV Mk-II vehicle on January 05, 2014. Compared to this stage, the C25 stage has a higher propellant loading (27 tonnes versus 12.5 tonnes) and higher engine thrust (19 tonne versus 7.5 tonne).

The recent successful endurance hot test of the first high thrust cryogenic engine is the tenth test in a series of tests planned and executed as part of the development of the engine, employing complex cryogenic technology. The performance of the engine closely matches with the pre-test prediction made using the in-house developed cryogenic engine mathematical modelling and simulation software.

Prior to engine realisation, a series of subsystem level tests were carried out to independently evaluate the design of major subsystems like the turbo pumps, thrust chamber, gas generator, flow control components, etc. Based on the confidence gained, the integrated engine testing was initiated.

As part of the C25 Stage development, further tests are planned in High Altitude conditions and in Stage configuration, prior to the flight stage realisation.

Mastering this complex, high performance cryogenic propulsion technology will go a long way in building self-reliance for the Indian Space Programme.

High Thrust cryogenic rocket engine undergoing heat testing

100th Consecutively Successful Launch of Sounding Rocket RH-200 from TERLS

Space activities in the country started during early 1960s with the scientific investigation of upper atmosphere and ionosphere over the geo magnetic equator that passes over Thumba near Thiruvananthapuram, using small sounding rockets. Vikram Sarabhai Space Centre (VSSC), Thiruvananthapuram has been pioneering the sounding rocket launch for scientific studies. Large numbers of sounding rockets have been developed and launched from Thumba Equatorial Rocket Launching Station (TERLS). ISRO has developed a series of sounding rockets called Rohini series, important among them being RH-200, RH-300 and RH-560, number in the name indicating the diameter of the rocket in mm.

1545 RH-200 rockets have been launched so far. Wednesday, July 15, 2015 became a prestigious and memorable day in the history of sounding rocket programme of India as the RH-200 rocket had its 100th consecutively successful launch from TERLS. It demonstrated the high level of quality and reliability, which have been built into this tiny rocket.

Panoramic View of Sounding Rocket RH-200 Launch from TERLS

The rocket, having a diameter of 200 mm and length 3590 mm, weighs 108 kg and carries a 12 kg chaff payload. The payload gets ejected at an altitude of 70 km and scientific information pertaining to wind and wind velocity will be obtained from 70 km to 20 km. Balloon and surface MET sensors will provide data up to ground surface.

RH-200, during its flight, encounters severe environment peaks and is an ideal platform to assess new technologies, testing their airworthiness by exposing them to hostile environment. Many technologies like application of super capacitors for pyrotechnic initiation, micro centralised encoder, sequencer with solid state switches replacing costly electromechanical relays, programmable DC-DC converter, MEMS (Micro Electro Mechanical System) based angular rate sensor, etc., have been tested for survivability and air worthiness in RH-200 rockets. The development and launch of sounding rockets was a prelude to the major launch vehicles of ISRO - PSLV, GSLV and GSLV MkIII.

Many important campaigns have been taken up using RH-200 rockets. The most important programme was MONEX (Monsoon Experiment) under which over thousand rockets were launched. Equatorial Wave Studies (EWS) by Space Physics Laboratory (SPL) had 51 launches of RH-200 rockets from SDSC SHAR. Another major programme was MIDAS (Dynamics Middle Atmosphere) by SPL, which had 180 launches of this rocket from TERLS Range.

Some of the studies aimed using rocket borne experiments and chaff payload over Thumba are:

- Middle atmospheric seasonal wind oscillations and its association with Indian summer monsoon
- Features and propagation of long period, medium period and short period equatorial wave modes
- Effects of long period waves on the background mean flow, gravity wave-tide-planetary wave interactions and their effects
- Middle atmospheric Climatology of Thumba

- Impact of monsoon circulations in stratospheric-tropospheric exchange process
- The influence of Middle atmospheric circulations on the onset, strength and withdrawal of monsoon
- Global analysis of the latitude-longitude variability of atmospheric oscillations (through interaction with external agencies)
- Middle atmospheric variations in connection with deep tropical convection and during the stages of tropospheric low-pressure systems
- Middle atmospheric variations during the polar Sudden Stratospheric Warming
- Possible tele-connections among Southern Oscillation / El Nino and the equatorial middle atmosphere
- Generation of gravity waves by tropospheric / stratospheric Jet streams
- Rocket triggered lightning programme
- Inter-annual variability of various atmospheric oscillations
- Diurnal and semi-diurnal tides derivation, Quasi-Biennial Oscillation (QBO) and Stratospheric Semiannual Oscillation (SAO) effects on tides by progressive shifting of rocket launch
- Payload design and development for middle atmospheric data probing
- Statistical structure of wind component distribution for aerospace meteorological demands – re-entry / fragmentation analyses
- The effect of climate change in the middle atmospheric regime
- Dynamical effects on the seasonal variability of tropospheric-stratospheric minor constituents like ozone and water vapour in the middle atmospheric dynamics

Thousands of visitors along with the senior functionaries of VSSC witnessed this historic launch of RH-200. Director, VSSC highlighted the usefulness of sounding rockets for scientific studies.

Visitors watching the historic launch of RH-200

Space Applications Centre Celebrates Ruby Year of SITE

"A national programme which would provide television to about 80% of India's population during the next ten years would be of great significance to national integration, for implementing schemes of social and economic development, and for the stimulation and promotion of the electronics industry. It is of particular significance to the large population living in isolated communities." These words were written by Dr. Vikram Sarabhai, India's space pioneer, as far back as 1969. In a paper presented at an international conference, Dr. Sarabhai spelt out his vision of what television could do for India. It was Sarabhai's vision that inspired Indian space scientists and engineers to usher in satellite television in 1975

Satellite Instructional Television Experiment (SITE) was Dr. Sarabhai's dream, which conducted during 1975-76 using American's Application Technology Satellite (ATS-6). SITE demonstrated the potential of satellite technology as an effective mass communication media for a developing country like India. SITE provided valuable experience in the development, testing and management of a satellite-based instructional television system, particularly in rural area.

The SITE was a collaborative programme lead by ISRO with the active participation of Doordarshan (at that time AIR), the national TV broadcast Organisation, the Ministry of Education, etc. The project was supported by various international agencies such as the UNDP, UNESCO, UNICEF and ITU.

Direct Reception Systems (DRS), for community viewing of the TV programmes, were installed in six states (Rajasthan, Bihar, Orissa, Madhya Pradesh, Andhra Pradesh and Karnataka) with "clusters" of about 400 each, totaling 2,400 villages. The instructional programmes were broadcasted for four hours every day – 1 ½ hour in the morning (for school children) and 2 ½ hour in the evening. The programmes were made primarily by Doordarshan in the four languages involved and were produced in four studios set up especially for SITE. Villagers in each "cluster" received programmes made especially for them in their own language plus a 30 minute "common programme" meant for all viewers and aimed at promoting national integration. The programs under the SITE were classified into two broad categories:

- Educational television (ETV) which was meant for the school children in the age group of 5-12 years.
- Instructional television (ITV) for adult audience, primarily designed for neo-literates and illiterates.

Developmental television programmes were beamed with the objectives in the areas of family planning, agriculture, national integration, education, teacher training, occupational skills, health and hygiene etc. Education and information inputs were provided in several languages.

ISRO established a TV Studio at Ahmedabad as the main studio for SITE programme broadcast while Bombay studio was established for making special education programmes. Space Applications Centre (SAC), Ahmedabad was the nerve centre of the entire SITE program as all the major facilities like Earth Station, Studio and SITE program management office etc were located there. SITE program is also considered as the "Cradle of the Direct-To-Home (DTH)" and hailed as "the largest sociological experiment in the world". SITE was widely acknowledged as "the greatest communication experiment ever".

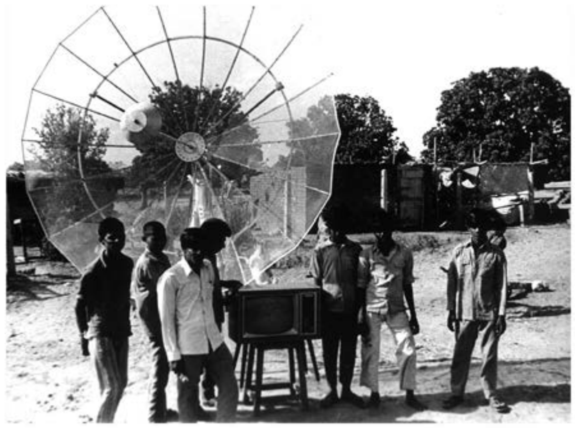
As ISRO's avant-garde Satellite Instructional Television Experiment – SITE turned 40 this year, SAC and DECU celebrated its ruby anniversary on August 21, 2015. All the members of Team SITE were invited to join this august occasion. The event was graced by luminaries like Prof. Yashpal, Prof. E V Chitnis, Dr. P V Krishnamoorthy (First Director General of Doordarshan), Shri. Pramod Kale, Shri. Kiran Karnik, Shri. K Narayanan, Shri. B S Bhatia, Shri. Leo Lasarado, Shri. S K Singh and Shri. G C Jain.

Shri. Tapan Misra, Director SAC, described this event as the "Tryst with History" and acknowledged astonishing contribution of SITE and its team in his welcome address. Shri. A S Kiran Kumar, Chairman, ISRO delivered the keynote address and explained the importance of SITE in the context of making understand the power of satellite Technology in the development of nation to the decision maker/Policy makers. He assured the pioneers of ISRO that current generation is committed to use space technology for addressing the country's needs and development. This was followed by the addresses by various personalities involved in the SITE programme. On this occasion, a coffee-table book "Satellite Instructional Television Experiment - Memoirs", a Video Documentary "The Story of SITE" with interviews of dignitaries and a DVD containing all reports and articles related to SITE were released.

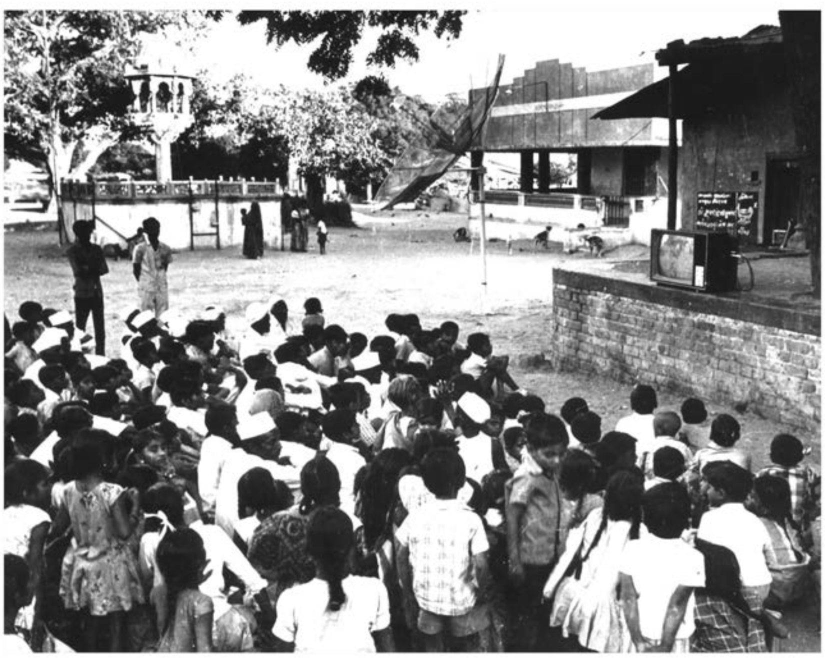
A view of Ahemadabad Earth Station beaming TV programme during SITE

Assembly of TV sets during SITE programme

NASA's ATS-6 satellite which broadcasted TV programme during SITE



The UHF chicken mesh antenna used for direct reception of TV programme from the satellite



Villagers curiously watching TV programme during SITE

GSLV Successfully Launches India's Communication Satellite GSAT-6

In its ninth flight (GSLV-D6) conducted on August 27, 2015, India's Geosynchronous Satellite Launch Vehicle, equipped with the indigenous Cryogenic Upper Stage (CUS), successfully launched GSAT-6, the country's latest communication satellite, into a Geosynchronous Transfer Orbit (GTO). The achieved orbit is very close to the intended one. The launch took place from the Second Launch Pad at the Satish Dhawan Space Centre, SDSC SHAR, Sriharikota, the spaceport of India. This was the fifth developmental flight of GSLV and the third to carry the indigenous CUS. GSLV-D6 was intended to further test and qualify the CUS developed by ISRO.

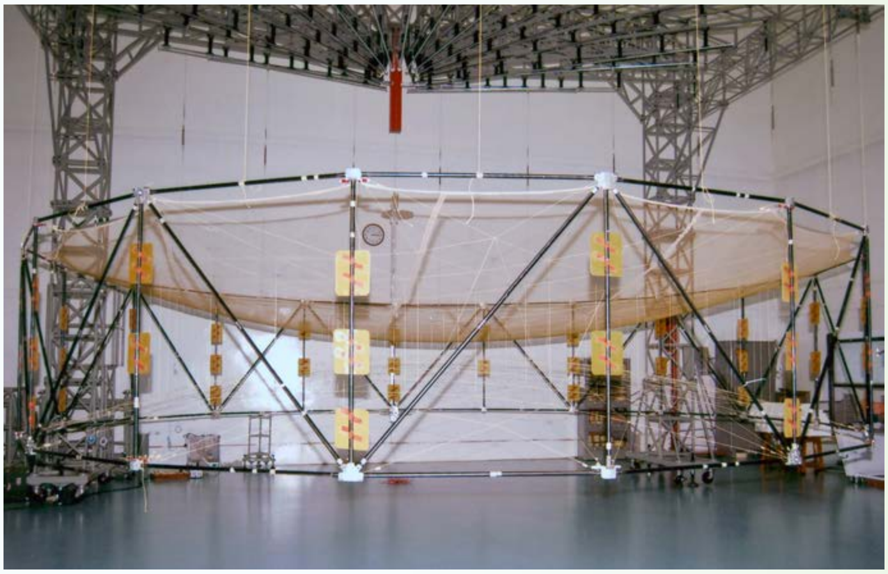
In its oval shaped GTO, the GSAT-6 satellite is now orbiting the Earth with a perigee (nearest point to Earth) of 168 km and an apogee (farthest point to Earth) of 35,939 km with an orbital inclination of 20.01 deg with respect to the equator.

After a smooth 29 hour countdown, the 416 tonne, 49 m tall GSLV-D6 carrying the 2117 kg GSAT-6, lifted off at 16:52 Hrs IST. About seventeen minutes after lift-off, GSAT-6 was successfully placed in GTO. With this flight, GSLV underscores the success of ISRO in mastering the highly complex cryogenic rocket propulsion technology.

At 4.8 seconds before the countdown reached zero, the four liquid propellant strap-on stages of GSLV-D6, each carrying 42 tonne of liquid propellants, were ignited. At count zero and after confirming the normal performance of all the four strap-on motors, the mammoth 139 tonne solid propellant first stage core motor was ignited and GSLV lifted off. The major phases of the flight included the core motor burn-out, strap on burn-out, ignition of the second stage, separation of the core motor together with strap-ons, payload fairing separation, second stage separation, CUS ignition and its timely shut down after satisfactory performance. Following this, GSAT-6 separated from CUS about 17 minutes after launch.

Soon after its injection into GTO, the two solar arrays of GSAT-6 were automatically deployed and the Master Control Facility (MCF) at Hassan in Karnataka took control of GSAT-6. Subsequently, GSAT-6's orbit was raised to the final circular Geostationary Orbit (GSO) by firing the satellite's Liquid Apogee Motor (LAM) in stages. The satellite was declared operational after the completion of orbit raising operations, deployment of its 6 m wide sieve shaped unfurlable antenna, the satellite's positioning in its designated orbital slot of 83 degree East longitude in the GSO and in-orbit testing of its communication payloads.

Unfurlable Antenna of GSAT-6 in stowed mode



Unfurlable Antenna of GSAT-6 in deployed mode

GSAT-6 seen with two halves of payload faring of GSLV-D6

GSAT-6 is the 25th geostationary communication satellite of India built by ISRO and 12th in the GSAT series. Five of GSAT-6's predecessors were launched by GSLV during 2001, 2003, 2004, 2007 and 2014 respectively. After its commissioning, GSAT-6 joins the group of India's other operational geostationary satellites. GSAT-6 satellite provides communication through five spot beams in S-band and a national beam in C-band for strategic users. The cuboid shaped GSAT-6 has a lift-off mass of 2117 kg. Of this, propellants weigh 1132 kg and the dry mass of the satellite is 985 kg. One of the advanced features of GSAT-6 satellite is its S-Band Unfurlable Antenna of 6 m diameter. This is the largest satellite antenna realised by ISRO. This antenna is utilised for five spot beams over the Indian main land. The spot beams exploit the frequency reuse scheme to increase frequency spectrum utilization efficiency. The other advanced feature of the satellite is the 70 V bus, which is flying first time in an Indian communication satellite.

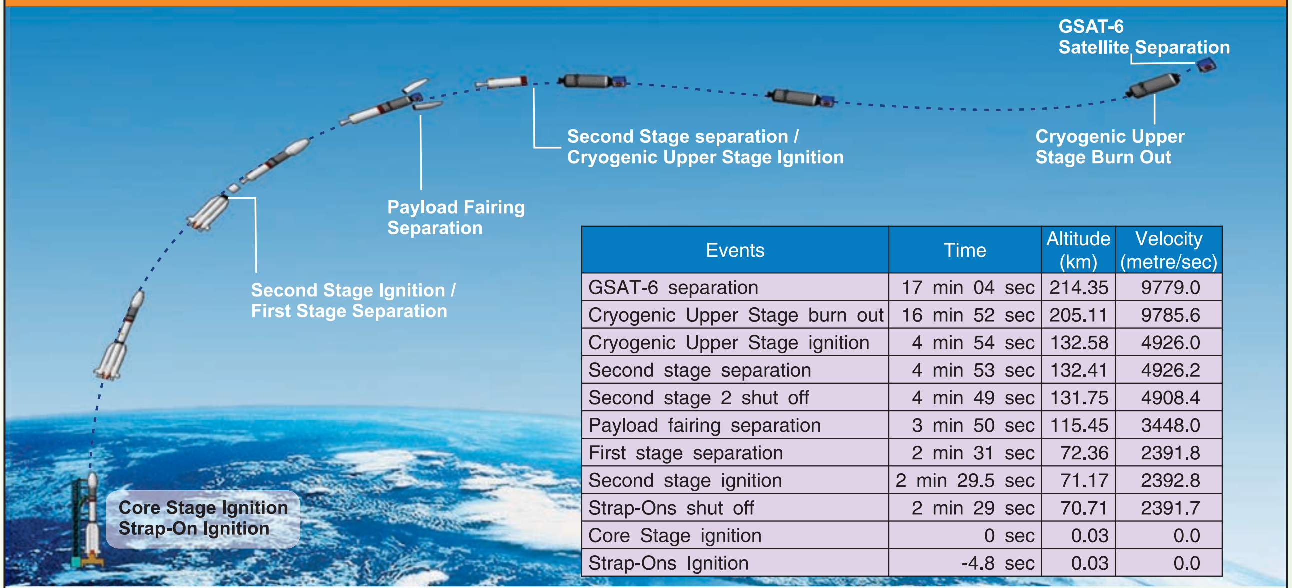
GSLV-D6 is the ninth flight of India's Geosynchronous Satellite Launch Vehicle (GSLV). It is also the fifth developmental flight of GSLV. This is the third time the indigenously developed Cryogenic Upper Stage (CUS) is being carried on-board during a GSLV flight. GSLV-D6 flight is significant since it intends to continue the testing of CUS. GSLV is designed to inject 2 ton class of communication satellites into GTO. GSLV-D6, carrying GSAT-6, India's Communication satellite was successfully launched from the Second Launch Pad at Satish Dhawan Space Centre SHAR (SDSC SHAR), Sriharikota. GSLV-D6 vehicle is configured with all its three stages including the CUS similar to the ones successfully flown during the previous GSLV-D5 mission in January 2014. GSLV-D5 GSAT-14 satellite carried on-board in the intended GTO very accurately. The metallic payload fairing of GSLV-D6 has a diameter of 3.4 m. The overall length of GSLV-D6 is 49.1 m with a lift-off mass of 416 t.

GSLV-D6 at a Glance

Parameters	Stages			
	FIRST STAGE		SECOND STAGE	THIRD STAGE
	Strap-Ons (4 L40 H)	Core Stage (S139)		
Length (m)	19.7	20.1	11.6	8.7
Diameter (m)	2.1	2.8	2.8	2.8
Propellants	UH25 & N_2O_4	HTPB	UH25 & N_2O_4	LH_2 & LOX
Propellant mass (T)	4 x 42.6	138.1	39.5	12.8
Max. Thrust (kN)	759.3	4815	799	73.55
Duration (sec)	148.9	106	150	720

HTPB: Hydroxyl Terminated Poly Butadiene, LH_2: Liquid Hydrogen, LOX: Liquid Oxygen
N_2O_4: Nitrogen Tetroxide, UH25: Unsymmetrical Dimethyl Hydrazine + 25% Hydrazine Hydrate

GSLV-D6 Flight Profile



Events	Time	Altitude (km)	Velocity (metre/sec)
GSAT-6 separation	17 min 04 sec	214.35	9779.0
Cryogenic Upper Stage burn out	16 min 52 sec	205.11	9785.6
Cryogenic Upper Stage ignition	4 min 54 sec	132.58	4926.0
Second stage separation	4 min 53 sec	132.41	4926.2
Second stage 2 shut off	4 min 49 sec	131.75	4908.4
Payload fairing separation	3 min 50 sec	115.45	3448.0
First stage separation	2 min 31 sec	72.36	2391.8
Second stage ignition	2 min 29.5 sec	71.17	2392.8
Strap-Ons shut off	2 min 29 sec	70.71	2391.7
Core Stage ignition	0 sec	0.03	0.0
Strap-Ons Ignition	-4.8 sec	0.03	0.0

The Cryogenic Upper Stage (CUS) being flown in GSLV-D6 is designated as CUS-06. A Cryogenic rocket stage is more efficient and provides more thrust for every kilogram of propellant it burns compared to solid and earth-storable liquid propellant rocket stages. The cryogenic stage is technically a very complex system compared to solid or earth-storable liquid propellant stages due to its use of propellants at extremely low temperatures and the associated thermal and structural challenges. Oxygen liquefies at -183 deg C and Hydrogen at -253 deg C. The propellants, at these low temperatures, are to be pumped using turbo pumps running at around 40,000 rpm. The main engine and two smaller steering engines of CUS together develop a nominal thrust of 73.55 kN in vacuum. During the flight, CUS fires for a nominal duration of 720 seconds. S-band telemetry and C-band transponders enable GSLV-D6 performance monitoring, tracking, range safety/flight safety and Preliminary Orbit Determination (POD).

GSAT-6 at a glance

Physical Properties	Lift off Mass : 2117 kg Main Structure : I-2K Overall size(m) : 2.1 x 2.5 x 4.1
Power	Generated power 3100 W
AOCS	Momentum biased 3-axis stabilised
Propulsion System	Bi propellant – MMH and MON-3
Antennas	One 0.8 m (fixed) and one 6 m unfurlable antenna (transmit and receive)
Communication payloads	• S-band payload with five spot beams covering India for user links • C-band payload with one beam covering India for hub links S-band payload uses 6 m unfurlable antenna and C-band uses 0.8 m antenna.
Mission life	9 years

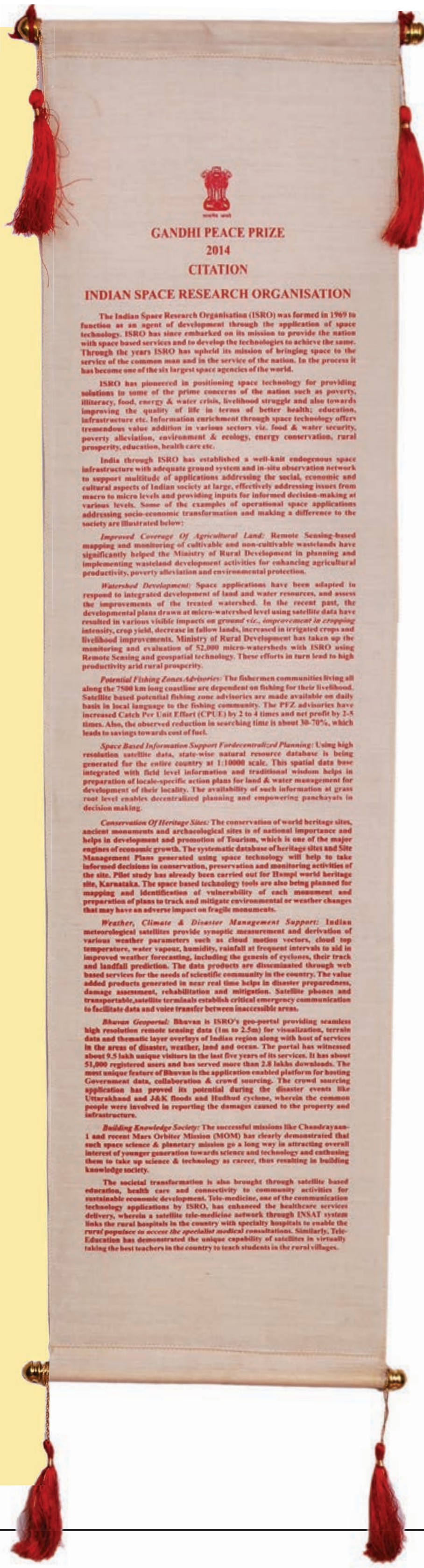
ISRO Receives Gandhi Peace Prize 2014

The President, Shri Pranab Mukherjee, presented the "Gandhi Peace Prize 2014" to Indian Space Research Organisation (ISRO) in recognition of its services in transforming India through the use of space technology and space based services, at a special ceremony in Rashtrapati Bhavan on September 9, 2015. Shri A S Kiran Kumar, Chairman ISRO, received the honour on behalf of ISRO. The Vice President, Shri Mohammad Hamid Ansari, Prime Minister, Shri Narendra Modi, Minister for Culture & Tourism (IC) and Minister of State for Civil Aviation, Dr Mahesh Sharma, members of Jury and a distinguished gathering including eminent Gandhians were present at the ceremony.

The "Gandhi Peace Prize" for social, economic and political transformation through nonviolence was instituted in the year 1995 on the occasion of the 125th Birth Anniversary of Mahatma Gandhi as a tribute to his ideals. Gandhi Peace Prize is presented annually by the President.

The Jury for the "Gandhi Peace Prize 2014" was chaired by Prime Minister, Shri. Narendra Modi and the members were Justice H.L Dattu, Chief Justice of India, Shri Mallikarjun Kharge, Leader of the single largest Opposition Party in the Lok Sabha, Shri. L.K. Advani, Member of Parliament (L.S) and Shri Gopalkrishna Gandhi.

Addressing on the occasion, the President congratulated each and every member of the Indian Space community. He touched upon few initiatives of ISRO, like, Rural Education and Health, Disaster Management, Improving livelihood of fishermen, Conservation of natural resources, etc., which led to significant societal transformation in India, embodying practical realisation of Gandhian goals. He said Science and Technology is a key driver for shaping the destiny of nations and people across the



GANDHI PEACE PRIZE
2014
CITATION

INDIAN SPACE RESEARCH ORGANISATION

The Indian Space Research Organisation (ISRO) was formed in 1969 to function as an agent of development through the application of space technology. ISRO has since embarked on its mission to provide the nation with space based services and to develop the technologies to achieve the same. Through the years ISRO has upheld its mission of bringing space to the service of the common man and in the service of the nation. In the process it has become one of the six largest space agencies of the world.

ISRO has pioneered in positioning space technology for providing solutions to some of the prime concerns of the nation such as poverty, illiteracy, food, energy & water crisis, livelihood struggle and also towards improving the quality of life in terms of better health; education, infrastructure etc. Information enrichment through space technology offers tremendous value addition in various sectors viz. food & water security, poverty alleviation, environment & ecology, energy conservation, rural prosperity, education, health care etc.

India through ISRO has established a well-knit endogenous space infrastructure with adequate ground system and in-situ observation network to support multitude of applications addressing the social, economic and cultural aspects of Indian society at large, effectively addressing issues from macro to micro levels and providing inputs for informed decision-making at various levels. Some of the examples of operational space applications addressing socio-economic transformation and making a difference to the society are illustrated below:

Improved Coverage Of Agricultural Land: Remote Sensing-based mapping and monitoring of cultivable and non-cultivable wastelands have significantly helped the Ministry of Rural Development in planning and implementing wasteland development activities for enhancing agricultural productivity, poverty alleviation and environmental protection.

Watershed Development: Space applications have been adapted to respond to integrated development of land and water resources, and assess the improvements of the treated watershed. In the recent past, the developmental plans drawn at micro-watershed level using satellite data have resulted in various visible impacts on *ground viz., improvement in cropping* intensity, crop yield, decrease in fallow lands, increased in irrigated crops and livelihood improvements. Ministry of Rural Development has taken up the monitoring and evaluation of 52,000 micro-watersheds with ISRO using Remote Sensing and geospatial technology. These efforts in turn lead to high productivity arid rural prosperity.

Potential Fishing Zones Advisories: The fishermen communities living all along the 7500 km long coastline are dependent on fishing for their livelihood. Satellite based potential fishing zone advisories are made available on daily basis in local language to the fishing community. The PFZ advisories have increased Catch Per Unit Effort (CPUE) by 2 to 4 times and net profit by 2-5 times. Also, the observed reduction in searching time is about 30-70%, which leads to savings towards cost of fuel.

Space Based Information Support Fordecentralized Planning: Using high resolution satellite data, state-wise natural resource database is being generated for the entire country at 1:10000 scale. This spatial data base integrated with field level information and traditional wisdom helps in preparation of locale-specific action plans for land & water management for development of their locality. The availability of such information at grass root level enables decentralized planning and empowering panchayats in decision making.

Conservation Of Heritage Sites: The conservation of world heritage sites, ancient monuments and archaeological sites is of national importance and helps in development and promotion of Tourism, which is one of the major engines of economic growth. The systematic database of heritage sites and Site Management Plans generated using space technology will help to take informed decisions in conservation, preservation and monitoring activities of the site. Pilot study has already been carried out for Hampi world heritage site, Karnataka. The space based technology tools are also being planned for mapping and identification of vulnerability of each monument and preparation of plans to track and mitigate environmental or weather changes that may have an adverse impact on fragile monuments.

Weather, Climate & Disaster Management Support: Indian meteorological satellites provide synoptic measurement and derivation of various weather parameters such as cloud motion vectors, cloud top temperature, water vapour, humidity, rainfall at frequent intervals to aid in improved weather forecasting, including the genesis of cyclones, their track and landfall prediction. The data products are disseminated through web based services for the needs of scientific community in the country. The value added products generated in near real time helps in disaster preparedness, damage assessment, rehabilitation and mitigation. Satellite phones and transportable,satellite terminals establish critical emergency communication to facilitate data and voice transfer between inaccessible areas.

Bhuvan Geoportal: Bhuvan is ISRO's geo-portal providing seamless high resolution remote sensing data (1m to 2.5m) for visualization, terrain data and thematic layer overlays of Indian region along with host of services in the areas of disaster, weather, land and ocean. The portal has witnessed about 9.5 lakh unique visitors in the last five years of its services. It has about 51,000 registered users and has served more than 2.8 lakhs downloads. The most unique feature of Bhuvan is the application enabled platform for hosting Government data, collaboration & crowd sourcing. The crowd sourcing application has proved its potential during the disaster events like Uttarakhand and J&K floods and Hudhud cyclone, wherein the common people were involved in reporting the damages caused to the property and infrastructure.

Building Knowledge Society: The successful missions like Chandrayaan-1 and recent Mars Orbiter Mission (MOM) has clearly demonstrated that such space science & planetary mission go a long way in attracting overall interest of younger generation towards science and technology and enthusing them to take up science & technology as career, thus resulting in building knowledge society.

The societal transformation is also brought through satellite based education, health care and connectivity to community activities for sustainable economic development. Tele-medicine, one of the communication technology applications by ISRO, has enhanced the healthcare services delivery, wherein a satellite tele-medicine network through INSAT system links the rural hospitals in the country with specialty hospitals to enable the *rural populace to access the specialist medical* consultations. Similarly, Tele-Education has demonstrated the unique capability of satellites in virtually taking the best teachers in the country to teach students in the rural villages.

globe. Technology is built not so much by individuals but by organisations. The characteristics of organisations – their leaders, their structures and their cultures have a great bearing on catalysing innovations and putting them to use for the benefit of society. ISRO is one such Indian organisation, which has nurtured, developed and demonstrated world-class capabilities. Even as it has sought to encompass the globe and reach for the stars, it has remained rooted in its core mission of national regeneration and improving the life of the common man, a goal set for the nation by Mahatma Gandhi.

Dr. Mahesh Sharma congratulated ISRO on behalf of the nation. He said that Gandhi Peace Prize is being awarded to an institution, which followed the footsteps of Mahatma Gandhi. ISRO has contributed to the nation through the application of space technology and changed the life of common man while bringing space technology to the service of people. He noted that ISRO's space technologies have been of great help during the natural disasters and have been helpful in the service of humanity and the nation.

Speaking at the award ceremony, Shri A. S. Kiran Kumar, Chairman, ISRO said that this is the recognition of the vision of Dr. Vikram Sarabhai and the successive leaders of ISRO and their contribution. He said that ISRO pledges and re-dedicates to bring the fruits of space technology to the people of the country.

The Prize carries a plaque, a citation and One Crore (10 million) Indian Rupees.

सत्यमेव जयते

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PSLV Successfully Launches ASTROSAT

In its 31st flight, India's Polar Satellite Launch Vehicle, PSLV-C30 successfully launches ASTROSAT, the country's Multi Wavelength Space Observatory along with six foreign customer satellites. PSLV was launched in its heaviest 'XL' version with six strap-on motors of the first stage. The launch took place from the First Launch Pad at the Satish Dhawan Space Centre SHAR (SDSC SHAR), Sriharikota, the spaceport of India, on September 28, 2015

The PSLV-C30 carrying seven satellites including the 1513 kg ASTROSAT, lifted off at 10:00 Hrs IST. About twenty-two minutes after lift-off, ASTROSAT was successfully placed in orbit and separated from the fourth stage of PSLV-C30. The separation of all the six co-passenger satellites was completed in the subsequent three minutes. The seven satellites carried by PSLV-C30 together weighed about 1631 kg at lift-off was placed into a 644.6 X 651.5 km orbit inclined at an angle of 6 deg to the equator. The achieved orbit is very close to the intended one. This was the 30th consecutive success for PSLV.

After a 50 hour smooth count down, the 320 ton PSLV-C30 was launched with the ignition of its first stage. The important flight events included the ignition and separation of the strap-ons, separation of the first stage, ignition of the second stage, separation of the payload fairing after the vehicle had cleared the dense atmosphere, second stage separation, third stage ignition and third stage separation, fourth stage ignition and fourth stage cut-off.

Through 30 successful flights during 1994-2015 period, PSLV has launched a total of 84 satellites so far. The vehicle has repeatedly proved its reliability and versatility by successfully launching satellites into a variety of orbits including polar Sun Synchronous, Geosynchronous Transfer and Low Earth orbits of small inclination thereby emerging as the workhorse launch vehicle of India.

So far, 51 satellites have been launched by PSLV for customers from abroad. Launch of six co-passenger satellites by PSLV-C30 was facilitated by Antrix Corporation Limited, the commercial arm of the Indian Space Research Organisation (ISRO), a government of India Company under the Department of Space (DOS).

Soon after its separation from PSLV-C30, the two solar arrays of ASTROSAT were automatically deployed and the Spacecraft Control Centre at the Mission Operations Complex of ISRO Telemetry, Tracking and Command Network (ISTRAC) at Bangalore took control of ASTROSAT.

PSLV-C30

India's Polar Satellite Launch Vehicle, in its thirty first flight (PSLV-C30), is scheduled to launch 1513 kg The 320 tonne, 45 m tall PSLV-C30 was launched from First Launch Pad (FLP) of Satish Dhawan Space Centre (SDSC) SHAR, Sriharikota. PSLV-C30 is the tenth flight of PSLV in its 'XL' Configuration. The earlier nine flights of PSLV-XL were PSLV-C11/ Chandrayaan-1, PSLV-C17/GSAT-12, PSLV-C19/ RISAT-1, PSLV-C22/IRNSS-1A, PSLV-C25/ Mars Orbiter Spacecraft, PSLV-C24/IRNSS-1B and PSLV-C26/IRNSS-1C, PSLV-C27/IRNSS-1D, PSLV-C28/DMC3 missions. The total payload weight of PSLV-C30 1631 kg including 1513 kg Astrosat and intended to place into a 650 km near-equatorial orbit of 6 deg inclination. Along with Astrosat, six satellites from international customers namely., 76 kg LAPAN-A2 of Indonesia, 14 kg NLS-14 (Ev9) of Canada and four identical LEMUR satellites of USA together weighing about 28 kg was launched in this PSLV-C30 flight.

With this successful flight, of PSLV further underscores the reliability and versatility of PSLV as well as the robustness of its design.

ASTROSAT is India's first dedicated multi wavelength space observatory. This scientific satellite mission endeavours for a more detailed understanding of our universe. ASTROSAT is designed to observe the universe in the Visible, Ultraviolet, low and high energy X-ray regions of the electromagnetic spectrum simultaneously with the help of its five payloads.

ASTROSAT was realised by ISRO with the participation of all major astronomy institutions including Inter University Centre for Astronomy and Astrophysics (IUCAA) of Pune, Tata Institute of Fundamental Research (TIFR) at Mumbai, Indian Institute of Astrophysics (IIAP) and Raman Research Institute (RRI) of Bangalore as well as some of the Universities in India and two institutions from Canada and the UK.

Subsequently, ASTROSAT was brought to the final operational configuration and all its five scientific payloads will be thoroughly tested before the commencement of regular operations.

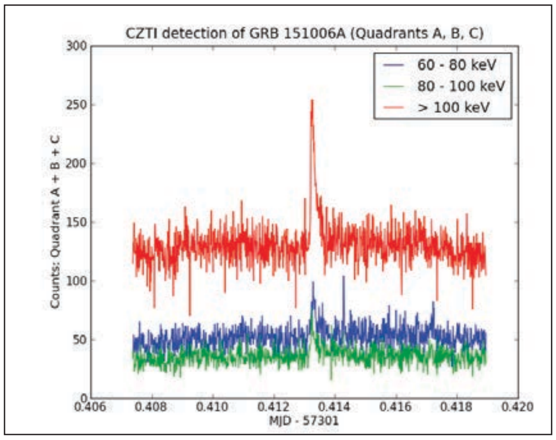
Results from Astrosat

The payloads onboard ASTROSAT are:

- Ultra Violet Imaging Telescope (UVIT) consisting of two identical telescopes, one covering the FUV band (130 - 180 nm) and the second sensitive in NUV (200 - 300 nm) and Visible (320 - 550 nm) bands.
- Soft X-ray Telescope (SXT) with CCD camera for timing and variability studies in the X-ray bandwidth of 0.3 to 8 keV.
- Three Large Area X-ray Proportional Counters (LAXPCs) operating in 3-80 keV band for timing and spectral studies.
- Cadmium Zinc Telluride Imager (CZTI) array with coded mask aperture for hard X-ray imaging and spectral studies in 10-100 keV.
- Scanning Sky Monitor (SSM) for X-ray transient monitoring in the 2.5-10 keV band using proportional counter system.
- Charge Particle Monitor (CPM) an ancillary payload, to detect high-energy particles during the satellite orbital path and alert the instrumentation.

All the payloads are made operational. Some of the results are provided in the next few paragraphs:

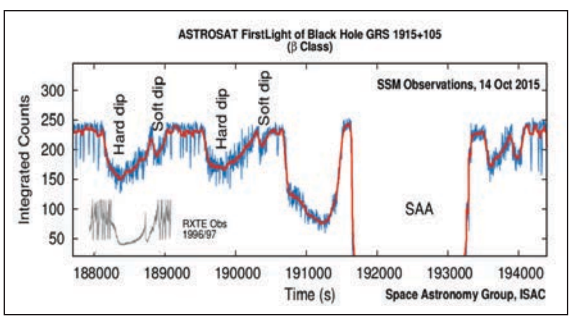
i) Detection of Gamma ray burst (GRB) 151006A by CZTI



GRBs are bursts of gamma-rays, coming from apparently random directions in the sky. This GRB is reported by NASA's Swift satellite. CZTI detected the GRB and has seen significant and sharp jump in the counts above 100 keV during the time of GRB. CZTI has demonstrated its ability in detecting Compton scattering events. This information is flashed to the scientific community through GCN circular 18422. CZTI has the capability to estimate polarisation of the incoming events at hard energies. This is to be demonstrated in future observations.

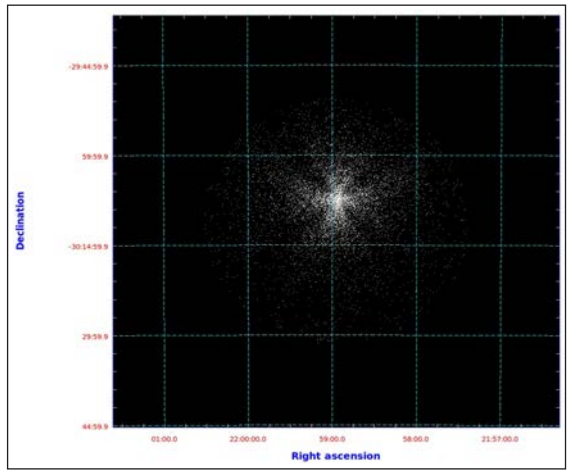
ii) GRS 1915+105 - a Galactic Black Hole source viewed by SSM

SSM observed the black hole source, GRS 1915+105. On 14 Oct, the source displayed 'structured' X-ray variability, the 'β class'. β class variability is associated with the ejection of material in the form of jets from the Black Hole system, accompanied by radio emission. Since this class of variability remains only for few days and may be associated with radio flares, Observation is reported as an "Astronomers' Telegram" ATel #8185.



iii) Blazar viewed by SXT

PKS2155-304 is a bright blazar (a special type of Quasar with a superluminal jet – a stream of particles accelerated to nearly the speed of light - pointing

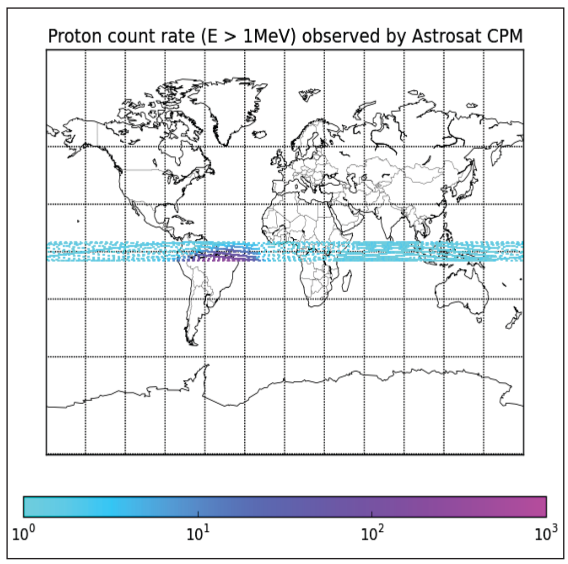


almost towards the telescope) about 1.5 billion light years away. The source is actually a point source. The wings and extensions are due to the special nature of grazing incidence optics and the way the 320 mirrors were assembled and held together to make the telescope optics.

iv) Charged particle counts monitored by CPM

Low particle rates – Cyan colour

Location of the high background SAA region - Magenta patch



Satellites in the Low Earth Orbit (LEO) pass through the trapped radiation belts of the South Atlantic Anomaly (SAA) region which has high fluxes of protons and electrons. SAA at altitudes above ~600 km spans approx -500 to 100 latitude and -900 to +400 longitude. Particle rates can go very high when the satellite enters SAA region. CPM will measure the count of charge particles at the satellite location and will automatically provide a signal to other instruments.

ISRO Crosses 50 International Customer Satellite Launch Mark

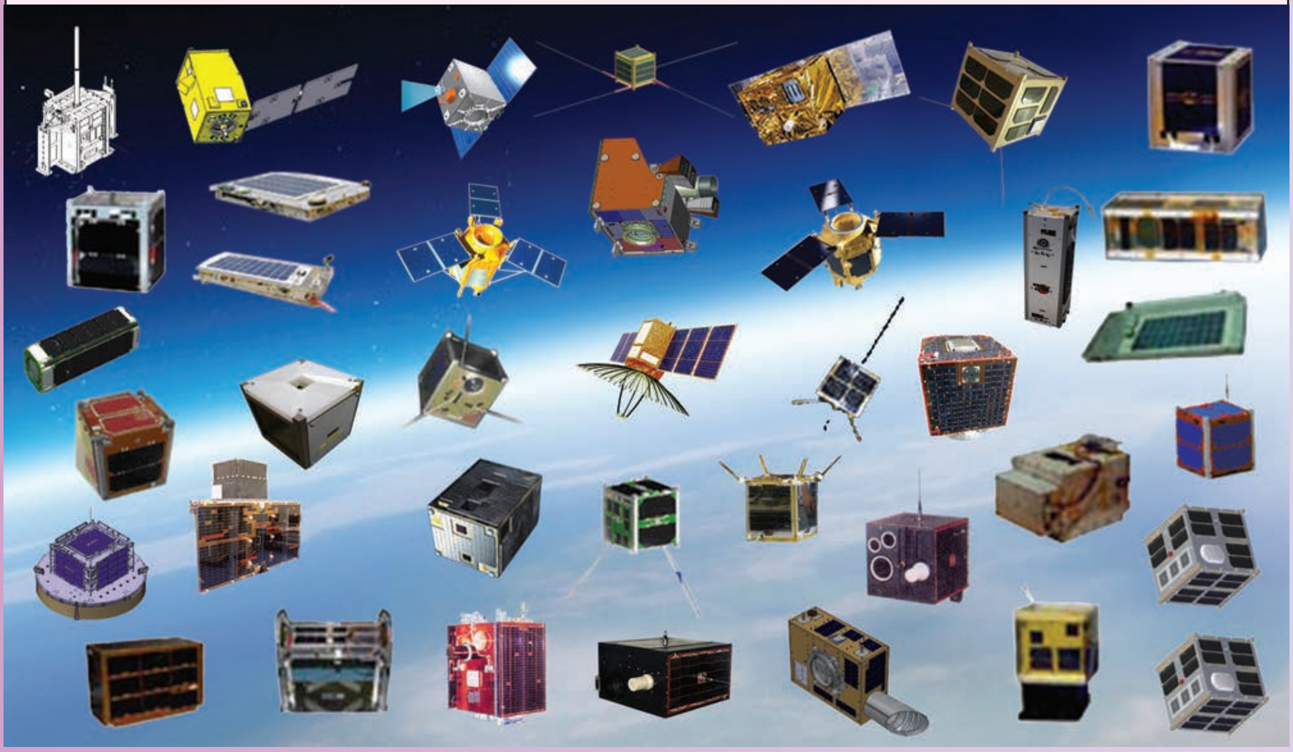
With the successful launch of PSLV-C30 carrying six foreign customer satellites (one each from Indonesia and Canada and four nano satellites from the USA) along with India's Multi Wavelength Astronomical Observatory ASTROSAT, ISRO crossed the 50 international customer satellite launch mark. Subsequently, PSLV-C29 launched six satellites of Singapore, rising in score to 57. All the 57 satellites from abroad launched by India so far have been placed in orbit by India's workhorse Polar Satellite Launch Vehicle (PSLV). During 1994-2015 period, PSLV has launched a total of 90 satellites of which 57 are for international customers.

Though PSLV was designed to launch Indian remote sensing satellites into polar sun synchronous orbit, the vehicle has repeatedly proved its reliability and versatility by successfully launching satellites into a variety of orbits including polar Sun Synchronous, Geosynchronous Transfer and Low Earth orbits of small inclination, thereby repeatedly proving the robustness of its design.

ISRO offers launch services to the international customers through PSLV. ISRO entered the commercial launch services market by launching KITSAT-3 of Republic of Korea and DLR-TUBSAT of Germany along with IRS-P4 (OCEANSAT) onboard PSLV-C2 on May 26, 1999. So far, International customers satellites from 20 countries (Algeria, Argentina, Austria, Belgium, Canada, Denmark, France, Germany, Indonesia, Israel, Italy, Japan, Luxembourg, The Netherlands, Republic of Korea, Singapore, Switzerland, Turkey, United Kingdom and USA) have been successfully launched by PSLV during 15 of its launches.

Antrix Corporation Limited (Antrix), incorporated in 1992, a wholly owned Government of India Company under the administrative control of Department of Space (DOS) and the commercial arm of ISRO has already entered into a number of agreements for launching satellites for international customers onboard PSLV. Antrix promotes and commercially exploits the products and services emanating from the Indian Space Programme. In addition to providing launch services for international customer satellites, Antrix provisions communication satellite transponders for broadcasting and telecommunication services, markets data from Indian Remote Sensing (IRS) satellites, builds and markets satellites and satellites subsystems and extends mission support services for satellite launches.

The outlook for commercial launches is promising for ISRO/Antrix with many other proposals from international customers under active discussion and consideration.



List of Foreign Satellites launched by PSLV

Sl.No.	Name	Country	Date of Launch	Mass (Kg)	Launch Vehicle
1	DLR-TUBSAT	GERMANY	26-05-1999	45	PSLV-C2
2	KITSAT-3	REPUBLIC OF KOREA	26-05-1999	110	PSLV-C2
3	BIRD	GERMANY	22-10-2001	92	PSLV-C3
4	PROBA	BELGIUM	22-10-2001	94	PSLV-C3
5	LAPAN-TUBSAT	INDONESIA	10-01-2007	56	PSLV-C7
6	PEHUENSAT-1	ARGENTINA	10-01-2007	6	PSLV-C7
7	AGILE	ITALY	23-04-2007	350	PSLV-C8
8	TECSAR	ISRAEL	21-01-2008	300	PSLV-C10
9	CAN-X2	CANADA	28-04-2008	7	PSLV-C9
10	CUTE-1.7	JAPAN	28-04-2008	5	PSLV-C9
11	DELFI-C3	THE NETHERLANDS	28-04-2008	6.5	PSLV-C9
12	AAUSAT-II	DENMARK	28-04-2008	3	PSLV-C9
13	COMPASS-I	GERMANY	28-04-2008	3	PSLV-C9
14	SEEDS	JAPAN	28-04-2008	3	PSLV-C9
15	NLS5	CANADA	28-04-2008	16	PSLV-C9
16	RUBIN-8	GERMANY	28-04-2008	8	PSLV-C9
17	CUBESAT-1	GERMANY	23-09-2009	1	PSLV-C14
18	CUBESAT-2	GERMANY	23-09-2009	1	PSLV-C14
19	CUBESAT-3	TURKEY	23-09-2009	1	PSLV-C14
20	CUBESAT-4	SWITZERLAND	23-09-2009	1	PSLV-C14
21	RUBIN-9.1	GERMANY	23-09-2009	1	PSLV-C14
22	RUBIN-9.2	GERMANY	23-09-2009	1	PSLV-C14
23	ALSAT-2A	ALGERIA	12-07-2010	116	PSLV-C15
24	NLS6.1 AISSAT-1	CANADA	12-07-2010	6.5	PSLV-C15
25	NLS6.2 TISAT-1	SWITZERLAND	12-07-2010	1	PSLV-C15
26	X-SAT	SINGAPORE	20-04-2011	106	PSLV-C16
27	VesselSat-1	LUXEMBOURG	12-10-2011	28.7	PSLV-C18
28	SPOT-6	FRANCE	09-09-2012	712	PSLV-C21
29	PROITERES	JAPAN	09-09-2012	15	PSLV-C21
30	SAPPHIRE	CANADA	25-02-2013	148	PSLV-C20
31	NEOSSAT	CANADA	25-02-2013	74	PSLV-C20
32	NLS8.1	AUSTRIA	25-02-2013	14	PSLV-C20
33	NLS8.2	AUSTRIA	25-02-2013	14	PSLV-C20
34	NLS8.3	DENMARK	25-02-2013	3	PSLV-C20
35	STRAND-1	UNITED KINGDOM	25-02-2013	6.5	PSLV-C20
36	SPOT-7	FRANCE	30-06-2014	714	PSLV-C23
37	AISAT	GERMANY	30-06-2014	14	PSLV-C23
38	NLS7.1(CAN-X4)	CANADA	30-06-2014	15	PSLV-C23
39	NLS7.2(CAN-X5)	CANADA	30-06-2014	15	PSLV-C23
40	VELOX-1	SINGAPORE	30-06-2014	7	PSLV-C23
41	DMC3-1	UNITED KINGDOM	10-07-2015	447	PSLV-C28
42	DMC3-2	UNITED KINGDOM	10-07-2015	447	PSLV-C28
43	DMC3-3	UNITED KINGDOM	10-07-2015	447	PSLV-C28
44	CBNT-1	UNITED KINGDOM	10-07-2015	91	PSLV-C28
45	De-OrbitSail	UNITED KINGDOM	10-07-2015	7	PSLV-C28
46	LAPAN-A2	INDONESIA	28-09-2015	76	PSLV-C30
47	NLS-14 (Ev9)	CANADA	28-09-2015	14	PSLV-C30
48	LEMUR	USA	28-09-2015	*	PSLV-C30
49	LEMUR	USA	28-09-2015	*	PSLV-C30
50	**LEMUR**	**USA**	**28-09-2015**	*****	**PSLV-C30**
51	LEMUR	USA	28-09-2015	*	PSLV-C30
52	TeLEOS	SINGAPORE	16-12-2015	400	PSLV-C29
53	Kent Ridge-1	SINGAPORE	16-12-2015	78	PSLV-C29
54	VELOX-C1	SINGAPORE	16-12-2015	123	PSLV-C29
55	VELOX-II	SINGAPORE	16-12-2015	13	PSLV-C29
56	Galassia	SINGAPORE	16-12-2015	3.4	PSLV-C29
57	Athenoxat-1	SINGAPORE	16-12-2015	-	PSLV-C29

Book on Indian Space Programme Released

India's Mars Orbiter Spacecraft, which successfully completed one year in orbit around Mars on September 24, 2015, was launched exactly two years back on November 05, 2013. On the second anniversary of the launch of the spacecraft, a technical meet was organised on November 05, 2015 at Mission Operations Complex, the location of Spacecraft Control Centre in the ISRO Telemetry, Tracking and Command Network (ISTRAC), Bengaluru.

The meet deliberated on the mission challenges during the past one year of spacecraft operations around Mars and also on the data received from the five payloads of the spacecraft.

A few weeks after its successful insertion into the planned orbit around Mars, the spacecraft operations team successfully managed the challenging task of safely maintaining the Mars Orbiter Spacecraft during the passage of Comet Siding Spring in October 2014 near Mars. Besides, the robust design, incorporation of full scale autonomy, extensive ground simulation tests and the operations strategy adopted by ISRO enabled the spacecraft to successfully survive during the month long solar conjunction around June 2015. During this period, communication with the Earth was not possible due to the blockage of radio signals by the Sun.

During its journey around Mars, the spacecraft has sent hundreds of Mars images including numerous full disc images of Mars, because of the unique elliptical orbit in which it was placed. Data sent by other four payloads (scientific instruments) of the spacecraft is being systematically analysed Mars Orbiter Spacecraft is now circling the Red Planet in an orbit with a peri-areion (nearest point to Mars) of 311 km and an apo-areion (farthest point to Mars) of 71,311 km. The health of spacecraft is normal.

Also on the occasion of the second anniversary of the launch of Mars Orbiter Spacecraft, a book "From Fishing Hamlet to Red Planet" was released by Prof. U R Rao, Chairman, PRL Council and former Chairman, ISRO, in the presence of Mr. A S Kiran Kumar, Chairman, ISRO, Dr K Radhakrishnan, former Chairman, ISRO and many distinguished dignitaries of ISRO. This comprehensive compendium traces the evolution of India's satellite, launch vehicle and application programmes from a historical perspective. Many pioneers of the Indian space programme, who contributed to this compendium, were present during the function. Speaking on the occasion, Mr. A S Kiran Kumar said the book places on record the innovative approach adopted by ISRO right from the beginning to develop space technologies for national development. He stressed the need for ISRO to shoulder new responsibilities in the contemporary times. The e-version of the book is made available on ISRO Website for download.

GSAT-15: India's Communication Satellite Launched Successfully

GSAT-15, India's communication satellite was launched successfully by the European Ariane 5 VA-227 Launch Vehicle in the early morning hours on November 11, 2015. The 3164 kg GSAT-15 carries communication transponders in Ku-band as well as a GPS Aided GEO Augmented Navigation (GAGAN) payload operating in L1 and L5 bands.

After a smooth countdown lasting 11 hours and 30 minutes, the Ariane 5 launch vehicle lifted off right on schedule at 3:04 am IST on November 11, 2015. After a flight of 43 minutes and 24 seconds, GSAT-15 separated from the Ariane 5 upper stage in an elliptical Geosynchronous Transfer Orbit (GTO) with a perigee (nearest point to Earth) of 250 km and an apogee (farthest point to Earth) of 35,819 km, inclined at an angle of 3.9 degree to the equator. The achieved orbit was very close to the intended one.

ISRO's Master Control Facility (MCF) at Hassan in Karnataka took over the command and control of GSAT-15 immediately after its separation from the launch vehicle. Preliminary health checks of the satellite revealed its normal health.

Orbit raising manoeuvres were performed to place the satellite in the Geostationary Orbit (36,000 km above the equator) by using the satellite's propulsion system in steps.

After the completion of orbit raising operations, the two solar arrays and both the antenna reflectors of GSAT-15 were deployed. The satellite was put in its final orbital configuration. and positioned at 93.5 deg East longitude in the geostationary orbit along with the operational INSAT-3A and INSAT-4B satellites. Later, the communication payloads of GSAT-15 were experimentally turned on. After the successful completion of all the in-orbit tests, GSAT-15 will was declared operational.

GSAT-15: India's communication satellite, GSAT-15, weighing 3164 kg at lift-off is a high power satellite being inducted into the INSAT / GSAT system. Indian National Satellite (INSAT) system, established in 1983, is one of the largest domestic communication satellite systems in the Asia Pacific Region. It presently comprises of twelve satellites,

providing transponders in S, C, Extended-C and Ku-bands. GSAT-15 carries a total of 24 communication transponders in Ku-band as well as a GPS Aided GEO Augmented Navigation (GAGAN) payload operating in L1 and L5 bands. GSAT-15 is the third satellite to carry GAGAN payload after GAST-8 and GSAT-10, which are already providing navigation services from orbit. GSAT-15 also carries a Ku-band beacon to help in accurately pointing ground antennas towards the satellite.

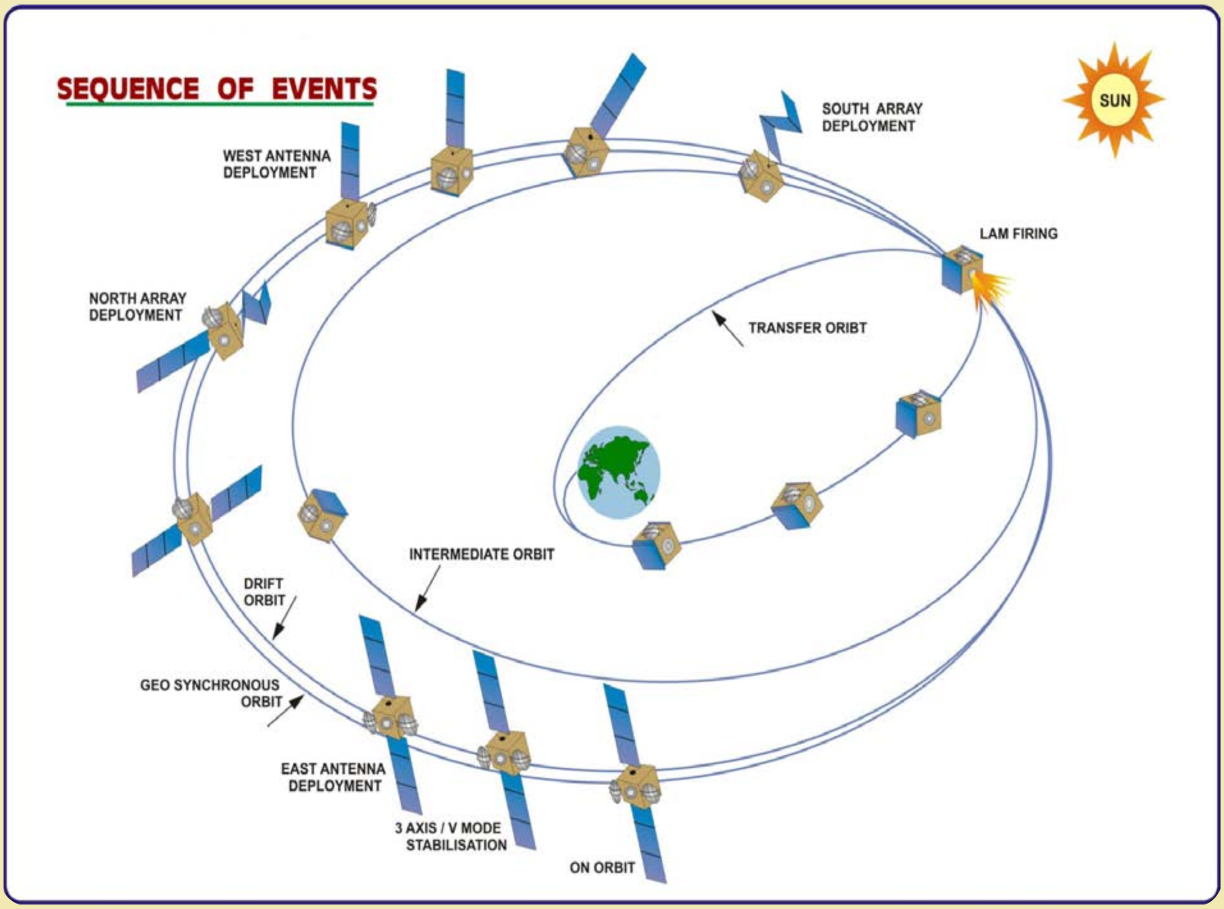
The 24 communication transponders onboard GSAT-15 will replace INSAT-3A, the mission life of which is nearing completion as well as augment the Ku-band capacity in the INSAT system. The GAGAN payload provides the Satellite Based Augmentation System (SBAS), through which the accuracy of the positioning information obtained from the GPS satellites is improved by a network of ground based receivers and made available to the users in the country through geostationary satellites.

SALIENT FEATURES

Services	:	Communication and Satellite Navigation
Orbit	:	Geostationary 93.5ºE longitude
Mission Life	:	12 years
Lift-off Mass	:	3164 kg
Dry mass	:	1440 kg
Spacecraft Control	:	3 Axis body stabilised
Propulsion System	:	Bi-propellant system
TTC	:	C-Band
Power	:	6200 W from Solar arrays, Three 100 AH Li-Ion batteries

The designed in-orbit operational life of GSAT-15 is 12 years.

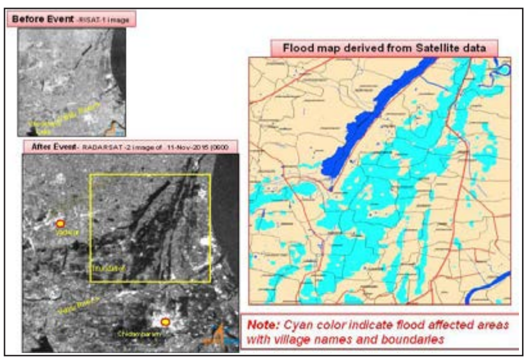
GSAT-15 Mission Profile



Satellite Images for Monitoring Heavy Rains

Heavy rains were experienced by Tamilnadu and Andhra Pradesh states during the second and third week of November 2015 due to the influence of a deep depression over southwest Bay of Bengal. These rains caused major loss to crop and infrastructure in Cuddalore, Kancheepuram, Thiruvallur and Nagapattinam districts in Tamilnadu as well as Nellore and Chittoor districts in Andhra Pradesh.

These areas were mapped using images from the Indian microwave satellite RISAT-1 as well as other satellites. Satellite derived maps, showing affected areas, were disseminated to the concerned departments of Central and State Government Ministries. The inundated areas with necessary attribute information are made available on the Bhuvan geo-spatial platform of NRSC, ISRO and also on the "National Database for Emergency Management (NDEM)" portal.



Decision Support Centre at NRSC/ISRO monitored and mapped the event in near real time using satellite data. The following are the glimpses of the efforts:

The first satellite data was acquired on November 11, 2015 from the Microwave Remote Sensing Satellite RADARSAT-2 that showed inundation areas near Chidambaram, Cuddalore district. The satellite data were quickly analysed and the inundation layers were generated and published on Bhuvan platform on near real-time basis. This data with other layers/ attributes clearly highlights the affected areas and helps the local administration for further decision making.

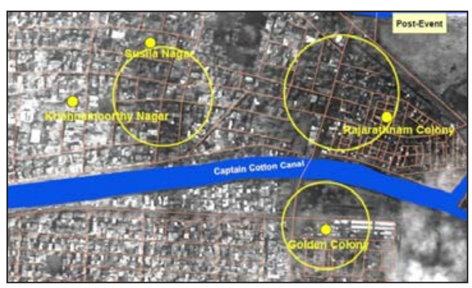
These satellite-based value added maps were disseminated to the users within 6 hours of data acquisition.

Further, regular updates on the status of inundation were also provided using the satellite data acquired on 14th, 17th and 22nd November 2015. Such data / information not only captures the status with respect to previous situation, but also highlights any new areas under problem.

The affected areas near Chidambaram in Cuddalore district (before and after the event) was studied and the cumulative inundation map of 11th, 14th and 17th November 2015 were prepared.

High resolution images from CARTOSAT-2 (1 m spatial resolution) of November 21, 2015 was further acquired over parts of Chennai. Specific information pertaining to residential areas such as Rajarathnam colony, Chennai, and Munuswamy Nagar, Thiruvallur have also been published and provided to local authorities.

The Bhuvan platform has dedicated online information on all the major disaster events that the country has been facing for the past few years. For example, severe floods in J&K and cyclone HUHUD in 2014, cyclone PHAILIN in 2013, floods in Uttarakhand in 2013, forest fires in Nagaland in 2015 and in Tirupathi in 2014 and earthquake in Nepal in 2015 are some of the recent disasters that have highlighted on this platform. These value added products are directly provided to the user departments on a regular basis to assist them in the required decision making.



PSLV Successfully Launches Six Satellites from Singapore

In its 32nd flight conducted from Satish Dhawan Space Centre (SDSC), SHAR, Sriharikota on December 16, 2015, PSLV-C29 successfully launched six satellites from Singapore, including the 400 kg TeLEOS-1, the primary satellite. The other five satellites were co-passenger payloads. PSLV-C29 launched all the six payloads into an orbit of 549 km height inclined at an angle of 15 deg to the equator. The six satellites carried by PSLV-C29 together weighed about 624 kg at lift-off.

These six satellites were launched as part of the agreement entered into between ST Electronics (Satcom & Sensor Systems), Singapore and Antrix Corporation Limited, the commercial arm of the Indian Space Research Organisation (ISRO), a government of India Company under the Department of Space (DOS). This is the eleventh flight of PSLV in 'core-alone' configuration (without the use of solid strap-on motors). PSLV has successfully launched 57 satellites for customers from abroad including the six Singapore satellites of the mission.

After a 59 hour smooth count down, the 227.6 ton PSLV-C29 lifted off from the First Launch Pad (FLP) at SDSC SHAR at 1800 hrs (6:00 pm) IST with the ignition of its first stage. The important flight events included the separation of the first stage, ignition of the second stage, separation of the payload fairing at about 117 km altitude, second stage separation, third stage ignition and separation, fourth stage ignition and cut-off. Once the intended orbit was achieved, TeLEOS-1 was deployed at about 18 min 12 seconds after lift-off. This was followed by the deployment of other five satellites, viz., Kent Ridge-1, VELOX-C1, VELOX-II, Galassia and Athenoxat-1 in quick succession in the subsequent three minutes.

ISRO Completes 50 Launches from Sriharikota

The successful lift-off of the PSLV-C29 Launch vehicle on December 16, 2015 from the First Launch Pad at Satish Dhawan Space Centre (SDSC), SHAR has created a historical milestone in the history of Indian Space Research Organisation. It is the 50th Launch of the Satellite Launch Vehicle from this spaceport of India. Sriharikota has witnessed injection of various indigenous and foreign satellites into the intended orbits through these Launch Vehicles.

It is interesting to know how the visionary initiatives of Dr.Vikram A Sarabhai and Prof. Satish Dhawan transformed this small island of natural beauty into a World-class Launch base. The journey started with the realisation of facilities for integration and launch of the first Satellite Launch Vehicle SLV-3. Initially independent Launch Pads were realised for the first generation Launch Vehicles of SLV-3 and Augmented Satellite Launch Vehicle (ASLV).

Subsequently, two versatile Launch Pads namely First Launch Pad and Second Launch Pad were realised. Both pads have provisions to integrate and launch the present operational vehicles of PSLV and GSLV. The Second Launch Pad is augmented to meet the requirements of integration and launch of next generation Launch vehicle GSLV MkIII. Parallelly facilities are established for production of Solid Motors required for all the Launch Vehicles of ISRO.

Starting with a modest frequency of launches, now we have witnessed a significant shift in the level of operations with 4 successful missions within last 6 months. With untiring efforts of all the teams of ISRO/DOS, 50 Launches have been completed from SDSC SHAR by December 2015.

Five Launches per year have been achieved during the last two years and it is targeted to increase the Launch frequency to 8 missions in the immediate future and more than 12 missions per year subsequently. Towards meeting these future targets, Second Vehicle Assembly Building (SVAB) is being realised as an additional integration facility, with suitable interfacing to Second Launch Pad. Necessary augmentations are also planned in Solid Motor production and other Launch base infrastructure.

Towards this, a function was arranged at SDSC, SHAR on December 29, 2015 graced by Chairman, ISRO and a multitude of Former and Present Senior Executives of ISRO/DOS along with the serving and retired employees of SDSC, SHAR. Shri A. S. Kiran Kumar, Chairman, ISRO dwelt upon the evolution of SDSC, SHAR from a bare island into a World Class Launch Base. He also explained about the role played by team culture of ISRO in sustaining successful missions.

Launch vehicle	Number of Launches
SLV	4
ASLV	4
PSLV	32
GSLV	9
GSLV MkIII-X	1

Phases of Transformation

Launches from Sriharikota, India			
	Vehicle	Launch Dates	Result
1.	SLV-3 E1	Aug 10, 1979	Unsuccessful
2.	SLV-3 E2	Jul 18, 1980	Successful
3.	SLV-3 D1	May 31, 1981	Successful
4.	SLV-3 D2	Apr 17, 1983	Successful
5.	ASLV-D1	Mar 24, 1987	Unsuccessful
6.	ASLV-D2	Jul 13, 1988	Unsuccessful
7.	ASLV-D3	May 20, 1992	Successful
8.	PSLV-D1	Sep 20, 1993	Unsuccessful
9.	ASLV-D4	May 4, 1994	Successful
10.	PSLV-D2	Oct 15, 1994	Successful
11.	PSLV-D3	Mar 21, 1996	Successful
12.	PSLV-C1	Sep 29, 1997	Successful
13.	PSLV-C2	May 26, 1999	Successful
14.	GSLV-D1	Apr 18, 2001	Successful
15.	PSLV-C3	Oct 22, 2001	Successful
16.	PSLV-C4	Sep 12, 2002	Successful
17.	GSLV-D2	May 8, 2003	Successful
18.	PSLV-C5	Oct 17, 2003	Successful
19.	GSLV-F01	Sep 20, 2004	Successful
20.	PSLV-C6	May 5, 2005	Successful
21.	GSLV-F02	July 10, 2006	Unsuccessful
22.	PSLV-C7	January 10, 2007	Successful
23.	PSLV-C8	April 23, 2007	Successful
24.	GSLV-F04	September 2, 2007	Successful
25.	PSLV-C10	January 20, 2008	Successful
26.	PSLV-C9	April 28, 2008	Successful
27.	PSLV-C11	October 22, 2008	Successful
28.	PSLV-C12	April 20, 2009	Successful
29.	PSLV-C14	September 23, 2009	Successful
30.	GSLV-D3	April 15, 2010	Unsuccessful
31.	PSLV-C15	July 12, 2010	Successful
32.	GSLV-F06	December 25, 2010	Unsuccessful
33.	PSLV-C16	April 20, 2011	Successful
34.	PSLV-C17	July 15, 2011	Successful
35.	PSLV-C18	October 12, 2011	Successful
36.	PSLV-C19	April 26, 2012	Successful
37.	PSLV-C21	September 09, 2012	Successful
38.	PSLV-C20	February 25, 2013	Successful
39.	PSLV-C22	July 01, 2013	Successful
40.	PSLV-C25	November 05, 2013	Successful
41.	GSLV-D5	January 05, 2014	Successful
42.	PSLV-C24	April 04, 2014	Successful
43.	PSLV-C23	June 30, 2014	Successful
44.	PSLV-C26	October 16, 2014	Successful
45.	GSLV MkIII-X	December 12, 2014	Successful
46.	PSLV-C27	March 28, 2015	Successful
47.	PSLV-C28	July 10, 2015	Successful
48.	GSLV-D6	August 27, 2015	Successful
49.	PSLV-C30	September 28, 2015	Successful
50.	PSLV-C29	December 16, 2015	Successful

GSLV-D6 carrying GSAT-6 is being moved from Vehicle Assembly Building to Launch Pad

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