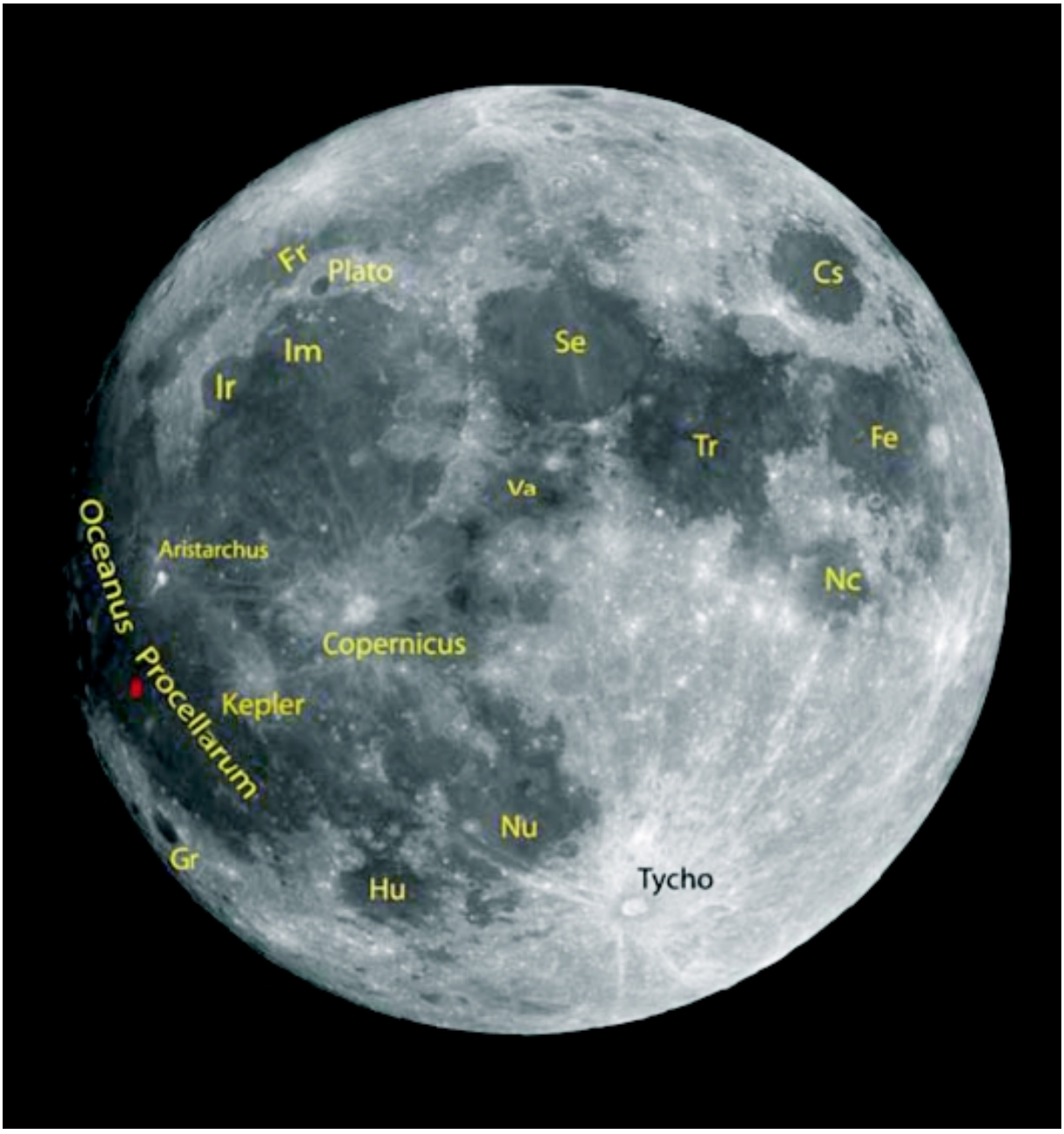
अन्तरिक्ष भारत
SPACE INDIA

भारतीय अन्तरिक्ष अनुसंधान संगठन

Indian Space Research Organisation

अक्तूबर 2010 – मार्च 2011 October 2010 – March 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.

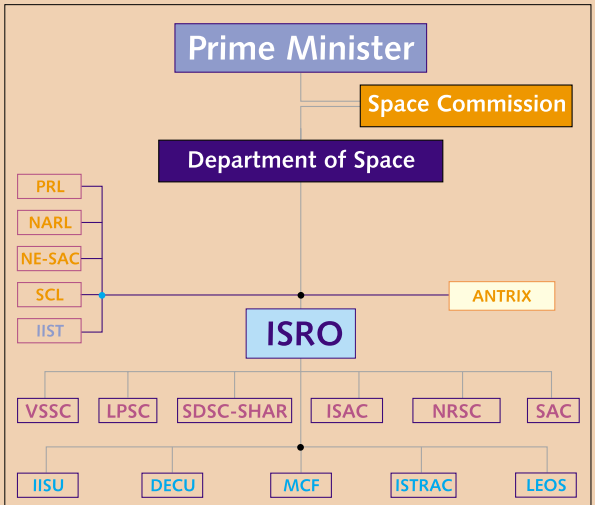
Department of Space (DOS) has the primary responsibility of promoting development of space science, technology and applications towards achieving self reliance and assisting in all round development of the nation. Towards this, DOS has evolved the following programmes:

- 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.

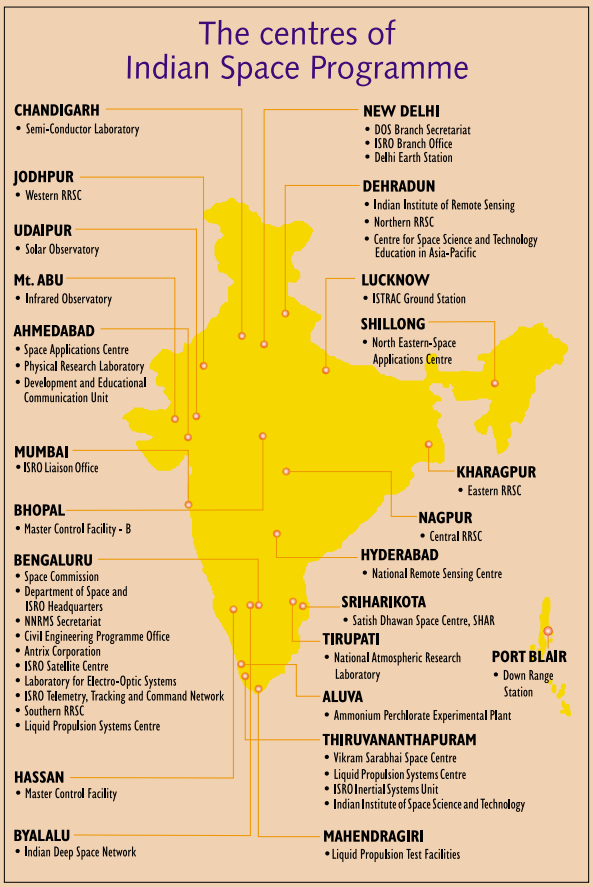
The Space Commission formulates the policies and oversees the implementation of the Indian space programme to promote the development and application of space science and technology for the socio-economic benefit of the country. DOS implements these programmes through, mainly, Indian Space Research Organisation (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, 58 Indian Satellite Missions and 32 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-SHAR:** 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



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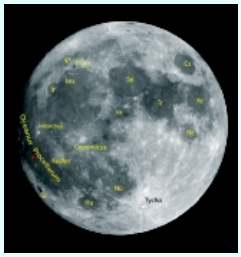

Cover Page:
Picture of full moon showing Oceanus Procellarum area where a Lava Tube has been found by Chandrayaan-1

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Hon. Prime Minister of India visits Space Applications Centre, Ahmedabad

Dr. Manmohan Singh, Hon. Prime Minister of India, visited Space Applications Centre (SAC), Ahmedabad on Saturday, March 26, 2011. Dr. K. Radhakrishnan, Chairman, ISRO/Secretary, Department of Space and Dr. R. R. Navalgund, Director, SAC received Hon. Prime Minister at SAC campus. The Prime Minister was taken around the laboratories where he saw the development of the payloads of communication satellites, viz., GSAT-7, GSAT-10 and several remote sensing satellite payloads under progress. The Prime Minister evinced keen interest in various aspects of payload activities in progress at SAC. He also interacted with a group of young scientists and engineers drawn from different Centres/Units of ISRO on various facets of space activities.

The Prime Minister, addressing ISRO community, which was broadcast live through an INSAT satellite to all the establishments of ISRO/DOS, recalled the stellar role played by Dr. Vikram Sarabhai and Prof. Satish Dhawan, the founding fathers of Indian Space Programme in the formative years. He had special praise for Space Applications Centre, which is located at Ahmedabad, the birthplace of Dr. Sarabhai.

Complimenting ISRO on the excellent record of PSLV with 16 successful launches placing 44 satellites into orbit out of which 25 were launched for international customers, the Prime Minister also mentioned that India has emerged as a leader in building satellites with versatile features and it is now time to look ahead so that space will be a tool for the welfare of mankind.

The Prime Minister being received by Dr. K. Radhakrishnan, Chairman, ISRO and Dr. R. R. Navalgund, Director, SAC

The Prime Minister paid rich tributes to Pandit Jawaharlal Nehru, who, while addressing the Indian Science Congress in 1949, stressed the need for spirit of inquiry and the role of science and technology in the development of the nation. Quoting Dr. Sarabhai, the Prime Minister said that technology is not an objective to aim, but is a tool to be used for the benefit of the common man.

He called upon ISRO scientists to work towards reducing the cost of access to space and to expedite the development of heavy lift launchers using advanced propulsion systems like cryogenic stages, recoverable and reusable launch vehicle systems. The role of space based observing systems, development of newer class of environmental monitoring sensors and study of weather related phenomena assumes greater importance in the backdrop of climate change. He stressed the need for mastering newer technologies in the communication satellites towards satellite based internet services which can serve the rural masses. He expressed his happiness that self reliance is being addressed by having our own Indian Regional Navigation Satellite System which will enable secure transport, air traffic management and search and rescue operations saving precious human life.

The Prime Minister appreciated the contribution of Indian Remote Sensing satellites in national as well as global resource monitoring and the role of earth observation data from IRS satellites in flagship programmes like NREGA, Accelerated Irrigation Benefit Programme and Bharat Nirman. He stressed the need for space based forewarning, preparedness and mitigation measures. He called upon ISRO to make space based information more comprehensive by suitably augmenting the space infrastructure for emergency management.

The Prime Minister expressed optimism that the newly established Indian Institute of Space Science and Technology would attract the best talent available in the country to serve the needs of the country's space programme.

Assuring continued support of the government for the country's space programme, the Prime Minister urged ISRO community to rededicate itself to march towards greater heights upholding the highest standards of professionalism, nurturing the spirit of scientific inquiry and striving for greater excellence.

The Prime Minister interacting with young scientists

PM's address at Space Applications Centre

March 26, 2011
Ahmedabad

It is a matter of great pleasure for me to be here with all of you today. The Space Applications Centre is one of the premier centres of the Indian Space Research Organisation. It is special because it is located in the city where Dr. Vikram Sarabhai, the father of our space programme, was born.

I also extend my greetings to the wider ISRO family who are participating in this event from across the country.

Before coming here, I was particularly keen to meet the younger scientists at this Centre. I am delighted that I got this opportunity a short while ago. What I saw has given me renewed confidence and hope. The young men and women whom I met represent the face of a young and resurgent India, and the future of our country. They are privileged to belong to a rich legacy of Indian astronomy that goes back several centuries to Aryabhatta and Bhaskara.

The desire to probe the mysteries of nature and the universe is as old as the universe itself. It is this spirit of inquiry that has propelled humankind towards progress. This was understood very early on by our founding fathers, and they went out of their way to promote a scientific temper among our youth.

Pandit Jawarharlal Nehru told the Indian Science Congress in Allahabad in 1949, and I quote that "It is the mind of man that has achieved everything and developed everything", unquote. This is a powerful thought. We were truly blessed not only to have enlightened leaders like Pandit Nehru but also men of vision like Dr. Vikram Sarabhai and Professor Satish Dhawan to guide our space programme in its formative period.

The Prime Minister addressing the gathering at SAC

Ours is a space programme that is unique on many counts.

For one, it is completely indigenous, adapted to suit our needs and conditions. It has achieved self-reliance in the areas of design and development of satellites, launch vehicles and provision of space based services to the people. Indigenously developed satellite systems for earth observations and communications have become the mainstay of our space infrastructure.

Secondly, we have proved all those wrong who claimed that a space programme is a luxury that developing nations cannot afford.

Our space programme has, in fact, helped us to leapfrog in technology and bring significant social, economic and industrial transformation to the most remote areas. With relatively modest financial outlays, we have put in place a space infrastructure that touches every aspect of an ordinary citizen's life. It has reduced uncertainties and ignorance, and shrunk time and distance. It has brought Indians closer to each other than we have ever been.

Thirdly, our programme has generated widespread spin-offs in other fields of science and technology and in industry. ISRO has played a leadership role in the indigenisation of strategic materials, increase in the level of technological skills and encouragement of a culture of partnership between government and the private sector.

Lastly, our space programme has earned international repute. We have achieved global standards in space technology and its applications. Recently, a visiting dignitary told me how impressed all the ASEAN countries were with our capabilities, and want to expand their cooperation with us in the field of space. I felt very proud to hear this.

The Indian National Satellite System is one of the largest constellations of communication satellites in the Asia Pacific region. Indian Remote Sensing satellites provide high resolution imaging capability not only over India, but also other parts of the globe. Our launch capabilities are recognised globally. The Polar Satellite Launch Vehicle has had sixteen successful flights and put forty four satellites in orbit, twenty five of which belong to foreign parties. India has emerged as a world leader in building versatile satellites, such as the recently launched OCEANSAT-2.

Having achieved so much, it is important that we look ahead and plan for the future.

Dr. Vikram Sarabhai had once said and I quote "Technology is not an objective to be aimed at, but a tool to be used for the benefit of the common man," unquote. I believe it is important for ISRO to concentrate its resources and evolve a perspective plan for its future development that is based on clearly defined objectives and benefits.

Large scale poverty is the foremost challenge facing our country. The unfortunate truth is that the fruits of our growth are not equally shared among different segments of our society. We have to be acutely conscious of regional disparities and imbalances within the country, and address the inequalities that exist.

Space based applications are a very potent means of bridging these divides in our society. It is therefore necessary that we work towards reducing the cost of access to space. This requires expediting the development of heavy lift launchers, advanced propulsion systems, including the cryogenic stage, and recoverable and reusable launch systems. We should pay greater attention to the Geosynchronous Satellite Launch Vehicle Programme.

As our economy expands, there will be growing pressure on our resources, whether it is land, water or minerals. Remote sensing applications for such purposes will be critical. Simultaneously, the processes of urbanisation will gather speed and we will have to face the challenge of management of urbanisation.

Food security and self-sufficiency in agriculture, particularly paying special attention to the needs of the small and marginal farmers, remains yet another fundamental goal.

In such a scenario, managing the environment and tackling climate change will be major challenges. Our disaster warning and response capabilities will have a major impact on livelihood security for our people. The role of space based observation

systems, development of newer class of environment and monitoring sensors and study of weather related phenomena assume great importance in this regard.

Taken together, the space programme has a vital role to play in making the concept of sustainable development a reality.

The other major goal before us is the socio-economic empowerment of our people. The Satellite Instructional Television Experiment, which was the brainchild of this Centre, demonstrated for the first time how space technology could be used for broadcasting and for reaching the benefits of education to the village level. Although we have come a long way since then, there is much more that needs to be done. Tele-education, tele-medicine and Village Resource Centre services deserve high priority. ISRO's contribution to the monitoring of programmes like the Mahatma Gandhi National Rural Employment Guarantee Scheme, the Accelerated Benefit Irrigation Programme and Bharat Nirman is laudable.

Empowerment requires that we ensure space services are available to all sections of society. Access to information should be easy. In the years ahead ISRO should make a conscious effort to reach out to beneficiaries and consumers of space products so that they can extract maximum advantage from the technology that is available in the country.

The information and communications revolution is upon us. It is changing the lives of millions of our people across cities, towns and villages faster than we could have imagined. This transformation has been made possible in large measure due to the space infrastructure you have built. We should aim to master newer technologies for more sophisticated communication satellites. For example, satellite based broadband internet services could bring about a new technological revolution that directly benefits rural and remote areas.

I am glad that ISRO is aiming to achieve self-reliance in the area of navigation through the Indian Regional Navigation Satellite System. This will enable secure transport and better air traffic management and search and rescue operations.

I have referred earlier to the spirit of scientific inquiry. We will do all that is necessary to promote scientific discoveries, and for ISRO to remain at the cutting edge of technology. You will have the government's support in your quest to better understand the solar system and universe, and in the continuing discovery of space.

There have been some aberrations and setbacks in the space programme in the recent past. These are being dealt with in accordance with laid down procedures. It is however important that you work with renewed dedication, sincerity and zeal to fulfil the high expectations we have from our space programme.

Dr. Vikram Sarabhai had rightly said that no organisation chart should stand in the way of recognising and rewarding talent. I would encourage the Centre Directors and other Heads of Departments to nurture and groom young talent, inculcate the qualities of leadership, and promote team work.

As a teacher myself, I know the joy that comes from seeing younger generations shape their own destiny. Here in ISRO you have the opportunity to shape not only your destiny but the destiny of the country. I therefore do hope that the Indian Institute of Space Technology will attract the best minds and grow into a world class institution.

With these words, I have great pleasure in wishing each and every one of you the very best in your professional and personal lives. The country is proud of your achievements, and wishes you greater successes in the years ahead.

Thank you.

French President visits ISRO Satellite Centre

President Sarkozy addressing the gathering at ISAC

President of France, His Excellency Mr. Nicolas Sarkozy and his wife Ms. Carla Bruni, visited ISRO Satellite Centre (ISAC), Bangalore on December 4, 2010 during their four day visit to India. It was a highly significant and impressive event for ISRO since ISAC was the first on the French President's itinerary during his visit to India. Thus, the visit underscored the importance accorded to space in Indo-French cooperation.

Dr. K. Radhakrishnan, Chairman, ISRO welcomed the visiting dignitary. In his address, Dr Radhakrishnan highlighted the rich legacy of co-operation between India and France in Space. He said that currently two spacecraft – Megha-Tropiques and SARAL – are being realised jointly by ISRO and the French Space Agency CNES.

Following his arrival at ISAC, Mr. Sarkozy visited the permanent space exhibition housing various satellite and launch vehicle models depicting the achievements of ISRO in the arena of satellites from a historical perspective. He visited one of the clean rooms at ISAC where Megha-Tropiques is being built. Megha-Tropiques mission is designed to study tropical atmosphere. Dr. Radhakrishnan explained the features of Megha-Tropiques to the visiting French President.

While addressing the ISRO community as well as from of the prominent invitees from the city, the French

Chairman, ISRO explains the features of Megha-Tropiques satellite to the President of the French Republic

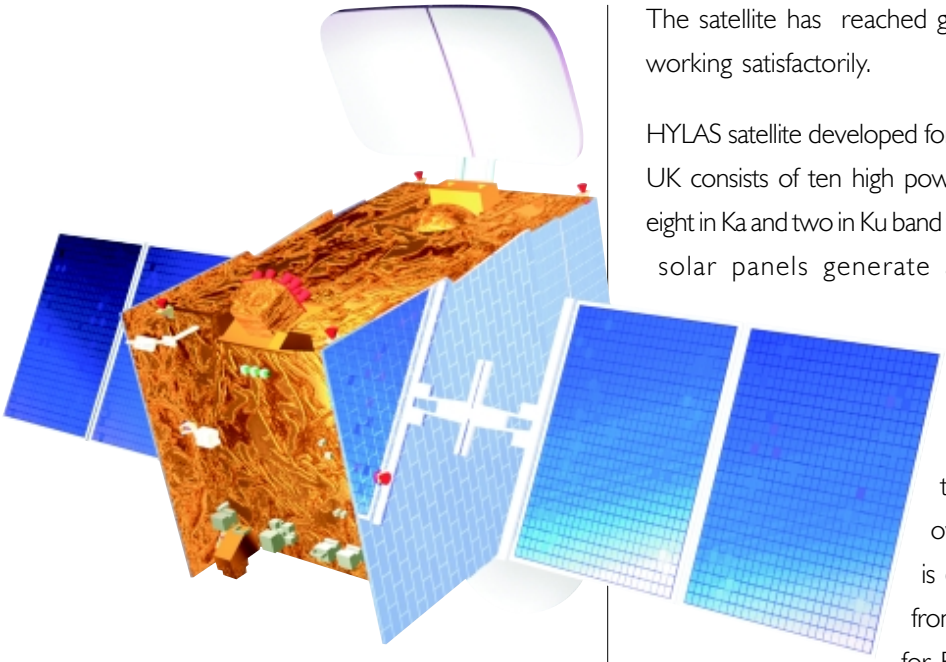
President mentioned that he made it a point come to Bangalore as his first stop in his visit to India because the city is a global hub for various industrial sectors. He said that ties France and India have been building in the field of Space would serve to further the ideals which form basis of their friendship in science, youth and the future.

Mr. Sarkozy hoped that this cooperation would lead to new avenues to build-up opportunities for higher education in France among youth in the near future. He was also of the view that what India and France can build together is not only limited to space industry, but also in the fields of nanotechnology, biotechnology, water resources, medicine, environmental protection, food security and improvement of agricultural yield, etc.

The French President at the permanent exhibition in ISAC

The visiting French President was accompanied by a delegation of businessmen and a large contingent of media persons from France who had a glimpse of Indian space capabilities during their visit to ISAC.

Antrix/ISRO builds Commercial Communication Satellite, HYLAS



Highly Adaptable Satellite (HYLAS), an advanced communication satellite built by ISRO on a commercial basis in partnership with EADS-Astrium of Europe, was successfully launched on November 27, 2010 at 00.09 hours Indian Standard Time (IST) by the European Ariane-5 V198 launch vehicle. The launch took place from the Guyana Space Centre at Kourou in French Guyana.

35 minutes after its lift-off, HYLAS separated from Ariane-5 launch vehicle after reaching its intended Geosynchronous Transfer Orbit (GTO) with a perigee of 250 km, apogee of 35,906 km and inclination of 1.99°.

Master Control Facility of ISRO at Hassan immediately took over the control and command operations of the satellite. The perigee was raised from 250 km to 35,521 km by firing the satellite's Liquid Apogee Motor (LAM) of 432 Newton thrust. The satellite has reached geostationary orbit and is working satisfactorily.

HYLAS satellite developed for Avanti Communications, UK consists of ten high power transponders that use eight in Ka and two in Ku band frequencies. The satellite's solar panels generate a maximum of about 3200 Watts of power. The satellite is designed to deliver high-speed broadband services through its spot beams over Europe. The satellite is expected to be operated from 33.5 deg. W longitude for European coverage.

The contract for building of satellite was won in the year 2006 after competing along other leading manufacturers of USA and Europe through a strategic alliance worked out between Antrix/ISRO and M/s. EADS Astrium of France. The alliance was formed to jointly develop communication satellites with ISRO platforms and Astrium payloads and market them internationally.

Astrium had the responsibility for overall program management and delivery of the communications payload and Antrix/ISRO provided the satellite bus and also performed the satellite integration and testing at ISRO's facility in Bangalore. HYLAS satellite weighing 2541 kg at lift-off is the heaviest satellite built by ISRO for I-2K bus capable of operating for over 15 years mission life as demanded by the customer. The satellite was handed over to the customer in March 2011.

National Conference on Electric Propulsion Systems (NCEPS – 2011)

Dr. T. K. Alex (third from left) and Mr. S. Ramakrishnan (to his right) during souvenir release

ISRO's Liquid Propulsion Systems Centre (LPSC) organised a two-day National Conference on Electric Propulsion Systems at LPSC Bangalore during February 23–24, 2011 in order to bring experts working in the field of Electric Propulsion on a common platform. This was first ever National Conference on this subject in india and it was organised against the backdrop of the successful qualification and realisation of Electric Propulsion System flight module for GSAT-4, which marks an important milestone in ISRO's quest for advanced spacecraft propulsion technologies for future missions despite many daunting technical challenges.

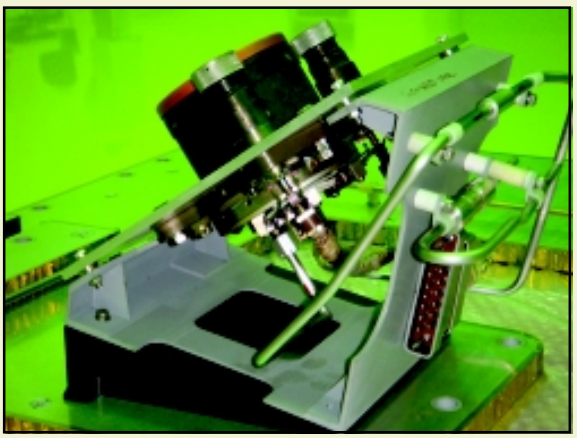
The Conference was formally inaugurated by Dr. T. K. Alex, Director, ISRO Satellite Centre (ISAC) who also released the souvenir on this occasion. The conference facilitated the sharing of experiences and new ideas amongst researchers in this field. Thus, it provided opporunties for scientists and technologists working in this area to update themselves with latest advances.

In the past 20 years, the use of electric propulsion in spacecraft has grown steadily worldwide, and advanced electric thrusters have been replacing chemical thrusters for station keeping applications in geosynchronous communication satellites. Several ion thrusters and Hall thrusters are in orbit aboard such satellites and have also been used successfully as the primary propulsion in deep space scientific missions.

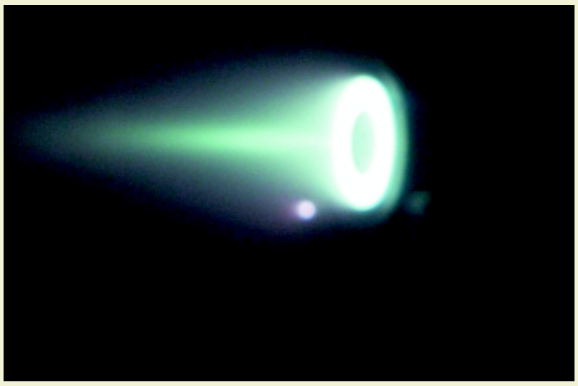
Nearly three hundred participants from ISRO and premier academic and research institutes like Indian Institute of Science (IISc), Indian Institute of Technology (IITs), Indian Institute of Space Science and Technology (IIST), Institute of Plasma Research (IPR), Saha Institute of Nuclear Physics, etc., attended the Conference. Delegates from industries and teaching faculty and students from leading engineering institutes of South India also participated.

Mr. S. Ramakrishnan, Director, LPSC presided over the inaugural function with Dr. T.K. Alex, Director, ISAC, as the Chief Guest. Dr. M. M. Nayak, Director, Launch Vehicle Program Office (LVPO) and Chairman of the technical committee, Shri. B. K. Venkataramu, Deputy Director, LPSC (Bangalore) and Chairman of the organising committee, Mr. H. S. A. Reddy, GD, Spacecraft Propulsion Systems Group and Chairman of the program committee and Mr. K. M. Shanbhogue, Member-Secretary of NCEPS, were also present.

In his presidential address, Mr. S. Ramkrishnan listed various challenges involved in Electric Propulsion Systems such as development of high voltage power supplies, anodes and cathodes with special materials that could withstand the bombardment of ions and the hostile environment of space, etc.



Electric Propulsion System Module developed by LPSC



Ground testing of Space Plasma Thruster

In his inaugural address, Dr. T. K. Alex pointed out that electric propulsion proves economical and feasible when used in spacecraft applications for interplanetary missions and for four tonne and above class of spacecraft, because of the higher specific impulse and power availability. He looked forward to LPSC for developing an advanced version of the EPS to be used in future missions of ISRO.

After a review of fifty nine papers received, forty were presented in the four technical sessions of the conference and ten papers were presented as posters. In addition, four plenary lectures were delivered by eminent personalities in the field.

An exhibition of the products related to electric propulsion like automation related equipments, vacuum pumps, pressure gauges, control systems, electrical connectors, etc., was organised on the occasion. The exhibition was inaugurated by Director, LPSC.

North Eastern-Space Applications Centre (NE-SAC)

NE-SAC, located at Shillong, is a joint initiative of DOS and North Eastern Council to provide support to the North Eastern region in using space science and technology for development. The centre has the mandate to develop high technology infrastructure support to enable NE states to adopt space technology inputs for their development. At present, NE-SAC is providing developmental support by undertaking specific projects by utilising space technology inputs from remote sensing, satellite communication and space science.

Interview with Dr. P. P. Nageswara Rao, who relinqueshed the office of Director, NE-SAC recently:

Dr. P. P. Nageswara Rao was the Director of NE-SAC from October 2007 to November 2010. He is the recipient of Satish Dhawan Award for the year 2009 from Indian Society of Remote Sensing (ISRS) for his contributions in the area of geo-spatial applications and the outstanding services rendered in the North - Eastern Region of our country. Dr. P. P. Nageswara Rao spoke to Mr. S. Satish, Director, P&PRU, ISRO Headquarters and shared his viewpoint on NE-SAC.

Dr. P. P. Nageswara Rao

Following are the excerpts:

1.0. What is the role of NE-SAC in Indian space programme?

The North Eastern - Space Applications Centre (NE-SAC) plays an important role in the Indian Space programme by providing space technology inputs and services to the process of developmental planning of the eight States in the North Eastern Region (NER) of our country, viz., Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura. The Centre provides geospatial information to assist in the development / management of natural resources and infrastructure planning in the region, enables the states to have satellite communication infrastructure and applications in education, health, disaster management support, and serves as a space science research hub with various academic institutions of NE Region.

2.0 What are the achievements of NE-SAC in the NER during the last few years during your tenure as Director?

During the recent years, NE-SAC has become a Centre of Excellence in the region. Sixteen space technology application projects of very high priority to the region are being implemented as per the Master Plan of Action for utilisation of space technology. The Centre is now equipped with high-end data processing

computers, photogrammetry suite, a regional node for natural resource database, a set of differential GPS, a state-of the-art satcom studio, an Expert Node under Village Resource Centres (VRC) programme, an EDUSAT-Satellite Interactive Terminal (SIT), etc. Many instruments like Multi Wavelength Radiometer, Aethalometer, SODAR, etc., have been added. The Centre has Mobile Satellite Service (MSS) terminals along with a transportable WLL-VSAT System for emergency communication during disasters. Large networks of 80 Automatic Weather Stations (AWS), 30 telemedicine nodes, 250 Satellite Interactive Terminals (SIT) under EDUSAT programme have been established and made fully operational in the region. The scientists of the Centre had an opportunity to analyse the data from Chandrayaan-1 sensors about Moon mineral composition and its terrain.

With a core team of 25 scientists/ engineers, most of them hailing from the region, the Centre is providing excellent services promoting the growth and development of the region.

3.0. What were the hurdles (both technical and managerial) that you had to face?

Since the Centre is in its infancy and most of the technical team members are very young and new to space applications, they had to be trained on-the-job while striving to keep up the schedules of the projects. The rugged terrain, inaccessible places due to poor road network and the pressures of socially deviant persons have sometimes delayed the plans. Over and above all, persistent cloud cover and heavy rainfall for almost half the year (May to October) were the hurdles for field surveys. Frequent transfers of senior people, shortage of experienced staff and many people unwilling to get a posting to north east have sometimes caused some setback to achieve the best.

4.0. Will you please highlight the application projects of NE-SAC?

NE-SAC is implementing many projects of relevance to NE Region covering agriculture, forestry (including biodiversity and wildlife habitat), disaster management support, epidemiological studies and health care, geomorphology, land use/land cover mapping, road network mapping, urban planning, wasteland map updating, watershed management, route alignment for laying power lines, etc. All projects taken up by NE-SAC are well defined, end-user oriented and carried out in partnership with the local State Remote Sensing Applications Centres, academic institutions, and regional offices of central government located in the NER.

NE-SAC in collaboration with other ISRO Centres is contributing significantly to the national projects that cover all NER States, viz., land use /land cover mapping on 1:50,000 scale (LULC - 50K), mapping of land degradation, preparation of ground water prospect maps under Rajiv Gandhi National Drinking Water Mission (RGNDWM), wasteland monitoring and wetland inventory and assessment. NESAC has developed an Agricultural Planning Information Bank (APIB) for the benefit of farmers, a Sericulture Information Linkages & Knowledge System (SILKS) for those farmers who practice sericulture as livelihood. Geospatial application projects that help improving the tea garden condition, inputs for preparation of forest working plans/schemes, soil and land capability assessment, conservation of medicinal and aromatic plants are in progress.

A view of NE-SAC campus at Shillong

Integrating the data from 80 AWS spread over the entire NER with satellite–based rainfall estimates, advisory services are supplied to the district level authorities regarding impending floods, drought and endemic diseases like Japanese Encephalitis, etc.

NESAC is coordinating establishment of Village Resource Centres (VRC), in partnership with reputed NGOs, Trusts and other institutions including the government organisations.

FLood Early Warning System (FLEWS) was developed for a few severely flood affected tributaries of Brahmaputra. It integrates satellite based rainfall estimates over the inaccessible Himalayan watersheds with the traditional run-off models in a GIS environment and gives spatial and temporal dimensions of an impending flood event.

5.0. What are the future directions of NE-SAC?

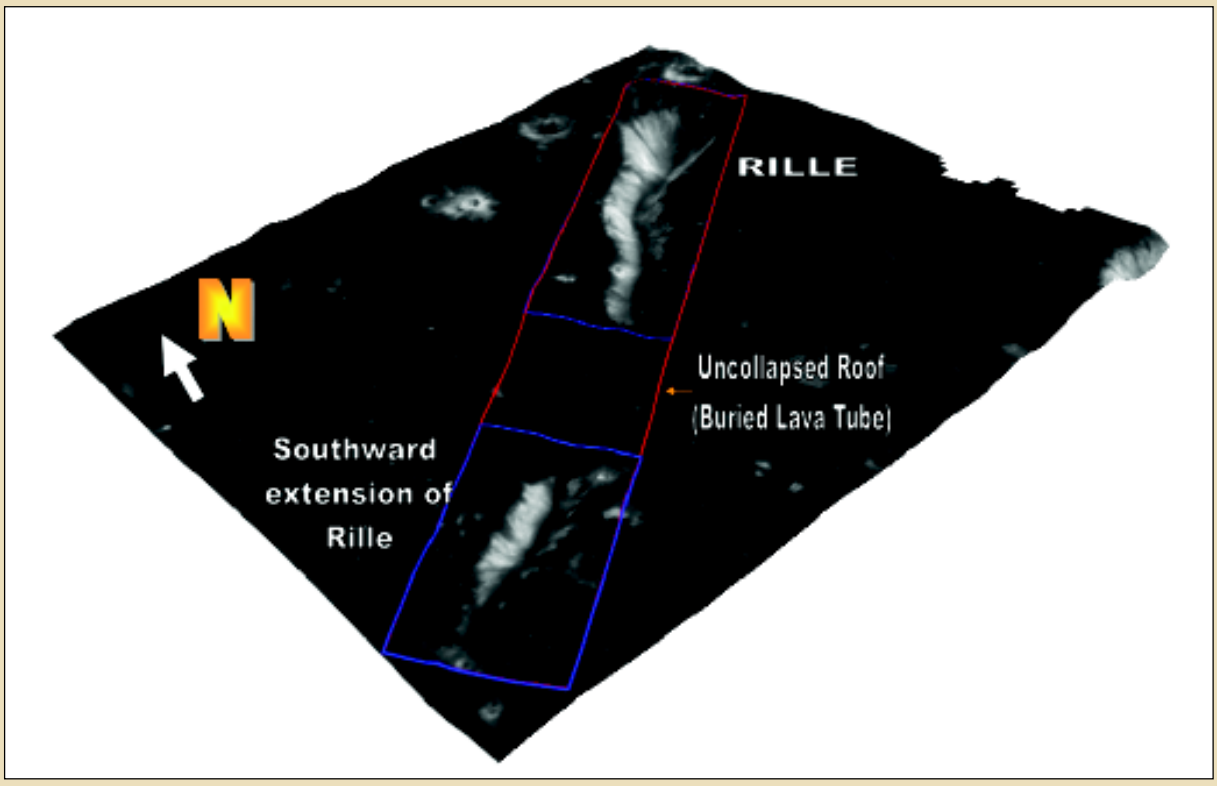
NE-SAC's future plan of action would continue to be guided by the planning and developmental needs of the region. NE-SAC would lay more emphasis on improving the productivity of that region's agricultural lands, conserving the biodiversity and ecology, study the ecosystem dynamics and model the climate change. Vast stretches of the region do not have geological and mineral prospecting maps. Geospatial applications related to this natural resource have to be taken up immediately. Rural connectivity, road network information and gap assessment have to be done using high resolution geospatial data. NE-SAC has to provide inputs to urban infrastructure planning and facilities management in many cities and moderate towns in the region. The region comes under zone V of earthquake proneness and needs seismic micro-zonation and risk assessment. Lot more needs to be done on capacity building towards earthquake risk reduction strategies using satellite communication and remote sensing.

The Centre has to put more efforts to improve weather prediction, disaster early warning, risk assessment and work out strategies for better preparedness. The Centre will further strengthen the SATCOM infrastructure to support education, healthcare, and community development. The SATCOM studio can be fully utilised for content generation, information dissemination and capacity building. It has to give more attention to atmospheric research, especially the monsoon variability and recent occurrence of "drought-like scenarios" in the region. There is tremendous scope for young and energetic scientists/engineers of NE-SAC to do dedicated research in space science including the exploration of outer space, study of planetary systems, their origin, habitability, and existence of life on the other solar and planetary systems in the universe.

Detection of a Lava Tube on Moon using Three Dimensional Chandrayaan-1 TMC Data

From time immemorial, mankind has aspired to colonise the Moon for various reasons. Scientific quest has been the major impetus for visualising human habitability on Moon, as a transit base for outer space exploration missions. Adverse conditions on Moon's surface such as direct exposure to galactic cosmic rays (GCR), solar particle events (SPE), extreme temperature conditions, meteoritic impact, etc., have always challenged the prospects of human settlement on Moon. However, sub-surface hollow lava tubes provide such a conducive locale for safe and future human settlement on Moon. Lava tubes are primarily formed when an active low viscosity lava flow develops a continuous and hard crust due to radiative cooling of its outermost part, which thickens and forms a solid roof above the still flowing lava stream beneath. At the end of the extrusion period, an empty flow channel free from molten magma is left in the form of a near-cylindrical shape tunnel below the surface.

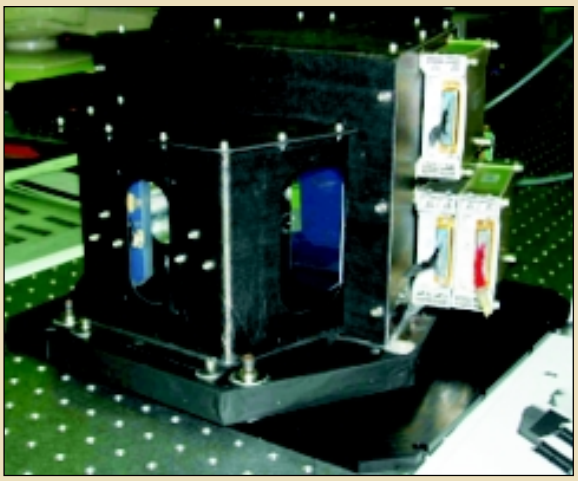
Previous laboratory analysis of radiation safety issues conducted on lunar lava tubes show that beyond



The uncollapsed roof of the Lava tube seen between two trenches (Rilles) on the near-side of the Moon

6 m depth, no effects of radiation due to GCRs are observable in the simulation, no effects of radiation due to or induced by SPE are observable beyond 1 m depth and natural or induced radioactivity does not seem to play any significant role in the lava tube exposures. Past studies using telescopic and orbital data have shown prospect of detecting lava tubes on the Moon.

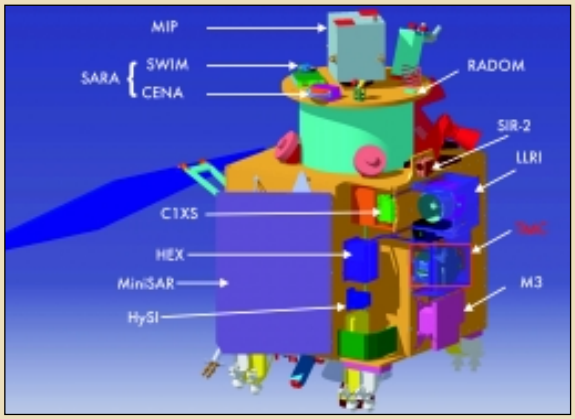
India realised its dream of planetary missions by successfully launching Chandryaan-1 on October 22, 2008. Among 11 different scientific payloads onboard this mission there was an important sensor – the Terrain Mapping Camera (TMC) – having high spatial resolution (5m) and three dimensional viewing capability. This had the best orbital sensor parameters ever flown to the Moon before this mission. The TMC could capture the Lunar surface features with an unprecedented clarity.



Terrain Mapping Camera

A buried uncollapsed and near horizontal Lava tube could be detected using TMC nadir image in Oceanus Procellarum area on Moon.

The lava tube detected by TMC has been analysed thoroughly in terms of morphometry, topography, surface composition and surface ages of the surrounding regions using sensors onboard



Terrain Mapping Camera along with other payloads of Chandrayaan-1

Chandryaan-1. A Digital Elevation Model was generated to view the feature in three dimensional perspective which has helped in estimating the dimensions of the tube which is about 1.7 kms long and approx. 120 meter in diameter. Compared to the most terrestrial lava tubes, this tube is larger. This may be due to the less gravity and absence of atmospheric pressure on the Moon. This lava tube lies between two rilles (collapsed portion of a larger original lava tube) indicating that the roof of this section of the tube has remained intact over the years.

Such a lava tube could be a potential site for future human habitability on the Moon and could be used for future manned missions aimed at scientific explorations, providing a safe environment from hazardous radiations, Galactic cosmic rays, meteoritic impacts, extreme temperatures, etc.

This tube could as well be used as a transit out-post enroute to other planetary bodies.

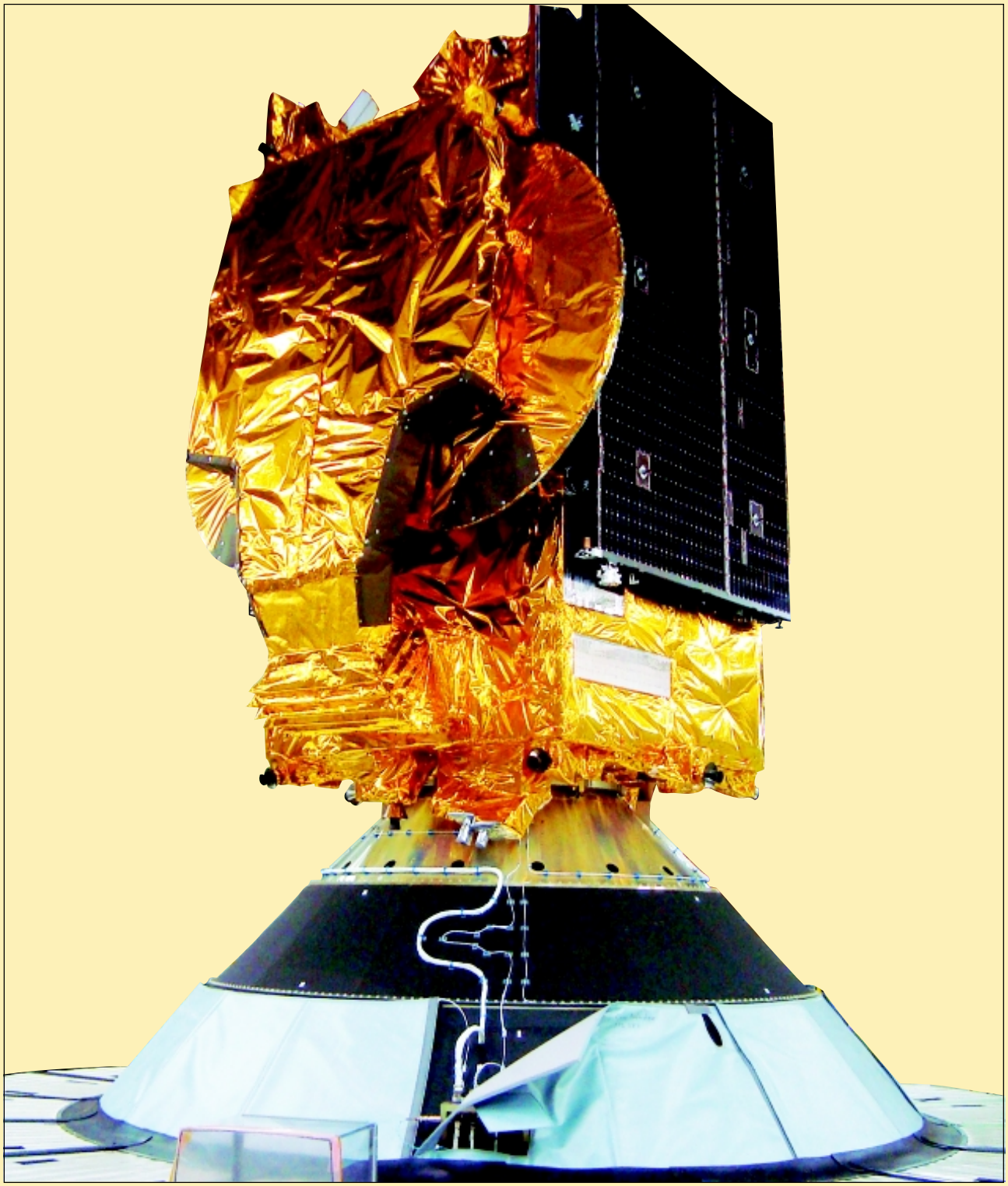
It may be noted that dimensions of a lava tube has been demonstrated for the first time on any planetary body. Past detections have mostly identified the 'sky-light' holes believed to open into lava tubes or identifying candidate tube in 2 dimensions without dimensional estimations of individual tube.

Mr. M. Annamalai receives Padmashree Award

Mr. M. Annamalai is the recipient of "PADMASHREE" Award of the Government of India for the year 2011 for his outstanding contributions in the field of Science and Engineering.

Mr. Annamalai is the former Director of Satish Dhawan Space Centre, Sriharikota, and is currently Senior Advisor (Space Transportations Systems) in ISRO Headquarters. He has got this distinction of getting this award for his significant contribution in all major programmes of launch vehicles of ISRO. Mr. Annamalai has contributed in multi-disciplinary areas in launch vehicle, namely, infrastructure development, design of launch vehicle subsystems, integration and testing of launch vehicle sub-systems, pre-launch preparations and launch campaign management. He has contributed in the areas of solid propulsion, liquid propulsion and cryogenic propulsion. His contribution as Chairman, Launch Authorisation Board is very significant for several missions. Mr. Annamalai, a post graduate in Engineering from Indian Institute of Science, Bangalore. Joined ISRO in 1970 and still continues to contribute to the programmes of launch vehicle.

His contributions also spread outside launch vehicle area. He is the designer of several new subsystems, namely, the 1.2 M Infrared astronomy telescope at Mount Abu owned by Physical Research Laboratory and various Antenna mounts used for tracking satellites and launch vehicles in ISRO network. He has played a key role in the development of High Precision Radar (PCMC Radar) used for launch vehicle tracking. He has promoted space industry cooperation which helped production of mechanical hardware for launch vehicles and building of major facilities, in SDSC-SHAR and LPSC, Mahendragiri.



HYLAS Satellite