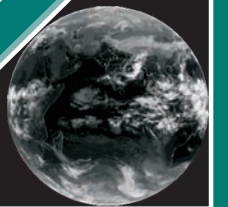
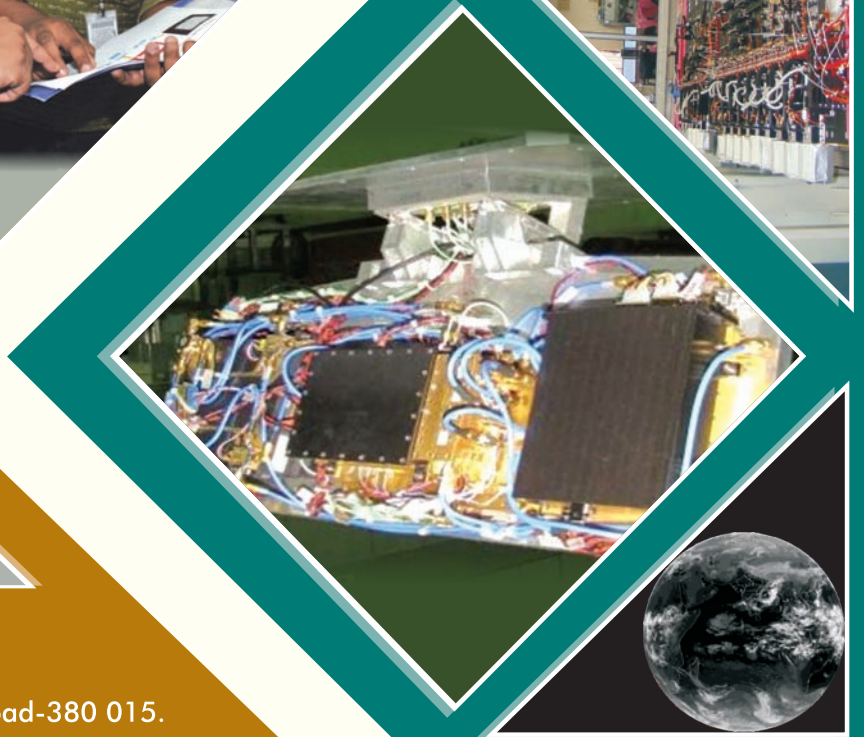


# वार्षिक रिपोर्ट Annual Report 2016-2017



अंतरिक्ष उपयोग केंद्र  
**Space Applications Centre (SAC)**  
Indian Space Research Organisation, Ahmedabad-380 015.

## MESSAGE FROM DIRECTOR

I am pleased to share the 2016-17 Annual Report of Space Applications Centre (SAC), ISRO. It is with great pride that I share this overview of the many accomplishments that we celebrate in SAC. Our priorities remain to be at the forefront of Space Research and Applications. These priorities align effectively with the goals and vision of Indian Space Research Organisation (ISRO). SAC shines as a beacon of excellence in the Space Fraternity.

In 2016-17, our Space Programme has witnessed exponential growth and has attracted global attention for its accelerated rate of development and it is attributed to our culture of innovation and hard work. I am happy to inform that we have successfully delivered payloads for GSAT-17, GSAT-19, GSAT-9, IRNSS-1G, Cartosat-2S, INS-1A and INS-1B, SCATSAT-1, Resourcesat-2A (LISS), Chandrayan-2 (TMC-2) and HSP PAT.

The latest additions in INSAT/GSAT system are GSAT-18, India's largest communication satellite to provide continuity of services in C-band, Extended C-band and Ku-bands and GSAT-9 for VSAT/DTH services providing communication services over SAARC countries. Recently three Earth observation satellites, INSAT-3DR, SCATSAT-1 & Resourcesat-2A were launched which were probably the most popular satellites among the user community for its wide ranging applications covering areas like Agriculture, Climate, Environment, Disaster management etc.

Development of GSAT-11, High Throughput multi-beam Satellite (HTS), is in advanced stage. In addition, GSAT-7A, GSAT-20 (HTS payload), GSAT-21 & AIS payload development work is under progress. AIS (Automatic Identification System) payload for Ship-to-Ship and Ship-to-Shore data broadcast system will enhance the coastal security of the nation.

For Navigation applications, subsystems for IRNSS-1H/-1I are under advanced stage of development. With the view of having indigenous Atomic Clocks onboard second generation NavIC satellites, the development of rubidium clocks is progressing well. SAC-ISRO utilized the in-house developed NavIC receiver with Satellite Reporting



Terminal to demonstrate the ship tracking application during Maritime India Summit-2016 at Mumbai.

For Mobile Satellite Services (MSS) in India, SAC has completed development of four types of handheld and portable terminals with IP based Hub to support different S-band communication services. SAC is developing a MSS network for Indian Railways to support automatic warning at Unmanned Level Crossing, Train Tracking and Emergency communication. The network proof of concept has already been completed and SAC is in advance stage to conduct pilot project with 20 trains and 20 UMLCs. SAC is also developing a MSS network for Indian Navy and Indian Coast Guard to support tracking of small boats for Coastal Surveillance application. MSS HUB is successfully installed at Delhi Earth Station.

For Remote Sensing, Meteorology and Planetary Sciences, payload development works for GISAT-1/-2, Chandrayan-2, RISAT-1A/-2A, Oceansat-3, INSAT-3DS, ADITYA-1 and Hyper Spectral Imaging Satellite are progressing in full swing. Development of ISRO-NASA collaborative project, NISAR for societal applications in which SAC contributes an S-Band Sweep SAR is also progressing well. The MiniSAR payload which is designed for a resolution of 0.3 m in a 5 Km swath had a successful flight and results were encouraging.



Development of various subsystems of Optical EO payloads for GISAT-1/-2, INSAT-3DS, Cartosat-2S, Microwave sensors for RISAT-1A/-2A, L&S band Airborne SAR, and Orbiter SAR projects are in progress. Our Earth Observation (EO) applications teams have generated Desertification Status Mapping, SARAL/AltiKa coastal products for the entire Indian mainland region, validation of improved atmospheric correction technique for 20 fields and Near Real Time updates for cyclones VARDAH & NADA in Bay of Bengal. Towards Astronomical missions, Mineralogical and spectral analysis of Mare Fecunditatis using the M3 data-sets onboard Chandrayaan-1 mission was completed. LTA data set for all five data sets of MOM instruments was also prepared.

Our data platforms, MOSDAC and VEDAS have showcased data products of Resourcesat-1, -2 & -2A, Cartosat-2S, INSAT-3DR & SCATSAT-1 payloads on these platforms. Weather Information Services and Decision Support for Oceanography and Meteorology (WISDOM) was uploaded on MOSDAC website. Using the available database in VEDAS, SAC has started conducting Research and Training programme under TREES (Training and Research in Earth Eco-System centre). Our Centre has also started RSS-based feed mechanism, ISROCAST, for publishing Satellite data products in near real time (NRT) with automatic identification and downloading of recent data by subscribers. Real-time predictions were done for tropical cyclone “VARDAH” through MOSDAC.

Advanced R&D programs in the fields of Terahertz Observatory, Ground Based Standalone Pseudolite Navigation, Infrared Spectrometer Development,

ASIC development for IRNSS receiver and High Throughput Satellite for enabling space based internet were carried out within the Centre.

SAC has achieved 100% expenditure against the budget earmarked for the Centre which played a key role in realizing the projects and critical facilities of the Centre on time. We interface with large number of Industries, Academic Institutions and Government Departments for research and development. 24 MoUs were signed with technical institutions for IRNSS ground receiver data acquisition exercise. Currently under RESPOND, 148 research projects are going on with academia across the country.

VSSE celebrated World Space Week with great enthusiasm and received excellent participation.

हमारे केंद्र में राजभाषा हिंदी का कार्यान्वयन सरकार की राजभाषा नीति के अनुरूप किया जा रहा है। यह बड़ी खुशी का विषय है कि हमारे वैज्ञानिकों ने इस वर्ष भी अंतरिक्ष विज्ञान के विषयों पर हिंदी में 3 पुस्तकें लिखी हैं जिसकी अंतरिक्ष विभाग ने बड़ी सराहना की है।

Under green initiative, more than 1000 saplings have been planted in SAC main campus and Bopal campus by the employees.

CMG, Administration, Accounts, Purchase & Stores have aptly supported the activities of the Centre.

I am confident that this report will give readers an enriching experience of activities and achievements of SAC.

**Tapan Misra**

## Foreword

Space Research & Applications continues to be the most sought after domain for societal as well as commercial applications. ISRO, being the face of the nation in the world space industry has grown in all dimensions and has achieved formidable milestones. Space Applications Centre (SAC) is the leading Centre of ISRO in the area of Space Research & Application.

In 2016-17, SAC has successfully delivered GSAT-17, GSAT-19, GSAT-9, IRNSS-1G, Cartosat-2S, INS-1A and INS-1B, SCATSAT-1, Resourcesat-2A (LISS), Chandrayan-2 (TMC-2) and HSP PAT payloads for various applications.

It gives me immense pleasure to present the SAC Annual Report for the year 2016-17. The report highlights the completed activities, significant achievements and future outlook of various SATCOM, SATNAV, Earth Observatory and Remote Sensing projects, their applications and data products.

The activities of Technical Facilities including Mechanical, Electronics and Construction & Maintenance, Systems Reliability & Assurance are presented.

Management support activities and achievements encompassing Research, Projects & Budget, Technology & Industrial Interface, Information System and Human Resource, and various Administration services of SAC are highlighted. The report further presents the major events and publications for the year 2016-17.

I would like to thank all the Areas and Groups of SAC for their timely inputs for making this report. I wish to congratulate PPMD-PPG team for bringing out this report in a precise manner.

**Vikas Patel**  
**Group Head, PPG**





VIKRAM A. SARABHAI  
(1919 - 1971)

(डॉ. विक्रम. ए. साराभाई )

हमें मानव और समाज की वास्तविक समस्याओं के समाधान के लिए  
उन्नत प्रौद्योगिकी के अनुप्रयोग में सबसे आगे रहना होगा ।

*We must be second to none in the application of advanced  
technologies to the real problems of man and society."*

प्रौद्योगिकी हासिल करना हमारा उद्देश्य नहीं है किंतु यह  
एक ऐसा साधन है जिसका उपयोग सामान्य मनुष्य के हित  
के लिए किया जाना है ।

*Technology is not an objective to be aimed at, but a tool to  
be used for the benefit of the common man.*



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***Image of Mahatma Mandir, Gandhinagar captured by CARTOSAT-2S***



## Space Applications Centre - Introduction (SAC)



Space Applications Centre (SAC) is one of the major Centres of Indian Space Research Organisation (ISRO) in Ahmedabad, Gujarat.

SAC has expertise in design of space-borne instruments for various ISRO missions and development and operationalization of applications of space technology for national development, ranging from communication, broadcasting, navigation, disaster monitoring, meteorology, oceanography, environment monitoring to natural resources survey. SAC designs and develops all the transponders for the INSAT and GSAT series of communication satellites and the optical and microwave sensors for IRS series of remote sensing satellites. SAC develops the ground transmit/receive systems (earth stations/ground terminals) and data/image processing systems.

SAC has world class facilities for payload integration, mechanical and electronic fabrication, environmental test facilities, project management support group, a well-stocked library and a dedicated Hindi division.

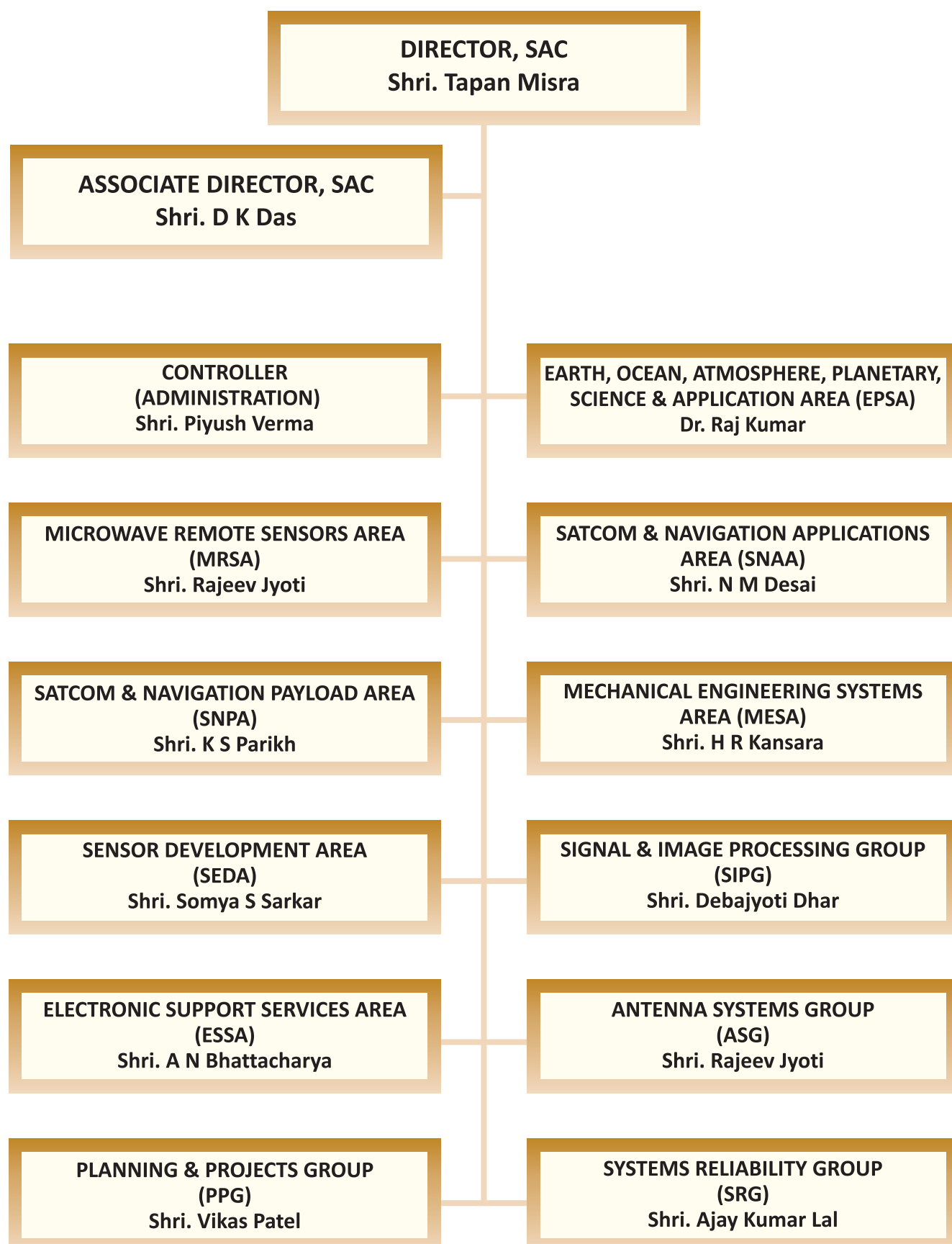
The Center also conducts nine-month post graduate diploma courses for students from the Asia Pacific region under the aegis of the Center for Space Science and Technology Education in Asia and the Pacific (CSSTEAP) in satellite communication and meteorology.

SAC works with industry for sourcing and indigenization, involves Indian universities in space research and propagates space technology and applications amongst students and public through in-house and mobile exhibitions.





## SAC Organisation Structure as on March 31, 2017







**SAC MANAGEMENT COUNCIL (SMC)** as on March 31, 2017

- ❖ Shri. Tapan Misra, Director-SAC, Chairman
- ❖ Shri. D K Das, Associate Director-SAC, Member
- ❖ Shri. Virender Kumar, Director-DECU, Member
- ❖ Shri. Piyush Verma, Controller-SAC, Member
- ❖ Shri. K S Parikh, DD-SNPA, Member
- ❖ Shri. N M Desai, DD-SNAA, Member
- ❖ Shri. Rajeev Jyoti, DD-MRSA, Member
- ❖ Shri. A N Bhattacharya, DD-ESSA, Member
- ❖ Dr. Raj Kumar, DD-EPSA, Member
- ❖ Shri. H R Kansara, DD-MESA, Member
- ❖ Shri. Somya S Sarkar, DD-SEDA, Member
- ❖ Shri. Debajyoti Dhar, GD-SIPG, Member
- ❖ Shri. Ajay Kumar Lal, GD-SRG, Member
- ❖ Shri. Vikas Patel, GH-PPG, Member Secretary

## **SATCOM & SATNAV Payload Development**

SATCOM and Navigation Payload Area (SNPA) under SAC, is responsible for conceptualizing, designing and building communications payloads of INSAT/ GSAT series and navigation payloads of IRNSS series of satellites. This mandate spans the entire gamut of activities such as system design & architecture, subsystem hardware development, payload integration & checkout, final delivery and in orbit performance verification. The technical competence and responsibility of SNPA extends beyond RF and microwave communications, to include on-board signal processing and optical communications systems for advanced communication and navigation satellites.



## Projects at a Glance: 2016-17

Satellite	Services	Unique Feature	Type of Transponder
GSAT-6A	Digital Multimedia Broadcast Services	6m unfurlable antenna	S-Band
GSAT-7A	Satellite Communication	Multiband Communication	Ku-Band
GSAT-9	Satellite Communication	Ku shaped reflector with graded gain over different coverage area	Ku-Band
GSAT-11	Satellite Communication	High Throughput Multi-Beam, Based on I-4K Bus	Ka & Ku Band
GSAT-17	Fixed Satellite Services	MSS Payload using digital filter, Wide Band C-DGR Antenna	C-Band, DRT/SAR
GSAT-18	Satellite Communication	Indigenous DGR Antenna with Rib-less Intercostal Structure	C-Band, Ku-Band
GSAT-19	Broadband Services	High Throughput Multi-Beam, Based on I-3K Bus	Ka & Ku Band
GSAT-20	Broadband Services	Ka-Band Spot beams, High Throughput	Ka-Band
GSAT-21	Mobile Satellite Services	Large Unfurlable Antenna, Digital Beam Forming	S-Band
GISAT	Monitoring of Disasters, Natural Hazards, Calamities	GEO Imager with multi spectral and multi resolution imaging instrument	High rate data Tx for Imager
INSAT-3DR	Climate, Environment & Disaster Management	Advanced meteorological satellite with imaging system and atmospheric sounder	Data Tx for meteorology payload
IRNSS (NAVIC)	Navigation Services	Regional Navigation satellite to provide accurate position information	L-Band, S-Band, C-Band

## SATCOM & SATNAV Payloads

### GSAT-7A

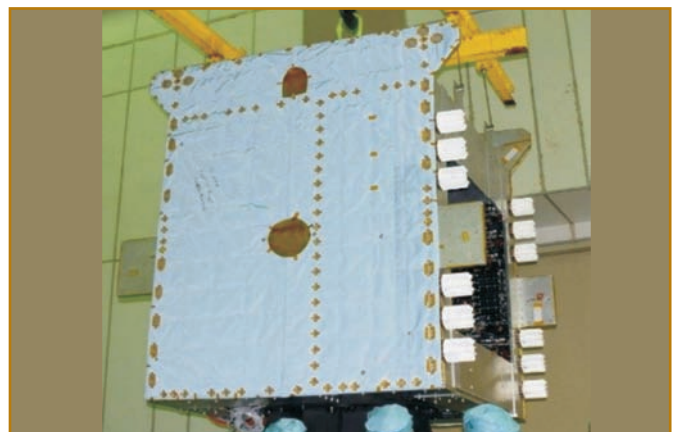
GSAT-7A has Ku-band transponders and provides three types of coverage beams: regional, wide and shaped India beams over Indian region.

In FY 2016-17, the Testing & Evaluation (T&E) of major active & passive sub systems were completed. The Critical Design Review (CDR) was presented to the CDR Committee and was completed. Feed Integration activity to realize Gregorian Antenna was completed and T&E was initiated for both Qualifying Model (QM) and Flight Model (FM).

### GSAT-9



*GSAT-9 Flag-off*



*Spacecraft level Tests*

GSAT-9 is a high power Ku-Band satellite designed to provide satellite communication services.

In FY 2016-17, the design optimization and characterization of all sub systems like Receivers, Drive Amplifiers, IMUX, OMUX, Couplers, Filters, as per new frequency plan, followed by T&E was completed. Fabrication & assembly surface treatment of Ku-Tx & Rx feed assembly for Shaped Reflector Antenna was completed. Assembly, Integration and T&E of payload including Thermovac test was completed successfully and was flagged-off from SAC to ISAC, Bengaluru for further integration with Spacecraft on 4th Jan 2017.

### GSAT-11





GSAT-11 is a high throughput multi-beam satellite with Ka x Ku and Ku x Ka transponders and based on I-4K bus.

In FY 2016-17, fabrication of Ku-Band LNA, Ka-Band LNA, Ka x Ku Down Converters, Ku x Ka Down Converters, OCXO Network, Front end elements of RF Tracking chain is completed. Most of the packages were delivered for integration.

### GSAT-17

GSAT-17 is designed with C-band transponders, forward and return link transponders and DRT/SAR transponder to provide Fixed Satellite Services.

In FY 2016-17, the design optimization and testing of all sub-systems followed by successful T&E and integration was completed. Development of patch array antenna with feed followed by successful Thermovac testing was achieved.

Payload performance was found satisfactory post T&E and Thermovac testing and was delivered to ISITE, Bengaluru on October 28, 2016.

All Antenna system mounted on spacecraft and integrated with payload at ISITE, Bengaluru. Satellite was ready for vibration test at ISITE, Bengaluru.

### GSAT-18

GSAT-18 is designed with C-band transponders and Ku-band transponders along with Ku-band beacons. Its unique Ku-band Tx-Rx DGR antenna with Rib-less Intercostal structure is designed and developed indigenously by ISRO.

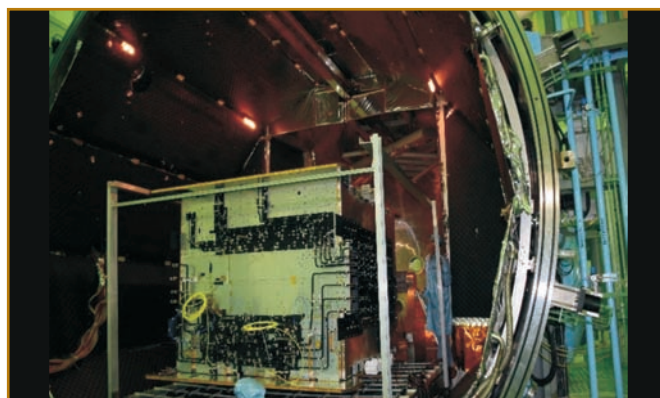
In FY 2016-17, the Antenna was integrated with spacecraft and complied with alignment checks. Spacecraft level Thermovac and CATF tests were completed. Payload and Spacecraft Pre shipment Review (PSR) was completed. Payload Pre-launch tests were completed at Kourou, French Guyana. Payload performance was normal.

In-orbit Testing of communication payload successfully completed. Payload performance is satisfactory.

### GSAT-19



*GSAT-19 Flag-off*



*GSAT-19 TVAC*

GSAT-19 is designed with Ku band user spot beams and Ka band hub beams. It is a high throughput satellite based on I-3K bus. The payload is configured to provide broadband services over Indian region and is planned to be launched by first development flight of GSLV-Mk3-D1.

In FY 2016-17, all sub systems were optimized at design level as well as fabrication level. The characterization and testing was completed. All FM units were delivered for integration. T&E and Thermovac tests of Integrated Payload were completed and results were satisfactory. Payload was flagged off from SAC on December 22, 2016.

Spacecraft level Assembled mode IST and thermos vacuum test was completed at ISITE, Bengaluru. Antenna integration activities with Spacecraft in progress at ISITE, Bengaluru.

### **GSAT-20**

GSAT-20 is a Ka-band high throughput multi-beam satellite with spot beams and Ka-band beacons providing broadband services over Indian region. The payload is planned to be launched by third development flight of GSLV-Mk-3-D3.

In FY 2016-17, payload configuration design was completed and sub system design was in progress. Characterization of Horn Array Antenna was successfully completed.

### **GSAT-21**

GSAT-21 is a S-band Geo-mobile satellite for providing services to hand-held terminals over Indian Region. The payload development is in progress.

### **GSAT-6A**

GSAT-6A satellite is intended to serve high power S-band communication applications including Digital Multimedia Broadcast services for the Indian mainland.

In FY 2016-17, Payload system and sub-systems specifications were generated. The hardware development and payload realization was in the advanced stage.

### **INSAT-3DR**

INSAT-3DR communication payload is designed with imager, sounder, DRT, SAS&R payloads.

In FY 2016-17, Spacecraft level Thermovac and CATF tests were completed at ISAC, Bengaluru. Payload Pre-Shipment Review (PSR) is completed.

In-orbit tests for DRT/SAT and MET payload were completed.

### **Geo-Imaging Satellite (GISAT)**

GISAT payload is a high resolution imager with multi spectral, multi resolution imaging capability to image full or part of the earth disc with basic imagers namely High resolution multi spectral VNIR imager, Hyper spectral VNIR imager, Hyper spectral SWIR imager, High resolution Multi spectral LWIR Imager.



In FY 2016-17, payload system and sub system specifications were generated. The payload development is in progress.

### **Automatic Identification System (AIS)**

AIS is a Ship-to-Ship and Ship-to-Shore data broadcast system operating in the VHF maritime band. The broadcasting information is shared between ships and shore stations.

In FY 2016-17, EPCs for RF and Digital subsystems and Amplifiers (SSPAs, LNAs) were optimized and successfully tested. The design of VHF antenna was completed.

### **Indian Regional Navigation Satellite, IRNSS (NavIC)**

IRNSS is a constellation of satellites based on I-1k platform. The payload is designed with L-band, S-band and CxC ranging transponders. It offers Standard Positioning Services (SPS) and Restricted Services (RS). Presently IRNSS-1H and IRNSS-1I payload development is in progress.

#### **IRNSS-1F**

In FY 2016-17, In-orbit test for Navigation and Ranging payload is completed at MCF-Hassan. Payload performance is normal.

#### **IRNSS-1G**

In FY 2016-17, Antenna integration with spacecraft and spacecraft level CATF test was completed at ISITE, Bengaluru. In-orbit test for Navigation and Ranging payload is completed at MCF-Hassan. Payload performance is normal.

#### **IRNSS-1H & 1I**

In FY 2016-17, the TVAC test of Helix array antenna was completed followed by successful T&E. NavIC Antenna for Launch Vehicle was delivered. The characterization and testing of all sub-systems was completed. The FM units of Up and Down Converters were delivered.

Indigenous Rb-Atomic Clock Development Functional testing was completed. Testing and reassembling of old ETM clock in under progress. The hardware development is in advanced stage.

## **SATCOM & SATNAV Payload Applications**

SAC is a lead center of ISRO for offering SATCOM and SATNAV applications. SAC is pioneer in design & development of NavIC User Receivers, Simulator, Encryption scheme and code analysis through its SATCOM and Navigation Applications (SNAA) entity. It has been instrumental in design and development of multimedia terminals and UHF receivers for satellites. SNAA is also involved in various technology development programs related to advanced communication systems apart from providing operations of Mobile Satellite Services (MSS).



## SATCOM Applications

### GSAT-6

#### MSS HUB

- ❖ Augmentation of existing Hub Baseband sub-systems at AES to provide simultaneous service in all five beams by integrating signaling modems, broadcast modulator and multiplexer was carried out.
- ❖ A limited capacity MSS HUB with 4 voice channel and 5 reporting carriers at Delhi Earth Station (DES) was successfully established in record time. The system is now operational and supports hub operations for all pilot projects / trials for users based around Delhi.
- ❖ Operational support of HUB for: a) pilot projects demonstration; b) Testing of MSS network for automatic warning at Un-Manned Level Crossings (UMLC's) and train tracking & emergency communication for Indian Railway and c) for Coastal Surveillance.
- ❖ For the Coastal Surveillance Pilot-Project, end-to-end connectivity using a leased-line between GSAT-6 Hub baseband system at AES-SAC and IMAC, Gurgaon was established for transferring reporting terminal data for GIS for the Indian Navy.
- ❖ Design and Development of Satellite Gateway Unit and Transcoder SIP Gateway for voice call routing and protocol conversion replacing the industry-developed Voice Gateway Unit (VGU) was successfully completed to provide a more flexible, cost-effective and reliable solution. The integrated system is currently operational at DES HUB, Delhi.
- ❖ Reporting Service HUB was made NavIC-ready. NavIC receiver is integrated with GSAT-6 Hub using terrestrial interface and tested successfully for real-time tracking application.
- ❖ MSS Hub was successfully developed and tested for PAT Mission for Human Spaceflight Programme (HSP) to receive data from Ka-band Radar Altimeter and NavIC receiver. Received parameters are used to track of crew module in real time on web browser.
- ❖ A full-fledged new MSS HUB is coming up at DES capable of operations through all five beams of GSAT-6 with a total of 125 voice carriers and 150 reporting carriers.



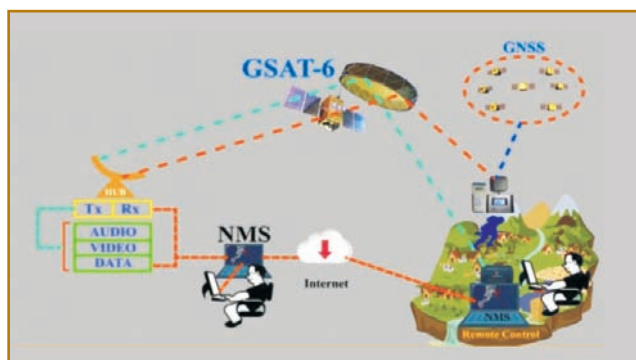
#### MSS Terminal Development:

- ❖ Four types of mobile satcom terminals namely, Reporting Terminal, Broadcast Terminal, Satellite Mobile Radio (SMR) Terminal and Portable Multimedia Terminal (PMT) were developed, manufactured and functionally tested for various users using GSAT-6 MSS services. Requisite numbers of units are fabricated and offered to various agencies for field trials.

- ❖ Ten number of ruggedized reporting terminal for Vessel monitoring manufactured and tested through satellite. Software application development for converting messages from Reporting Terminal to NAIS format using TCP Link was completed successfully for demonstration of vessel monitoring application using GSAT-6 MSS network. The tracking data is being received and forwarded to IMAC hub successfully after field installation for coastal surveillance network of Indian Navy. Four reporting terminals were provided to special user group.
- ❖ The application of vehicle tracking using GSAT-6 Reporting Terminal satellite based position reporting was demonstrated at IETE workshop, LD Engineering college. The team also developed GSM/GPRS based system for tracking. Demonstrated tracking application at BRTS using integrated NavIC & GSAT-6 reporting terminals through on GSAT-6 hub and on Internet. Outernet Application over GSAT-6 network was demonstrated successfully using reporting terminal & broadcast receiver terminal for offline transfer of large data for information or educational purposes on request-queue basis.
- ❖ Development of host application software for data as well as audio-video reception and streaming data content in real-time to user interface port is completed and tested using broadcast receiver over MSS network. Fifty (50) number of broadcast receiver terminals were developed and tested in satellite link.
- ❖ Five (05) units of Railways MSS Terminal for locomotive (RMT-L), five (05) units of Indian Rail Navigator (IRN) and ten (10) units of Railways MSS Terminal for Warning (RMT-W) hardware development were completed and satellite link testing for Warning at Un-Manned Level Crossing (UMLC) and Emergency Communication was completed. Railways MSS network was successfully tested and demonstration of the same was carried out. Development of new terminals for Real-Time train tracking (RTIS) initiated.



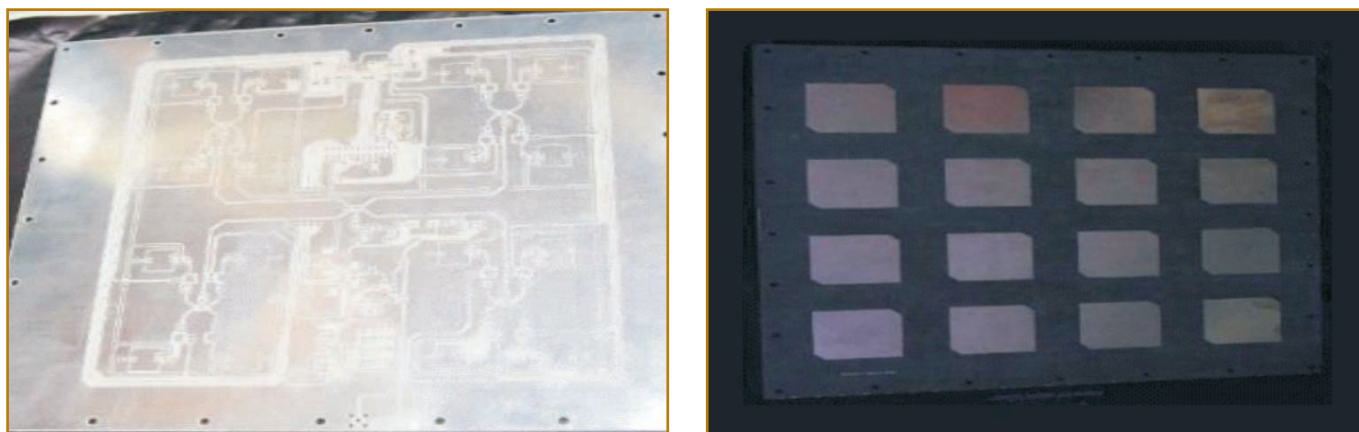
- ❖ Personnel Tracker application for CRPF using GSAT-6 MSS network was developed and demonstrated. The application was further augmented with broadcast receiver-based technology to support real-time in-field Network Management and control application for CRPF to assist in personnel tracking from more than one location simultaneously. The application was demonstrated to CRPF successfully.





## Beamformer Development

A Beamformer for a mobile terminal antenna is under development with a capability to point a relatively narrow beam to the satellite in the dynamic scenario. Beamformer Controller card has been fabricated and tested. Antenna Beamformer card PCB fabrication and component wiring in progress.



*Beamformer PCB (Top & Bottom Side)*

## GSAT-11

### Ground Network System:

To support operations of the GSAT-11 (high throughput - HTS) satellite, a comprehensive ground segment is being put into place. This includes Ka-band gateway stations at specified locations incorporating a site diversity station at each (4 + 4 stations); Ku-band field terminals and other equipment. Optical fiber connectivity is provided between the diversity stations for seamless takeover in case of precipitation events causing high attenuation. System design has been completed to finalize the system requirements.

### Onboard Tracking System & Tracking Receiver:

An on-board tracking system including a tracking receiver has been successfully developed for enabling the narrow-beam width Ku-band antennas to lock to a ground-uplinked beacon to ensure signal stability.

- Critical Design Review of Tracking System & Receiver was successfully completed.
- Development and T&E of One QM unit and Two FM completed and units delivered to Project.
- Development and T&E of Automated Testing Software for rapid, reliable testing of the Onboard Tracking Receivers was carried out.
- Requirements of Ground Beacon Network, required for Onboard Tracking System operation were generated to aid the setting up of the station.

## GSAT-19:

Configured as a subset of GSAT-11, the GSAT-19 payload will provide a test-bed for technologies related to high throughput satellite network operation. The requisite Ground Network and System has been configured and the design has been completed along with RFP preparation for its establishment. Procurement of the same is under progress.

### **Onboard Tracking System & Tracking Receiver:**

- The Critical Design Review of both Tracking System & Receiver are successfully completed; followed by The development and T&E of two FM units completed and delivered to project.
- Tracking System testing at various stages of spacecraft integration were carried out successfully:
  - Integrated Payload Testing & Payload Thermo-Vacuum Testing.
  - Disassembled & Assembled Integrated Spacecraft Testing.
  - Spacecraft Thermo-vacuum.
- The GSAT-19 is now launched successfully by the GSLVM-3 D1 heavy-lift launch vehicle. Preparations are underway for in-orbit testing (IOT) of the satellite.
- Requirements of Ground Beacon Network required for Onboard Tracking System operation were generated on similar lines as for GSAT-11.



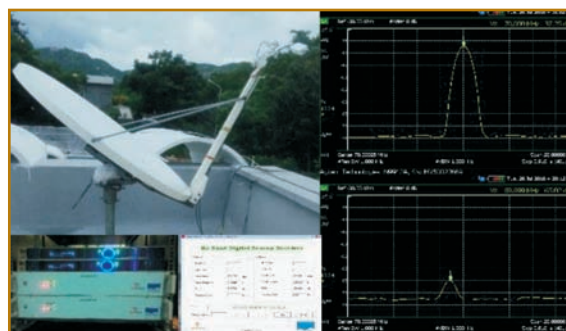
*GSAT -19 Tracking Sys Closed Loop Test at ISITE CATF*

### **Satellite Distance Education Network (SDEN):**

- Design and development of base band system for single forward-link carrier transmission for DTH setup box and interactive terminals.
- The SDEN has been developed to support both DTH and interactive terminal in single carrier and successfully demonstrated in satellite link.

### **Ka-band Propagation Experiment:**

- Beacon receiver has been successfully installed at NARL Gadanki for Ka-band propagation experiment. Indoor unit of beacon receiver for Kolkata integrated, tested and dispatched.
- Final site at Kolkata is nearing completion. New meteorological instruments installed at all stations.
- Data collection continued at all stations during the year. Analysis of Ka-Band propagation and associated meteorological data for 2016-17 done and new findings reported.



*Ka-band Beacon Receiver Installed at NARL*



### Monopulse Tracking Receiver for Earth Stations:

- Technology and prototype hardware for a generic digital monopulse tracking receiver has been successfully developed.
- Developed a new unit of Tracking Receiver and successfully completed in-system-testing in Two channel configuration at MCF, Bhopal and deployed at MCF for long duration testing.
- Developed and tested Single-Channel Generic Digital Monopulse Tracking Receiver for Earth Stations and offered for in-system testing at NRSC, Hyderabad.



*TCDMTR\_\_ES installed at Ku-DBS station*

## SATNAV APPLICATIONS

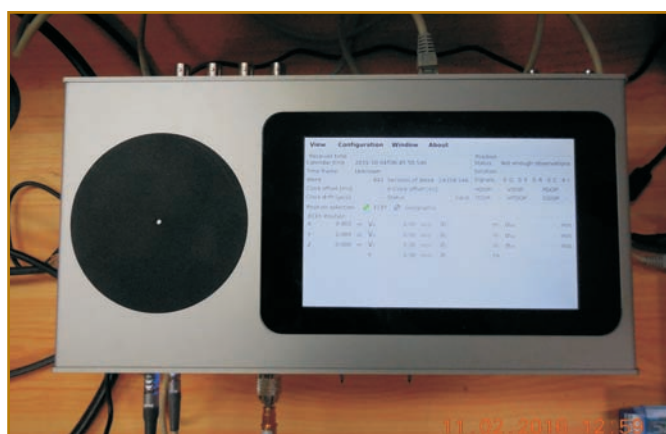
### NavIC (IRNSS)

#### Antenna:

- NavIC triband Ground terminal antennas are successfully tested with satellite. The single feed tri band circularly polarized antenna has been designed.
- Dual band (L5/L1) antenna: The planar antenna with size of 100mmx100mmx35mm using quad probe with sequential rotation for circular polarization has been designed.

#### NavIC User Receiver:

- 22 units of NavIC RS Receivers delivered by M/s IFEN were functionally tested. 2 units were given to SNPO/ISAC for monitoring and 15 units to IDS for field trails.
- 105 SAC-designed receivers were delivered by M/s Data Pattern. Out of which 30 receivers were given to academic institutes for field trial and 15 units to ISTRAC for time synchronization between their ranging stations.

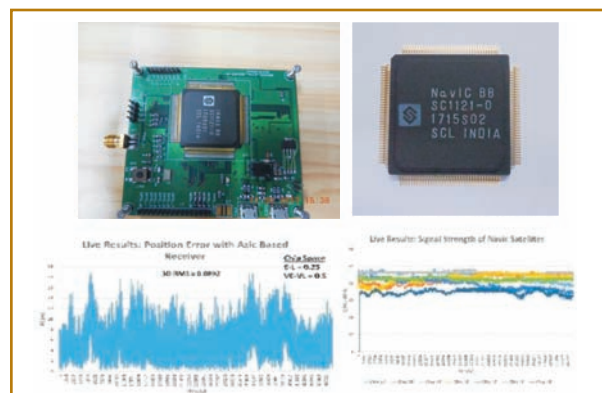


*IFEN RS Receiver*



*Data Pattern SPS Receiver*

- ASIC development for NavIC receiver has progressed considerably. ASIC for SPS Receivers with RF IC are now in an advanced stage of development. The BBASIC COB testing has been done and RF-IC package level characterization has been completed.
- 1 channel messaging receiver developed and demonstrated.
- PTR for NavIC 1H with capability of utilizing long codes has been delivered.



*BBASIC for NavIC SPS Receiver and characterization plots*

### NavIC Receiver for Launch Vehicle:



*Receiver for Launch vehicles*

NavIC Receiver for Launch Vehicle was successfully tested and delivered for PSLV C36 Flight.

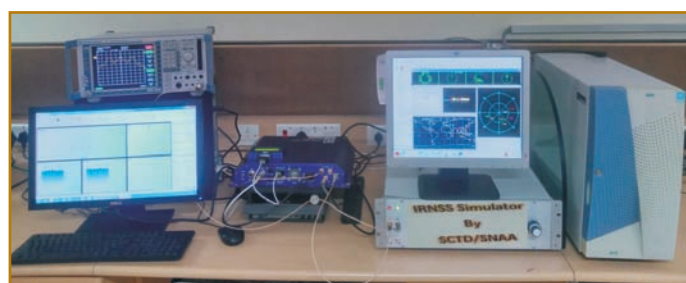
- NavIC Receivers for Launch Vehicle and HSP PAT Abort Test are under development and testing.
- NavIC receiver for GSLV MK-III successfully integrated and tested.



*Receiver for HSP PAT*

### NavIC Simulator:

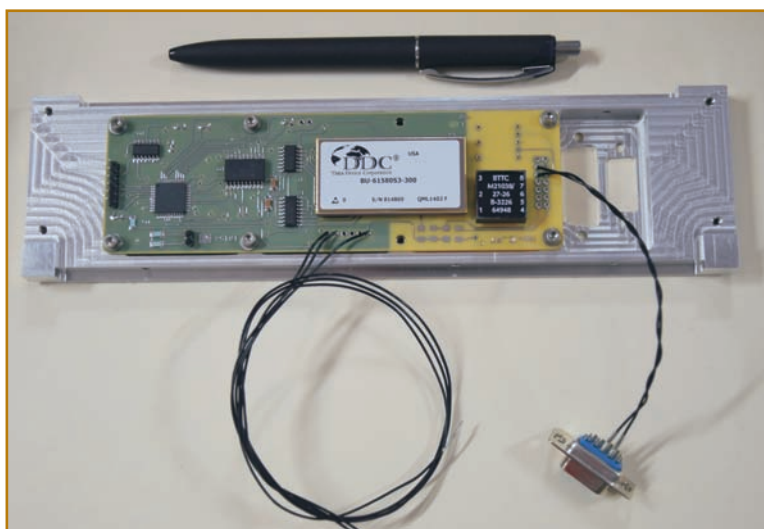
- 7 channel L5 and S Band In-House NavIC Simulator as per professional standard has been developed and successful completion of T&E has been done.



*Integrated test setup of In-house simulator with M/S ACCORD Receiver*



- In-House NavIC Simulator successful installed and delivered to IIST, Trivandrum to be used in the design and development of NAVIC Receiver in collaboration with IIT Chennai, IIT Jodhpur, IIT Bombay and SAMEER under the initiative of Department of Electronics and Information Technology (DeITY).
- In-house NavIC Simulator has been delivered to M/S Data Patterns, Chennai for the mass manufacturing and testing of NavIC Receivers production units.
- 52-week long code generator design for NavIC has been completed and is shared with NSGU team for implementation. The testing of the integrated long code generator along with the parameter generation module in hardware is completed.
- Implementation of 52-weeks long code for RS has been carried out in one channel of in-house NavIC simulator.
- In-house NavIC Simulator was extensively used during the environmental testing of NavIC Receiver for PSLV-C36 Mission.



#### **NavIC Remote Terminal for Launch Vehicle:**

NavIC-RT for launch Vehicle has been successfully designed, developed and tested to provide MIL-1553 bus interface to NavIC-Receiver. A unit has been delivered for - PSLV C39. It is also planned to be used for future missions.

#### **Carrier-Phase based Precise Positioning:**

Carrier-phase based Differential positioning software was developed at SAC which provides positioning solutions with centimeter level accuracy. The RMS 3D error in absolute position of the rover receiver depends on the baseline and geometry of the satellite. In the current year, differential positioning with accuracy of 28 cm to 49 cm was achieved up to baseline 6.65 km. using indigenously developed NavIC receivers.

#### **Pseudolite navigation system**

SBAS Systems has limitations that it does not meet the accuracy requirements below altitude of 250 m for precise approach and landing of aircrafts. A ground based system, pseudo satellite or Pseudolite, is being developed, where Navigation signals are emitted from ground based transmitters. POC with targeted accuracy of better than 0.6 m V and 4.1 m H using code phase is in progress.

## REMOTE SENSING PAYLOAD DEVELOPMENT

Remote Sensing Payloads are mainly developed in SAC under two areas namely, Sensors Development Area (SEDA) and Microwave Remote Sensing Area (MRSA).

SEDA is responsible for realization of Electro-Optical Remote sensing payloads for IRS series of satellites, Planetary missions like Chandrayaan-2, Small Satellites, MARS Orbiter Mission, Meteorological payloads for INSAT series of satellites, Geo Imaging Satellite (GISAT) and Hyperspectral Imaging sensors and also for various airborne applications.

MRSA is responsible for development and operation of state-of-the-art active and passive microwave space-borne, airborne and ground based sensors which include Synthetic Aperture Radars (SAR), Wind Scatterometer, Radiometers, Altimeters and Ground penetrating Radars etc. for ISRO's Earth Observation (EO), Space Science & Inter-planetary missions. For realization of these systems, new technological developments and advanced R&D activities including indigenization and miniaturization efforts have been the prime endeavor of the area. MRSA also pursues in exploring and configuring sensors for venturing in new spectrum for advanced R&D to make impact on science and its applications.



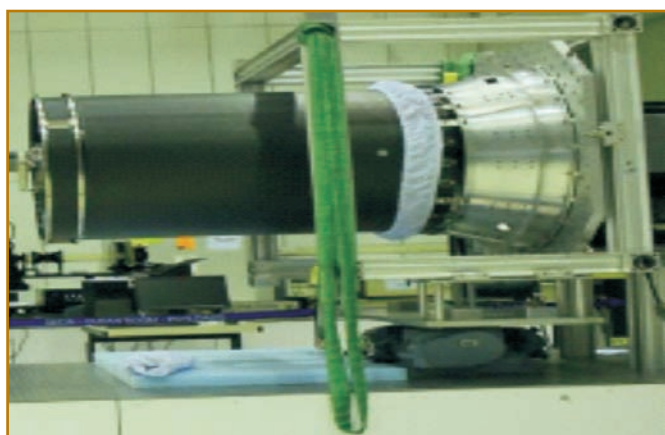
## Earth Observation Satellites

### Cartosat-2S

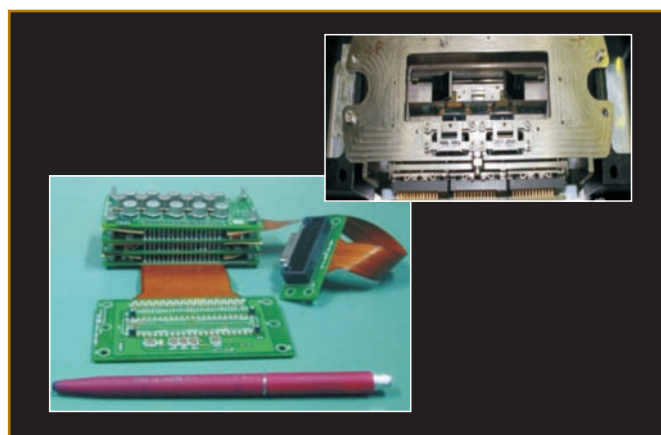
Cartosat-2S series satellite is the primary satellite carried by PSLV-C37. Cartosat-2S series payloads cater to the mission objectives for improving spatial resolution in panchromatic band and incorporating multi-spectral capability for host of civilian applications with an operational life of 5 years. It provides spatial resolution of 0.63 m in PAN and 1.57 m in MX bands. It also has two event monitoring cameras viz. EVM-1 & EVM-2.

After successful T&E, Cartosat-2S payload was airlifted to ISAC, Bengaluru on December 27, 2016 and was successfully launched on February 15, 2017 onboard PSLV-C37. All payloads were switched ON and excellent images were acquired. In-orbit performance analysis was carried out and payload performance was found to be satisfactory.

Another payload of Cartosat series was delivered to ISAC, Bangalore on March 28, 2016 and launched on June 22, 2016 onboard PSLV-C34. In-orbit data analysis for PAN, MX, EvM-1 & 2 payloads were carried out and results were generated. Payload performance was found to be satisfactory.



*Cartosat-2S Telescope*



*CARTOSAT-2S Subsystems*



*Cartosat-2S Image of Ahmedabad*



*Image of (BKC Block and Mithi River, Mumbai)*

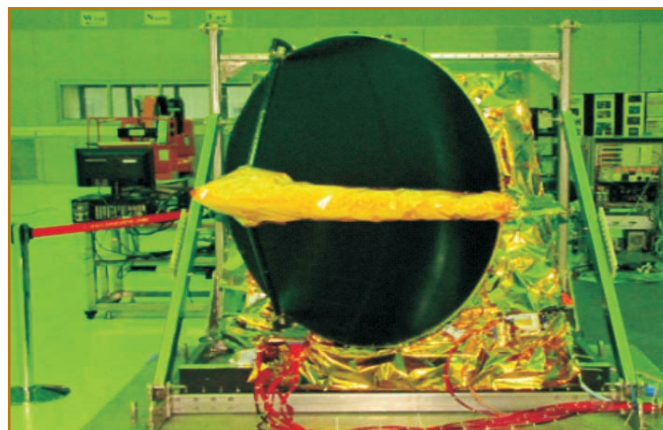
## ScatSAT-1

ScatSAT-1 is the follow-on mission to OSCAT and has many advancements in the payload over the earlier mission like enhanced on-board signal processor, ability to upload software patches, captive payload telemetry unit etc.

Payload was delivered on June 17, 2016 and launched on September 26, 2016 onboard PSLV-C35. In-Orbit Test (IOT) was carried out successfully. Full payload Switch On was carried out on October 3, 2016. From first day onwards it provided excellent sigma naught performance. Data is processed for brightness temperatures and found to be satisfactory.

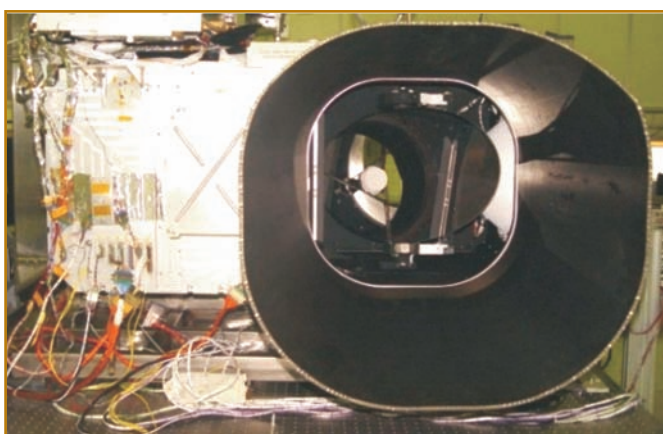


*Flag off of ScatSAT-1 payload*

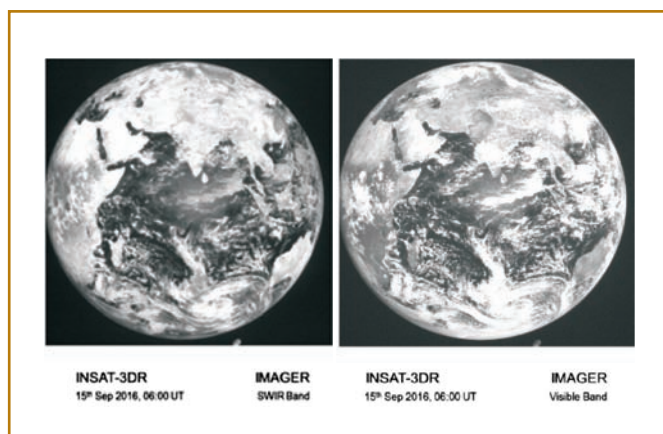


*ScatSAT-1 payload*

## INSAT-3DR



*INSAT-3DR Imager*



*Images of INSAT SWIR and VIS bands*

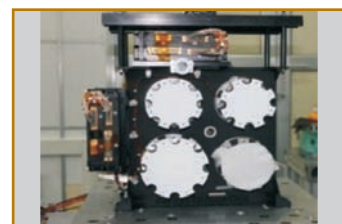
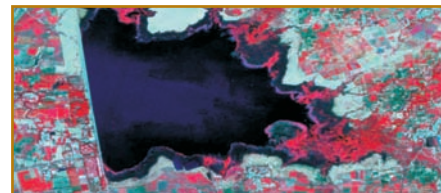
INSAT-3DR has 2 meteorological payloads viz. Imager & Sounder. It provides enhanced meteorological observation and monitoring of land and ocean surfaces as well as weather forecasting and disaster warning. The payloads were flagged off from SAC on November 19, 2015 and were launched on September 8, 2016. IOT was completed and reports were generated. Performance of the payloads was found to be satisfactory. First Day Images from Imager and Sounder Payloads were received by extended C- band Meteorological Reception System using 4.5-meter Antenna and RF system at BES, Ahmedabad.

## RESOURCESAT-2A

Resourcesat-2A is a follow on mission to Resourcesat-1 and Resourcesat-2 launched in 2003 and 2011 respectively. Resourcesat-2A carried three payloads viz. AWiFS, LISS-3\* and LISS-4 to have unique 3-Tier

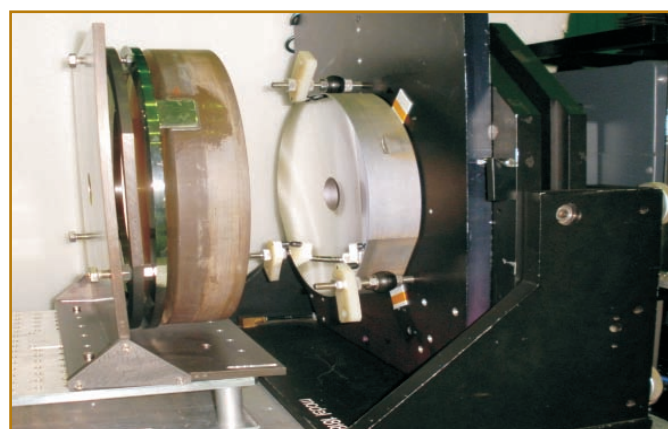


imaging capability. Linear Imaging Self Scanner (LISS-4) camera is a high resolution sensor operating in three spectral bands in Visible and Near Infrared Region (VNIR) with 5.8 m spatial resolution and swath of 70km. LISS-3\* camera operates in three-spectral bands in VNIR and one in Short Wave Infrared (SWIR) band with 23.5 m spatial resolution and swath of 141km. Advanced Wide Field Sensor (AWiFS- A&B) camera is a coarse resolution wide swath sensor operating in three spectral bands in VNIR and one band in SWIR with 56m spatial resolution with swath of 740 km. LISS-3\*, LISS-4 and AWiFS A&B were flagged-off from SAC for integration with spacecraft on August 17, 2015, May 16, 2016 and Sep 20, 2016 respectively. The satellite was launched successfully on December 7, 2016 onboard PSLV-C36 and cameras were switched on December 15, 2016. Images acquired by LISS3\*, LISS4 and AWIFS payloads are of excellent quality. Payload performance was found to be satisfactory.

*LISS-3\***AWiFS-B**AWiFS-A**LISS-4**Image of LISS-3\* -Mumbai**Image of AWiFS-Gujarat**Image of LISS-4 - Ajwa Lake, Vadodara*

## INSAT-3DS

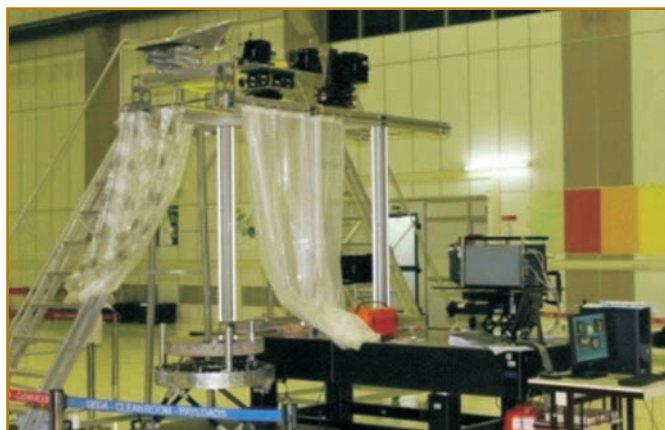
INSAT-3DS is a flight worthy ground spare of INSAT-3D/3DR. Subsystems & Antenna development is in progress. FM- 1 & FM -2 of DRT/SAS & R Receiver is under testing. UHF Hybrid Antenna for the DRT and SAR P/L is ready for Integration. SWIR DHA assembly and integration is completed. PSR of Optics (from LEOS) of Sounder was carried out. T&E of Imager Test Setup is completed.

*Bonded Mirror under Testing**Camera Electronics Package*

## CARTOSAT-3

Cartosat-3 is a highly agile advanced satellite having imaging capability with a very high spatial resolution of 0.28m in Panchromatic and 1.14m in multi spectral from an altitude of 505 km with an operational life of 5 years. Electro-optical characterization of PAN and MX TDI detectors has been completed. Sub-system development is in progress.

## GISAT



*Null-lens test setup for GISAT ETM Primary Mirror surface figure characterization*



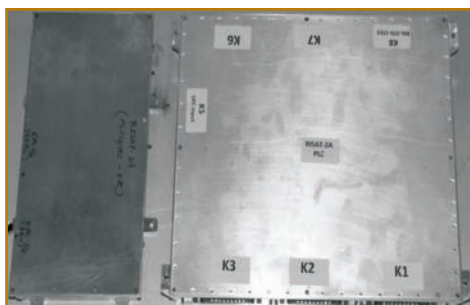
*SWIR IDCA Dummy model*

GISAT consists of Multi-spectral and Hyper spectral cameras. Subsystem development of all the payloads is in advanced stage. The sub-systems/sub-assemblies for the Electro-optical (EO) payloads are being realized. The two mirror telescope using ETM mirrors with BBM structure has been realized. The bread-board models (BBM) of camera electronics packages are completed. Critical design review of HySI spectrometers (VNIR and SWIR bands) for grating, slit and OSF are completed. Test set-up development for EO parameter characterization of GISAT payload is currently in progress. Detectors for MX VNIR, HYS SWIR and MX LWIR are in advanced stage of procurement. GISAT GCU hardware and software configuration have been completed. DVM of Ku-Band Driver Amplifier has been developed. Development of phased array antenna operating in Ku band is in progress.

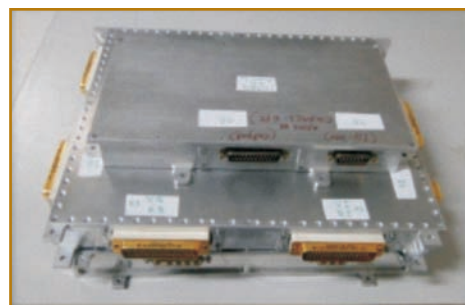
## RISAT-1A

Subsystem development of RISAT-1A is in progress. Configuration of SAR payload has been reviewed by Director, SAC and Director, ISAC, during configuration review of entire spacecraft. Payload PDR was conducted on March 15, 2017.

## RISAT-2A



*DVM PLC*



*DVM CGDACS*



RISAT-2A satellite should provide continuity of services for RISAT-2. RISAT-2A is larger than its predecessor due to the new X-band SAR payload configuration with an active array antenna.

Subsystem & antenna development is in progress. DVM units of Payload Controller (PLC), Tile Control Unit (TCU), Chirp Generator & Data Acquisition System (CG-DACS), Frequency Generator (FG) were delivered to the integration team. Development of 1/4th tile antenna using indigenously developed redux and cyanate ester adhesive was completed. Payload PDR was conducted on March 16, 2017.

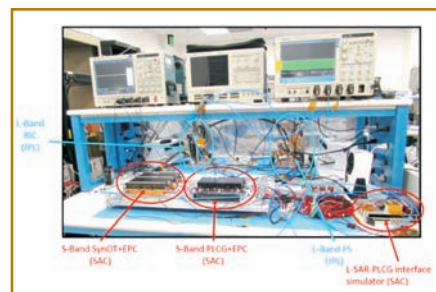
## NISAR

This collaborative effort between ISRO and NASA is a dual band SAR instrument in which SAC contributes an S-Band Sweep SAR and JPL provides an L Band instrument, sharing a single 12m reflector.

All the subsystem & antenna development is in advanced stage. Ground checkout unit was made ready. PLCG and SynOT hardware was shipped to JPL/NASA. Joint Interface Verification Testing (IVT) for S-Band PLCG and L-Band RIC was completed at JPL, USA. DVM of full S-FRAp was developed successfully.



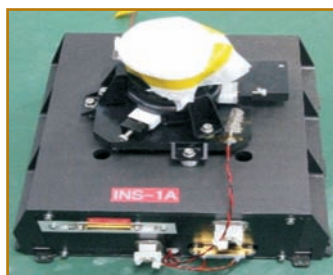
*S-Band DVM LTCC & High Power units of TRM*



*S-Band PLCG & SynOT Interface test with L-Band RIC & FS at JPL/NASA*

## INS-1A & -1B

ISRO has taken up the development of ISRO Nano Satellite (INS) bus. The first two nanosatellites in this series are named INS-1A and INS-1B. The payloads for INS-1A and 1B are designed to meet the INS bus configuration with payload weight within 5 kg and payload power not exceeding 10 W. Two payloads were developed at SAC for INS-1A namely Surface BRDF Radiometer (SBR) and Single Event Upset Monitor (SEUM). SAC developed MMX-TD (Miniature Multispectral Payload – Technology Demonstration) payload for INS-1B. The payloads of INS-1A were flagged-off for integration with spacecraft on January 10, 2017. MMX-TD was flagged-off on January 27, 2017. These two satellites were launched along with Cartosat-2 series satellite onboard PSLV-C37 on February 15, 2017.



*SBR and SEUM*



*Integrated Payload INS-1A*



*Flag off of INS-1A payload*



*Flag off of INS-1B payload*

### Oceansat-3

Oceansat-3 is envisaged to provide service continuity for the operational users of Oceansat-2 as well as to enhance the application potential in other areas. SAC is responsible for developing two electro-optical payloads viz. Ocean Colour Monitor-3 (OCM-3) & Sea Surface Temperature Monitor (SSTM-1) and one microwave payload viz. Scatterometer. OCM-3 payload is having 13 spectral bands & will have ground sampling distance (GSD) of 360m with 1440 km swath for two days repetivity. SSTM-1 is having two LWIR bands and will have GSD of 1080m and swath of 1440km. PDR of both electro-optical payloads was completed in March 2017. Sub-systems development is under progress.

### Human Space Programme (HSP)

Crew module NavIC and S-MSS antennas tested and delivered for integrated testing. T&E of Transfer antennas (12 nos.) completed. T&E and qualification of NavIC System for HSP-PAT (Pad Abort Test) is completed successfully and payload was flagged off from SAC on March 30, 2017.

### Airborne MiniSAR

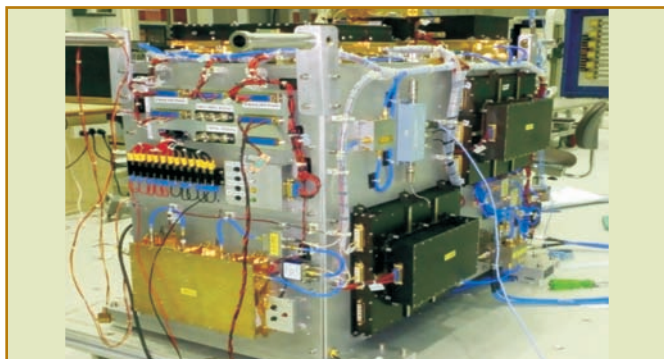
MiniSAR will operate in X-band, Single/Dual/Circular Polarization with high spatial resolution and it can accommodate altitude variation of 3km to 10km. It has very less size and weight so that it can be flown in small aircrafts as well as in UAVs.

Development of airborne MiniSAR was completed and initial flight was carried out on Beechcraft. The system is transported to NRSC for upcoming flights and data was captured successfully for all modes.



### L & S band Airborne SAR

As a pre-cursor to the space-borne SAR for NISAR, SAC has planned to develop an Airborne SAR in L & S band. It will provide invaluable data for various land & ocean applications. Subsystem development and AIT is completed. Second phase of flight campaign is in progress.



*LS\_ASAR System under AIT*

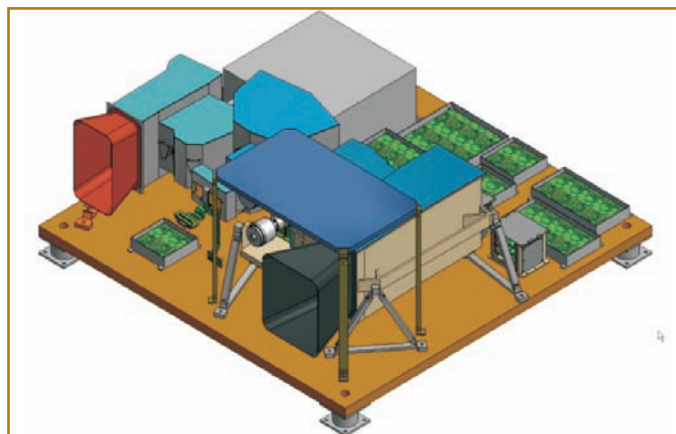


*LS\_ASAR System Inside Aircraft*



## HySIS

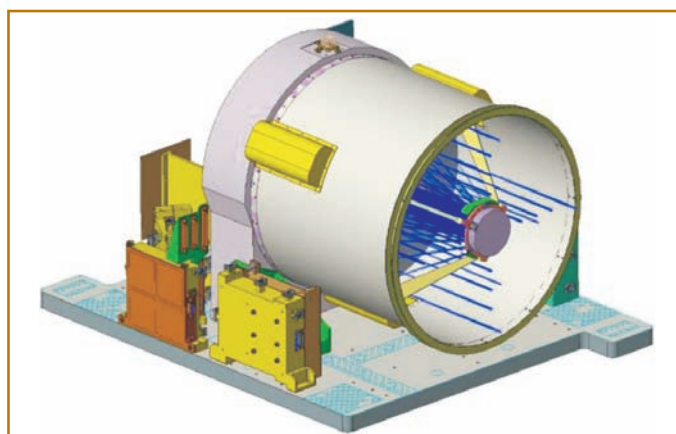
HySIS mission will provide global coverage on repetitive basis to users and also supplement the existing multi-spectral missions. The space-borne Hyper Spectral Imaging Spectrometer (HySIS) will provide earth surface image in VNIR (0.4 to 0.95  $\mu$ m) and SWIR (0.9 to 2.5  $\mu$ m) spectral region in “70+256” contiguous spectral bands in each spectral range with 10 nm bandwidth. It will provide 30 m spatial resolution and a swath of 30 km. Two spectrometers (VNIR and SWIR) are being developed and the integrated payload deck will be delivered for satellite level integration. Development is in progress.



*HySIS 3D Visualization*

## Microsat

In addition to IRS, Metrological and Oceansat, ISRO has developed microsatellites (Microsats). These are small satellites with small volume and low power requirements. These satellites find usage in remote sensing and disaster monitoring. It will provide a low cost development platform to carry out experiments and technology demonstration. Microsat is a technology demonstration payload and consists of a PAN camera with resolution of 0.91m with step-n-stare and will have swath of 3.7 km. It also has MIR and LWIR bands with resolution of 5.6m and swath of 2.15 km. The satellite will have an altitude of 350Km. Vacuum compatibility of commercial IR detectors is established. EO characterization of PAN detectors completed. Interface checks with BDH subsystem completed. FM development is in progress.



*Microsat 3D Visualization*

## Space Sciences and Planetary Mission

### CHANDRAYAAN-2

Chandrayaan-2, India's second lunar mission is an advanced version of Chandrayaan-1. SAC is developing optical & microwave sensors for this mission.

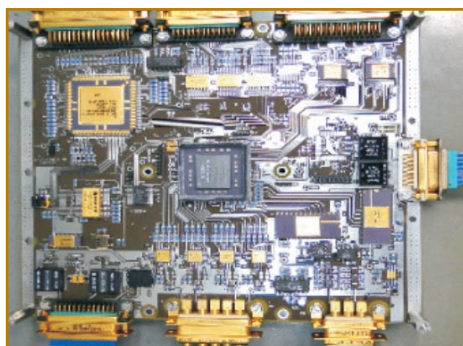
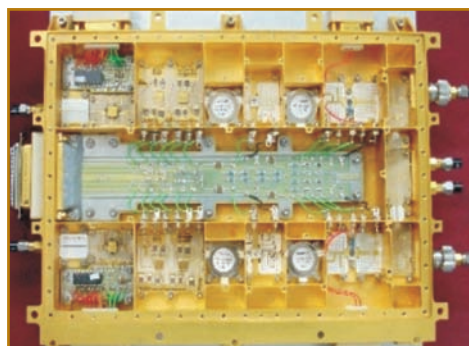
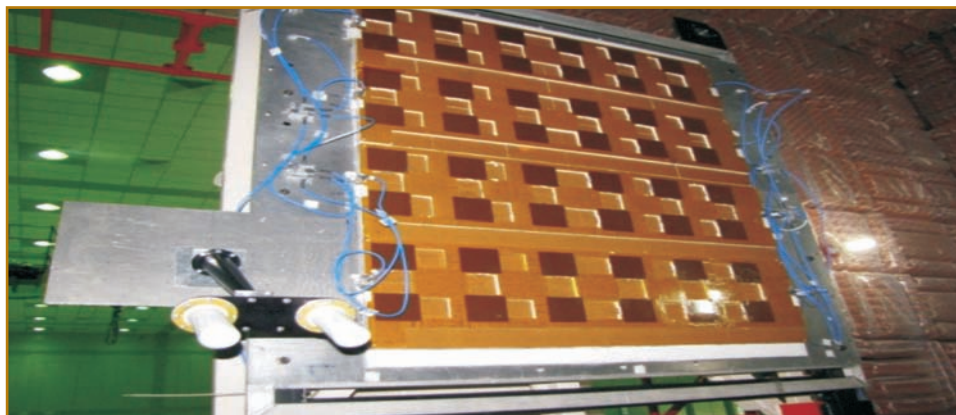
After T&E, Rover Imager is delivered for spacecraft integration. The development of IIRS is in advanced stage. Grounding scheme for IIRS along with integration, power supply and detector was finalized.

Orbiter High Resolution Camera (OHRC), Lander Position Detection Camera (LPDC), Lander Hazard Detection and Avoidance Cameras (LHDAC) are identified for the navigation and safe landing on moon surface. Units are ready for T&E.

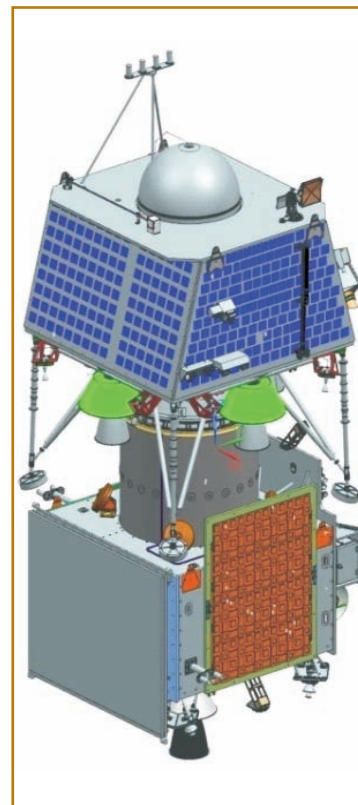
Ka band Altimeter is shipped to ISAC, Bangalore for integration with other sensors for Lander Sensor Performance Test (LSPT). Imaging session of aircraft test-2/LSPT-2 (Lander Sensor Performance Test-2) was completed on March 10, 2017.

Final bench test of TMC-2 was completed and Payload performance is found satisfactory at all environmental temperatures. Payload is delivered to ISAC, Bengaluru on December 17, 2016 and Autonomous Test was completed successfully at ISAC.

The orbiter for Chandrayaan-2, is configured to operate stand-alone or simultaneously in L- and S- bands, sharing a common antenna. SAR payload consists of 4 packages: 1) L band RFDS, 2) L band SSPA, 3) S band RFDS and 4) S band SSPA. RFDS package consists of three sub-systems: 1) digital subsystem (a single board consists of Payload Controller, Digital Chip Generator and Data Acquisition and Compression System), 2) RF Sub-system (Frequency Generator & Receivers) and 3) EPC. All FM packages have been realized and T&E has been completed successfully. Currently payload integration and testing is under progress.



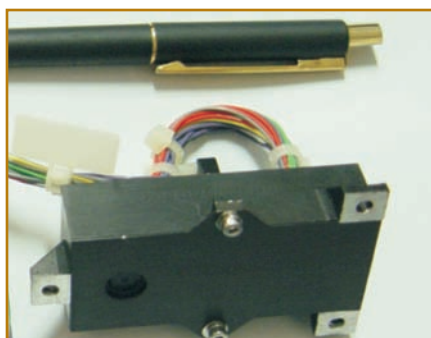
*Lander Position Detection Camera*



*Chandrayaan-2 3D Visualisation*

## ADITYA-L1

Aditya-L1 mission is planned to investigate the physical processes of sun like heat of the solar corona, solar wind and Coronal Mass Ejections (CMEs). SAC is responsible for design and development of detection systems of coronagraph. Subsystem development of detection unit is in progress. PDR document submitted.



*SVIS and captured image of C2E separation*



## Airborne Missions

Airborne missions, in which payloads are mounted on aircraft are carried out for Air Surveillance, Rescue, Disaster Management, Land Survey, Mineral Exploration etc. These missions are carried out by National Remote Sensing Centre (NRSC). These missions have advantage over satellite imageries in terms of better resolution, quality of images, local area imaging etc. SAC has following airborne sensors namely, Airborne Hyperspectral Imager (A-HySi), Airborne Terrain Mapping Camera (A-TMC), A-Nano, Airborne Imaging Spectrometer-2 (AIMS-2) and AIMS-3. AHySi is a wedge filter based compact hyperspectral sensor. A-Nano is a multi-spectral payload with 4 VNIR bands viz. B1, B2, B3 & B4. AIMS-2 (Airborne Imaging Spectrometer-2) is a hyperspectral payload having 270 bands with 3.5nm bandwidth. A-TMC is a panchromatic camera with three views (Fore, Nadir & Aft) for stereo imaging. AIMS-3 (Airborne Imaging Spectrometer-3) is a hyperspectral payload having 260 bands with 2.7 nm bandwidth. Air campaigns for A-Nano was carried out in February, 2016.



*Airborne Nano(A-NANO); Airborne Hyper Spectral Imager (AHySi); A-TMC; Airborne Imaging spectrometer-2 (AIMS-2); Airborne Imaging spectrometer-3 (AIMS-3)*



*Image Captured by AHySi Nagpur*



*Image Captured by AIMS-2 Hyderabad (ICRISAT)*



*Image captured by A-Nano near Gaya, Bihar*



*TMC-FORE*



*TMC-NADIR*

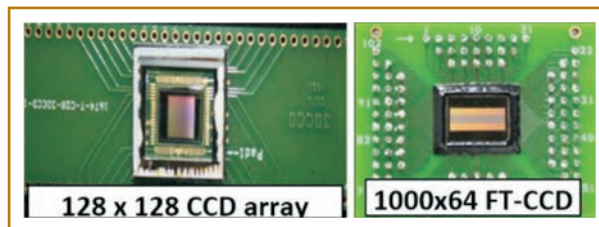


*TMC-AFT*

*Image captured by 3 views of A-TMC*

## New Initiatives

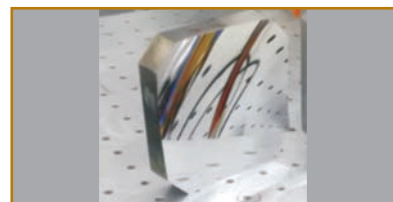
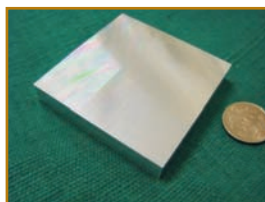
**In-house development of detectors:** Image Sensor chip (128x128 CCD array) was designed for the first time in SAC. This is a unique chip, designed to capture 2D images along with depth information of target when integrated with a laser illuminator. 1000 x 60 FT-CCD is designed at SAC and developed at SCL for HYSIS mission.



**Development of Metal Mirrors through Indigenous Sources:** Various types of mirrors like spherical, aspheric, obscured, off-axis parabolic etc. were developed through indigenous sources. These are being utilized in the development of space-borne and airborne payloads for INS-1C (Origami multi-fold aspheric mirrors), GSAT-29 GHRC and OCT (RC telescope mirrors), HYSIS (Off-axis mirrors) and Airborne spectrometers (Off-axis mirrors)



**In-house Development of Hyperspectral Imagers:** In-house development of metal optics and spectral optical components has been initiated. Curved metal mirror, Plane and curved metal gratings have also been developed. Bread board model of spectrometer with convex grating has been developed in-house.

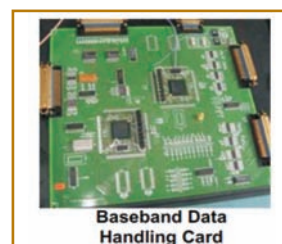
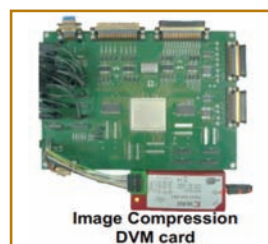


*Plane Aluminum grating    Aluminum mirror developed indigenously*

**ASIC based camera electronics:** CE for Electro-Optical (EO) payloads consists of analog, mixed signal and digital circuitries. To reduce size, weight and power and facilitate use of indigenously developed ICs, various analog and digital Application Specific ICs (ASICs) have been developed along with SCL. Use of indigenously developed ASICs will replace discrete based design and achieve reduction in power, resources and development time.



**In-house development of CCSDS compliant image data compression and data handling system:** CCSDS standard data compression and data formatter algorithm was implemented at SAC using FPGAs. The achieved performance is comparable to leading compression algorithms like JPEG2000/SPIHT etc.



**Terahertz technology development:** SPAC approval has been obtained for initiating the development of technology for Tera-Hertz telescope for exploring Interstellar medium (ISM). Initial studies related to Facility establishment & Test Set-ups for Sub-mmWave Sensors is in progress.







## **Remote Sensing Payload Applications & Data Products**

SAC through its areas namely, Earth, Ocean, Atmosphere, Planetary Sciences and Applications Group (EPSA) and Signal & Image Processing Group (SIPG) is developing RS Applications & Data Products respectively.

EPSA is responsible for all activities related to understanding Earth System, its components, processes and interactions using earth observation data, and its applications towards societal benefits. EPSA shall also carry out space data analysis for planetary sciences.

SIPG is responsible for the design, development, operationalization and maintenance of software for remote sensing data processing related to earth, planetary and astronomical observations for Indian as well as international user community



## MOSDAC Services

MOSDAC is the platform for archival & storage system for visualization and access to data from various ISRO's missions. MOSDAC website is modified and the new applications released are

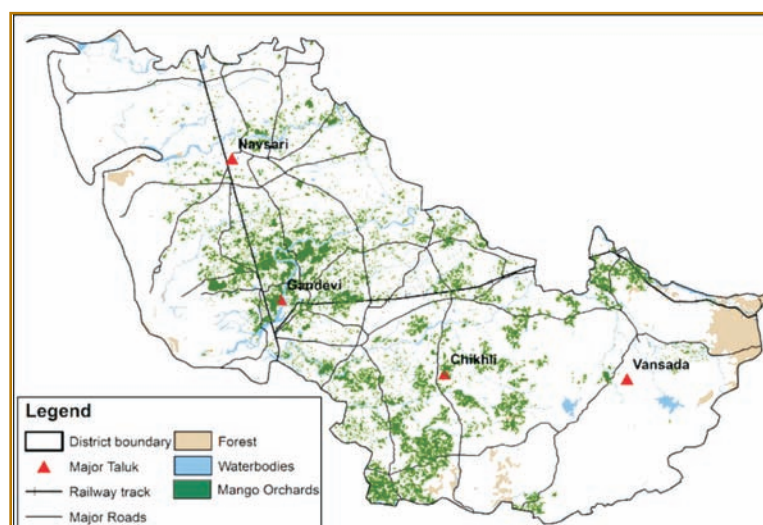
- Ocean Eye - Forecasted parameters are Ocean Surface Currents, Surface Winds, Wave Height and Sea Level Pressure
- RIP Current Forecast for Goa Beaches - Advice, Suggestion, beach weather, wave height, wave period and wave direction
- RISAT Ocean Observations - Wave height, wave energy, wave period and wind speed for the period 2012–2016
- Soil Wetness Index and Soil Moisture Maps (April 3, 2015 onwards)
- WISDOM - Weather Information System and Decision Support System for Oceanography and Meteorology)
- Geoserver based cyclone visualisation including predicted track and intensity and overlay of relevant collateral layers such as administrative boundaries, land type, district wise population, drainage ...)
- Updated Weather App
- Web site for International Fleet Review
- GSICS web site



MOSDAC is also managing SMART (Satellite Meteorology and Oceanography Research and Training) program - ISRO's initiative to support students, academics and researchers across the country to pursue research in the field of meteorology and oceanography using satellite data.

## Agricultural/FASAL Activities

Rabi Pulse crops area was estimated for major pulse growing states of India. The area reported was estimated to be 7.571 Million ha. There is about 15% reduction in rabi pulses area in 2015-16 compared to 2014-15. Mustard pre-harvest yield is predicted using GEO-LEO satellite data at 1 km grid resolution for five states. The variability of spatial yield is found to be 0.8 to 3.5 tha<sup>-1</sup>. Fodder crop assessment for Haryana & Rajasthan is completed using IRS LISS-III. Quality checking for Horticulture crops inventory for selected districts of Gujarat, M.P. and U.P. was carried out. Inventories of Banana, Citrus and Mango orchards created using IRS LISS-3/4 data (CHAMAN project) were verified in presence of officials from MNCFC, New Delhi, and directorate of state horticulture departments and state remote sensing centers. The mango orchard area estimate for Surat district is derived using LISS-4 data and Mango orchard map for Surat district, Gujarat is prepared.



*Classified Mango Orchards: Navsari District, Gujarat*

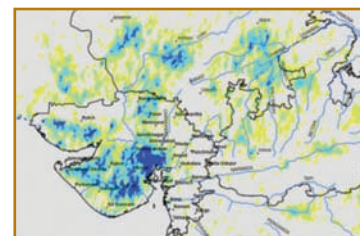
## Snow and Glacier studies

The project on Monitoring Snow and Glaciers of Himalayan Region with Ministry of Environment, Forests and Climate Change (MoEF & CC) is successfully completed and the report was published by SAC as a book entitled, “Monitoring Snow and Glaciers of Himalayan Region”.

## Hydrological / Ocean Process studies

Impact of climate change on Hydrology was studied. Water bodies (reservoirs, tanks, ponds, Lakes) with area greater than 500 ha were mapped using RISAT-1 MRS data of 2013 for the entire country. Water level retrieved for inland water bodies (10 reservoirs and 10 rivers with 30 locations) using SARAL-Altika waveform datasets along with various GIS shape files for Altika tracks, retrieved locations etc. are transferred to VEDAS. Satellite based Hydrological Model (SHM) was developed and testing was completed.

Sea-ice thickness of 1.2 – 1.5 m was observed by analyzing GPR data collected using in-house developed GPR at 500 MHz frequency and commercially available GPR at 1 GHz frequency during Antarctic expedition-35 ISEA. Arabian sea was observed to have maximum concentration of micro phytoplankton (size > 20 microns) during the month of February with northern Arabian Sea having the maximum concentration (~80%) based on a phytoplankton size class model developed and implemented on remotely generated chlorophyll-a datasets.



*Flood inundation change analysis (6-10 July Vs 22-26 July 2017) in Gujarat and neighboring regions*



*Sea Ice Studies using GPR, Quilty Bay*

## INSAT-3D Utilization

Operational dissemination of various products using IMAGER and Sounder was carried out. Radiances and products are being assimilated in NWP models in IMD and NCMRWF. The FIRE product derived using MIR (T3, 3.9 $\mu$ m) and TIR1 (T5, 11 $\mu$ m) channel BT from INSAT-3D imager was evaluated for Uttarakhand forest fire during 21 April – 05 May, 2016. INSAT-3D L3B SST daily data are analyzed for 2016 summer for Gulf of Kachchh region in order to monitor the SST anomalies. The Higher SST anomalies results obtained reveals that there is a likelihood of coral bleaching in Gulf of Kachchh in summer 2016 if the anomaly (i.e. PA = 0.72 is Very High PA for Gulf of Kachchh) persists. Sensitivity of noise on the simulated INSAT-3D thermal observations is performed to analyze the impact of noise on the SST retrieval accuracy.

## Planetary Science

Lunar surface science using Chandrayaan-1 data was completed. Studies on Martian analogues and Atmospheric and Surface composition using Indian MARS mission was carried out. MOM-MCC datasets analyzed to study the formation of seasonal clouds over Elysium Mons region of Mars. Clouds are observed in the MCC datasets over the Elysium Mons between Ls 76 to 100 Ls mainly occurring during northern hemisphere summer at Mars. Lee wave clouds over Tharsis region of Mars were detected using MCC data and analysis was performed to obtain wind speed in Mars Atmosphere.

## Desertification and Land Degradation

State-wise Desertification and Land Degradation maps interpreted in GIS environment on 1:500 K using digital Resourcesat/IRS AWiFS data of 2011-13 and 2003-05 time frames along with respective satellite images and area statistics are compiled as “Desertification and Land Degradation Atlas of India” and the atlas was released & uploaded on web portals of MoEF & CC





and VEDAS. Desertification and land degradation status maps on 1:50K for time frame 2011-13 and 2003-04 was prepared using IRS LISS-III data for Bokaro (Jharkhand) and Kanpur Dehat (UP) districts.

### Visualization of Earth Observation Data and Archival System (VEDAS)

VEDAS is a geo-spatial data Archival and Dissemination System for land observations. It is developed for disseminating output of research and applications of optical and microwave remote sensing data in various themes. VEDAS has various application like;

- Web-GIS based Vegetation Monitoring system; which helps the user to budget overall picture of the country and warns against drought and other adverse growing conditions. This web based system facilitates users to browse maps and profiles of parameters viz. NDVI, Temperature, Soil Wetness Index, Soil Moisture. Web-based geo-processing is also available on VEDAS.
- New and renewable Energy Potential; A web-based application has been developed for potential solar, wind and wave energy at a given location. Such information is required for locating potential sites for tapping New and Renewable Energy resources. The website provides the technical solar energy potential, peak power generation potential, built-up area, temperature profile and optimum tilt-angle of solar panels for 98 proposed Smart cities and 60 Solar cities in India.
- Urban Sprawl Information System (USIS) for visualising urban sprawl.
- Air quality monitoring portal for dissemination of remote-sensing data and sensor data relevant to monitoring air-quality.



Under TREES program, eleven training modules were conducted resulting in 257 participations from organizations / institutes distributed to all over country. The topics covered include Remote sensing geo-informatics, Calibration Validation, Hydrology, Planetary sciences, SAR Polarimetry and Hyper Spectral remote sensing. Under research initiative, thirty-two students have worked on research initiative in various fields of EO applications.

### AVIRIS-NG Flights

Airborne campaign using AVIRIS-NG was carried out over 57 sites during December 16, 2015 to March 6, 2016 under the ambit of ISRO-NASA joint initiative for Hyper Spectral Imaging (HySI) programme. The sites represent agriculture, horticulture, forest, geology, coastal, ocean, river water, snow etc. The initial results of the hyperspectral data analysis for the phase – 1 campaign cover calibration and validation, data processing and retrieval algorithms, thematic applications. The results showed that airborne hyperspectral data are able to discriminate crops in mixed agriculture, horticultural orchards, forest species and to assess their abundance and health. Subsequent to successful completion of the campaign, the instrument was uninstalled from the aircraft and shipped back to JPL. Data acquired in the campaign was archived with due clearances. About 1.5 TB data has been archived in VEDAS. In addition to that, ground-truth data and field campaign reports were also archived in VEDAS. Data was disseminated to JPL and principal investigators. Processed reflectance data was received from JPL and this was also disseminated to the principal investigators. Second phase of airborne campaign would facilitate the validation of models/techniques, building up of spectral library with spectro-chemical characterization, development of automated tools for general users, definition of future space-based hyperspectral mission and creation of skilled human resources in the country.

## ISROCast: Satellite Data and Information Dissemination in Near Real time

It is a RSS-based feed mechanism for publishing Satellite data products in Near Real Time (NRT) with automatic identification and download of recent data by subscribers. This service was inaugurated by Shri A.S. Kiran Kumar, Secretary, DOS and Chairman, ISRO on November 18, 2016 at SAC, Ahmedabad.

## RISAT-HRS Processor

RISAT-1 (Radar Imaging Satellite) SAR of ISRO operates in Hybrid Polarimetric mode, apart from the regular dual and single polarization modes. m-chi decomposition was applied on the data sets shown below, and then image enhancements were performed, for identifying features such as bridges, power lines, man-made structures, and ships.



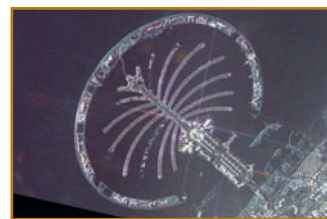
*Fig (a) Power Lines*



*Fig (b) Ship Detection*



*Fig (c) Bangalore Metro*



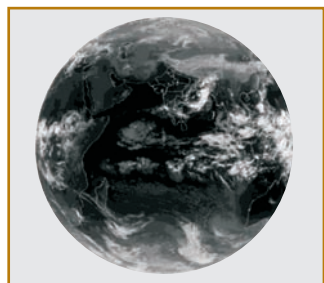
*Fig (d) Palm Island, Dubai*

## Satellite Data Processing

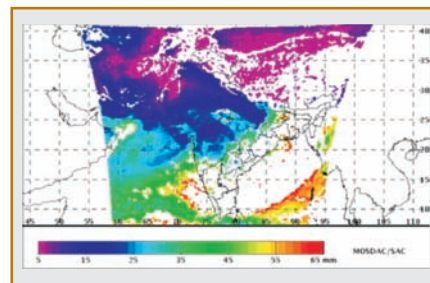
### INSAT-3DR Data processing & special products software

As part of readiness for INSAT-3DR launch DP processes for raw data extraction, Radiometric correction, servo Correction, Navigation, Fixed Grid were made ready and tested on simulated data sets. First Day Products of INSAT-3DR (Imager and Sounder) were successfully evaluated. Provided feedback on RAW data quality, Band-to-Band Registration, Geo-location Error & Residual Attitude to DP team. Operational support for full day evaluations as part of IOT exercise was provided.

Operationalization of INSAT-3DR data products generation at BES, Bopal and transfer of the products to IMD Delhi. Operationalised integrated DQE software for INSAT-3D & INSAT-3DR missions at MOSDAC.



*INSAT-3DR Visible*



*INSAT-3DR TPW Oct 11, 2016 2130GMT*

## Cartosat-2S DP

CDR is completed and its T&E is performed at NRSC. The software packages are installed for processing real data at NRSC. Designed and evaluated the Radiometric Calibration of the C2CPAN camera data. Optical Butting Registration (OBR) estimation tool is developed. Image fusion algorithm based on the principal component analysis using python programming language was developed and tested. Algorithm and software for Optical Butting noise correction for PAN & MX payload was developed and operationalized at NRSC. Developed an algorithm for frame based un-even illumination correction and colour balancing of EVM-2 image frames and is made operational at NRSC. Generated Digital Elevation Model (DEM) from Cartosat-2S Multi-view images.



## Mars Orbiter Mission (MOM) DP

SAC data processing solution deployed at ISSDC and SAC POC processes, MCC, TIS, MSM, LAP and MENCA datasets for the period from 24th September, 2014 to till date are processed, raw and calibrated products are generated for active archive PDS, raw and calibrated products are prepared in long term archive PDS. Long term archive in PDS v3 is created for all Five instruments. Chairman, ISRO released MOM data to public on September 23, 2016.

## ASTROSAT – DP

Total 12 packages are developed including Level-2 i.e. Science Data Processing for 4 payloads (CZTI, SXT, UVIT, LAXPC), Quick Look Display for above mentioned instruments as well as Archive, Browse and Dissemination of Level-1 and Level-2 for the data processing of Astrosat. Level-2 software generated important science results which are showcased to international astronomical community through ISRO as well as IUCAA/Astrosat web portal.

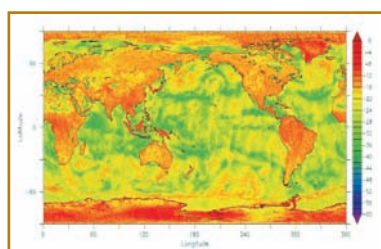
## Chandrayaan-2 DP

Rover Imager Camera: MTF study on Acquired/original and restored images, SNR study on acquired outdoor images, Study on different JPEG compression ratios, HDR image generation have been carried out on the datasets acquired from Rover imager. The study of camera position coordinates estimated by collinearity equation model for consistency check is carried out.

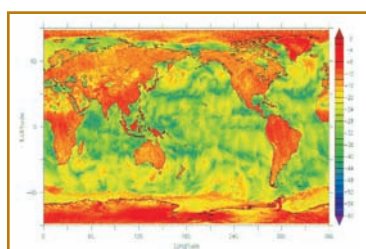
Lander: Developed and supplied three algorithms for crater pseudo edge removal, crater rim grouping and landmark identification for feasibility evaluation. Generated DEM of landing site using DEM based elevation densification. Completed the modification and implementation of Crater Matching Algorithm.

## SCATSAT-1 DP

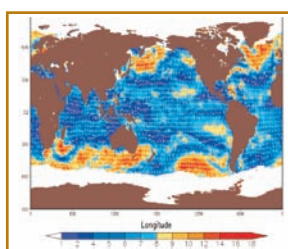
Day-1 onwards, all levels of data products are being generated successfully. High resolution data products (2 km) for India and Polar regions are generated. Further analysis of data and fine tuning of the processor is under progress.



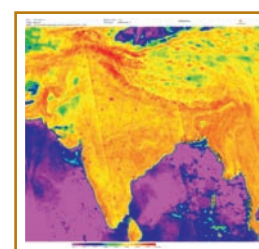
*L2A VV Sigma0 in dB (25 km)*



*L2A HH Sigma0 in dB (25 km)*



*Wind Velocity (m/s)*



*High Resolution Sigma0-VV: India*

## Resourcesat-2A DP

Installation and operationalization of Data Products Generation System(DPGS) and Data Quality Evaluation (DQE) system at IMGEOS was done. Generation of strip based products, and scene based products with high fidelity in terms of geometry and radiometry is achieved. Additionally, an atmospheric correction procedure is also established. New Atmospheric Correction Algorithm (ATCORR) for land and water surface reflectance was developed.

## Technical Facilities

SAC has in-house world class technical facilities for mechanical & electrical services. The mechanical services are provided by Mechanical Engineering Systems Area (MESA) and Electrical services are provided by Electronic Support Services Area (ESSA).



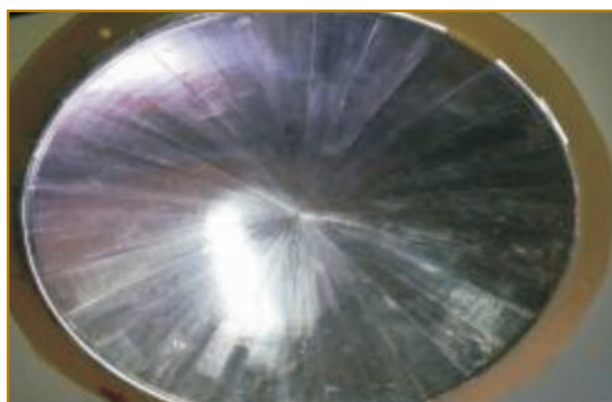
## Mechanical Engineering Systems

*Mechanical engineering activities at the Centre comprises of design, development, realization, testing and delivery of mechanical components and systems for communication, remote sensing and navigational payloads, various ground antennas and other ground optical system projects.*

*MESA undertakes mechanical design, development and realization of antenna systems for GEOSAT, MRSP, airborne applications, earth stations and antenna systems for TDP's and advanced R & D and is responsible for the integration and alignment of antenna systems. The mechanical fabrication and quality control of space and ground components for all the projects in the centre is executed. MESA also undertakes the structural and thermal analysis of payload systems and sub-systems.*

Following activities were undertaken in last year;

- Sheet metal forming, welding, precision fitting and assembly related work for different projects and R&D activities of the centre.
- In-House Fabrication of Waveguide Run assemblies by Bending, Twisting and Joining by TIG welding for WR-75, WR-51, WR-28, WR-NS sections.
- In-house precision machining of payload components for different payloads and ground hardware using CNC machines and other precision machines.
- New developments in machining of newer materials like CFRP, PEEK, Ceramics, etc.
- Installation of Scaffolding platform for 20 Ton shaker system and Vibration testing of CARTO-2E payload and Ka Band Reflector of GSAT-19 on 20 Ton shaker system.
- Structural Analysis, Design and Development of light weight Spacecraft reflector using new material P.E.E.K (Poly Ether Ether Ketone)-450 mm parabolic in shape, C-Band and its CATF TESTING.



**LOW EMISSIVITY L.E TAPE METALIZATION, LIGHTER THAN ALUMINUM BY ~45% &  
FROM CFRP BY ~ 10%**

- Structural Analysis and Design Development of Proof-of-Concept of Reconfigurable Spacecraft Antenna using smart material and smart structural systems, 1200 MM C-BAND for PPNF TESTING
- Structural Analysis and Design of Chandrayaan-II Electro Optical and Microwave payloads.
- Structural Analysis, Design and Development of light weight Spacecraft reflector using new material P.E.E.K-LSG 57% Carbon (Poly Ether Ether Ketone) - 500 mm shaped Sub-reflector for GSAT-7A and its catf testing

- First new Polycarbonate Smart Parabolic Reflector 1000 mm DIA. C-Band Ready for CATF testing.



*USING SMART SHAPE MEMORY ALLOY- NITINOL*

- Fabrication of more than 1135 nos. of Waveguide Assemblies (WR-75, WR-51, WR-28 and WR-NS Section) for running GSAT projects namely, GSAT-18/19/11/7A/17.
- TDP activity of In-house Designing and Development of 3 Axes CNC Milling Machine initiated. Procurement of required mechanical and electronic hardware carried out. Required in-house machining and fabrication activities carried out. PLC programming training imparted to identified TDP team members.
- Facility Augmentation activities initiated: 3 Axes CNC Milling Machine, Coordinate Drilling Cum Milling Machines – 02 Nos, Profilometer, High Precision Lathe Machine, CNC Wire EDM, Diamond Turning Machine, DMLS Machine.
- Operationalization of Hexagon Optiv Classic 322 TP 3D CNC Multi Sensor Measuring Machine.
- Carried out Vibration testing of approximately 450 nos. of packages/payloads of various satellite projects. (Total no. of runs – 3100 approx.).



## Electronic Support Services

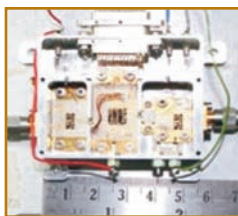
The Electrical services are provided by Electronic Support Services Area (ESSA) which is responsible for design and development of Surface Acoustic Wave (SAW) devices, Monolithic Microwave Integrated Circuits (MMICs), MMICs based subsystems; design, fabrication, assembly and packaging & Laser/Solder hermetic sealing of packages of Microwave Integrated Circuits (MICs), Printed Circuit Boards (PCBs), Low Temperature Co-Fired Ceramics (LTCC) and High Temperature Co-Fired Ceramics (HTCC); development of qualified processes required for manufacturing of subsystems/systems; design, development, realization, maintenance and operation of environmental test facilities, like, thermos-vacuum and climatic test chambers; Surface treatment and thermal control coating; maintenance and calibration of precision equipment; etc. for various communication/navigation, microwave and optical remote sensing payloads and payloads for planetary and interplanetary missions.

**Major accomplishments under ESSA are given below:**

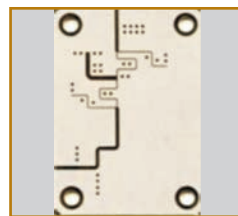
- ❖ **MMICs** – Higher level of integration from Multifunction MMIC to system on chip:



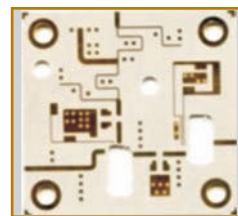
*Ku-band Transmit Module (Duriod) for GISAT Data Transmitter*



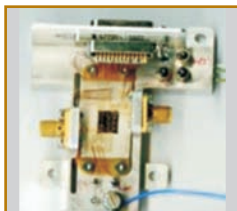
*Ku-band Transmit Module with 1W PA (Duriod) for GISAT Data Transmitter*



*C BRF for GISAT U/C (Duroid)*



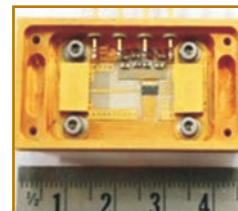
*Ku up convertor SIP for GISAT (Duroid)*



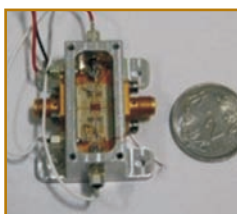
*Ku-band TTD core chip (Duriod) for GISAT Data Transmitter*



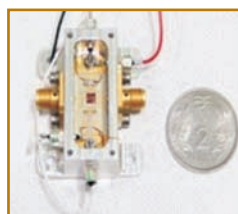
*Ku-band sub-harmonic Mixer MMIC for GISAT Up convertor*



*Ka-band LNA*



*Ku-band PA HEA-V1A*

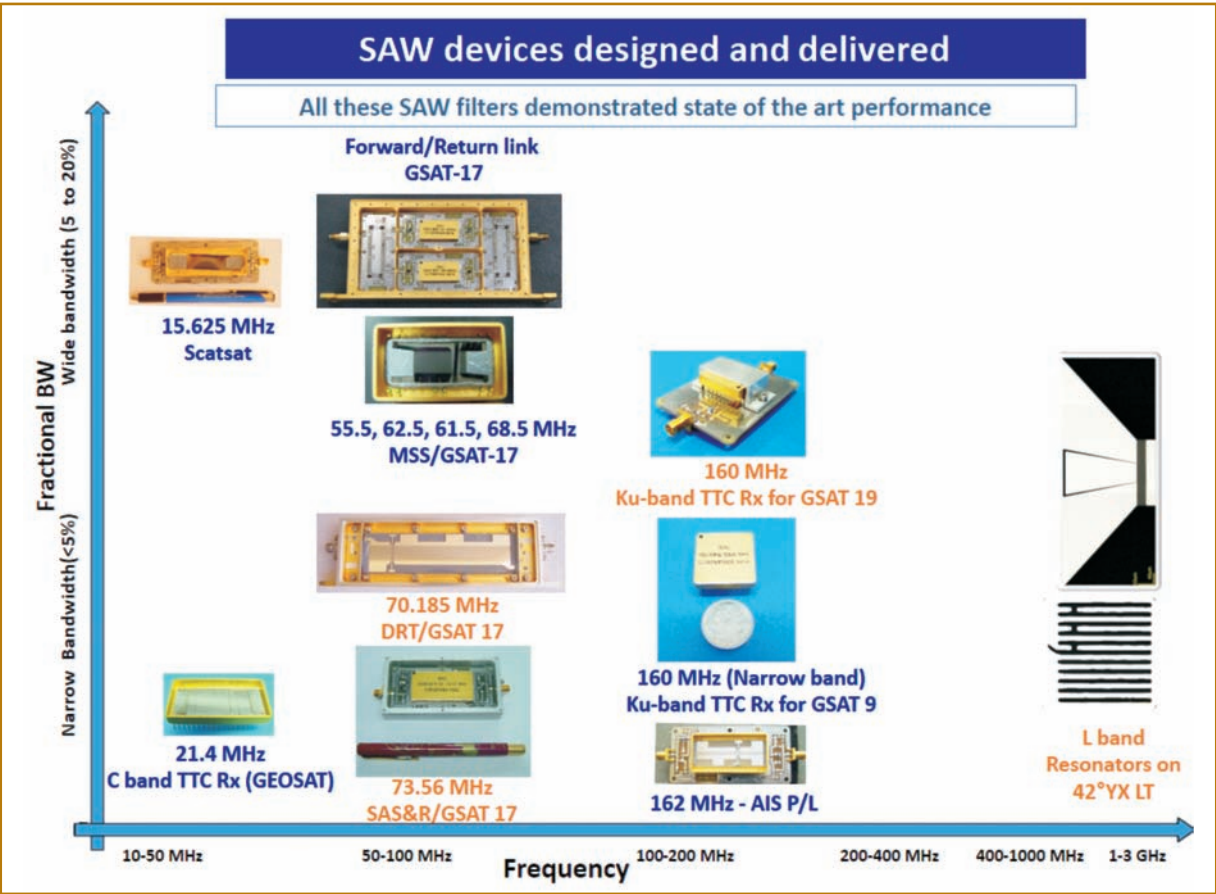


*Ku-band PA HEA-V1B*



*Ku-band PA HEA-2A*

*SAW - Technologies development for RF Filters on chip SAW & FBAR*



**In house Qualified Process**

- Sand Blasting Process for the pit generation on the back side for

- 1) 0.5mm, 1mm and 1.5mm thick Quartz wafers &
- 2) 1mm thick X-112 Y Lithium Tantalite (LT) wafers.

❖ **LTCC & HTCC- The SiP Platform: Design, Fabrication, Test and Delivery**

<i>X band TRM for RiSAT-2A</i>	<i>X band 4:16 Power divider for RiSAT-2A</i>	<i>C band TRM for RiSAT-1A</i>	<i>S band TRM for NiSAR</i>
<i>64 pin HTCC QFN package successfully realized. Firing done at M/s. CUMI, Hosur</i>	<i>W band SiP with integrated Antenna -TDP</i>	<i>S band 1:4 Power Divider for NiSAR</i>	<i>X band 16 watt Transmit Module-RiSAT-2A</i>



## LTCC Facility Augmentation



*LTCC Mechanical punching machine*



*LTCC Dicing machine*

### In house Qualified Process:

Development of Integrated thin film passive components” for MHMIC realization.

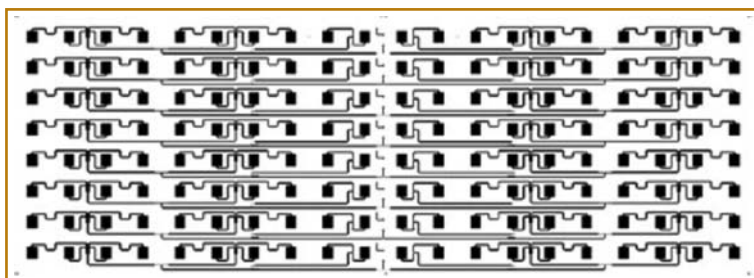
#### ❖ Technology for Micro Optical components:

Equipment like Resist film thickness Measurement, Automated resist development System, Profiling (Ra), Dry Etching etc. are expected by second half of 2017.

#### ❖ Electronic fabrication:

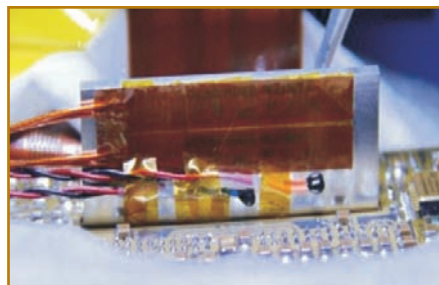
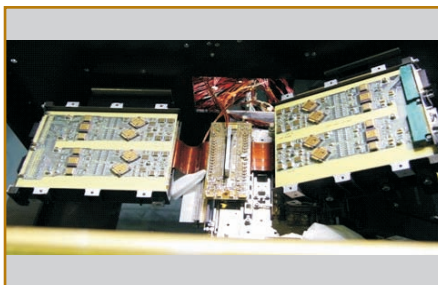
##### 1. PCBs fabrication

- ENIG (Electroless Nickel Immersion Gold) finish qualification on Al6061 T6 alloy Boxes
  - ENIG is solderable, EMI/EMC gasket compatible
  - 0 times reduction in gold consumption.
- Metallization on CFRP horn structure
  - Copper metallization for base seeding with silver plating and Immersion Gold on silver
- ENIG finish on coppersolators for Carto-2C project (3 types) Jobs delivered for Carto-2C, 2D & 2E
- Immersion gold plating on silver plated Aluminum Air borne Altimeter payload (Chnadrayan-2) wave guides, bends & couplers.
- TFE PCB fabrication for projects such as NISAR, SAR, GISAT, CY-2. 20 PCBs are delivered through external PCB fabrication facility.



- Large size PCBs Active Array Antenna for RISAT-1A
  - Size: 1000mm x 350mm Material: RT6010 – 5mil & 10mil
  - Films plotted, process under optimization for large size PCB realization at in-house facility.

## 2. PCBs wiring and Packaging



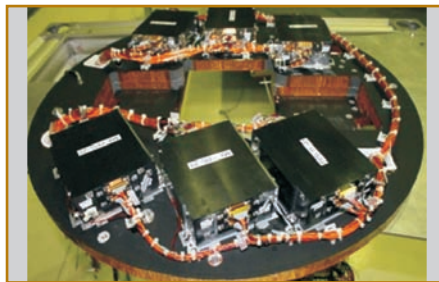
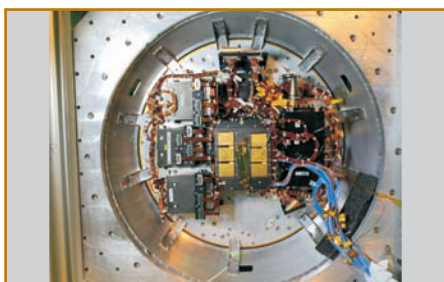
*3 Mx Detector Soldering; PAN Detector Soldering; Thermistor fixing on Pan detector cold finger*

**Detector Soldering on Carto-2S FPA:** MX (5 Nos-72 Pins each) & PAN (2 Nos- 132 Pins each) detector soldering on focal Plane Assembly for Carto-2S. The criticality involves soldering of 7 detectors in sequence with electronics packages mounted on the soldering jig. Thermistor fixing is also fixed (2 on each detector).

**Integration of Scatsat-1** - Scatsat-1 integrated payload harness with 200 Nos D - Sub Connectors, 60 RF connector assembly preparation & harness routing on scatsat-1 Dummy Deck using flexible wires, MF141 cable and Semi-rigid cable, same Harness has been transferred to the FM deck.

### In-house Qualified Process:

TNC Connector soldering assembly with MF-141 cable qualification - (-1300C to +1200C) (Normal Assembly of MF-141 cable with SMA RF Connector) – used in CHY-2



*Completed PLE Deck Harness; Flexi Routing; Power Supply Side Harness Routing*

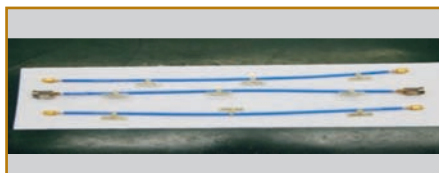
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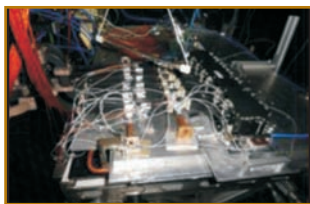
*Integration for Scatsat-1*





❖ **Environmental Testing:**

*INTEGRATED PANELS OF  
IRSS-1G IN 5.5m TVC*



*7#KU-OMUX IN  
1.7M TVC*



*AWIFS-B OF RESOURCESAT-  
2A IN 3m TVC*



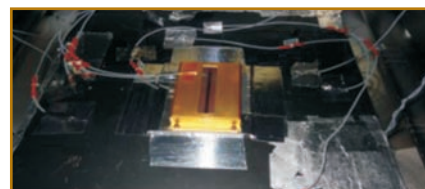
*TVM OF DHA (CARTO-2S)  
IN 1.2M H3 TVC*



*NE FEED CLUSTER OF GSAT-11  
TEMP CYCLING-100°C & 140°C*



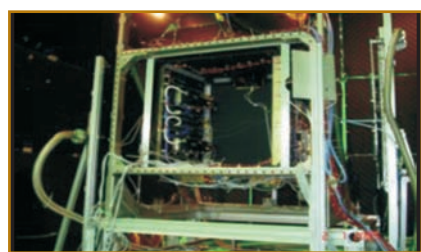
*TEMP CYCLING OF SAR ANTENNA  
SAMPLE TILES (CY-2)*



*6K SWIR LINEAR DETECTOR  
IN 0.8M TVC*



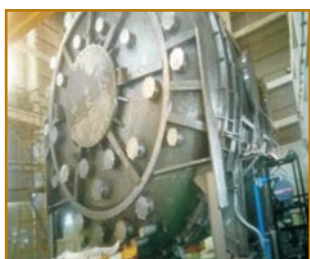
*SCATSAT - 1 WITH THREE  
THERMAL PLATES IN 3M TVC*



*INTEGRATED PAYLOAD  
OF SCATSAT-1 IN 5.5M TVC*



*LISS-4 OF RESOURCESAT-2A  
IN 3M TVC*

**Facility Augmentation**

*Chamber, TCUs, Large sized cryo pumps & gate valves, Other vacuum system components*



*134KL large LN2 Tank*



*Under Painting*



*Erected at site*



*SI cryo lines*

## In-house Qualified Process: Surface Treatment and Thermal Painting

- PU1 Black thermal control paint on Titanium alloy.
- Silver plating on Invar with electro less nickel under coat in place of copper under coat for better corrosion protection,
- AkzoNobel black thermal paint on silver plated invar.
- Silver plating on DMLS Aluminum.
- AkzoNobel Black paint on DMLS AL and Gold plated Al alloy.
- PU1 black thermal paint on bare Mag alloy.
- Gold plating on un-machined CE 7 alloy on flat samples
- Qualification of White thermal paint on Silver plated aluminum alloy for temp. of +120 & -190.
- Electroless silver plating on aluminum waveguides by using feed and bleed technique (Cu undercoat) on flat samples.

## ❖ Electronic System Support Activities Completed:



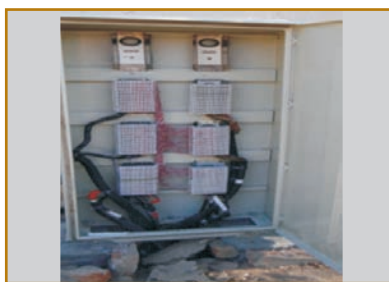
*Finger print based Biometric Access control system is installed & made operational. Finger print based Visitor management system (VMS) is also installed and made operational.*



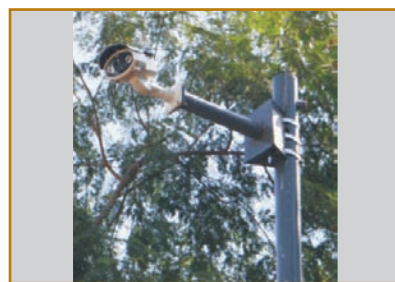
*VHF walki-talki for CISF is augmented*



*Telephone exchange with duplicated hotstandby control section & capacity of 600 extensions is installed & accepted at Bopal campus.*



*Outdoor Telephone junction boxes are made weather proof and with drawing for telephone lines.*



*SAC CCTV surveillance system is expanded with 19 more cameras & augmentation of storage from 65 TB to 105 TB*



## ❖ Networking:

### Network

- Internet leased line from is augmented from 6 Mbps to 18 Mbps

### Wi-Fi

- Secured design and implementation of Wi-Fi internet is completed including testing.

### Security

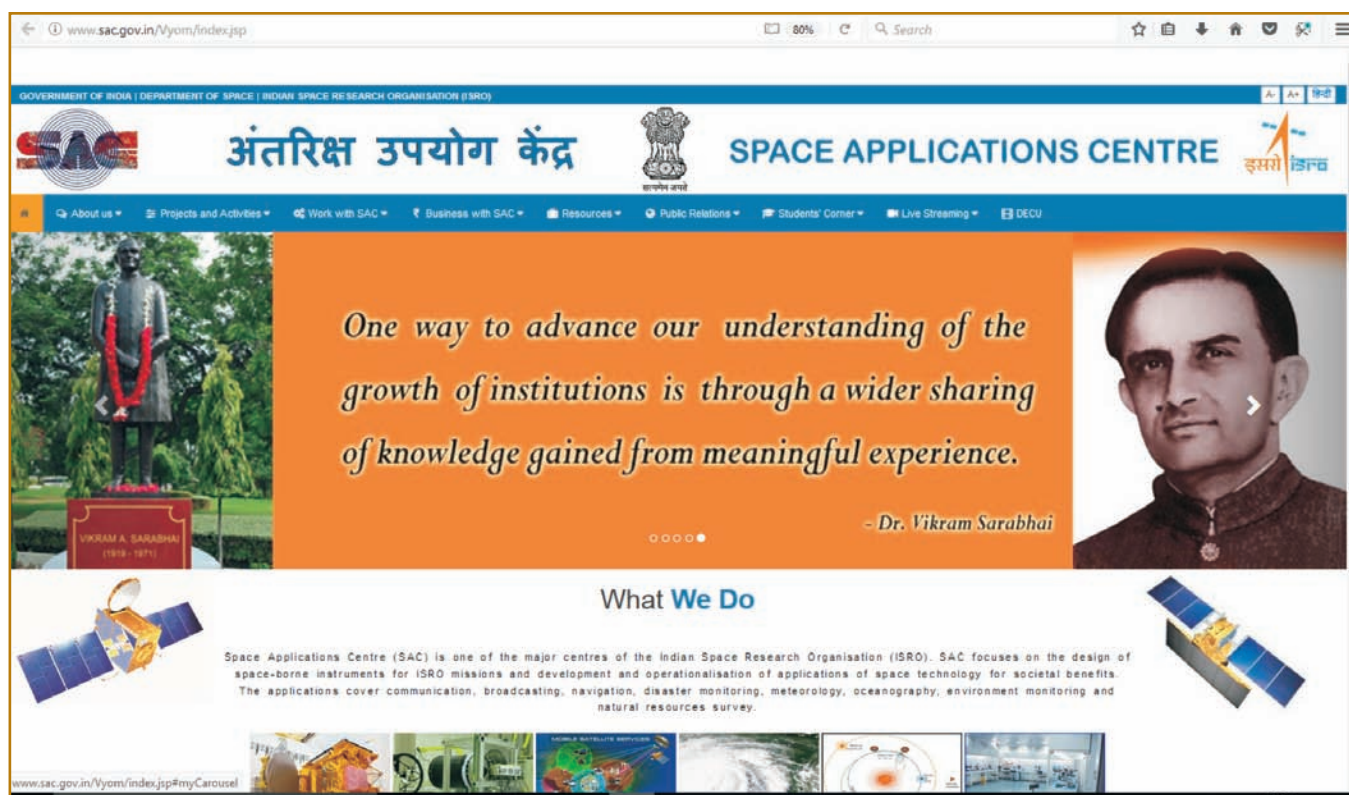
- Safe Network admission control software is developed and tested to protect from unauthorized internet connection on SACNET as well as machines having non approved software.
- Exhaustive security audit of 20+ internet service of SAC and PRL was carried out.
- Multi-layer, multi-level security architecture is implemented (March 2016)

### Cloud

Server cloud infrastructure for ITND service is implemented and service like live streaming, backup, DHCP, DNS, APAR, NAC and software testing are migrated.

### Others

- Vyom is revamped for English as well as Hindi
- Software Asset Inventory software is operationalized.



## **INFRASTRUCTURE DEVELOPMENT**

Construction and Maintenance Group (CMG) at SAC is executing new constructions and day to day maintenance of existing facility buildings, Labs, Clean rooms, Auditoriums, Offices, Housing colonies, Delhi Earth Station including 24 x 7 operation of services like Water supply, Power Supply, Air-conditioning etc.



CMG has undertaken 11 Capital Civil works (6nos. completed + 5nos. ongoing) and 126 minor & maintenance works.

## COMPLETED PROJECTS

### ❖ PAYLOAD INTEGRATION LAB AT 39 ACRE NEW SAC CAMPUS AT BOPAL

CMG has completed the major project for SAC i.e. Payload integration & checkout facility at 39 acres New Land at Bopal. The facility is one of its kind having a 52 m long clean room with a column free span of 39.50 metres and height of 21 metres which is done for the first time in ISRO. Class 10000 clean room was commissioned for atomic Clock lab. AC system consists of 250TR X 3 nos. of water cooled screw chillers. DDC system is installed for precise control of inside conditions and power savings. The work is completed and inaugurated by chairman on August 10, 2016.



*Elevations of Payload Integration & Testing Facility*

### ❖ VERTICAL EXTENSION OF BUILDING NO. 38 AT SAC

The existing facility has been extended at Second floor to meet the demand for additional sitting space for SEDA Engineers.



*Front elevation of Rear block*

### ❖ HORIZONTAL EXTENSION OF BUILDING NO. 37-A for CATF

CATF facility has been augmented for integration & alignment and safe storage of large size of FM antennas.



*Front view of 37-A Extension*

### ❖ Renovation of Delhi earth Station at Delhi.



*Front view of DES*

### ❖ Renovation (adopting improved norms) of existing quarters of block C3 to C6 at Vikramnagar DOS Housing Colony, Ahmedabad.

## ONGOING PROJECTS

### 1. BUILDING FOR LTVC AND HPTD FACILITY AT 39 ACRES NEW SAC CAMPUS, AT BOPAL

The facility is being constructed for installation of 6.5 m Thermovac chamber & PFD, HPTD. The facility is having high bay clean rooms, thermovac plant room and other facilities.

### 2. Construction of RCC approach road, service trench & storm water drain for Infrastructure facilities at 39 acres New land at Bopal, Ahmedabad

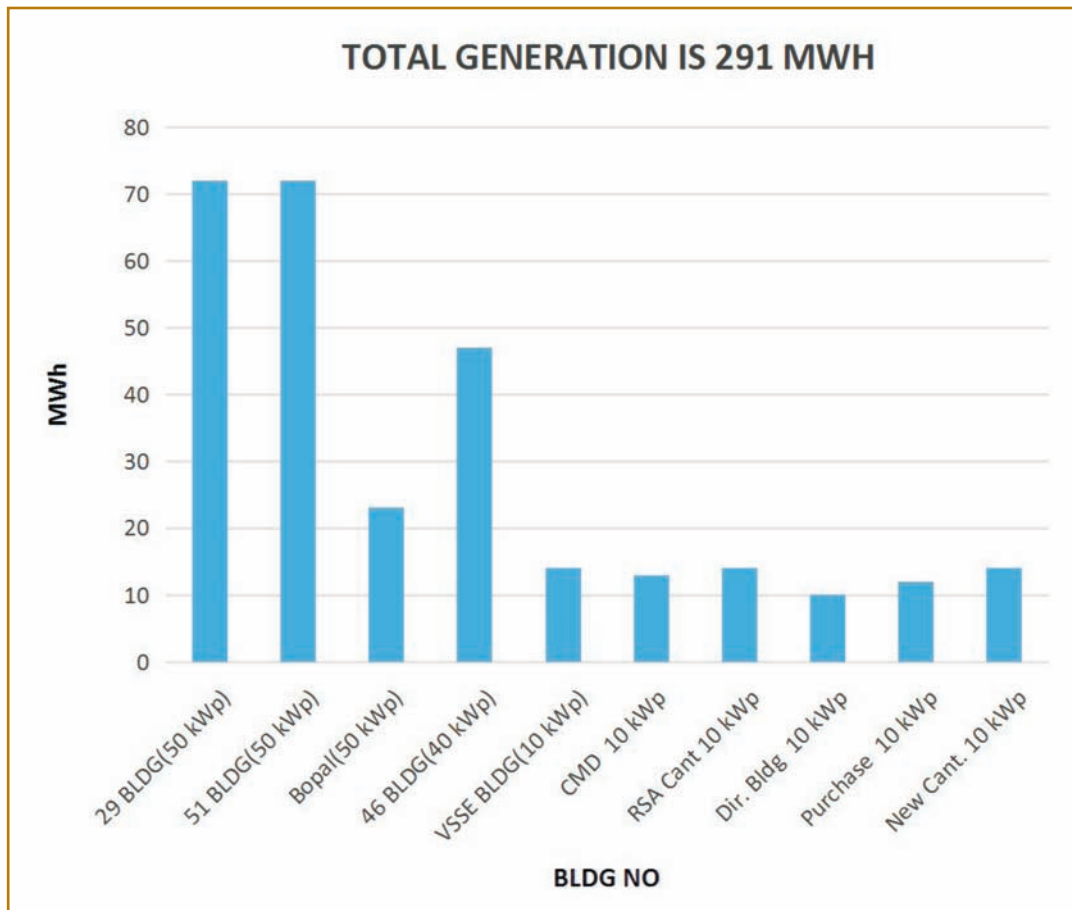
### 3. Implementation of improved norms in existing quarters of A1 & A2 blocks at Vikramnagar DOS Housing Colony, Ahmedabad.

### 4. Construction of Payload Fabrication & Test Facility (PFTF) building at 39 acres new land of SAC at Bopal, Ahmedabad [Civil, PH, Internal Electrification, Central Air-conditioning (AC) system for Class 10 to 1,00,000 Clean Rooms & other allied works]

## Green Building Measures for new projects:

- Vertical facades of the buildings are planned to generate electricity.
- Environmental friendly Modular dry wall construction.
- Terrace gardens over roof.
- Low Solar Heat Gain Coefficient glass for structural glazing/ windows are being used to reduce the heat load on AC inside building.
- Green cover: There are 6750 Nos. grown trees of different species in SAC Campus and around 5000 Nos. trees in four housing colonies and Bopal campus in addition to landscaped areas which maintain the green cover.
- 1000 nos (approx.) of bearing trees / shrubs have been planted by SAC employees around buildings under a novel initiative taken by Director SAC.
- Composting pits are developed to recycle the garden waste for production of organic in-house compost. Due to this, Inorganic fertilizer is not required for the gardening purpose.
- SAC has sewage treatment plants and 2.40 lakh litres of treated effluent water per day from STP's is used for gardening purpose.
- To sustain the biodiversity at SAC Bird bath & Bird feed are placed at identified locations.
- 250 kWp solar power plants have been installed to use renewable energy (solar) & installation of 350 kWp is in progress.
- CFC free green refrigerant gas based AC plants, AC units, water coolers, refrigerators, deep freezers etc. only are used.
- VRF AC system planned to be adopted for new buildings to reduce electricity consumption.
- Narmada water made available for drinking purpose at building no 27-A, 27-B & C., 29E, 32A, 36, 37A, 51, 52, 41B, VSSE at SAC campus and RO plants to be removed.
- Action has been taken to provide Narmada water for drinking at all buildings of SAC campus within one year in two phases.





## SYSTEMS RELIABILITY

SAC has a dedicated group namely, Systems Reliability Group (SRG) which is responsible for the formulation and implementation of Quality practices, to ensure that all projects undertaken in the centre meet the high degree of Quality and consistency that ISRO is recognised for.

This is implemented through a comprehensive and all-encompassing Quality programme, covering all aspects of product development, that includes multi-tiered design review and approval; careful selection of components and materials which is followed by extensive acceptance testing; thorough qualification of fabrication processes along-with stringent Quality Control followed by comprehensive characterisation of the developed product through a rigorous Test and Evaluation. Each of these activities are regularly monitored through Audits.



The quality programme and practices are implemented, not only within the centre, but at sub-contractor's facilities as well. SRG is equipped in terms of technical expertise and resources to ensure all quality assurance activities from Bare die to complex sub-systems and integrated payloads in the frequency range of 10MHz to 90 GHz; RF power range of 1W to 1680 Watts; components and instruments for Optical remote sensing in the Visible, NIR, IR, SWIR bands. Expertise and tools have been established and implemented for software quality assurance of FPGA, ASIC designs, Micro-controller and ground software developed on different platforms.

Quality & Reliability of Parts, Materials, Mechanical, Electro-mechanical & Opto-mechanical assemblies & integrated payloads were carried out through:

- Project specific Product Assurance plans, following established quality guidelines
- Package Design Review followed by approval and configuration control of all schematics
- Thorough review and analyses of each system, for electrical and mechanical (Stress, FMECA, Reliability, Thermal and structural) aspects
- Comprehensive component management programme, for procurement, inspection, qualification and stocking.
- Qualification of advanced fabrication and material treatment processes
- Ensuring complete traceability at all stages from Raw Material to finished system
- Specifying quality requirements and ensuring compliance by vendors.
- Assuring Quality control at all stages of fabrication, assembly & integration; through on-line inspection/ audits of all facilities, hardware and documentation, including vendors.
- Test & Evaluation for Acceptance / Qualification of a variety of sub-system & integrated payloads, for Optical. Microwave remote sensing, Communications and Navigation.
- Detailed analysis of all failures at the component, sub-system and payload level; followed by implementation of corrective actions.
- Surveillance of facilities to ensure cleanliness control, use of calibrated tools/fixtures for assembly & handling and transportation.

During the past year quality assurance activities were carried out for on-going and future projects consisting of 9 Communications, 3 Navigation, 8 optical remote sensing and 7 microwave remote sensing payloads. (GSAT-9,11,15,17 through 20, IRNSS-1F to 1H, Resourcesat-2A, Cartosat-2S, INSAT-3DR/3DS, GISAT, Chandrayaan-2 (optical & SAR P/Ls), Aditya, Microsat, RISAT-1A, 2A, Scatsat-1, NISAR, Oceansat-3). Payloads for Chandrayaan-2 from PRL were also supported.

Bonded Stores serves as the central repository of EEE components, materials, bare PCBs, fabricated hardware and subsystems; including relevant documents received. Humidity, temperature & cleanliness (class 100,000) are controlled and maintained on 24x7 basis.

SRG has undertaken studies and testing for the qualification of a variety of new materials, components and processes; like Indigenous thermal paints, CFRP and CFRP- metal-hybrid parts, electro-optical components for communication systems and the use of non-hermetic MMICs

#### **Major activities carried out in the past year include:**

- ❖ Reliability estimation of GSAT-17/11/7A, Carto-2S, Scatsat-1 payloads was done. Based on changes in electronic chain for SWIR band, estimations were revised for Resourcesat-2A. FMECA, Electrical Stress Analysis Failure Rate prediction of 40 subsystems and integrated GSAT-7A/ 19 payloads were carried out.

- ❖ Engineers participated in the review of 82 circuits (in-house designs) of various projects as well as bought-out subsystems for GEOSAT, Resourcesat-2 and NAVIC receiver.
- ❖ Land pattern library using CADSTAR was revised, for a total of 485 components, including 102 new items. These are made accessible to all design teams through centralized repository.
- ❖ QA requirements / RFPs were generated for 287 EEE parts, bare die, CCD Detectors MCM, ASICs, MMICs (S to Ka band) and Optical elements, 245 offers assessed and test data reviewed for 1 Lakh devices prior to shipment. During the year, IRC reviewed 169 indents.
- ❖ More than 1.9 Lakh components were inspected and cleared for QM/FM subsystems. Of these, 2500 were bare die semiconductors.
- ❖ Non-standard & commercial parts were up-screened and qualified for the following, like GaN Transistors for use in Chandrayaan-II payload, Proto quality Triple output DC-DC converter for Carto-2S payload, CP less 4x4 multi-port Ku band hybrid & SAW filters, for of GSAT-17, 11 and INSAT-3DS.
- ❖ Life test of more than 65,000 device-hrs was carried out on MMIC as part of experiment to evaluate environmental effect on Bare chip in absence of hermetic sealing.
- ❖ Analysis of Radiation shielding requirements has been operationalised for payload subsystems.
- ❖ A total of more than one million items were handled during the process of receipt, storage, and issue of components for payloads. This includes 2340 subsystems and 4100 PCBs and 1729 material items. Sensitive items like CCDs, PCBs and SAW substrates were stored with N2 purging.
- ❖ QA activities was carried out for (FM) procurement of optics components like; Two band strip filter, Telescope mirrors, focal plane optics mirrors, Telescope mirrors, optical components, optical assemblies, diffraction gratings, strip filters, MWIR & TIR IDCA and detectors.
- ❖ QA support was provided for procurement of VNIR & SWIR Imaging Spectrometers.
- ❖ Failure cases were analysed for GaAs FETs, LVDS devices, Op-amps, capacitors and connectors; during realisation of IRNSS, Carto-2, GSAT and Chandrayaan payloads.
- ❖ Screening & Qualification of the following commercial detectors was carried out



GK SWIR Detector

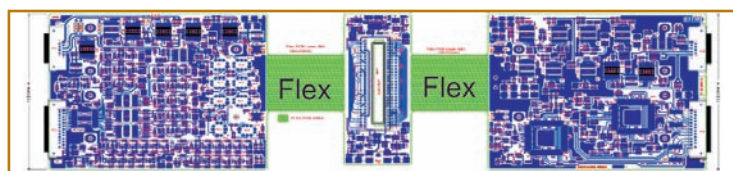
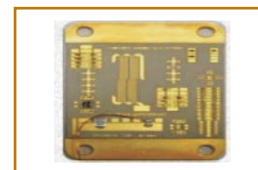
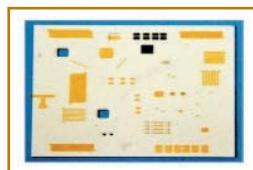
- ✓ CMV4000 detectors (New batch) for SBR payload of Nano Satellite - INS-1A.
  - ✓ MWIR & SWIR IDCA evaluated for use in Microsat project.
  - ✓ 6K SWIR Linear Detector (2 nos.) for AWiFS-A & B was successfully screened.
- ❖ Origami Lens was successfully qualified for use in INS-1B. Optical components were screened and cleared for INSAT-3DS & Carto-2S.
  - ❖ **A total of 25 new electronic, 3 mechanical and 21 surface treatment processes were qualified,** and Process Identification Documents for 7 processes approved.
  - ❖ 1,222 batches of plated and 67 batches of thermal painted mechanical parts and 219 PCB batches were cleared after evaluation of samples.
  - ❖ To reduce time for audit of hardware, at vendor's facilities, new practice of "**Photographic Audit**" was operationalised wherein all inspection reports, images and interim T&E results are transferred through FTP. Also, experiments were successfully conducted for "**Remote Audit**", which would enable control of the vendor's microscope & inspection stage.



- ❖ Significant contributions were made for **Indigenisation of technologies**, by successfully qualifying a wide and diverse range of fabrication processes, manufacturers.
- ✓ Crystal filters from M/s. Andhra Electronics & Capacitor Feed-through by M/s. Cera Seals.

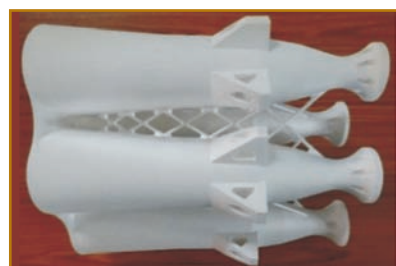


- ✓ Indigenous vendor developed and qualified for fabrication of Large-sized Flexible/ rigid etched PCBs and used for Antennas of Chandrayaan-2 SAR, RISAT-1A/ 2A.



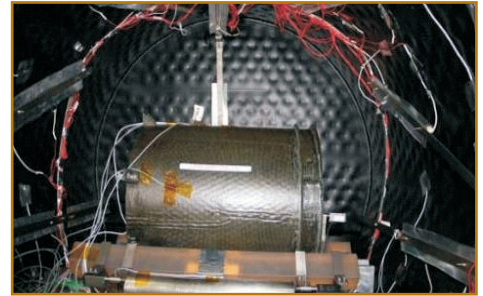
*WR75,28,51 W/G*

- ✓ Mechanical parts using DMLS (3-D printing) of Aluminium alloy (Indian Industry)
- ✓ Silver plating on DMLS-Al alloy and on DMLS-Invar (In-house)
- ✓ Electro less Nickel plating on DMLS-Invar.
- ✓ Qualification of DMLS-Invar based Mirror Fixation Device (MFD) and its bonding with large mirror of camera for Cartosat-2S

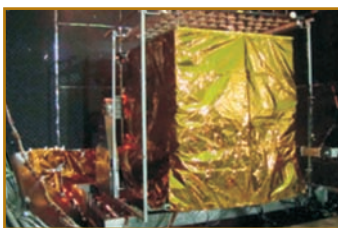
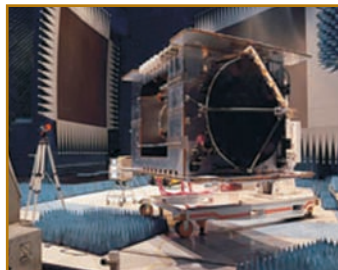


- ✓ Black Thermal Paint from MRF for temperature control (Indian Industry)
- ✓ Application of White thermal paint and Silver plating on Al alloy for -190°C (In-house)
- ✓ Hybrid CFRP Feed horn (with Aluminium lining) Qualified for GSAT-19.

- ✓ Test setup preparation & experiment for measurement of CTE & CME of CFRP based OHRC cylinder; under ambient & vacuum.
- ✓ Based on Quality evaluation of Planar Array Antenna Facility (PAAF) and multiple iterations, the material stack-up and process parameters for fabrication and assembly of Multilayer Patch antennas was optimised and PIDs generated. Process & Product level qualification completed for antennas of Chandrayaan-2 SAR and GSAT-17.



- ❖ On-line QA surveillance during integration of 8 payloads, at the panel & Camera level was carried out for Cartosat-2 & IRNSS series, GSAT-9, 17, 19 and Chandrayaan-2. QA check points were implemented during incoming inspection of bare panels & during transportation and handling of integrated payloads for TVAC testing.
- ❖ Audits were initiated at 10 facilities under Work Order Committee (WOC). Audit covered use of Approved drawing, proper Jigs, Fixtures measurement tools and documentation.
- ❖ Raw data of vibration test was used to understand the notching behaviour in TMC-2 QM & FM Tests. Locations of watchdog accelerometers & notching Levels were decided, ensuring effective vibration testing.
- ❖ For the first time in 20 years, Inspection and certification of all EOT cranes in the centre, for handling Payload elements was completed. Load testing also conducted.
- ❖ Generic guidelines for Handling & Transportation of integrated S/C panels on DSS were generated and DSS validated through analysis & load test for I3K.



- ❖ Audit was carried out during containerization and de-containerisation of antennas, panels. Rain simulation test was carried out for LISS-IV RS-2A and Carto 2S. Details of newly fabricated container for Scatsat-1 P/L and usability of existing Meghatropique container for Chandrayan-2 were reviewed, and corrective actions recommended.
- ❖ Verification carried out for 12 FPGA designs of L & S Band Dual SAR & X-ray spectrometer (Chandrayaan-2), new digital filters (DRT/MSS of INSAT-3DR & GSAT-17), cameras (INS-1, 2 & SVIS); and NSGU for future IRNSS.
- ❖ Software T&E of ATS for tracking receiver & TC-TM simulator.



❖ The details of various on-line inspection activities are summarised below:

Sr. No.	Activity	Nos.
1	Drawings approved for various projects (sheets)	1,607
2	PCB / MIC / HMC layouts	175
3	Package Drawing Sheets	492
4	Chrome masks	301
5	Cut MIC substrates	5,501
6	Patterned MIC substrates (in-house & from vendors)	6,357
7	Patterned SAW substrates	77
8	Assembly inspection at various stages of fabrication and at different assembly and integration laboratories	1,528
9	PCB wiring and assembly	4,673
10	Mechanical part inspection- In-house	6,753
11	Mechanical part inspection- Vendor	13,903
12	Box level Assembly	4,508
13	MIC level Assembly	8,000
14	Semi Rigid Cables	1,719
15	Harnessing	1,300
16	Torque Wrenches Calibrated	196
17	Quality Audits	218
18	Total No. of subsystems certified for T&E	316
19	Vibration Testing	286
20	Surface Treatment on Mechanical Parts	17,032

- ❖ SQA activities for 19 ground projects; including performance testing and final document review successfully carried out for Data Products Generation System(DPGS) & DQE for ResourceSat-2A, Cartosat-2S, Scatsat-1 & INSAT-3DR Geophysical Parameter SW Packages, Vibration Test Facility Job Card app.; Web-based IGIS and Web-email.
- ❖ GSQAD developed and deployed packages and software tools
- ❖ For generating QA Clearance Certificate at 4 different stages of hardware realisation.
- ❖ For registering all Legacy-Current- Future SW projects at SAC for monitoring compliance to ISCB guidelines.
- ❖ T&E including EMI/EMC successfully carried out for 400 subsystems. Also re-validation/ Acceptance testing completed for 200 procured subsystems like DAs, Receivers & TWTAs.
- ❖ EMI/EMC test conducted on MINISAR and Ka Band Altimeter, for Air flight clearance.
- ❖ T&E was carried out for 13 different Integrated payloads, namely GSAT-9, 17, 19, IRNSS- 1G/ 1H, 2 payloads of Cartosat-2S, QM and FM of TMC-2 for Chandrayan-2 INS-1, INS-2, multiple units of NAVIC receiver and cameras for Launch vehicle and Pad Abort Test.
- ❖ Dedicated test software and ATE were developed and used during all stages of T&E; for:
- ✓ Characterisation of Fixed/ Flexible Bandwidth Digital filters (INSAT-3DR & GSAT-17)
- ✓ Simultaneous testing of multiple sub-systems in T-Vac, to increase the throughput.
- ✓ Data Analysis Tool for Integrated EO Payloads. It has enabled quick data analysis, plotting and report generation. This has been used for LISS-4, AWiFS, TMC-2, and Carto-2D payload.
- ❖ Optical evaluation of payloads and test benches:
- ✓ Spectral & LTC measurement of LISS-4, AWiFS-A & B, TMC-2 and Cartosat-2D.
- ✓ Alignment measurement test setup for TMC-2 FM payload.
- ✓ Calibration of Monochromator using HgCd source for spectral measurement of AWiFS.
- ❖ In IPAB meetings, Product Assurance appraisal of payloads and drafts of ISRO guidelines discussed for adoption at ISRO level. Major among these are
- ✓ SRG, SAC was focal agency for development, T&E and roll-out “Path Sampada” software application, a Lessons Learnt Data Base SW for Pan-ISRO use.
- ✓ “Breakthrough in QA Practices” to address increased work load.
- ✓ ISRO standard for fasteners.
- ❖ SRG coordinated comprehensive documentation audit of all Product Assurance activities for Payloads delivered from SAC. During the year this activity was carried out for IRNSS-1F, 1G, 1H, Scatsat-1, Carto-2D/E, GSAT-9, 17, 19.

#### **Facility Augmentation:**

- ❖ New systems for testing activities were installed. These include Flexo-scope for inspection of narrow waveguides; 3-D EMI scanning system as a pre-compliance test bed for RE measurement, ESD setup for Radiated field ESD, Single point discharge & Structural current tests.
- ❖ Vibration Test Facility at M/s. Komoline Ahmedabad was evaluated and cleared.





## TECHNICAL MANAGEMENT

SAC has a dedicated group for technical management namely, Planning & Projects Group (PPG). It undertakes activities related to Projects & Budget Management (Projects & Progress Monitoring Division), Research Management (Respond & Research Coordination Division), Human Resource Management (Human Resource Development Division), Information Systems Management (Manpower Information System Division) and Technology Transfer & Industrial Management (Technology Transfer & Industrial Interface Division).



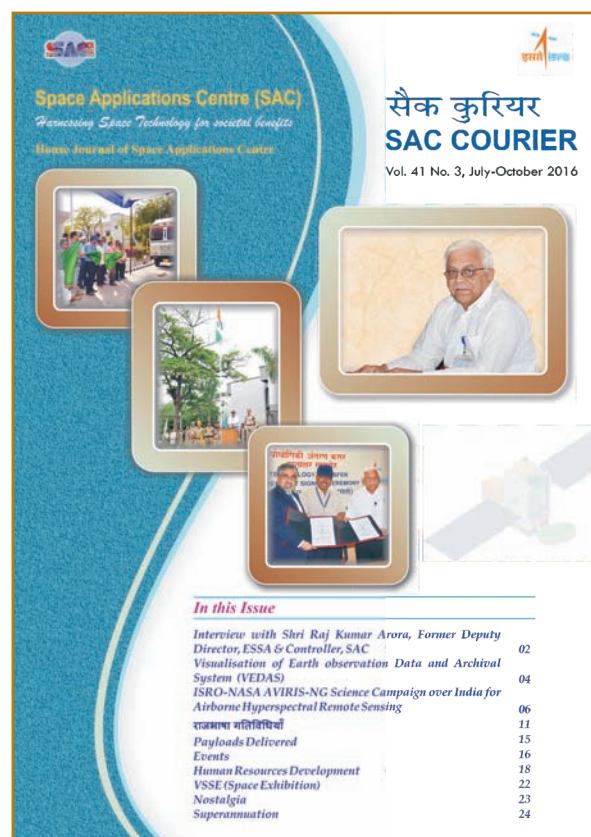
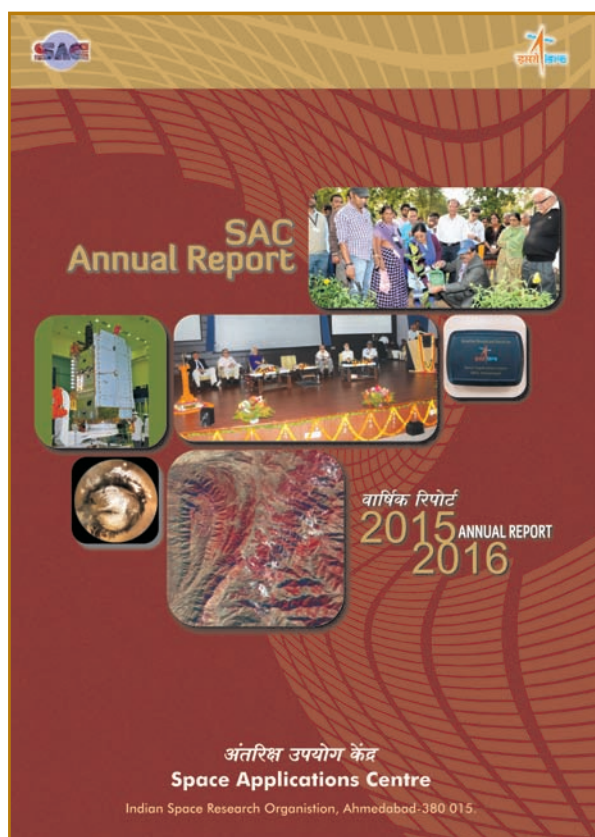
## PROJECTS AND PROGRESS MONITORING

Progress monitoring of various ongoing projects in the Centre, independently and through various committees, assessing and coordinating the resource requirements, identifying critical areas and generating follow-up action items are crucial activities to keep the projects on track. In order to evolve an effective Project Monitoring mechanism in the centre, a compilation of the scheduled activities and sub-tasks of all the projects and TDP activities of the centre are carried out. Monthly progress & status of the Centre is generated every month from the inputs of the Divisions/Groups and Areas in the Centre and a highlight of the activities is sent to ISRO Headquarter. An Archival of the monthly progress reported by various division, groups and areas is being maintained.

In order to have comprehensive and independent project monitoring a Collaborative Intra centre Review Mechanism is implemented through committees as mentioned below;

1. Communication & Navigation Systems Monitoring and Review Committee (CNMRC)
2. Remote Sensing Sensors Monitoring & Review Committee (RMRC)
3. Applications Projects - Monitoring and Review Committee

These Committees are responsible for monitoring the status and progress of on-going activities/projects in the respective areas and helping the project functionaries. They enable inter-entity coordination and help to identify the critical areas of the project.



The Annual Report of the Centre for the year 2015 – 2016 was generated. Periodical reviews of several ongoing projects by Director, SAC were arranged. Problem areas were highlighted during the review and action items generated were followed for timely resolutions.

## Budget Planning & Monitoring

Overall budget of the centre is monitored through regular expenditure reviews with purchase, account and Budget Coordinator to realize the targeted spend ability. Centre budget expenditure was depicting the smooth and well planned operation. In FY 2016-2017, 100% expenditure was achieved against the budget of Rs.667 crores allocated.

ISRO Awards for the year 2012-2015 were finalized and nominations were uploaded/submitted to ISRO Headquarter.

## RESPOND & RESEARCH COORDINATION

Research activities are monitored and coordinated by the RESPOND and Research Coordination Division (RRCD) in the Projects and Planning group (PPG). In-house, sponsored and collaborative research is carried out at SAC with the objective to promote advanced research and development in the field of Space Science Technology and its Applications. Sponsored Research (RESPOND) Program and Technology Development Program/Research and Development Program (TDP/R&D), are two important research avenues for research activities at SAC.

### ❖ RESPOND Program

RESPOND at SAC is implemented under the umbrella of ISRO RESPOND Program and caters to specific research topics pertaining to SAC activities which lie in the areas of Payload Development, Data Processing and Applications in the areas of Satellite Communication (SATCOM), Satellite Navigation (SATNAV) & Remote Sensing. The program is running at SAC with the continuous support of Academic Institutions geographically located in different states of India including IITs, NITs, Central and State Universities, VIT, DA-IICT, Nirma University, NIAS, CEPT University, etc. continuously participate in the RESPOND Program at SAC and hence it has evolved into a dynamic & responsive part of main program by significantly contributing to ISRO Programs.

In the year 2016-17, RESPOND program was strengthened through proactive research solicitation through Interest Exploration Meetings (IEMs) held at Tamil Nadu, Jharkhand and Odisha to invite Letter of Intent (LOIs) for pursuing sponsored research. This novel approach has been initiated to enhance the participation of Academia in pursuing research related to Space Science and Technology involve Academia throughout the geographical span of the country.

Interest Exploration Meetings Institute/Particulars	Bhartidasan University, Tiruchirappalli, Tamil Nadu (6-9-2016) & VIT, Vellore, Tamil Nadu (8-9-2016)	IIT (ISM), Dhanbad, Jharkhand (23-3-2017)	Utkal University, Bhubaneswar, Odisha (25-3-2017)
No. Of Academic Institutes Invited	29	14	35
No Of Institutes Participated	18	06	12
No Of Academicians Participated	94	77	37
No Of Letters Of Intent Received	90	33	30



A total of 15 IEMs have been organized by SAC spanning across the country. In the year 2016-17, four IEMs were organized on RESPOND Program of ISRO in Tamil Nadu, Jharkhand, and Odisha with emphasis on SAC programs.



*Annual Respond Review*



*Interest Exploration Meeting*

The 17th Annual RESPOND Review (ARR) Meeting held on 15th-16th December, 2016 at Space Applications Centre in which 31 ongoing projects were reviewed with presentations from Academia. 6 RESPOND Review Committee (RRC) Meetings were held in 2016-17 which reviewed for 41 ongoing projects and 134 new proposals. 19 new RESPOND project proposals as recommended by RRC were approved by ISRO HQ in 2016-17. As of 31st March, 2017, the status of RESPOND Program at SAC is as follows:

- No of Completed Projects: 15
- No of Ongoing Projects: 54

#### ❖ TDP/R&D

TDP/R&D is the in-house research program of SAC. TDP/R&D projects follow a two-layer review mechanism. The projects were reviewed in July, 2016 and January, 2017 and as of the last review 9 new projects have been approved, 78 projects are ongoing, 29 fall under Completed-A and B. The evaluation on 20 completed TDP/R&D projects in 2015-16 was published in July, 2016 titled “Evaluation of Completed TDP/R&D Activities (2015-16) Review I, July 2015 and Review II, January 2016”. The overall outcome from 20 completed TDP/R&D activities under various parameters is as follows:

##### **a. Total Human Resources Developed: 75**

##### **b. Total Papers/ Reports Published/ IPR**

- Papers Published: 28
- Reports/ User Manual generated: 23
- IPR (Patent/ Copyright): 1

##### **c. Technological development:**

- Methodology/ Techniques delivered: 08
- Algorithms/ Software/ Model developed: 16
- Hardware developed: 21

The projects were rated as Excellent, Very Good and Good and the projects rated as Excellent are listed below:

- 1. Design and development of EPC with high switching frequency resonant converter
- 2. CCSDS “Space Packet Protocol” Development for Configurable Data Formatting System
- 3. Development of Universal Drivers for Electronic Expansion Valves and implementation in existing R & AC systems for energy conservation
- 4. Ku-band High Power (10 kW) HRF with wide rejection band
- 5. Development of Transmitter and Receiver modules for 1Gbps Optical Communication Terminal along with beacon

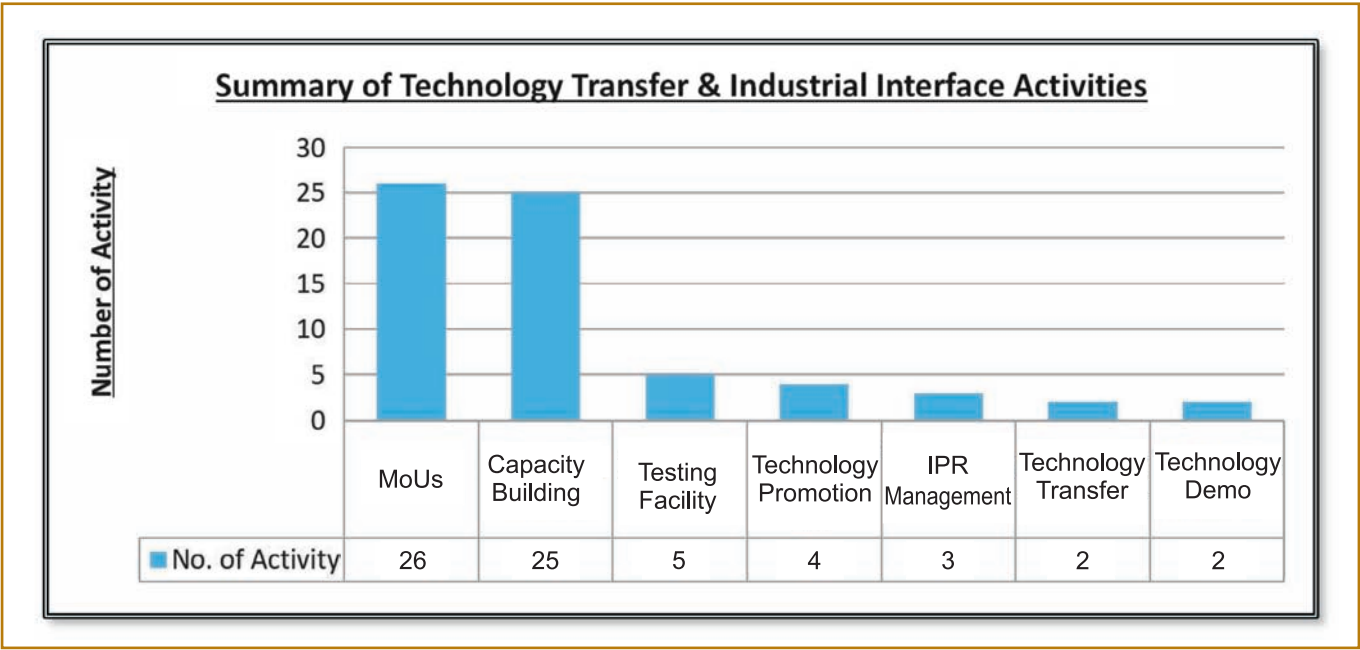
❖ Reports/Publications

The following documents have been brought out by the division during the year 2016-17:

- Compendium of Research at SAC Vol-I and Vol-II.
- Annual Report of RESPOND at SAC for 2015-16.
- Impact of completed RESPOND Projects on Academia and SAC.
- Evaluation of Completed TDP/R&D Activities (2015-16) Review I, July 2015 and Review II, January 2016.
- State-of-the-Art Practices and Technology Trends (10 volumes).

TECHNOLOGY TRANSFER & INDUSTRIAL INTERFACE

Space Applications Centre, ISRO, Ahmedabad round the year has put in magnanimous efforts for effective Industrial Partnering as well as Educational Institutions ties up and bringing out best technology transfer application in various fields.





SAC has signed 26 MoUs with different agencies, few are listed below:



*MoU with Nirma University*



*MoU with M/s. Bharat Electronics Limited*

- In plant training for ITI students at SAC-ISRO with Directorate of Employment & Training, Labor and Employment, Govt. of Gujarat
- IRNSS Navigation Receiver Field Trial and Data Collection with 20 organizations which includes Government Organization, Educational Institutions & Universities as well as Private Organization. Prestigious amongst them were CSIR-National Physical Laboratory, IIT-Mumbai, SVNIT-Surat, Defense Institute of Advance Technology, DRDO etc.
- Utilization of SAR data for vegetation characterization and retrieval of above ground biomass of Indian forests with Forest Survey of India, Dehradun, Ministry of Environment, Govt. of India
- Indigenous Design, Development & Qualification of KU Band (140-210 Watts) and KA Band (100-150 Watts) Travelling Wave Tube (TWT) with CSIR-Central Electronic Engineering Research Institute (CEERI), Pilani.
- Technical co-operation for the development of a Space Gallery at PSP, Bhubaneswar with Pathani Samanta Planetarium, Bhubaneswar (PSP), Department of Science and Technology Government of Odisha
- Technical Co-operation with M/s. Bharat Electronics Limited, Bengaluru
- Collaboration in the area of meteorology with Karnataka State Natural Disaster Monitoring Centre.

### Technology Transfer Agreement

- SAC has signed two Technology Transfer Agreements for FY -16-17 which are mentioned below:
- Manufacturing KU/DBS-Band Feed System for Earth Station Antennas with Electronics Corporation of India Ltd. (ECIL), Hyderabad
- Transfer of Know-how of Optical Imaging System with M/s. Optimized Solutions Pvt. Ltd., Ahmedabad

### Testing Facility Support

- SAC has provided testing facility support to industries namely, M/s. Centum Electronics Ltd. & Komoline Aerospace Ltd.

### Patent Granted

- Non-linear microwave pulsed power amplified and method for amplifying microwave signal, dated 24-01-17.

- A sensor and data logger based system and method for real-time monitoring, processing and prediction of weather information, dated 30-01-17

### Patent Filed

- Dielectric resonator based filter using TE mode, dated 20.02.2017

### Capacity Building

- In June 2016, 30 students of Government ITI institute were provided theoretical as well as practical training in Space Applications Centre, ISRO, Ahmedabad.
- Hi-Rel Fabrication training to participant of Industry partner on PCB wiring & Assembly and MIC Assembly & Packaging. Total 24 Hi-Rel fabrication training were organized successfully.

### Technology Promotion

Participation in outreach and promotional activities such as Exhibition & Industry Expo are key ways to carry out technology promotion. SAC has participated in 4 prominent exhibitions this year which are mentioned below:

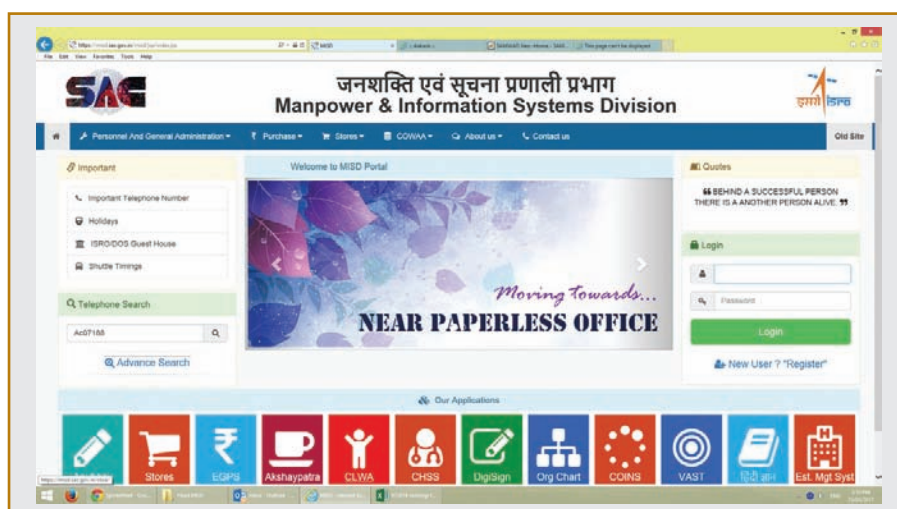
- Bengaluru Space Expo (BSX) – 2016
- National Level Vendor Management Programme by MSME, Rajkot – 2016
- Conference on Enabling Spacecraft System, Realization through Industries – 2016
- Vibrant Gujarat Global Trade Show (VGGTS) – 2017

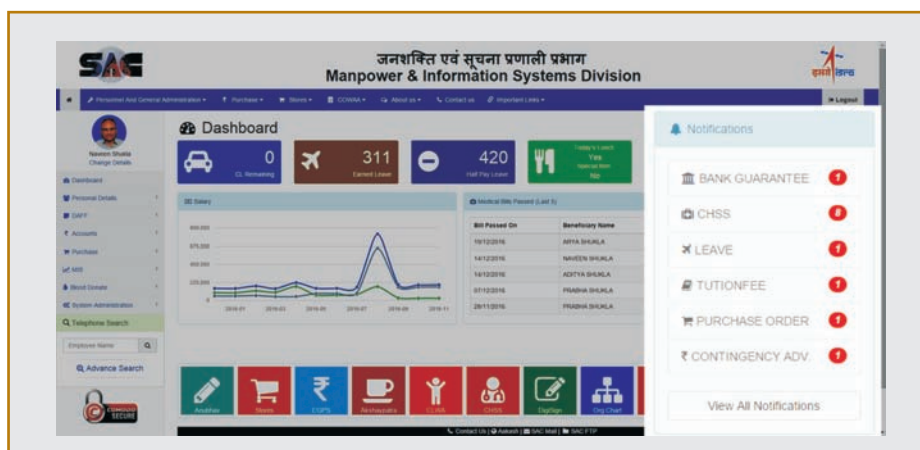
### Technology Demonstration

- Demonstration of Fire Retardant Paint was given to leading Paint Companies and its Association
- Technology Demonstration of Optical Imaging System was given to leading companies of Opto-Electronics Industry.

## MANPOWER INFORMATION SYSTEM

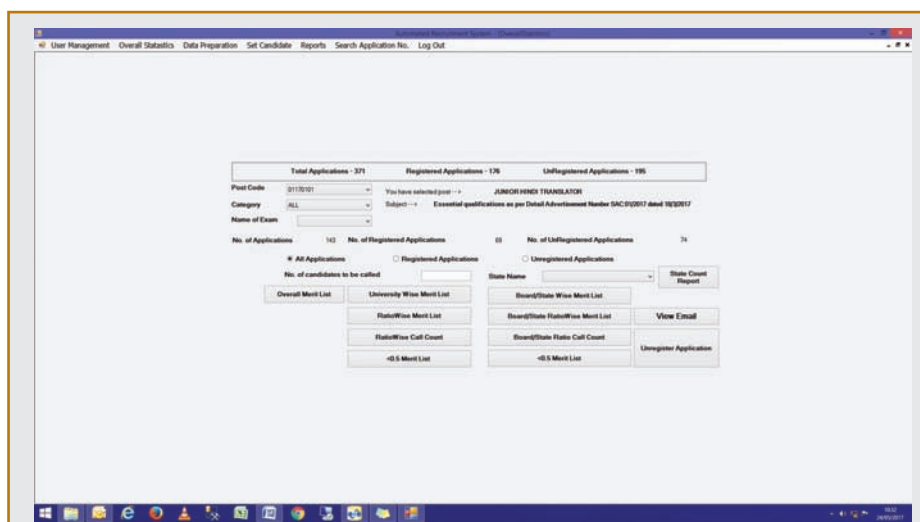
- ❖ **MISD Web Site:** MISD Web Site was completely redesigned/revamped with large no. of new features added.





- All Leave Balances, - Lunch Booking Status, - Daily Tea/Coffee consumed, - Single Screen 12-month Salary figures (Gross/Ded/Net), - Last Five Medical Bills passed, - Links to all important MISD softwares, - Logical grouping of information, - Notifications

- ❖ **Canteen Billing System:** In-house software designed, developed and implemented for smooth functioning of canteen billing of kiosk and credit services
- ❖ EGPS MIS Sharing with all ISRO centres: EGPS MIS developed at SAC is shared with all ISRO centres and is also in use by ISAC, LPSC, ISRO HQ, IPRC and SDSC, SHAR.
- ❖ Successfully implemented 7<sup>th</sup> CPC recommendation in record time along with Organization PRIS payment
- ❖ For the first time record no. (Approx. 77000/-) Online Applications were received for record no. (Approx. 250) of posts for recruitment in SAC. Online Screening to these Applications was done with in-house developed s/w. This has reduced the timeline of entire screening process from more than 6 months to just 1 month.



- ❖ DigiSign Application was enhanced for Online Consent to increase the subscription for SAC Recreation/Sports Club membership.
- ❖ Successfully implemented COINS ver 3.0 as a major change from Client Server environment to web/browser based architecture
- ❖ “Akshaypatra” software is enhanced to cater to serving of large no. of items and services also extended to New Bopal Campus



## HUMAN RESOURCE DEVELOPMENT

- ❖ Human Resource Development Division is playing a major role in providing learning platforms for SAC/DECU employees through Training & Development activities.
- ❖ 15 in-house programs were designed and organized during 2016-17 that accommodated about 400+ participants. This includes ISRO Level programme IITP-28 and Structured Training Programs (STP). Besides, HRDD organized 14 other programs including Seminars/Educational visits.
- ❖ 334 staff members deputed to attend various conferences/seminars/training courses/et al. About 56 papers were presented by Scientists/Engineers in various Conferences/Symposiums/et al. 27 higher-studies cases were also recommended during 2016-17. HRDD has been processing the award nominations conferred by various institutes including ISRO/ASI awards.
- ❖ HRDD organized 9 lectures under SAC Lecture Series and 8 lectures under Knowledge Sharing Series. We invited eminent personalities from different walks of life which are getting appreciated by SAC & DECU fraternity. one events were also conducted under
- ❖ HRDD organized an Award function: ISRO Awards Function 2012, 2013, 2014 & 2015 on November 18, 2016 at SAC. Director-SAC handed over the certificates to 420 individual/team awardees.
- ❖ HRDD continues its liaison role under SAC-Academic Associate Programme (SAC-AAP) with academic institutions for providing in-plant training for students' project/internship. 228 students from various academic institutions located in different parts of the country benefited during 2016-17.



Organised by  
**CII**  
Confederation of Indian Industry



5<sup>th</sup> BENGALURU SPACE EXPO 2016

# world space-biz

International Conference on Space Technology

1-3 September, 2016, Bengaluru



5th Bengaluru Space Expo 2016

## **Administration, Accounts, Purchase & Stores**



## ADMINISTRATION

For Recruitment, written tests for nearly 28000 candidates at different venues in Ahmedabad, Skill tests for 1124 candidates and Personal Interviews for 1085 candidates were conducted.

Personal files in respect of 1784 employees, 194 apprentices and 38 JRFs/RAs are maintained by the Section. A large scale Pension Adalat was organised in the Centre for redressal of grievances of pensioners and 25 cases were resolved.

Allotment of a total no. of 221 quarters has been made at different Housing Colonies, apart from routine allotments under lateral change, etc. Establishment of an E-gallery at Vikram Nagar Colony has been completed and made ready for occupation.

H1N1 Vaccination camp was organised at Departmental Dispensaries and around 1137 beneficiaries were vaccinated. Based on the recommendations of CMAC, a good number of new Hospitals and Specialists have been empanelled under CHSS. Annual Medical Examination under 'SHAPE' programme has been carried out for 625 CISF personnel.

An Interaction Programme with local Residential Associations/Residents staying in the vicinity of the Centre was organised with the help of CISF and local

## FINANCE & ACCOUNTS

Fiscal year 2016-17 saw the smooth implementation of 7<sup>th</sup> CPC and the associated activity for SAC & DECU employee. Pension cases were also taken up as per the changes in the 7th CPC. There is a substantial increase in the activity of SAC with the ongoing project. With consistent efforts, SAC could meet the expenditure target with 99.99% utilization with reference to the final allocation.

Audit of SAC by Internal Audit Wing of DOS (IAW) for the F.Y.2014-15 and 2015-16 were taken up by IAW Auditors during August-September 2016.

Re-appropriation Orders for SAC & DECU were submitted to DOS in time and successful closing of 2016-17 account was achieved on March 31, 2017. The total cash flow for PAO SAC for F.Y. 2016-17 was 1142.69 crores and final expenditure for SAC was 667 crores.

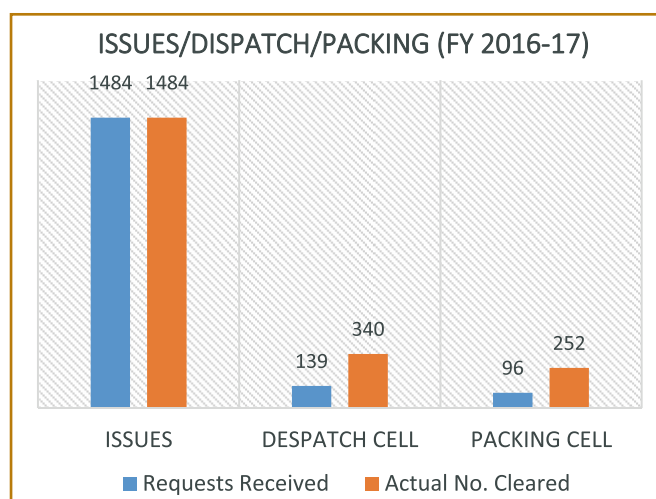
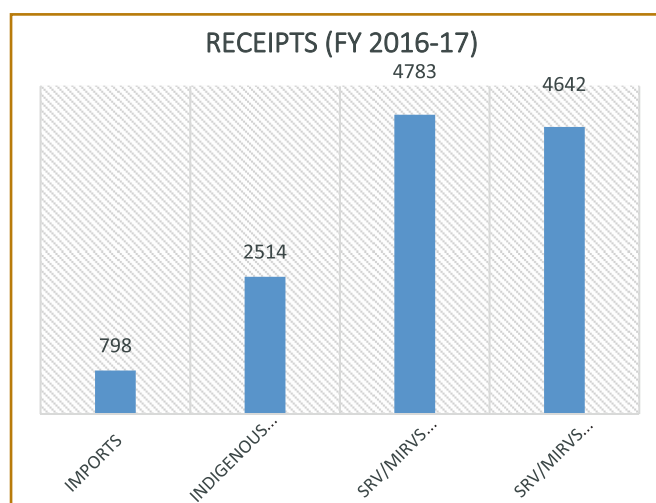
## PURCHASE

Purchase section is responsible for the procurement related activities of the Centre. In FY 2016-17, following activities were completed,

No. of Indents (COWAA)	: 2612
No of Indents (EGPS)	: 1165
No. of POs IN COWAA	: 2796 (Value:524.06 crores)
No. of POs IN EGPS	: 788 (Value:1224.66crores)

## STORES

Stores Section is responsible for handling the complete requirement of SAC and DECU for day to day stationary, packing, shifting, transportation & disposal requirement. Stores supports the receipt and issue of all the ordered items, both import & indigenous till the SRVs are forwarded to the Accounts Department.



## RESOURCE FACILITIES

SAC has dedicated resource facilities for learning & development of the employees and community at large.

## LIBRARY

SAC library continued to be a knowledge hub and played a significant role in facilitating creation and dissemination of knowledge during the year. With its specialised collection and keeping in view information needs of its users', library has rapidly transformed itself into a hybrid library. During 2016-17 the number of printed documents added in library collection are as mentioned below:

Type of Document	S&T Books, Conference Proceedings	Hindi books / Misc. books	Reports	Reprints	Standards	Trade Literature	Journal
Number	259	226	350	10	3	1	2

Users' preference of remote access to information, was duly kept in mind while procuring information resources and added non-print material as below:

Type of Document	Non-Print media	E-Books	E-Journals (Through Consortia)
Number	130	52	14

Renewed 59 printed periodicals, 51 print + online and 86 e-journals from major publishers and Commodities database facilitating full text access using Internet from SAC, Bopal, DES Campuses as well as remote access. SAC library also renewed institutional memberships of ION, IPC and British Library. IEL DL, SPIE DL, AIAA and Journal Table of Contents are subscribed through ISRO library Consortia.

Physical footfalls to library were approx. 75,064, whereas access to different pages of Library website, which links to other library services such as- mirrored CD/DVDs, NPTEL Videos, Institutional and Digital Repositories, News Clips etc.; were accounted to be 1,31,014. Library provided 5 ISBN nos. and procured 101 Digital Object Identifier (DOI) for data sets and other digital objects.

This year library extended its memberships to 432 regular and retired employees, student trainees, apprentices, JRFs etc. Also, provided membership to trainees enrolled under TREES and other projects. Inter-library loan requests were received from various cooperating libraries and 98 requests for books and monographs were fulfilled. Total 147 requests for journal articles on Inter Library Loan from our users and other libraries were received out of which 130 were fulfilled. In reprographic facility of SAC Library, approx. 2,81,685 B&W and 3,72,843 color pages were printed, and 10,011 documents were bounded in-house.

**Major initiatives** during the period, Antariksh Gyaan web portal was designed developed and hosted in SAC premises. The web portal was inaugurated by Chairman, Antariksh Gyaan on November 17, 2016 in presence of Shri Tapan Misra, Director SAC. Also, a new library web portal was designed using Drupal Content Management System which was inaugurated by Director, SAC on August 5, 2016. A 100 TB Network Attached Storage was procured and 1816 Nos. of CD/DVDs' content was migrated from existing CD mirror servers to NAS Storage and linked to library website. Journal Table of Content (TOC) service was incorporated for the users' in August 2017.





A Library Orientation Programme was organized for all Scientists/Engineers SC & SD and Research Scholars (JRF, SRF and RA) along with an exhibition of S&T Books at New Auditorium on Feb. 08, 2017 which was inaugurated by Director, SAC.



One-day educational visit of Department of Library and Information Science, University of Jammu was arranged on Feb. 21, 2017 at Library and Documentation Division. A group consisting of 21 students and 01 teacher participated in the Programme.

SAC Library was awarded second prize for Hindi Implementation in year 2014-15, by Director SAC on Jan. 26, 2017.

## VIKRAM SARABHAI SPACE EXHIBITION (VSSE)

VSSE operates with a vision of spreading space awareness among the community at large.

About one lakh thirty-three thousand visitors from 655 schools, colleges, groups and families & individuals have visited VSSE during the year.

Delegates of Indian National Academy of Engineering's (INAE) Annual Convention, His Holiness Jagadguru Puri Shankaracharyaji, Directors of various institutions, Chairman ISRO were amongst the distinguished guest at VSSE.

On May 11 National Technology Day was celebrated as NavIC Day in VSSE. About 4,000 visitors visited and joined during the celebration. Special lectures on Navigation were arranged and paper model making kit of IRNSS, stickers were distributed. The scientists involved in IRNSS have interacted with visitors during the day.

World Space Week-2016 at Vikram Sarabhai Space Exhibition had witnessed large number of Space enthusiasts, approx. 10,000 visitors of all age-groups and various sections of the society. Several competitions like Satellite Model Making competition, Colouring/drawing and Painting competitions, Space Quiz, Workshop on Remote Sensing for Undergraduate students and teachers was organized, and Space Antakshri events were organized as a part of World Space Week celebrations during October 4-10, 2016. About 65 schools, colleges and Universities were personally approached and invited by VSSE team members. Calendars of satellite models, model making kit, stickers of NavIC, a booklet on life and vision of Dr. Sarabhai were distributed to all visitors. Besides prizes, pens were also distributed to all participants

On February 28 National Science Day was celebrated with a theme "Science and Technology for Specially-Abled Persons". About 1200 visitors have participated in the event.

### Mobile Exhibition:

In order to enhance outreach activity VSSE conducts mobile exhibition at various school/colleges ranging from IITs/NITs to far flung rural school. VSSE has conducted mobile exhibition across Gujarat, Maharashtra, Rajasthan, UK, MP and NIT-Manipur-Imphal in North East. During Kankaria-Carnival celebration at Kankaria Lake of Ahmedabad city Space Exhibition has attracted about 25 Lakhs visitors. Total 26 mobile exhibitions were conducted and more than 28 lakhs footfalls are registered.

Under Corporate Social Responsibility, VSSE/SAC has invited students of municipal schools, Government schools, Trusts/Societies run by NGOs for uplifting under privileged, physically challenged students. Transport facility and lunch/snacks were offered to them. Total 27 such schools were invited during the year.

A CD prepared by Lok Vigyan Kendra Bhavnagar on ISRO's Space Exhibition organized at Bhavnagar was released by Director-SAC.



*Chairman, ISRO and Director, SAC at Vikram Sarabhai Space Exhibition (VSSE)*

## हिंदी गतिविधियां

### पुरस्कार

- अंतरिक्ष उपयोग केंद्र (सैक) को क्षेत्रीय राजभाषा पुरस्कार (प्रथम स्थान): राजस्थान के माननीय राज्यपाल श्री कल्याण सिंह ने 30 जनवरी 2017 को उदयपुर में संपन्न क्षेत्रीय राजभाषा सम्मेलन के दौरान अंतरिक्ष उपयोग केंद्र (सैक) को वर्ष 2015-16 के लिए पश्चिम क्षेत्र (गुजरात और महाराष्ट्र) में स्थित केंद्रीय सरकार के कार्यालयों की श्रेणी में सर्वश्रेष्ठ राजभाषा हिंदी के कार्यान्वयन के लिए क्षेत्रीय राजभाषा पुरस्कार (प्रथम स्थान) प्रदान किया। यह पुरस्कार श्री तपन मिश्रा, निदेशक, सैक की और से श्री दीपक कुमार दास, सह निदेशक, सैक ने ग्रहण किया। इस अवसर पर केंद्र की वरिष्ठ हिंदी अधिकारी श्रीमती नीलू सेठ को माननीय राज्यपाल ने प्रशस्ति-पत्र प्रदान किया।
- वर्ष 2015-16 के दौरान सर्वश्रेष्ठ राजभाषा कार्यान्वयन तथा सैक परिसर में नराकास बैठक की मेजबानी के लिए सैक को नराकास अहमदाबाद की ओर से चल वैजयंती प्रदान की गई। वर्ष 2015-16 के दौरान 100 से कम स्टाफ सदस्यों वाले केंद्रीय सरकार के कार्यालय की श्रेणी में विकास एवं शैक्षिक संचार यूनिट (डेकू) को सर्वश्रेष्ठ राजभाषा कार्यान्वयन के लिए प्रथम पुरस्कार से सम्मानित किया गया।
- 05 अगस्त 2016 को आईआईआरएस, देहरादून द्वारा अंतर-केंद्र हिंदी संगोष्ठी का आयोजन किया गया। इस संगोष्ठी के तकनीकी सत्र में सैक के श्री कृपाशंकर सिंह को प्रथम पुरस्कार तथा राजभाषा सत्र में श्री दिनेश अग्रवाल को द्वितीय पुरस्कार प्राप्त हुआ।
- अंतरिक्ष विभाग, बंगलूरु में 27 दिसंबर, 2016 को आयोजित हिंदी तकनीकी संगोष्ठी के राजभाषा सत्र में श्रेष्ठ प्रस्तुति के लिए सैक के श्री कमलेश कुमार बराया को पुरस्कृत किया गया।
- एड्डिन में 10 मार्च 2017 को संपन्न हिंदी तकनीकी संगोष्ठी के राजभाषा सत्र में श्रेष्ठ प्रस्तुति के लिए सैक के श्री कमलेश कुमार बराया को पुरस्कृत किया गया।

### विशेष गतिविधियां

- 05 अगस्त 2016 को "भारतीय अंतरिक्ष कार्यक्रम में मेक-इन-इंडिया अभिगम" विषय पर हिन्दी तकनीकी संगोष्ठी का आयोजन किया गया, इसके साथ ही "भारतीय अंतरिक्ष कार्यक्रम की सफलता में राजभाषा हिंदी की भूमिका" विषय पर राजभाषा सत्र भी शामिल किया गया।
- सैक तथा डेकू में विगत कई वर्षों से हिन्दी माह का आयोजन किया जाता है जिसमें कार्यालय के कर्मचारी अत्यंत उत्साह से भाग लेते हैं। वर्ष 2016 में भी सितंबर माह के दौरान हिंदी माह का आयोजन किया गया। हिन्दी माह के दौरान हिंदी भाषी वर्ग के लिए 15 तथा हिंदीतर भाषी वर्ग के लिए 15 हिंदी प्रतियोगिताओं का आयोजन किया गया।
- केंद्र में हिंदी दिवस के उपलक्ष्य में 14 सितंबर, 2016 को अंतर्राष्ट्रीय हृदयरोग विशेषज्ञ डॉ. विपुल कपूर का विशेष व्याख्यान रखा गया। इस व्याख्यान में स्वस्थ जीवनशैली पर विस्तार से चर्चा की गई। व्याख्यान में केंद्र के अधिकारी/कर्मचारियों की उत्साहजनक उपस्थिति दर्ज की गई।
- निदेशक, सैक की अध्यक्षता में सैक की राजभाषा कार्यान्वयन समिति की 21.05.2016 को 145वीं, 15.09.2016 को 146वीं, 26.12.2016 को 147वीं तथा 15.03.2017 को 148वीं बैठक का आयोजन किया गया। जिसमें संबंधित तिमाहियों के दौरान केंद्र में राजभाषा नीति के अनुपालन की समीक्षा की गई।
- वर्ष के दौरान 04 राजभाषा कार्यशालाओं का आयोजन किया गया।
- दिसंबर 2016 के दौरान हिंदी गृह पत्रिका अभिव्यक्ति के 10वें अंक का विमोचन निदेशक, सैक द्वारा किया गया। पत्रिका अंतरिक्ष विभाग/ इसरो के विभिन्न केंद्र/यूनिटों को प्रेषित की गई। अभिव्यक्ति के 11वें अंक के लिए परिपत्र जारी कर सैक/डेकू स्टाफ सदस्यों से रचनाएं आमंत्रित की गई।
- अंतरिक्ष विभाग की पहल पर कोइन्स प्रणाली के अंतर्गत सैक द्वारा विभिन्न प्रशासनिक, लेखा, क्रय तथा भंडार संबंधी प्रारूप द्विभाषी रूप में तैयार करने में सहयोग प्रदान किया गया।



- वर्ष के दौरान अधिकतर कार्यालयीन काम हिंदी में करने हेतु लागू प्रोत्साहन योजना के अंतर्गत हिंदीतर भाषा वर्ग एवं हिंदी भाषा वर्ग के 25 स्टाफ सदस्यों को पुरस्कार प्रदान किया गया।
- अंतरिक्ष उपयोग केंद्र तथा विकास एवं शैक्षिक संचार यूनिट (डेकू), अहमदाबाद में जनवरी 2017 माह में विश्व हिंदी दिवस मनाया गया।
- 31 अक्टूबर- 5 नवंबर 2016 तक केंद्र में आयोजित सतर्कता सप्ताह के दौरान हिंदी निबंध प्रतियोगिता का आयोजन किया गया और इसी भाँति 4-10 मार्च 2017 के दौरान आयोजित सुरक्षा सप्ताह के दौरान भी हिंदी निबंध लेखन प्रतियोगिता का आयोजन किया गया।
- 22 दिसंबर 2016 को श्री मनोहर एल वणियार, वरिष्ठ प्रधान, कार्मिक एवं सामान्य प्रशासन, इसरो उपग्रह केंद्र (आईजैक), बेंगलूरु द्वारा विकास एवं शैक्षिक संचार यूनिट (डेकू) का वर्ष 2015-16 के लिए हिंदी के प्रगामी प्रयोग से संबंधित वार्षिक निरीक्षण किया गया।
- श्री डी.आर. पटेल, नियंत्रक, सैक द्वारा 05 अक्टूबर 2016 को इसरो मुख्यालय, बेंगलूरु का वर्ष 2015-16 के लिए हिंदी के प्रगामी प्रयोग से संबंधित वार्षिक निरीक्षण किया गया। निरीक्षण में प्रस्तुत दस्तावेजों का अवलोकन किया गया तथा सुझाव और प्रेक्षणों का उल्लेख करते हुए विभाग तथा संबंधित कार्यालय को निरीक्षण रिपोर्ट भेजी गई।
- केंद्र में पूर्ण कार्य हिंदी में करने के लिए विनिर्दिष्ट 13 अनुभागों का आंतरिक निरीक्षण हिंदी कार्यान्वयन समीक्षा समिति द्वारा किया गया। 22 फरवरी 2017 को निदेशक, सैक के हस्ताक्षर से हिंदी कार्यान्वयन समीक्षा समिति की रिपोर्ट संबंधित अनुभागों को भेजी गई।
- केंद्र के सभी प्रकार्यात्मक पदनामित अधिकारियों को कार्यालय में प्रयोग करने हेतु वैज्ञानिक तथा तकनीकी शब्दावली आयोग द्वारा प्रकाशित प्रशासनिक शब्दावली (हिंदी-अंग्रेजी तथा अंग्रेजी-हिंदी) का वितरण किया गया। हाल ही में अद्यतित एवं प्रकाशित की गई अंतरिक्ष विज्ञान शब्दावली (अंग्रेजी-हिंदी) की प्रतियाँ सभी प्रभागों तथा मौलिक वैज्ञानिक लेखन में रुचि रखने वाले वैज्ञानिकों को वितरित की गई।
- प्रशासनिक क्षेत्र के कर्मचारियों को उनके अनुभाग में जाकर हिन्दी अनुभाग के कार्मिकों द्वारा कंप्यूटर पर हिन्दी में कार्य करने का प्रशिक्षण प्रदान किया गया।
- अंतरिक्ष विभाग द्वारा जारी विक्रम साराभाई मौलिक हिन्दी पुस्तक लेखन योजना का सभी स्टाफ सदस्यों के बीच व्यापक परिचालन किया गया।
- केंद्र की मासिक प्रगति रिपोर्ट का हर माह नियमित रूप से हिंदी रूपांतरण तैयार कर विभाग को प्रेषित किया गया।
- निदेशक, सैक 26 जनवरी 2017 को अंतरिक्ष उपयोग केंद्र परिसर में गणतंत्र दिवस समारोह के दौरान सैक/ डेकू में हिंदी कार्यान्वयन से संबंधित विभिन्न गतिविधियों/ प्रोत्साहन योजनाओं के विजेता प्रतिभागियों तथा 10वीं तथा 12वीं कक्षा में हिंदी विषय में सर्वाधिक अंक प्राप्त करने वाले सैक/डेकू स्टाफ सदस्यों के बच्चों को पुरस्कृत किया।

# PUBLICATIONS

## TECHNICAL PUBLICATIONS:

- ❖ R B Upadhyay, K Jalaja et.al. “Structural & Electrical properties of Ba<sub>0.6</sub>Sr<sub>0.4</sub>TiO<sub>3</sub> thin film on LNO/Pt electrode” International Conference on Functional Oxides and Nano materials (ICFONM), Nov, 2016
- ❖ “Development of Micro Lithography Technology, on thick resist using LASER Direct Write Technique for Mask-less PUP”. Published in Compendium of Research at SAC, Volume-2, April 2016.
- ❖ Screening and Qualification of Packaged MMIC for space program: Application specific approach: Authors: Nandini Deshpande, Shilpa Pandya, A K Lal; EEE-Con 2017 at ISAC.
- ❖ Failure Analysis tools and techniques for Hi-Rel Electronics, Authors: Ms. Meghal Desai, Ms. Urmi Raval, R.R. Patel, Ms. Shilpa Pandya, M.M. Vachhani, R.M. Parmar, EEE-Con 2017 at ISAC.
- ❖ Evaluation of Area Array CMOS Sensor for Indian Space Programs; Authors: Rishi Kaushik, S. L. Dhaker, Udayan Choudhury, Ashwani Kr. Gupta, Pawan Kr. Brahma, A. K. Lal, EEE-Con 2017 at ISAC.
- ❖ Experience During COTS Qualification; Authors: Sanjeev Jain, A. K. Lal, Jagdish B Bhatt, Nazrul Islam, Kirtiman Sharma, EEE-Con 2017 at ISAC.
- ❖ Qualification of ultra-light plastic lens & body CMOS camera module for Remote Sensing Space programs; Authors: S. L. Dhaker, Rishi Kaushik, Udayan Choudhury, Ashwani Gupta, Pawan Kr. Brahma & Mukesh Patel, EEE-Con 2017 at ISAC.
- ❖ Inventory management & Storage of EEE parts for Space Payloads; Authors: J M Jesalpura, V M Patel, Kamal Poddar, P M Kholia, EEE-Con 2017 at ISAC.
- ❖ 3GHz SAW BPF becomes a possibility with Qualification of 250nm Process Capability; Authors: Gyan Singh, Prashant Verma (ESSA), N R Jivani (ESSA), EEE-Con 2017 at ISAC.
- ❖ New Packaging Configuration of CCGA1752 leading to Challenges in its Assembly Process Reliability Assessment; Authors: Ishwar Lal Prajapati, N K Verma, Deep Pandey (ESSA), EEE-Con 2017 at ISAC.
- ❖ Feasibility Study on use of RF Interface Component (RF Flexible Cable with Connector Assembly) for Temperature Range Extended Beyond Rating; Authors: Mukesh Patel, Ms. Nandini Deshpande, Mahesh Makwana (ESSA), EEE-Con 2017 at ISAC.
- ❖ Qualification of Imaging Optics for First Interplanetary Mars Orbital Mission of ISRO; Authors: Udayan Choudhury, Brijesh Kumar, SCQAD, STD-2017
- ❖ “Functional verification of DSP based on board VLSI design” at a IEEE International conference –VLSI-SATA Bangalore.
- ❖ “Institutional Repository for long-term access of digital information” by Rachna Patnaik and Shelly Jamwal, Paper presented and published in TIFR-BOSLA "National Conference on Future Librarianship: Innovations for Excellence", on April 22-23, 2016, Mumbai.
- ❖ “Digital preservation and procedures” by Shelly Jamwal and Rachna Patnaik, Paper Presented and published in TIFR-BOSLA "National Conference on Future Librarianship: Innovations for



Excellence", on April 22-23, 2016, Mumbai.

- ❖ Yogesh Tyagi, V K Singh, S B Chakrabarty, Rajeev Jyoti, "Improvement in Side-lobe Performance of Prime Focal Reflector Antenna", Accepted for publication in Microwave and Optical Technology Letters
- ❖ Ranajit Dey, S.B. Chakrabarty and Rajeev Jyoti, "Analysis and Application of Triple-Post Discontinuity in Circular Waveguide", Electromagnetics, VOL. 36, NO. 2, 67–77, 2016.
- ❖ Ranajit Dey, S.B. Chakrabarty, Rajeev Jyoti and Thomas Kurian, "Higher Order Mode Analysis of Dual-post Discontinuity in a Circular Waveguide", IETE Journal of Research, Vol. 62, Issue-1, PP. 55-62, 2016.
- ❖ A paper on "Retrieval of Wind Stress at the Ocean Surface From AltiKa Measurements" M. M. Ali, Mark A. Bourassa, Suchandra A. Bhowmick, Rashmi Sharma and K. Niharika has been accepted in IEEE GRSL.
- ❖ Abhineet Shyam, Rajesh Shikhakolli and A K Varma, 2016, 'Science Proposal for the Retrieval of Atmospheric and Oceanic Parameters from SAR: Utilization of RISAT-2 & Preparation for NISAR,' SAC/EPSC/AOSG/GRD/SR/3/2016.
- ❖ Sarangi, R.K., 2016, Remote Sensing Observations of Ocean Surface Chlorophyll and Temperature with the Impact of Cyclones and Depressions over the Bay of Bengal Water, Marine Geodesy, 39(1), pp.53-76.
- ❖ Sahu, G., Mohanty, A.K., Sarangi, R.K., Bramha, S.N. and Satpathy, K.K., 2016, Upwelling-initiated algal bloom event in the coastal waters of Bay of Bengal during post-northeast monsoon period (2015), Current Science, 110(6), 979-981.
- ❖ Niti Singh, K.N.Chaudhary, K.R.Manjunath.2016. Comparison of Citrus Orchard Inventory using LISSIII & LISS-IV data. SPIE Paper Number:9880-91.
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- ❖ Pandya M. R. (2016). Development of algorithm for retrieving aerosols over land surfaces from NEMO-AM polarized measurements. SPIE Proceedings. 4-7 Apr. 2016. New Delhi.
- ❖ Pandey, D., Maity, S., Bhattacharya, B. K. and Misra, A. 2016. Model-based Surface Soil Moisture (SSM) retrieval algorithm using multi-temporal RISAT-1 C-band SAR data. SPIE Proceedings. Apr. 4-7, 2016. New Delhi.
- ❖ Rahul Nigam, Rajsi Kot, Sandeep S Sandhu, Bimal K Bhattacharya, Ravinder S Chandi, Manjeet Singh, Jagdish Singh and K R Manjunath. (2016). "Ground Based Hyperspectral Remote Sensing to Discriminate Biotic Stress in Cotton Crop".SPIE 4-7 April 2016.
- ❖ Rahul Nigam, Swapnil Vyas, Bimal K Bhattacharya, K. R. Manjunath and Prakash Chauhan (2016). Inter-seasonal variability of early-season water deficit and country-scale crop prospect from satellite-based soil moisture and vegetation products.SPIE April 4–7, 2016.
- ❖ Singh, S. K., Dutta, S., Singh, V. K., Sharma, M. P., Yadav, S., Gavli, A., Bisen, P. K. Srivastava, Aditi, Nagori, R., Om Pal, Sood, A., and Ray S. S. Study of Whitefly Damage in Cotton crop using Remote Sensing Technique. MNCFC/SR/01/2016. Mahalanobis National Crop Forecast Centre, New Delhi. 30p.

- ❖ A paper entitled “Estimation of particulate matter (PM<sub>2.5</sub>) using satellite and meteorological products” was presented at international conference SPIE (Asia-Pacific Remote Sensing Symposium), New Delhi, during April 4-7, 2016 by Dr. Manoj K Mishra.
- ❖ A paper entitled Regional Estimates of Phytoplankton Size Class in the Arabian Sea using in-situ and satellite data during Noctiluca Blooms” was presented at international conference SPIE (Asia-Pacific Remote Sensing Symposium), New Delhi, during April 4-7, 2016 by Dr. Arvind Sahay.
- ❖ A paper entitled “Estimating Chlorophyll-a Concentration in Chilika Lake using In- situ and Satellite Data” was presented at international conference SPIE (Asia-Pacific Remote Sensing Symposium), New Delhi, during April 4-7, 2016 by Dr. Arvind Sahay.
- ❖ Jain, N. S. And P. Chauhan (2016), Elorza Crater on Mars: Identification of phyllosilicate-bearing minerals by MRO-CRISM, 10th SPIE Asia-Pacific Remote Sensing Conference, New Delhi, April 04-07, 2016, Abstract #9880-51.
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- ❖ Sreejith, K. M., Sunil, P.S., Agrawal, R., Saji, A.P., Ramesh, D.S. and Rajawat, A.S., 2016, Coseismic and early postseismic deformation due to the 25 April 2015, Mw 7.8 Gorkha, Nepal, earthquake from InSAR and GPS measurements, Geophys. Res. Lett., 43, doi:10.1002/2016GL067907.
- ❖ Koul, M.N., Bahuguna, I.M., Ajai, Rajawat, A.S., Sadiq Ali and Sumit Koul, 2016, Glacier area change over past 50 years to stable phase in Drass Valley, Ladakh Himalaya (India), American Journal of Climate Change, 2016, 5, 88-102 Published Online March 2016 in SciRes.
- ❖ Sriram Saran, Anup Das and Dharmendra Pandey. “Physical properties of lunar volcanic terrains using LRO data”, Abstract # 2249, 47th Lunar and Planetary Science Conference, 21-25 March 2016, Texas, USA.
- ❖ “Spatial-correlation based Persistent Scatterer interferometric study for ground deformation”, By Koushik Biswas et al, & Arundhati Misra, JISRS, Jan-2017
- ❖ “Analysis of Adaptive and Advanced Speckle Filters on SAR Data”, Arundhati Misra & Dhwan Ajmera, IOSR Journal of Computer Engineering (IOSR-JCE), Volume 19, Issue 1, Ver. II (Jan.-Feb. 2017),
- ❖ Jinya John, Ipshita Dey, Bipasha P. Shukla, “Preliminary validation of INSAT-3D Cloud Microphysical Product using MODIS data”, SAC/EPISA/AOSG/SR/23/2016.
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- ❖ “Signaling Traffic Generator & Analyzer for Multi-Beam Mobile Satellite Services”, S P Singh, Sudhir Agarwal, A Compendium of Research at SAC (Jan 2012 to Dec 2014) Vol-1, pp 262-265, April 2016
- ❖ Screening and Qualification of Packaged MMIC for space program: Application specific approach: Authors: Nandini Deshpande, Shilpa Pandya, AK Lal; EEE-Con 2017 at ISAC.

## Seminars/Conferences/Lectures/Workshops

- ❖ ISRO Level Seminar on "Space Qualified Processes" is organized on April 7, 2016. The document "Life Cycle Activities and Documentary Structure for ISRO Payloads" was released by Chairman, ISRO during Seminar on 'Space Qualified Processes'.
- ❖ Dr. Gufran Beig, Project Director, SAFAR, Indian Institute of Tropical Meteorology, Pune delivered a lecture on 'SAFAR: A National Mission for Forecasting Metro Air Quality' on April 13, 2016 under SAC Lecture series.
- ❖ Dr. Thejesh N. Bandi, Head, ACD/ODCG/SNPA delivered a lecture on 'Inside an Atomic Clock' on April 15, 2016 under Knowledge Sharing Series.
- ❖ Prof. (Dr.) Anand Teltumbde, Indian Institute of Technology, Kharagpur delivered a lecture on 'Dr. Ambedkar and his Vision' on April 22, 2016 under SAC Lecture series.
- ❖ Mr. Rajendra Singh, Sci./Engr. SE, MSTD/ MSTG/MRSA and Ms. Maya Suryawanshi, JRF, EPSA delivered a lecture on 'SAC GPR Measurements in Antarctic Snow and Ice: 35 ISEA' on May 23, 2016 under Knowledge Sharing Series.
- ❖ Peter A Beerel, Associate Prof., Faculty Director, Innovation and Entrepreneurship in Engineering, Los Angeles, CA delivered a lecture on 'Asynchronous Design Styles for Low Power Design' on June 14, 2016 under SAC Lecture series.
- ❖ Dr. Ashish Kumar Shukla, Sci./Engr.-SF, SNTD/DCTG/SNAA delivered a lecture on 'Pseudolite Based Navigation System' on June 15, 2016 under Knowledge Sharing Series.
- ❖ Swami Adhyatmanandji, Shivanand Ashram, Ahmedabad delivered a lecture on 'Yoga and Benefits' on June 17, 2016 under SAC Lecture series.
- ❖ Mr. Ramagiri Santhosh Kumar, Sci./Engr.-SE, PFD/RFSG/SNPA delivered a lecture on 'Indigenous Development of Circulators' on July 27, 2016 under Knowledge Sharing Series.
- ❖ Shri Chandrasekar G, Head, P&GA delivered a lecture on 'Establishment Rules: Induction to Probation closure' on August 26, 2016 under Knowledge Sharing Series.
- ❖ Dr. Ripal Shah Medical Director, Redcross delivered a lecture on 'A Talk on Blood Donation' on August 29, 2016 under SAC Lecture Series.
- ❖ A seminar on 'ASICs developed @ SAC' was conducted on August 30, 2016 under Know Your Achievement Series.
- ❖ Lecture on "Indian Launch Vehicle Technology" at Sardar Vallabhbhai Patel Institute of Technology (SVIT-VASAD) in the Techfest "Prakash-16".
- ❖ IRNSS GAGAN UPAO evaluation workshop was conducted in SAC on September 14, 2016. Total 32 proposals were presented by Principal Investigators of academic institutes from all over India and 1 proposal was presented from SAC.
- ❖ AVIRIS-NG Announcement of Opportunities (AO) proposals workshop was organized and 37 proposals were evaluated during September 7-8, 2016 at SAC.



- ❖ Dr. Sandip Oza delivered a lecture on ‘Arctic expedition for cryospheric studies’ on October 26, 2016 under Knowledge Sharing Series.
- ❖ Shri D Ram Rajak, Dr. Sushil Singh & Dr. Sanid delivered a lecture on ‘Challenges for validation on Himalayan glaciers: Exploring Khardung glacier’ on October 26, 2016 under Knowledge Sharing Series.
- ❖ NISAR Science workshop focusing on “Research Opportunities from L&S Airborne SAR” was held on November 17, 2016 at SAC, Ahmedabad. About 150 participants attended the workshop.
- ❖ Shri Manish Saxena, Head, SSD/EOSG/SEDA delivered a lecture “Hyperspectral Remote Sensing and its Potential” on December 05, 2016.
- ❖ Shri Ujjwal Gangele, Sci/Engr, SNPA delivered a lecture on ‘Space Studies Program-2016: A Unique learning experience’ on January 23, 2017 under Knowledge Sharing Series.
- ❖ Dr. Ajit Tyagi, Ex-Director General, Indian Meteorological Department, New Delhi delivered a lecture on ‘Evolution of Early Warning System for Hydro-Meteorological Hazards’ on January 25, 2017 under SAC Lecture Series.
- ❖ A Training Programme for Housekeeping Workers was organized on February 19, 2017 at Ahmedabad Management Association (AMA), Ahmedabad. 43 participants attended the programme.
- ❖ A lecture on ‘Green Innovative Bopal Campus’ was organized on February 23, 2017 under Knowledge Sharing Series.

## Events Highlights

- ❖ SAC celebrated the National Technology Day as the NavIC day on May 11, 2016.
- ❖ SAC Observed May 21, 2016 as Anti-Terrorism Day.
- ❖ SAC Employees have taken mass pledge in the presence of Director, SAC as a part of Swachh Bharat Mission on May 26, 2016 followed by Swachh Bharat activities.
- ❖ SAC celebrated International Yoga Day on June 21, 2016.
- ❖ A blood donation camp was organized at SAC on August 31, 2016.
- ❖ SAC celebrated 70<sup>th</sup> Independence Day on August 15, 2016 and Director, SAC unfurled the National flag.
- ❖ SAC observed Sadbhavana Diwas on August 20, 2016.
- ❖ On the occasion of the 97<sup>th</sup> birth anniversary of Dr. Vikram A Sarabhai, a function was organized at SAC on August 12, 2016.
- ❖ SAC, organized Engineer's Day celebration at LDCE in collaboration with IETE Ahmedabad Centre and LD college of Engineering (LDCE), Ahmedabad on Sept 19<sup>th</sup>, 2016.
- ❖ SAC participated in BSX-2016 held on September 1-3, 2016 at Bangalore. Nearly 23 exhibitors participated in Expo and 20 delegates participated in conference.
- ❖ VSSE celebrated World Space Week on October 04-10, 2016. Exhibition was opened to the public. On this occasion SAC celebrated Swachhata Abhiyaan.
- ❖ SAC observed Vigilance Awareness Week from October 31, 2016 to November 5, 2016. The main focus was on 'Public participation in promoting Integrity and eradicating corruption'.
- ❖ SAC organized ISRO Awards Function for the year 2012, 2013, 2014 & 2015 on November 18, 2016. On this occasion Chairman, ISRO along with Director SAC released the book on "Monitoring Snow and Glaciers of Himalyan region".
- ❖ Poorvamnaya Sri Govardhanmatt Puri Peethadheeswar Srimad Jagadguru Shankaracharya Swamy Nischalananda Saraswati and Nijisachiv Swamy Nirvikalpanand Saraswati visited SAC on November 25, 2016.
- ❖ SAC observed Constitution Day on November 26, 2016 to promote constitutional values among citizens.
- ❖ Indian National Academy of Engineering - Annual convention-2016 was hosted by SAC, during December 8-9, 2016.
- ❖ SAC participated in Vibrant Gujarat Global Trade Show at Gandhinagar during January 10-13, 2017.

- ❖ Parliamentary Standing Committee visited SAC on January 16, 2017. Visited various lab at SAC and Committee appreciated SAC activities.
- ❖ 68<sup>th</sup> Republic Day was celebrated in SAC campus on January 26, 2017. Director, SAC unfurled the National Flag. The meritorious students of SAC & DECU community in X & XII Board exams were awarded by Director, SAC.
- ❖ SAC conducted National Safety Week during March 04-10, 2017 and 'International Women's Day' on March 8, 2017.









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