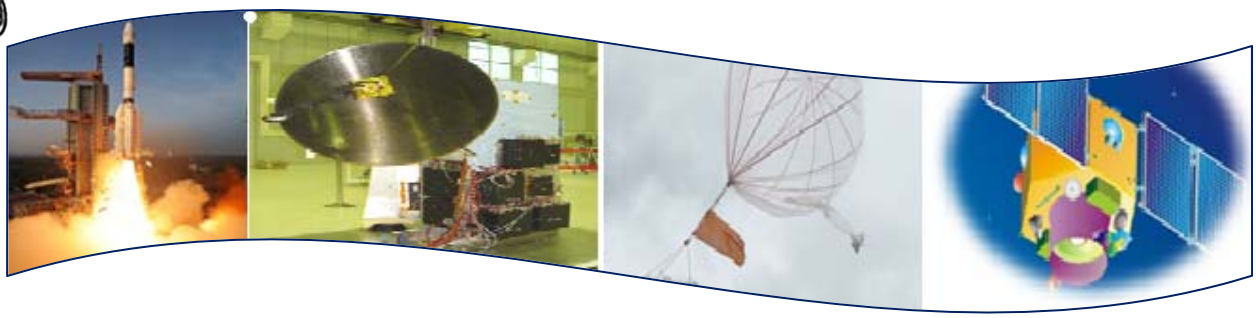

# Research Areas in Space

***A Compendium for Preparing Project Proposals by Universities/Institutes***

**Respond Programme**
**ISRO Headquarters, Bengaluru**

**July 2016**

# Contents

# 1.0 Introduction

The Indian Space Research Organisation (ISRO) has evolved a programme through which support is provided for conducting research and development activities related to Space Science, Space Technology and Space Application to academia in India. This programme of Research Sponsored by ISRO is called RESPOND. The main objective of the RESPOND Programme is to establish strong links with Academic Institutions in India to carry out quality research and developmental projects which are of relevance to space and to derive useful outputs of such R&D to support ISRO programmes.

To enable faculty to prepare suitable proposals of relevance to Space programme, a detailed list of R&D areas/sub areas/topics/problems have been worked out as per major programmes of ISRO and the same has been given in this document. *The concerned ISRO/DOS centre to be approached by the faculty/researcher is given in the brackets after areas/sub areas/topics/problems. The faculty/researcher may select a suitable topic/problem and prepare the proposal after discussing with the experts from concerned ISRO/DOS centre/unit and submit the proposal to the concerned Space Technology Cell for consideration*.

| Sl. No | List of ISRO/DOS Centre/Units referred in the document |
|---|---|
| 1. | Vikram Sarabhai Space Centre (VSSC) |
| 2. | Satish Dhawan Space Centre (SDSC), SHAR |
| 3. | Liquid Propulsion Systems Centre (LPSC) |
| 4. | ISRO Satellite Centre (ISAC) |
| 5. | Space Applications Centre (SAC) |
| 6. | National Remote Sensing Centre (NRSC) |
| 7. | Indian Institute of Remote Sensing (IIRS) |
| 8. | Physical Research Laboratory (PRL) |
| 9. | ISRO Inertial Systems Unit (IISU) |
| 10. | Laboratory for Electro Optics Systems (LEOS) |
| 11. | National Atmospheric Research Laboratory (NARL) |
| 12. | Semi Conductor Laboratory (SCL) |
| 13. | Space Physics Laboratory (SPL) |
| 14. | ISRO Propulsion Complex (IPRC) |
| 15. | North Eastern Space Application Centre (NESAC) |

# 2.0 Launch Vehicle Programme

| | | |
|---|---|---|
| **A** | **Area** | **Aerospace (VSSC)** |
| **A 1** | **Sub Area** | **Interplanetary Missions(VSSC)** |
| **A 1.1** | **Estimation of Gaseous Radiation for Interplanetary Missions (VSSC)**<br>Gaseous radiation is significant in re-entry from interplanetary mission when entry velocity is greater than 1.5 km/s. Both equilibrium and non-equilibrium air radiation have to be modeled for the estimation of radiative heating. Number densities of various chemical species, translational, rotational and vibrational temperatures of heavy particles and electrons are to be evaluated for modelling emission and absorption characteristics of air under these conditions. The study is required for evaluating radiation heating under these conditions. | |
| **A 2** | **Sub Area** | **Thermal Analysis (VSSC)** |
| **A 2.1** | **Estimation of Heat Flux Distribution in the Vicinity of Protrusions on the Cone Cylinder Body Under Varying Mach Number and Reynolds Number Conditions (Experimental &Theoretical) (VSSC)**<br>There are established procedures to estimate heat flux at different regions of a launch vehicle, which are essentially axi-symmetric clean configurations. The presence of protuberances like DMRJ engine modules, wire tunnels, fins, etc will enhance heat flux locally due to shock wave interference with boundary layer. Analysis using CFD methods and possible evolvement of engineering solution in terms of geometric and flow parameters will help in estimating the heart flux near proturberances. Results substantiated by carrying out experiments will give confidence in using the model for configurations with protrusions on cone cylinder body. | |
| **A 3** | **Sub Area** | **Thermal measurements (VSSC)** |
| **A 3.1** | **Heat Flux Measurements on RLV-TD (VSSC)**<br>TPS design of RLV-TD is based on heat flux data generated using engineering methods. Limited 2D CFD data generated for validation heat flux. Validation of heat flux data for the current configuration is important, especially for regions of shock-shock interaction, leeward region flow, base flow, fuselage wing interaction. Flow enthalpy about 2 MJ.kg, M = 6.6, To = 1700 – 1800 K. Conditions corresponding to maximum heat flux and max dynamic pressure to be simulated. Diagnostic shall be (a) heat flux (b) liquid crystal thermography/IR thermography (c) Flow visualization. Models used for wind tunnel studies in VSSC/ATFD can be used after proper | |

| | | |
|---|---|---|
| | instrumentation. Generic data generated will be useful for further mission of RLV TD also. | |
| **A 4** | **Sub Area** | **Thermal simulation (VSSC)** |
| **A 4.1** | **Flow-thermal Simulation of Hypersonic Air Intake (VSSC)**<br><br>3 D parametric geometry is to be created using VSSC supplied air intake configuration with identified variable geometric parameters. To predict complex flow field in the presence of shock-boundary layer interaction and heat transfer, 3D numerical simulation is to be carried out using Computational Fluid Dynamics (CFD) Software with wall friction & wall heat transfer. Based on air intake operation condition specified by VSSC for each simulation, boundary conditions and initial conditions are to be generated. Structured multi-block meshing is to be used for grid generation.<br><br>Simulations are to be carried out converging o grid independence & interaction independence. Post processing includes (a) generation of Control plots & pallets for identified flow parameters at specified locations and (b) computation of specified parameters like mass flow rate, pressure recovery, mass capture ratio, skin friction, heat transfer etc. | |
| **A 5** | **Sub Area** | **Studies on Re-entry (VSSC)** |
| **A 5.1** | **Wing body reentry vehicle optimization studies (VSSC)**<br><br>Wing body reentry vehicle is a reusable launch vehicle concept to reduce the satellite launch vehicle cost drastically by safely returning the launch vehicle back to earth surface after the satellite/payload insertion in required orbit for re-launch. During reentry, the vehicle has to pass through low density atmosphere to high density atmosphere, High hypersonic Mach number to low subsonic mach number during touchdown and it also encounter viscous flow regime and pass through laminar to turbulent flow regimes. The key aerodynamic and aero-thermodynamic design aspects are optimum heat flux, heat load, load factor, less than 4g deceleration, sufficient payload bay, down range and cross range capability, good longitudinal and lateral- directional aerodynamic stability, adequate control surface effectiveness, reduced TOPS cost. The optimum external aerodynamic design must fulfill some of the important objectives given above.<br><br>Re-entry module is used for scientific mission, or to bring back astronauts from space back to earth. Re-entry module can be a ballistic/or semi ballistic concept with minimum control. The key aerodynamic and aero thermodynamic parameters are minimizing the maximum heat flux, heat load and ‘g’ force with optimum stable aerodynamic shape for the purpose. | |

| | | |
|---|---|---|
| | The module must be free from any dynamic stability issues, must have less dispersion in the down range and cross range, both soft landing on land and sea has to be considered within the design. | |
| **A 6** | **Sub Area** | **Eddy simulation studies (VSSC)** |
| **A 6.1** | **Large Eddy Solver (LES) – for aerospace application (VSSC)**<br>Large eddy simulations are presently the need of the hour with increased computing power and using parallel computing. LES resolves all the range of large eddies without the use of any turbulence model and it is been used for simple problems so far, but presently publications are available on the application of LES for launch vehicle with jet, aircraft etc, LES compressible solver is to be developed for a generalized grid with high order schemes for convective terms. It can have both full LES and wall modeled LES. The solution acceleration techniques like dual time stepping with multi-grid or other methods can be adopted. The LES is intended to get unsteady data over aerospace vehicle, jet interaction studies, and high angle of attack studies. | |
| **A 7** | **Sub Area** | **Vehicle analysis and design (VSSC)** |
| **A 7.1** | **NS RANS solver development (VSSC)**<br>Navier-stokes RANS solver is used for the design and analysis of aerospace vehicles. The code need to have both implicit and explicit solving capacity and must work in parallel mode using MPI and/or using GPU for faster turnaround time. The code must perform comfortably well in both compressible and incompressible regime and must have various schemes like Roe, AUSM+, HLLC, SLAU for convective terms computations. The various established turbulence models like SA, SST, realizable k-epsilon, RNG model must be available for selection. The code must work on generalized grids. Acceleration techniques must be available like multi-grid, dual time stepping, RK methods and accuracy must minimum second order. The solver must have further scope of introducing high temperature effects, combustion model. | |
| **A 8** | **Sub Area** | **Aerodynamics study (VSSC)** |
| **A 8.1** | **Flow Visualization Technique (VSSC)**<br>Following flow visualization techniques are to be developed:<br>1) Qualitative Flow field visualization: Qualitative flow visualization of nozzle jets interaction using Glow Discharge Method. 2) PIV and stereoscopic PIV: Qualitative and quantitative measurements of flow field information such as velocity profile/vorticity associated with double delta wing, capturing of | |

| | | |
|---|---|---|
| | stream wise vorticity generation and its strength over RLV like geometries at angles of attack. Lift off jet impingement studies of launch vehicles using PIV. Studies of scramjet flame holding strategies such as cavity flow physics using PIV. Vortex enhanced mixing studies in typical scramjet combustion chambers. | |
| A 8.2 | **Hybrid solution methodology with a combination of Cartesian grid and meshless method for high speed turbulent viscous flow solution from Cartesian mesh (VSSC)**<br>Cartesian mesh has tremendous advantage in completed automated grid for complex geometries. However the near wall resolution to obtain skin friction and heat flux is not possible without some special near wall treatment. The solution proposed is to have a mesh less method for near wall solution and standard Cartesian mesh solution away from wall. The starting point is the Cartesian mesh over the geometry. The necessary code for near wall resolution with meshless method to obtain viscous solution is the key research work in this. It should be noted that there is a Cartesian mesh near the wall which can be used to generate points. | |
| A 9 | Sub Area | Multidisciplinary study options (VSSC) |
| A 9.1 | **Development of a MDO Tool for Aerospace Applications (VSSC)**<br>The aerospace problems are complex and often require interactions among different disciplines. Due to non-linear dependencies of various disciplines, conventional optimization procedures do not result in system optimum. As the name suggests, Multidisciplinary Design Optimization (MDO) involves optimization of the system by coupling two or more disciplines together. For example, structure design software could be NISA software and trajectory design software could be written in Fortran. The MDO tool has to suitably wrap these programs. | |
| A 10 | Sub Area | Trajectory Design (VSSC) |
| A 10.1 | **Re-entry Trajectory Design and Analysis of Two Closely Following Bodies with a Possibility of Break ups (VSSC)**<br>Re-entry trajectory design is complex as large amount of heat has to be dissipated and structural integrity of the body has to be ensured. Design becomes challenging when two bodies closely follow each other. This typically occurs in one of the missions where crew module and cryostage enters the Earth's atmosphere and are in close vicinity. The possibility of cryostage breakup during the re-entry is to be analyzed. Number of pieces during the break-up is to be evaluated based upon detailed structural analysis of the cryo stage components. The survivability of these pieces | |

| | | |
|---|---|---|
| | and the effect of impact of these pieces on the ongoing crew module are to be assessed. | |
| **A 11** | **Sub Area** | **Aero Design (VSSC)** |
| **A 11.1** | **Aerodynamic Design and Prediction Methodology of the Grid fins (VSSC)**<br>A prediction method has to be developed for the estimation of aerodynamic characteristics of grid fin-body combinations at subsonic to supersonic Mach numbers regime. Aerodynamic effect of depth-to-height ratio, web thickness, web leading edge angle, cell width-to-height ration and various isolated cell shapes has to be studied. | |
| **A 12** | **Sub Area** | **Spacecraft Trajectories (VSSC)** |
| **A 12.1** | **Development of analytical tool for low thrust interplanetary mission trajectories (VSSC)**<br>Spacecraft trajectories are obtained from the integration of the spacecraft's equations of motions, which contain terms for the external forces that are acting on the spacecraft and for the thrust force. The convergence behavior of trajectory optimization methods depends on an adequate initial guess of the solution, which is often hard to find. An efficient analytical tool can provide with good initial approximation which can reduce exhaustive numerical computation. | |
| **A 13** | **Sub Area** | **Space debris (VSSC)** |
| **A 13.1** | **Space debris studies (VSSC)**<br>Space debris consists of all defunct objects in orbit around earth. These objects are real threat for all space related activities especially in low earth orbit. This project aimed at setting up experimental set ups in ground lab level simulating space conditions. | |
| **B** | **Area** | **Aerospace Structures (VSSC)** |
| **B 1** | **Sub Area** | **Structural Data Analysis (VSSC)** |
| **B 1.1** | **Automated Acoustic Emission Data Analysis Through ANN (VSSC)**<br>AE monitoring is being used for the integrity evaluation of various flight hardware during their proof pressure test for example Titanium Gas Bottles, Aluminium, Maraging steel and 15 CDV6 chambers etc. Implementation of an automated AE monitoring with Neural Network for the Real time integrity evaluation of the hardwares helps in minimizing the AE expertise and speed up analysis. AE criteria based on the values of various AE parameters like | |

| | | |
|---|---|---|
| | amplitude, duration, counts, energy etc. from the test results of similar hardware will be the input for the automated integrity evaluation. | |
| **B 2** | **Sub Area** | **Noise Filtering (VSSC)** |
| **B 2.1** | **Filtering Out Noise From Genuine AE Signature Based on Spectral Content Analysis (VSSC)**<br>In AE monitoring differentiating the genuine AE signals from external noises is a big problem for the real time AE monitoring of flight hardwares during pressure and structural tests. This is especially trouble some in case of pneumatic pressurisation. Due to the noise, the initiation of any defects like crack, yield etc. could not be identified during the loading phases. Since some of the noise signals are similar to genuine AE signals, identifying these noise signals in real time is a tedious job. Implementing a criterion for filtering these noises alone based on the combination of different AE parametric values is required for future tests | |
| **B 3** | **Sub Area** | **Defects Analysis (VSSC)** |
| **B 3.1** | **Monitoring and Assessment of EB Weld of Titanium, Spot Welding of Aluminium Inter-stages Through Acoustic Emission (VSSC)**<br>Real time monitoring of Electron Beam Welding process by using AE Technique enables online detection of weld defects like porosity, lack of fusion in the weld etc. Corrective actions can be taken and weld quality can be maintained. | |
| **B 4** | **Sub Area** | **Stress Measurement (VSSC)** |
| **B 4.1** | **Through Thickness Measurement of Non-Uniform Residual Stresses in Metallic Components (VSSC)**<br>The current technique of incremental hole drilling technique measures the residual stress to a depth of 2mm only. The development envisaged is the implementation of an accurate method for measuring residual stress through thickness for metallic materials for thickness more than 5 mm with a resolution better than 10 MPA. | |
| **B 4.2** | **Inter laminar shear stress evaluation of bonded structures (VSSC)**<br>To estimate accurately the stresses in the sandwich structures, in particular in the bond between the skin (metallic/ FRP laminate skin) and honeycomb core higher order shear deformation theory is followed. Provide the software code that will be useful for studies in related areas. | |
| **B 4.3** | **Development of an algorithm and codes for Measurement of Non-** | |

| | | |
|---|---|---|
| | **Uniform Residual Stresses in Composite Components using the method of incremental hole drilling (VSSC)**<br><br>The current technique of incremental hole drilling technique measures the residual stress to a depth of 2mm only in metallic materials with analysis methods like integral method. The development envisaged is the implementation of an accurate algorithm including codes for measuring residual stress in composite materials for thickness up to 2 mm with a resolution better than 20 MPa | |
| **B 5** | **Sub Area** | **Strain Measurement (VSSC)** |
| **B 5.1** | **Studies on the different aspects of Digital Image Correlation Technique for measurement of displacement and strain (VSSC)**<br><br>The state of the art technique of Digital Image Correlation Technique for measurement of displacement and strain makes use of a random pattern painted on the surface. The various aspects like the intensity maps of the pattern, illumination, orientation, curvature of the surface etc affect the accuracy of measurement. The degrees to which these affect the results have to be studied and parameters bench marked. The calculations need to be carried out in polar or cylindrical coordinate systems and required codes developed. The development envisaged is better understanding of the various aspects when the technique is applied in an industrial scenario. | |
| **B 6** | **Sub Area** | **Structural Analysis (VSSC)** |
| **B 6.1** | **Development of Digital Holographic Microscope for MEMS Characterization, Deflection and Shape Measurement (VSSC)**<br><br>To characterize the performance and reliability of Micro and Nano Electro Mechanical Systems like sensors, actuators and controls under static and dynamic conditions a robust non-destructive quantitative measurement tool has to be developed. Digital holographic interferometry technique presently used for testing of macro structures is to be adapted to the application in micro and nano structures. Digital holographic microscope, loading fixtures for micro sensors and phase map generator for deformation mapping, 3D profile measurement, micro material property measurement etc. are to be developed and validated by testing of MEMS and NEMS intended for the future ISRO programs. | |
| **B 6.2** | **Semi- analytical approach for the evaluation of acoustic performance of CFRP skinned sandwich panel (VSSC)**<br><br>Acoustic performance of CFRP skinned metallic honeycomb sandwich panels under low frequency were obtained through test using reverberation chamber. Honeycomb cells were embedded with semi-flexible PUF. | |

| | | |
|---|---|---|
| | Comparisons were made for the acoustic attenuation in terms of insertion loss for the rectangular panels with and without PUF. Based on say, LS DYANA obtain a semi analytical approach for the prediction of attenuation of sandwich panel for variables like skin thickness, core height, density of PUF etc . | |
| **B 6.3** | **Spectrum Analysis Technique Using Maximum Entropy Method (VSSC)**<br>Formulation for the power spectral density estimation of vibration signals are measured during launch vehicle flight using maximum entropy method. This method overcomes the limitations of the FFT based methods for short length and time varying vibration signals measured during the atmospheric flight of launch vehicles and transient vibration signal measured during stage separation, ignition and shut-off of rocket engines. | |
| **B 6.4** | **Characterization of SS 321 at low temperatures (LPSC)**<br>Study of phase transition relating to Strain rate & temperature | |
| **B 7** | **Sub Area** | **Thermal Studies (VSSC)** |
| **B 7.1** | **Thermal characteristics of PUF core sandwich for a temperature range of 600K (VSSC)** | |
| **B 8** | **Sub Area** | **Structural Characterization (VSSC)** |
| **B 8.1** | **Evaluation of acoustic characteristics Polyamide foam for sandwich application (VSSC)**<br>Honeycomb sandwich panels embedded with Polyimide foam inside the honeycomb cells have been tested for insertion loss (dB) over a range up to 1200 Hz. using reverberation chamber and air pulse tube. For analytical model for a theoretical prediction for insertion loss of the honeycomb sandwich panel, it is necessary to evaluate properties like porosity, sound flow resistivity etc. as per the standard apparatus. | |
| **B 9** | **Sub Area** | **Sandwich Structures (VSSC)** |
| **B 9.1** | **Development of Sandwich Structures With Negative Poisson's Ratio Honeycomb Core (VSSC)**<br>The core with negative Poisson's ratio improves the shear strength and resistance to piercing for the core and keeps inserts more intact in sandwich structures. The geometry of core and skin material/processing provides negative Poisson's effect for the sandwich structures as reported in literature. This will help to increase the load carrying capacity of the | |

| | | |
|---|---|---|
| | sandwich structure. | |
| **B 10** | **Sub Area** | **Structural Optimization (VSSC)** |
| **B 10.1** | **Optimal Shaping of Cut out corners in non-linear range (VSSC)**<br><br>Launch vehicle structures are optimized for the mass and hence are highly stressed. In this kind of highly stressed structures, rectangular cut outs are commonly used. Hence very high stress concentrations are observed in the cut out corner which is very much local in nature. If not attended properly, this zone can be cause failure initiation and further propagate to a catastrophic failure of launch vehicle. Normally designers overcome this stress concentration problem by giving liberal fillet. Useful size of fillet to overcome the stress concentration blocks the free entry of large object and defeat the purpose for which the cut out is intended. There is no quantification of allowable or safe stress in this type of zones. AJ Durelli, K. Rajaiah etc. has done extensive research in shaping the cut out in the elastic stress range through photo elastic methods. As the material is stressed in the non-linear range in a launch vehicle structure, the shape proposed through this study is inapplicable. The stress in cut out corner is also very much local in nature which is also not considered in the study. Hence there is a need to shape the cut out including fillet considering the stress in the non-linear range and nature of the stress field at the cut out corner. Theoretical determination and experimental validation is expected. The study is expected to arrive at a parametric definition of minimum fillet radius based on geometry of cut out like r/w etc for using it in all sizes of cut outs of different width. | |
| **B 11** | **Sub Area** | **Composite Structures (VSSC)** |
| **B 11.1** | **Damage tolerant designs for laminated composite structures used in aerospace structures (VSSC)**<br><br>The initiation and propagation of manufacturing induced or service induced damage in the structural design of laminated composites are of primary concern for aerospace structures. The laminated composite wing and fuselage structure with low transverse strength, low inter-laminar shear strength and no plastic deformation are more susceptible to damage growth. A stress based criterion can determine the locations of potential damages followed by fracture analysis to predict the initiation of delamination. Based on suitable failure criterion, the failure is predicted.<br><br>A thorough understanding is required to predict the multiple complex failure mechanisms in composite structures which are used especially in aerospace industry such as the wing structure. Virtual Crack Closure Technique (VCCT), Cohesive Zone Modelling (CZM) and Progressive | |

| | | |
|---|---|---|
| | Failure Analysis (PFA) are the techniques used to predict the failure followed by the experiments to validate the criterion. A series of aerospace materials ranging from the metals to composites has to be tested and predictions through analytical and numerical method have to be carried out for the better understanding for future requirements. | |
| **B 12** | **Sub Area** | **Inflatable Structures (VSSC)** |
| **B 12.1** | **Development of Finite Element Software for Inflatable Structures (VSSC)**<br><br>For space applications, structural weight should be the minimum possible. At the same time it should serve the purpose for which it is meant. Inflatable structures have become increasingly popular in recent years for a wide range of space applications. An inflatable structure not only has lower weight but also can be folded when it is not in use giving it the advantage of minimum storage space. It can be unfolded to the required size and shape as and when required. Applications of such structures in space applications are solar sail boom, airship, antennas etc.<br><br>The finite element to suit such applications needs special treatment in the formulations. Because the deformations of such structures depend on the applied load, inflation pressure and the constitutive law of fabrics. Beam element and shell elements are widely used finite elements for structural applications. This study is proposed for the development of beam and shell finite elements, which can be used for inflatable structural applications. | |
| **B 13** | **Sub Area** | **3-D Contact Element (VSSC)** |
| **B 13.1** | **Development of 3-D Contact Element with Friction (VSSC)**<br><br>The structures which are made for the launch vehicle and other space applications are made of several segments and joined together to give the required shape and size and also meet the design and functional requirements. Structures are made of segments having the flexibility to separate as and when its purpose is served. Two different segments made of same materials and /or of different materials are joined together with bolted/clip joints. When such structures are subjected to loadings the gaps between the two bodies either open or close, depending on the nature of the loading. Load is transferred from one body to the other if the gap between the two bodies closes. To study such structures connected with joints contact elements are required. This project is proposed for the development of 3-D contact element with friction for the application for both bodies deformable. | |
| **B 14** | **Sub Area** | **Data Analysis (VSSC)** |

| | | |
|---|---|---|
| B 14.1 | **Health Monitoring of Structures Using Vibration Data (VSSC)**<br>Monitoring the health of a structure subjected to severe dynamic load condition is essential particularly for assessing the reusability of the structure. Health monitoring is a process aimed at providing accurate information concerning the structural condition and performance. It consists of continuous or periodic recording of representative parameters like vibration measurements over short or long duration. The measured responses can be used for assessing the damage of the structure, if any. Damage can be defined as changes introduced in the system that adversely affects its current or future performance. The damage will alter the stiffness, mass or energy dissipation properties of a system, which in turn alter the measured dynamic response of the system. From these vibration measurements, the health of the system can be assessed.<br>Damage detection and health monitoring scheme have to be developed for aero- space structures using vibration data. The scheme includes data acquisition, feature extraction and information condensation and statistical discrimination of features for health monitoring of structures. | |
| B 15 | **Sub Area** | **Simulation & Analysis (VSSC)** |
| B 15.1 | **Development of Analytical Techniques for the Design of Impact Resistant Structures (VSSC)**<br>In the future missions of ISRO like reusable launch vehicles, human space flight, etc., the structural components will be subjected to impact loads during orbital and landing operations. These structures should be designed with highest probability of human, package and critical component survival. Design and analysis methodologies including structural, material and environment modelling needs to be established for effective design of impact resistant structures. Analytical methodologies to assess response of human body and critical packages to impact load needs to be developed. | |
| B 16 | **Sub Area** | **Noise control (VSSC)** |
| B 16.1 | **Active Noise Control for Composite Payload Fairings (VSSC)**<br>Acoustic loads are one of the important environments for launch vehicles. The acoustic load transmission into the vehicle, particularly inside the heat shield needs to be attenuated for the proper functioning of satellite. The magnitude of acoustic loads transmitted to the payload is a function of external environment as well as design of payload fairing and its sound absorbing treatments. At present, passive acoustic blanket is used to reduce the internal acoustic field.<br>The use of composite payload fairing has the advantage of reducing mass, | |

| | | |
|---|---|---|
| | but it has detrimental effect on acoustic levels inside the payload fairing especially at low frequencies. Passive approaches for acoustic attenuation are limited at low frequency because of sound absorption is limited in low frequencies. Active control offers an attractive approach for low frequency acoustic noise attenuation inside payload fairing. The study is required to develop structural actuators such as piezoelectric patches for noise control inside composite payload fairing. | |
| **B 17** | **Sub Area** | **Space flight Environment (VSSC)** |
| **B 17.1** | **Dynamic Modelling and Analysis of Human Body Exposed to Vibration Environment During Space Flight (VSSC)**<br>In manned mission, human body may be exposed to various severe environments for a long time. This may be detrimental to life or may cause illness/fatigue to the body. One of the major environments is vibration. Therefore, it is essential to study the influence of vibration on human body and necessary to find solutions to prevent such environment. To understand the effect of vibration on human body, it is required to generate three-dimensional dynamic model of the human body and carryout dynamic analysis for human biomechanical responses. The human body shall be idealized using beam, spring and mass elements to represent the various dynamics of the body. The model needs to be validated with the available literature / test results. | |
| **B 18** | **Sub Area** | **Vibration studies (VSSC)** |
| **B 18.1** | **Development and Realization of Shock and Vibration Isolation System for Payloads (VSSC)**<br>The payload experiences severe vibration loads during launch, which may result in its malfunctioning. To avoid this, an isolation system for shock and vibration has to be introduced for payloads. Reduction of vibration and shock loads on spacecraft during launch would significantly minimize the damage of the spacecraft and its instruments. It will also allow more sensitive equipment to be included in the missions. Moreover, as the launch environments are severe, it requires much of expertise in designing, qualifying and testing of spacecraft components. Introduction of an efficient isolation system would greatly reduce the cost for the development of the spacecraft. Thus an isolation system needs to be developed to isolate the spacecraft from the dynamic loads from the launch vehicle. | |
| **B 18.2** | **Development of a Noise-cancelling Headphone Using Active Noise Control (VSSC)**<br>Noise cancelling headphones reduce unwanted ambient sound or acoustic | |

| | | |
|---|---|---|
| | noise using active noise control (ANC). This involves using a microphone placed near the ear, a signal processing circuitry which generates antinoise so that the noise within the enclosed volume is cancelled. This is useful for an operator working in noisy environment such as vibration test facility, machine floor etc. The cancellation may be achieved using filtered X-LMS algorithm using some DSP processor. The minimum requirement of sampling is 12KHz with cut-off frequency of 5KHz. The required reduction is 40dB in the band of 100Hz to 2000Hz. The system should operate in battery and the electronics should be miniaturized and kept inside the headphone. | |
| **B 18.3** | **Control Algorithm for Multi Axial Vibration Testing (VSSC)**<br>Vibration testing is done to ensure that the flight structures and system will work satisfactorily in its service environment. In conventional vibration testing the vibration in each axis is separately simulated using single axis shakers using vibration controllers. But to simulate the actual vibration condition in flight, techniques to be developed to excite the structure in all the three axes simultaneously using three shakers in mutually perpendicular axes. For this a special vibration controller to control all the three shakers is required.<br>The proposed work is to develop the control algorithms for sine and random multi shaker vibration testing. All the required algorithms have to be developed, implemented with suitable DSPs (Digital Signal Processor) and tested. | |
| **B 18.4** | **Data Compression Technique for Vibration Signals (VSSC)**<br>The measured vibration signals from launch vehicle flights contain high frequency signals upto 2000 Hz. In order to telemeter these signals to ground during flight high bit rate is required. Typically for a measurement with 8 bit data resolution with a sampling rate of 6000 samples /second, it works out as 48 kbits/second per channel. In a typical launch vehicle flight around 10 channels of vibration measurements are made which requires a telemetry bit rate of 480 kbits /second. the bit rate for the typical launch vehicle is only 1 megabit/second. Hence suitable data compression techniques are required to reduce the telemetry bit rate. | |
| **B 19** | **Sub Area** | **Fracture Studies (VSSC)** |
| **B 19.1** | **Development of Constitutive Equations for Nano Composites (VSSC)**<br>Constitutive equations have to be developed for composites containing both functionalised and non-functionalised nanotubes using continuum modelling technique. The elastic properties of both composite systems amorphous and crystalline polymer matrices with various nanotube lengths (continuous | |

| | | |
|---|---|---|
| | / short discontinuous), volume fractions and orientations are to be evaluated. | |
| **B 19.2** | **Fracture Studies on Textile Composites (VSSC)**<br>Textile Composites are being used in the aerospace industries, specifically in the areas of impact resistant structures and hot structures. The increased use of these materials calls for the proper understanding of their fatigue behaviour. To ascertain the endurance of structural components made of Textile composites, fatigue and fracture studies on materials and structures are essential. A suitable method to perform the progressive fibre/matrix failure analysis has to be established in the presence/absence of defects useful for life estimation. | |
| **B 20** | **Sub Area** | **Structural Health Monitoring (VSSC)** |
| **B 20.1** | **Structural Health Monitoring Through Classification of Strain Patterns Using Artificial Neural Network (VSSC)**<br>Structural health monitoring technology has become an important approach to increase the safety and reduce the maintenance costs of high performance composite structures used in aircraft and re-entry vehicles. There is a requirement to develop the tools to detect damages such as fibre failure, matrix cracking, de-laminations; skin-stiffener de-bonds in composite structures. Neural network is one of the tools. Tool will be used to classify sensor malfunctioning and structural failure(s) based on the observed static strain patterns of the healthy and unhealthy structures. Analytical and experimental studies have to be made to validate the adopted methodology. | |
| **B 21** | **Thermo structural analysis for the integrated engine (LPSC)** | |
| **C** | **Area** | **Propulsion (LPSC/ VSSC/ SDSC)** |
| **C 1** | **Sub Area** | **Slosh Analysis (VSSC)** |
| **C 1.1** | **Microgravity Slosh Analysis (VSSC)**<br>Liquid sloshing dynamics under micro gravity field experiences different problems from those encountered under gravitational field. Gravitational potential has a stabilizing effect, wherein it brings the liquid volume towards the bottom of its container. When this body force diminishes, the liquid volume can assume any location inside its container in an unpredictable manner. This problem causes reorientation of the liquid in its container and poses difficulty in moving and handling, as the body forces are almost negligible. Analysis tools have to be developed for studying the liquid | |

| | | |
|---|---|---|
| | sloshing in low gravity environment. | |
| **C 2** | **Sub Area** | **Propellants (VSSC)** |
| **C 2.1** | **Development of Hydrogen Peroxide Based Propellant Systems (VSSC)**<br><br>Hydrogen peroxide based propellant systems (monopropellant and bipropellant with RP1) have several advantages over conventional liquid propellants. However, this requires (i) development of 98% $H_2O_2$ (ii) development of method for safe storage of 98% $H_2O_2$ which involves development of suitable stabilizers (iii) development of suitable catalyst for decomposition of $H_2O_2$. | |
| **C 2.2** | **Visco-elastic Structural Analysis of Solid Propellant Grains in the Presence of Voids (VSSC)**<br><br>Solid rocket systems are used extensively in situations where the total impulse is known in advance and restart is not required. Structurally, a rocket motor consists of the solid propellant grain, liner, insulation, motor case and the igniter. Solid propellant grains are strained / stressed due to thermal, gravitational, flight acceleration and ignition pressure loads. The structural response of the propellant grain in the presence of voids / porosity disrupt the stress/strain field. It is essential to examine the criticality of voids in solid propellant motor grains based on structural as well as ballistic and thermal considerations. A detailed viscoelastic solid propellant grain analysis in the presence of different void shapes and sizes is to be carried out for storage, thermal and ignition pressurization loading conditions for the development of an acceptance criterion. A methodology has to be established to model the void and examine its deformation criticality through finite element analysis | |
| **C 2.3** | **Development of Software for Modeling/Simulation of Mechanical/Ballistic Properties of Solid Rocket Propellants (VSSC)**<br><br>Objective is to develop a code/software to accurately predict the mechanical properties and burn rate of HTPB-Al-AP based composite solid propellant. This may be effected in two phases:-<br><br>**Phase I:** In this phase the concept and general framework of a modelling/simulation code for the propellant should be established.<br><br>**Phase II:** In this phase a working code containing a full graphical user interface (GUI) and capable of running on a multi-processor platform should be provided. The code should predict the mechanical properties of the propellant and burn rate at a given pressure with a minimum of empirical correlations. | |

| | |
|---|---|
| **C 2.4** | **Development of Cubane and Substituted Cubanes for High Energy High Density Propellant Fuel for Rocket Applications (VSSC)**<br>Positive heat of formation of cubane and substituted cubanes and their high density render them potential candidates for fuels for semi-cryo engines. Considerable improvement in specific impulse has been predicted for these fuels in comparison with RP-1 type hydrocarbon fuels. However, their syntheses in required quantities and propellant formulation are challenging tasks. |
| **C 2.5** | **Synthesis and scale up of Energetic Nitrate Binders for Solid Propellants (VSSC)**<br>Synthesis, characterization and scale up in 5 Kg batches for use at VSSC. Evaluation of the binders will be done at VSSC. Eg:- polyglycidyl nitrate(PGN) and Poly vinyl Nitrate(PVN). |
| **C 2.6** | **Ultra Fast Reaction Monitoring of energetic Materials (VSSC)**<br>The basic understanding of decomposition kinetics and dynamics of energetic materials in the ultrafast time regime (femto, $10^{-15}$/pico, $10^{-12}$ seconds). Theoretical understanding of the reaction mechanism using computational tools. Elucidation of the ignition behaviour, reaction pathways, complex combustion phenomenon, measurement of species and flame structure profile etc of solid, liquid (storable and cryogenic) propellants |
| **C 2.7** | **Enrichment of $H_2O_2$ to Rocket Grade $H_2O_2$ (SDSC-SHAR)**<br>$H_2O_2$ available in the market with 50% concentration has to be converted to Rocket Grade $H_2O_2$ i.e. $H_2O_2$ with at least 80% and above concentration for getting high pressure and high temperature in combustion chamber |
| **C 2.8** | **Propellant formulation with ingredients of Nano size (SDSC-SHAR)** |
| **C 2.9** | **Effect of Humidity on Solid motor processing operations like rubber lining, casting etc (SDSC - SHAR)** |
| **C 2.10** | **Estimation of Decoring loads (mandrel decoring from a cured segment ) (SDSC-SHAR)** |
| **C 2.11** | **Theoretical estimation of scale factor between sample carton & segment (SDSC-SHAR)** |
| **C 2.12** | **Measurement of internal moisture content for hydroscopic materials like AP ( both in fine and coarse form ) (SDSC-SHAR)** |

| | |
|---|---|
| C 2.13 | **Homogeneity checks of premix for Resin & DOA content and total moisture content including in solid particles(SDSC-SHAR)** |
| C 2.14 | **Thermal & mechanical phenomena of solid propellant during Curing (SDSC-SHAR)** |
| C 2.15 | **Theoretical prediction of burn rate using Ammonium Perchlorate particle size analysis and Activated Copper Chromate particle size analysis (SDSC-SHAR)** |
| C 2.16 | **Theoretical prediction of Mechanical properties from a given Resin (SDSC-SHAR)** |
| C 2.17 | **Effect of Particle Size Distribution (PSD) of AP(Coarse) & AP (Fine) on propellant/ grain properties: Mechanical, Burn rate & flow properties (SDSC- SHAR)** |
| C 2.18 | **Mass Flow Meters performance during Two phase flow of fluid (SDSC-SHAR)**<br>Mass Flow Meters are critical elements of the propellant filling system. It is used for flow quantity measurement during Launch vehicle propellant filling. The performance of the Mass Flow Meters depends upon several factors including fluid flow characteristics. The effect of gas and liquid flow (two phase flow) has to be studied for better understanding of performance of Mass Flow Meters. |
| C 2.19 | **Stress-Strain analysis of pressure vessels during hydrostatic testing (SDSC-SHAR)**<br>All the pressure vessels are subjected to hydro test as a part of qualification for further usage. During hydro test the tank is subjected to 3 dimensional stress and strain (Von Mises Theory). The stress and strain are to be pre-determined for safe hydro/pneumatic testing. |
| C 2.20 | **Performance Evaluation of Spiral Plate Heat Exchanger (SDSC-SHAR)**<br>Spiral Plate Heat Exchanger is being used in earth Storable Propellant System for propellant chilling operations. The performance characteristics of the heat exchanger are to be studied for better maintenance and operation. Based on analysis any improvement as a outcome can be suitably adopted |
| C 2.21 | **Pressure vessels qualification by advanced NDT technique (SDSC-SHAR)**<br>An alternative method for hydrostatic qualification testing of Pressure vessel |

| | |
|---|---|
| | to be invented |
| C 2.22 | **Supersonic film cooling of nozzle divergent (LPSC)** |
| C 2.23 | **Annular spiked nozzle divergent for TSTO applications (LPSC)** |
| C 2.24 | **Droplet modelling in cryogenic injectors (LPSC)** |
| C 2.25 | **Development of a throttleable injector element for future liquid engine designs (LPSC)** |
| C 2.26 | **Development of an analytical mathematical model to study Feed line coupled-flow related-low frequency instabilities in liquid engines (LPSC).** |
| C 2.27 | **Development of a hot gas Variable Flow Regulator for cryogenic engine (LPSC)** |
| C 2.28 | **Ignition modelling & analysis of throat film cooling for Semi Cryogenic Thrust Chamber (LPSC)** |
| C 2.29 | **Regenerative cooling analysis with kerosene for Semicryogenic thrust chamber to study coking characteristics (LPSC).** |
| C 2.30 | **Transient thermal modelling of Semicryogenic engine (LPSC)** |
| C 2.31 | **Development of foil bearings for high speed cryogenic turbopumps (LPSC)** |
| C 2.32 | **Development of damper seals for turbopumps (LPSC)** |
| C 2.33 | **Prediction model for vibration in Turbopumps considering the effects of unbalance, constraints, fluid forces, seals, internal clearances (housing/shaft/bearing) etc. (LPSC)** |
| C 2.34 | **Mathematical modelling of liquid migration under Zero 'g' condition and the associated heat transfer with warm tank wall and pressurent gas is essential to predict the rate of pressure build up in LH2 tank (LPSC)**<br>In cryogenic propulsion Stage residual liquid migration in LH2 tank is generally observed after engine shut down. This causes higher tank pressure due to mixing of liquid hydrogen with warm pressurent gas and heat transfer with warm tank wall. |
| C 2.35 | **Modelling of plasma and its dynamics inside hollow cathode in** |

| | |
|---|---|
| | **Electric Thruster (LPSC)** |
| **C 2.36** | **Measurement of Plasma/Plume parameters of Stationary Plasma Thruster and pulsed Plasma Thruster (LPSC)** |
| **C 2.37** | **Prediction of life of hollow cathode and reduction in life due to poisoning (LPSC)** |
| **C 2.38** | **Non contact type measurement of thruster anode liner erosion and prediction of thruster life (LPSC)** |
| **C 2.39** | **Electronics and Signal processing of Ultrasonics used for spacecraft propellant gauging using Ultrasonic Flow meter (LPSC)** |
| **C 2.40** | **The complete thermal modelling of the thruster (LPSC)**<br>The monopropellant hydrazine thrusters are used in reaction control system of IRS projects. The monopropellant hydrazine thrusters use the principle of dissociation of hydrazine using catalyst to produce the exhaust gases. These exhaust gases are expanded through the nozzle to produce thrust. The complete hydrazine dissociation model for the monopropellant thruster is required for thruster design and optimization. Based on the dissociation model, the complete thermal modelling of the thruster to be carried out. |
| **C 2.41** | **Alternate green propellants (LPSC)**<br>The monopropellant hydrazine is highly corrosive, carcinogenic and not environmental friendly. The alternate green propellants such as Amonium Di Nitramide (ADN), Hydroxyl Ammonium Nitride (HAN) based monopropellants are under studies. The green propellant formulation and its detail properties, dissociation phenomenons are essential to replace the existing hydrazine system. Development of suitable catalyst for the green propellant. |
| **C 2.42** | **Flow modelling in Dual Bell Nozzle for Liquid Rocket Engines (LPSC)** |
| **C 2.43** | **Life cycle prediction of thrust chamber for reusable regeneratively cooled liquid engines (LPSC)** |
| **C 2.44** | **Heat transfer characterization of kerosene with Aluminium Nano particles (LPSC)** |
| **C 2.45** | **Liquid film cooling study of thrust chamber with kerosene for LOX/Kerosene semi-cryogenic Engine (LPSC)** |
| **C 2.46** | **Modelling and analysis of throat film cooling for semi cryogenic** |

| | |
|---|---|
| | **Engine Thrust Chamber (LPSC)** |
| **C 2.47** | **Multi plume interaction studies of clustered Engines (LPSC)** |
| **C 2.48** | **Characterization of Heat transfer parameters in Gel Propellant Engines (LPSC)** |
| **C 2.49** | **Modelling of film cooling / sweat cooling in Liquid Rocket Engines (LPSC)** |
| **C 2.50** | **Combustion modelling & combustion instability modelling of liquid rocket Engines (LPSC)** |
| **C 2.51** | **Combustion studies on Gel Kerosene& Gel kerosene with Aluminium Nano particles (LPSC)** |
| **C 2.52** | **Numerical modelling of nonlinear thermo acoustic instability in liquid rocket Engine (LPSC)** |
| **C 2.53** | **Optimization of passive suppression devices for thermo acoustic instability in liquid rocket chambers (LPSC)** |
| **C 2.54** | **Two phase flow modeling in cryogenic propellant feed lines (LPSC)** |
| **C 2.55** | **Conjugate Heat Transfer Analysis in Cryogenic Engine systems(LPSC)** |
| **C 2.56** | **Flow separation modeling in nozzles (LPSC)** |
| **C 2.57** | **Modeling of inter element mixing of sprays (LPSC)** |
| **C2.58** | **Studies on deflagration to detonation transition (LPSC)** |
| **C 2.59** | **Studies on supercritical combustion-Theoretical & Experimental (LPSC)** |
| **C 2.60** | **Modeling of atomization of coaxial injectors, impinging jet injectors (LPSC)** |
| **C 2.61** | **Spray characterization of swirling liquid sheets in an acoustic field (LPSC)** |
| **C 2.62** | **Prediction of break up characterization of liquid sheets in hot environment (LPSC)** |
| **C 2.63** | **Two Phase flow: Suppression of gas injection into drain port of liquid engine propellant tanks (LPSC)** |

| | | |
|---|---|---|
| C 2.64 | **Transient chill down analysis of regeneratievely cooled thrust chambers (LPSC)** | |
| C 2.65 | **Film cooling breakage studies under unstable combustion conditions (Boundary Layer breakage) (LPSC)** | |
| C 2.66 | **Modeling of Xenon flow in Electric Thruster (LPSC)** | |
| C 2.67 | **Modeling of plasma and its interaction in vacuum chamber during electric thruster firing (LPSC)** | |
| C 2.68 | **Non contact type measurement of electric thruster anode liner erosion & prediction of thruster life (LPSC)** | |
| C 2.69 | **Satellite onboard propellant estimation: simple & effective methods of assessing the spacecraft life (LPSC)** | |
| C 2.70 | **Design of packaging/interfaces for MEMS based fabricated valves & actuators (LPSC)** | |
| C 2.71 | **Development of a mathematical model for characterizing the dynamic behavior of a check valve under different operating conditions (LPSC)** | |
| C 2.72 | **Design & development of solenoid coils for Liquid Helium applications (LPSC)** | |
| C 2.73 | **Development of a mathematical model for estimation of crimping loads for different material and design configurations (LPSC)** | |
| C 2.74 | **Theoretical Investigation of pressure waves generated by heat addition in a gaseous medium (LPSC)** | |
| C 2.75 | **Estimation of torque co-efficient and load distribution in threaded joints (LPSC)** | |
| C 2.76 | **Development of a mathematical model for propellant tank pressurization system chain for cryogenic application (LPSC)** | |
| C 2.77 | **Micro machining of metals to provide low mass flow rates (>0.1 SCM) of Xenon gas for EPS application (LPSC)** | |
| C 3 | **Sub Area** | **Polymers (VSSC)** |
| C 3.1 | **Development of Addition Curing Silicone Binder Resin Systems Along With Its Catalyst (VSSC)**<br>These polymers are used for thermal paints for satellite components. The | |

| | | |
|---|---|---|
| | proposal involves indigenous development of silicone polymers with pendant hydrosilyl (-SiH) and vinyl groups and suitable platinum catalyst soluble in these silicone polymers. | |
| C 3.2 | **Modelling of polymerization reactors (VSSC)**<br>This is intended to develop mathematical models for polymerization reactions of polydimethylsiloxane, phenol formaldehyde and hydroxyterminated polybutadiene systems using advanced software programs. | |
| C 4 | **Sub Area** | **Energy Systems for Satellite & Launch Vehicles (VSSC)** |
| C 4.1 | **Simulation & Analysis of Different Humidification Methods for Hydrogen and Oxygen Gases with Regard to Space Applications of Fuel Cells (VSSC)**<br>The proposal involves simulation & analysis of different humidification methods for hydrogen and oxygen gases with reference to flow rates, dew point, size, weight and power requirement in microgravity environment. Methods for using product heat and water for humidification are also to be analysed. | |
| C 4.2 | **Analysis of Different Gas-Water Separation Techniques for Oxygen and Hydrogen Gases with Regard to Space Applications of Fuel Cells (VSSC)**<br>The proposal aims at analysis of different techniques for separation of liquid water from exhaust hydrogen and oxygen gases at variable flow rate in microgravity environment. | |
| C 4.3 | **Study of Water Permeation Characteristics of Fuel Cell Proton Exchange Membrane Under Different Operating Conditions (VSSC)**<br>Optimum water balance across PEM is crucial in getting required performance from PEM type fuel cells. Balancing of electro-osmotic drag and back-diffusion of water provides the required optimum water balance. The proposal aims at study of the influence of various parameters such as membrane type, membrane thickness, temperature, stack clamp force, saturation level, etc on the water balance of PEM fuel cells. | |
| C 4.4 | **Developing a Model for Bipolar Plate to Optimise the Gas Flow Field with Regard to Water management and Current Distribution (VSSC)**<br>Fuel cell performance is controlled mainly by bipolar plate flow field geometry. A reliable model enables faster design fine tuning and scale-up. | |

| | |
|---|---|
| | The proposal aims at development of a reliable model. |
| C 4.5 | **Development of high energy electrode materials (VSSC)**<br>Power requirements of satellite and launch vehicle programs of ISRO calls for the development of efficient battery technology, especially advanced Lithium-ion cell technology. Thus, to improve the energy density of present-day Li-ion cells (150 Wh/kg) to >400 Wh/kg, realization of newer electrode materials with light weight and high energy storage capacity is essential. Suitable anode materials like nano-sized silicon, reduced grapheme oxide encapsulated silicon, lithium alloys of Silicon and/or tin, etc. and suitable cathode materials such as sulphur, carbon-sulphur composites, fluorophosphates, etc. need to be developed, characterized and evaluated. |
| C 4.6 | **Development of high voltage electrolyte (VSSC)**<br>As a part of realizing high energy Li-ion systems, it is essential to develop electrolytes that can perform satisfactorily with chemical and electrochemical stability under a wide electrochemical window from 0 – 5 V, like sulfones, sulfoxides, fluorinated carbonates, etc. |
| C 4.7 | **Development of solid electrolytes (VSSC)**<br>Solid state lithium batteries that make use of solid electrolytes rather than a liquid electrolyte can provide higher energy density cells and can eliminate the safety issues of present-day cells. Hence, Lithium ion conducting solid electrolytes with ionic conductivity of the order of 10-3 S/cm at room temperature need to be developed. This development shall lead to realization of thin, flexible batteries and thus pave the way for processing versatility of cells. |
| C 4.8 | **Materials for advanced Supercapacitors for space applications**<br>Towards improving the power density and energy density of supercapacitors, development of high surface area materials such as activated carbon, carbon aerogels, carbide derived carbon, pyrolytic graphite, etc. need to be developed. |
| C 4.9 | **Development of Electrolytes/Ionic liquids (VSSC)**<br>In line with improving the energy and power density of present day supercapacitors, hybrid ion capacitors are advancing by invoking the principles of battery as well as supercapacitors. Suitable electrolytes/ionic liquids shall be developed with high voltage and conductivity capabilities for implementation in device level applications. |

| | | |
|---|---|---|
| **D** | **Area** | **Control, Guidance & Simulation (VSSC)** |
| **D 1** | **Sub Area** | **Control System (VSSC)** |
| **D 1.1** | **Development of Control algorithms for autonomous mobile robotic manipulator (VSSC)**<br><br>The research proposal is for developing advanced control algorithms for an *autonomous mobile robotic manipulator* which consists of a six degree of freedom (6 DOF), robotic manipulator mounted over a four wheel mobile robot with the wheels having independent drive and steering control. Conventional control and intelligent control shall be hybridized to develop a hierarchical control and vision-based control for robots. The control algorithm provides *dynamic coordination* of manipulator arm joints and mobile robot wheel drives to execute precision tasks in unstructured environments using multiple sensor feedback. With the development of *multilayered control architecture*, the robot should be able to automatically compute its motions from the high level description of tasks. The proposed study also needs to develop algorithms for *Simultaneous Localization and Mapping* for the navigation and locomotion of mobile robot. | |
| **D 2** | **Sub Area** | **Control & Guidance (VSSC)** |
| **D 2.1** | **Rendezvous and docking (VSSC)**<br><br>To achieve docking during the final phase of the mission, the relative position and velocity of the target spacecraft and chaser spacecraft has to be brought to zero. To ensure proper alignment of the docking port, the relative angular orientation needs to be precisely aligned. Moreover, relative angular rate of the target and chaser are to be very close to zero for successful docking. Simultaneous control of the translational and rotational dynamics is required to achieve the docking conditions. | |
| **D 3** | **Sub Area** | **Simulation (VSSC)** |
| **D 3.1** | **Multi-body Dynamics Simulator (VSSC)**<br><br>Launch vehicle simulations require solving multi-body dynamics for addressing scenarios such as space transportation missions, crew module ejection, stage separation, booster/strap-on separation, satellite separation etc. All individual bodies having its own inertial systems and are bound to possess independent mass-inertia characteristics, propulsion systems, aerodynamic properties, guidance and control algorithms, control power plants etc. Simultaneous solving of translational and rotational dynamics for each body (during ascent and descent phase) is required with real-time plotting of trajectory parameters and other critical states. Software model | |

| | | |
|---|---|---|
| | can follow modular or component architecture whereby system modules can be plugged in and used as required. | |
| **D 4** | **Sub Area** | **Actuators (VSSC)** |
| **D 4.1** | **Piezoelectric actuators for position control applications (VSSC)**<br>Piezoelectric materials produce voltage when stress is applied. This effect is also reversible in manner, i.e. a voltage across the sample will produce stress within the sample. Because of this reversible property, piezoelectric materials can act both as sensor as well as actuator. Piezoelectric actuation can be used in precision (small strain, fast response time) applications. One application envisaged is the precision position control of mirrors used in optical structures of satellites. Procurement and characterization of Piezoelectric actuation capability of piezo stack actuators and Macro Fibre Composite (MFC). MFC is a specific configuration of piezo electric patch where the patch is flexible and can be bonded over curved structures.<br>Development and demonstration of closed loop control algorithm for precise position control of an object mounted over a tubular composite tripod structure. | |
| **D 4.2** | **Design and analysis (static & dynamic) of a planetary roller screw (VSSC)**<br>Planetary rollerscrews having double nut configuration are used in high power electromechanical actuators for converting the rotary motion to linear. The scope of project includes<br>Mechanical design of the rollerscrew based on input requirement which includes detailed specification and outer dimensions of Rollerscrew.<br>Generation of 3D CAD model<br>Kinematic analysis and estimation of slip<br>Static analysis (Finite Element Analysis ), stiffness and efficiency<br>Dynamic analysis (Using solvers like ADAMS)<br>Fabrication drawing of all components | |
| **D 4.3** | **Design and development of 25kW quadruplex BLDC motor with quadruplex hall sensor sets (VSSC)**<br>25kW quadruplex BLDC motor with quadruplex hallsensor sets is planned as a driver for linear electro-mechanical actuators generating high actuation forces. The scope includes<br>Design of motor and controller for the input requirements<br>Modelling and analysis using finite element analysis software to validate the | |

| | |
|---|---|
| | motor performance<br>Generation of fabrication drawings and PCB layout<br>Procurement of components needed for the motor and controller<br>Realization, assembly and testing of motor and controller |
| D 4.4 | **Design and analysis of harmonic drive (VSSC)**<br>Harmonic drive replaces the conventional gear train of the rotary actuator The scope includes<br>Mechanical design of the harmonic drive for the input requirements<br>Modelling and quasi-static analysis using finite element analysis for the tooth mesh conditions [for stress, strain and stiffness]<br>Kinematic and kinetic analyses using ADAMS like software<br>Tooth profile optimization for maximizing performance<br>Generation of fabrication drawings<br>Procurement of components (like elliptical bearings, circlip, etc, needed for the assembly)<br>Realisation, assembly and testing |
| D 4.5 | **Design and development of Dual redundant 22.5$^{o}$ stepper motor (VSSC)**<br>22.5$^{o}$ stepper motor with is planned as a driver for the rotary actuator. The scope includes<br>Design of motor for the input requirements<br>Modelling and analysis using finite element analysis software to validate the motor performance<br>Generation of fabrication drawings<br>Procurement of components<br>Realisation, assembly and testing of motor |
| D 4.6 | **Development of electro-active actuators for positioning& control of aerospace components (VSSC)**<br>Electro-active actuators are necessary for shaping, tuning and positioning of reflectors/antennae/ solar panels in aerospace field. Ionic polymer-metal composites IPMCs) are attractive candidates for this application as it can be actuated even with very low voltage potential (1-5 V). On subjecting to current/voltage, ionic movement occurs in IPMC. The movement of ions facilitates the actuation of mechanical shape. Compared to common |

| | | |
|---|---|---|
| | actuation by heat, it is superior in control and accuracy. | |
| **D 5** | **Sub Area** | **Robotics (VSSC)** |
| **D 5.1** | **Modeling, simulation, analysis and design of a controller for a robotic manipulator having five degree of freedom for lunar mission (VSSC)**<br>Robotic manipulator having five degree of freedom forms part of a lunar exploration rover. The scope of project includes,<br>Generation of a mathematical model and its analysis which includes forward and inverse kinematics, work space analysis, trajectory planning, static and dynamic analysis. Design of a controller and simulation of certain predefined tasks. Hardware realization of the controller (control electronics to drive the manipulator). Experimental demonstration of the predefined tasks. | |
| **D 5.2** | **Design, analysis and experimental verification of a force and slip controller for the object grasp by an under actuated three fingered robotic hand (VSSC)**<br>Design of force and slip controller (including selection and procurement of appropriate sensor / sensors). Simulation of grasp (Spherical, Cylindrical & Planar) with objects of various sizes and shapes. Experimental demonstration of grasp (Spherical, Cylindrical & Planar) with objects of various sizes and shapes (Under actuated robotic hand will be provided for this purpose) | |
| **E** | **Area** | **Aerospace Materials, Composites & Mechanical Systems (VSSC/LPSC)** |
| **E 1** | **Sub Area** | **Materials Characterizations (VSSC/LPSC)** |
| **E 1.1** | **Study of fracture under explosive conditions of 17-4 PH stainless steel in different heat treatment conditions (VSSC)**<br>17-4 PH stainless steel is used for separation systems in which the steel has to get severed by use of an explosive. Heat treatment condition determines whether the material will get cut or not. Correlation of heat treatment to behaviour under explosive is to be done. | |
| **E 1.2** | **Development of Processing Maps for High Temperature Aerospace alloys (VSSC)**<br>High temperature materials are being developed or the futuristic launch vehicles like RLV, TSTO, SSTO, HSP missions of ISRO. High temperature deformation processing of these materials is complex and posses many challenges to manufacturers. The scope of the work include development of | |

| | | |
|---|---|---|
| | flow stress data as a function of strain, strain rate and temperature for these materials as well as processing maps useful for the identification of flow instabilities. | |
| **E 1.3** | **Material behaviour at hot hydrogen environment (LPSC)** | |
| **E 1.4** | **Fracture behaviour studies of rocket engine materials for cryogenic application (LPSC)** | |
| **E 1.5** | **Characterization and development of new thermionic material for hollow cathode of electric thruster which cannot easily get poisoned (LPSC)** | |
| **E 2** | **Sub Area** | **Cryogenic applications (VSSC)** |
| **E 2.1** | **Development of solders for use in cryogenic applications (VSSC)**<br>Most of the conventional solders which are tin based become brittle at cryogenic temperatures. For cryogenic applications it is necessary to design alloys with good soldering characteristics and also having ductility at cryo temperatures. | |
| **E 2.2** | **Physical property measurement at low temperature up to 20K (LPSC)** | |
| **E 3** | **Sub Area** | **Study of defects (VSSC)** |
| **E 3.1** | **Defect formation in steel and aluminium welds (VSSC)**<br>The effect of process parameters. Identifying root cause for formation of defects during welding of high strength steels, stainless steels, aluminium alloys being used in ISRO. | |
| **E 4** | **Sub Area** | **Fibre Reinforced Composites (VSSC)** |
| **E 4.1** | **Development of Process Technology to coat SiC chopped fibres with BN and Carbon (VSSC)**<br>SiC fibre reinforced composites are suitable candidates for thermo-structural components of reusable launch vehicles and air breathing engines. In order to maintain the integrity of the composite for a longer duration under loading these fibres need to have suitable coating before incorporating intro the matrix. In addition reinforcing the coated fiber leads to proper adhesion aids in stress release. Thus the proposed work serves a base to develop fiber reinforced composites for various thermo-structural applications. | |
| **E 5** | **Sub Area** | **Aluminium, Aluminium-Lithium Alloys & other Alloys** |

| | | |
|---|---|---|
| | | **(VSSC)** |
| **E 5.1** | | **In plane and through thickness anisotropy in Li containing Aluminium Alloys (VSSC)**<br>Al Li alloys are known to possess in plane and through thickness anisotropy which make it difficult for designers to effectively utilize them in structural applications. The scope of the study includes in plane and through thickness anisotropy properties like tensile strength and fracture toughness and suggest measures to minimize it. |
| **E 5.2** | | **Sub microstructure characterization of Al-Li alloys (VSSC)**<br>Al Li alloys are being developed as a potential candidate for the future propellant tankages and structural material for the launch vehicles and satellites. These alloys are strengthened by T1 precipitates which need to be uniformly distributed throughout the matrix avoiding the sub grain boundaries for optimum cryogenic properties. The scope of the work is to evaluate the sub microstructures under different thermo mechanical treatments using TEM and EBSD to optimize mechanical properties. |
| **E 5.3** | | **Microstructure and Micro texture evaluation in Age hardenable Aluminium Alloys (VSSC)**<br>A variety of age hardenable aluminium alloys are used in the launch vehicles and satellites of Indian space programmes. These alloys are subjected to a number of thermo mechanical processes to get the final shape and put in service. This introduces varying textures and microstructures which influence the performance of these materials in service. Scope of the project is to study the microstructure and micro-texture as a function of the process parameters and to identify their influence on the performance of these alloys. |
| **E 5.4** | | **Studies on delayed cracking phenomena on High strength Aluminium alloys using fracture mechanics (VSSC)**<br>High strength aluminum alloys such as AA7075 and AA2219 are widely used in the aerospace industries due to its high strength, light weight, fabricability etc. However, they are prone to stress corrosion cracking (SCC) failures especially in marine environment containing chlorides. Although studies were carried out and reported in the literature, understanding the variations in microstructure and its crack growth characteristics especially in the case of forgings is needed. The above topic envisages to understand the crack growth rate with respect to microstructure using fracture mechanics concept. |

| | |
|---|---|
| **E 5.5** | **Oxidation behaviour of advanced high temperature coatings for super alloys and Ti-based intermetallic alloys (VSSC)**<br>Intermetallics such as Gamma TiAl and super alloys are considered as good candidate alloys for high temperature applications due to several advantages. However, these alloys can be used at high temperature with good coatings covering bond coat along with TBC ceramic coatings. Although several coatings were developed and published in the literature, still the coatings could not protect the base alloys especially at high temperature. Currently, application of coatings based on methods such as magnetron sputtering, EB-PVD and HVOF are reported to provide good bonding and oxidation resistance along with intermediate coatings using variations in surface preparation, anodizing etc. Hence the above topic involves developing a superior oxidation resistant coating and understanding the mechanism of oxidation and scale growth using TGA and extensive surface analysis studies. |
| **E 5.6** | **Drilling techniques/technology for drilling of miniature size holes of dia less than 10 microns in super alloys for a depth of 1.0mm (LPSC)** |
| **E 5.7** | **Development of materials/alloys including coatings for high pressure oxygen environment (LPSC)** |
| **E 5.8** | **Development and characterization of oxygen, moisture and nitrogen absorber (non heating type) for flight use (LPSC)** |
| **E 5.9** | **Development of thermal barrier coating with Nano materials (LPSC)** |
| **E 5.10** | **Laser ultrasonic for online EBW evaluation of Ti alloys (LPSC)** |
| **E 6** | **Sub Area** — **Welding (VSSC/LPSC)** |
| **E 6.1** | **Development of coating/manufacturing technology for friction stir welding tool for welding of 3mm thick stainless steel sheets (VSSC)**<br>Friction stir welding of Aluminium alloys is handy in terms of tool material and expected axial and feed forces. Vital part in this technology being tool development, for carrying out friction stir welding of materials like steel / titanium, appropriate tools are to be looked into. Hardened tool-steels with proper coating to withstand service temperatures up to $700^0$C and also that will not form compounds / intermetallics with the material to be welded are to be developed and studied. |
| **E 6.2** | **Analysis of weld bead instability in the overlap zone of keyhole electron beam welds (VSSC)** |

| | |
|---|---|
| | Keyhole electron beam welding is being carried out for circumferential joints in the liner and gas bottle made out of Titanium alloy (Ti6Al4V). An underfill is found to occur in the run-out zone of the overlap region. In the run-out area, already formed root reinforcement will be ejected and replaced as long as transmitted power is capable to do so. A little consideration would show that ejection of root reinforcement will stop as a function of transmitted power and hence there present a zone of underfill, where due to power transition instability ejected root reinforcement will remain as it is. Localized bead depression often exceeds acceptance level as specified by AMS2680. The problem is due to thermal overloads. Variable parameters are beam current, focus current and travel speed and the fixed parameters are work distance and acceleration voltage. A study is proposed to analyze the thermal effects in the overlap area so as to predict the conditions that avoids the cited effects. |
| **E 6.3** | **Reducing spatter formation in electron beam welding of superalloys (VSSC)**<br>Spatter is formed on the root side of weld joints made by EBW. As spatter is undesirable for many applications, it is to be avoided. Scope of the activity: develop techniques to reduce spatter either by process control or by joint design. Correlation between spatter formation and process parameters to be made. |
| **E 6.4** | **Metallurgical studies on Copper - Nickel dissimilar metals EB weld interface (LPSC)** |
| **E 6.5** | **Development of Vacuum Brazing Technique for joining carbon fiber reinforced Silicon Carbide (C-SiC) to Columbium and C-SiC to Titanium (LPSC)** |
| **E 6.6** | **Theoretical & Experimental evaluation of 3D weld porosity effects on integrety of welded structures (pressure vessels & thrust chambers) (LPSC)** |
| **E 7** | **Sub Area** — **Ceramics (VSSC)** |
| **E 7.1** | **Evaluation of Ceramic matrix composites based on SiC and $ZrB_2$ for behaviour under water vapour containing environments at high temperatures and development of suitable coatings to improve the performance (VSSC)** |
| **E 7.2** | **Simulation, Modelling and Design of UHF, L and S band Antenna in 2D EBG structures with high – permittivity (k>60) low-loss (<0.001) ceramics (VSSC)** |

| | | |
|---|---|---|
| | Generally, low-k substrates are preferred for antenna applications due to less confinement and surface wave effects. However, for UHF, L and S bands, the size reduction is possible only with high-k substrates, which have surface wave effects that limits the Performance of antenna. EBG concept can be very effectively applied to design 2D periodic dielectric structures that at small in size as well as don't have surface wave. | |
| **E 7.3** | **Development of ceramic material with higher electrical insulation at high temperature (LPSC)** | |
| **E 7.4** | **Development of ceramic coating to prevent metal burning in high temperature and oxygen rich environment (LPSC)** | |
| **E 7.5** | **Thermal barrier coating studies to reduce the heat flux in semi cryogenic Engine Thrust Chamber (LPSC)** | |
| **E 7.6** | **Development of coating materials used in high temperature environment (LPSC)** | |
| **E 8** | **Sub Area** | **Corrosion studies (VSSC)** |
| **E 8.1** | **Development of nano composite coatings for corrosion protection of light alloys such as Aluminium and Magnesium (VSSC)**<br>Aluminum and magnesium alloys are widely used in the aerospace industries due to light weight and other properties. However, they are prone to corrosion in the environment containing chlorides. Hence these alloys are mostly used in coated conditions covering single and multiple layered coatings of epoxy and polyurethane. Currently nano composite coatings are reported to show good barrier corrosion properties and hence show more advantages than the traditional coatings. Hence the above work is aimed to develop dispersion of nano particles in the above coatings and to study their performance using polarization, impedance and other surface characterization techniques to understand their prospective mechanisms against corrosion | |
| **E 8.2** | **Influence of Pitting Corrosion on the Fatigue and Fracture Toughness of High Strength Aluminum Alloys (VSSC)**<br>Aluminum alloys such as AA2219 and future generation alloy such as AA2195 Al-Li alloys are prone to environmental degradation such as pitting corrosion and stress corrosion cracking in humid chloride containing environments. Although these alloys are given suitable aging treatment (T87) to avoid SCC, the localized corrosion is still persisting. It is also well known that pits act as stress concentration sites promoting early nucleation of cracks resulting in sudden failure even though SCC is not there. In this | |

| | |
|---|---|
| | case, the component fails by purely mechanical manner initiated from pitting. Several studies have addressed the importance of localized corrosion in reducing the fatigue life of aluminum structures. Currently prediction of life estimation of high strength aluminum alloys undergoing localized corrosion and its modeling using several advanced software are current areas of interest. This will be more useful for the above aerospace alloys. |
| **E 8.3** | **Development of Plasma Electrolytic Oxidation (PEO) For the Corrosion Protection of Light Alloys (VSSC)**<br>Aluminum alloys such as AA2219 is prone to localized corrosion in view of the presence of strengthening phases $CuAl_2$. Currently anodizing is widely used as a measure of corrosion protection of aluminum alloys including AA2219. Since the thickness of oxide film is less, long term corrosion protection is not possible only through anodization. Currently conversion coating based on plasma electrolytic oxidation (PEO) is widely used for the improvement of corrosion and wear properties of light alloys (aluminum, lithium and Titanium alloys). This process utilizes environment which does not affect the environment unlike acidic solutions used in anodizing. This process creates thick ceramic alumina and protects these alloys very efficiently. In this research, it is expected to develop suitable coating with improved ductility so as to protect the light alloys with high corrosion resistance as well as improved mechanical properties |
| **E 8.4** | **Corrosion behaviour at atmospheric conditions of materials used in rocket engine (LPSC)** |
| **E 9** | **Sub Area** — **FEM Simulation (VSSC)** |
| **E 9.1** | **Finite element simulation of a closed die forging (VSSC)**<br>Closed die forgings like hemispherical domes are widely used for various systems and sub-systems in launch vehicle and satellite applications. Closed die forging under non-isothermal conditions is routinely carried out industrially. Prediction of temperature, strain, strain rate at different locations of the die forging under a given set of conditions is useful for predicting the flow localization or fracture for different materials. This proposal expects the usage of 3D non-linear finite element analysis tools for metal forming operations. The output of the analysis should be useful for optimization of processing parameters during closed die forging |
| **E 10** | **Sub Area** — **Casting and solidification (VSSC)** |
| **E 10.1** | **Solidification behavior and grain refinement of cast super alloys** |

| | |
|---|---|
| | **(VSSC)**<br>Super alloys are used for making many cast components used at turbine side of the turbo-pumps. Investment casting is the process used for making these components. Grain coarsening happens due to inherent slow cooling involved in the process. Suitable grain refinement techniques are needed to control the grain size for better fatigue and strength properties and weldability. Detailed study is envisaged to understand the solidification behavior, homogenization parameters and aging characteristics for the Ni-base and Ni-Fe base super alloys. |
| **E 10.2** | **Understanding Casting defects and development of repair procedure for cast super alloy (VSSC)**<br>Many critical cast components are made through casting route. Complex components possess challenge in realization of defect free castings. Based on the solidification behavior of the alloy it is required to predict the type of shrinkage defects the alloy is prone to. Also proper corrective measures should be identified in terms of gating and risering design as well as in terms of weld repair procedure. |
| **E 10.3** | **Development of Cast components in high entropy alloys (VSSC)**<br>High entropy alloys are considered as a future material due to exotic combination of properties. Considering the issues in working of these alloys, it is proposed to evaluate these alloys for making cast components. It is expected to finalize few alloys and evaluate their properties after casting and heat treatment. |
| **E 10.4** | **Oxidation behavior of cast super alloys and stainless steel (VSSC)**<br>Cast alloys are prone for oxidation during heat treatment or during operation. It is envisage to study the oxidation behavior of cast alloys during heat treatment (in air, under Ar or under vacuum) and during operation. |
| **E 10.5** | **Development of cast components in Ti-Al intermetallic base alloys (VSSC)**<br>Intermetallic are known for their high strength and stiffness. Light weight intermetallic alloys can find applications in aerospace field. Casting can be an ideal route for inducting these alloys. It is envisage to identify few potential alloys and evaluate their properties in cast and heat treated condition. |
| **E 10.6** | **Effect of processing parameters on cryo impact properties of cast alloys (VSSC)**<br>Many alloys are used in form of castings at cryo temperatures. In this |

| | | |
|---|---|---|
| | project it is envisage to evaluate cryo-temperature properties, particularly impact properties at cryo temperatures and to study the effect of heat treatment on different phase and cryo-properties | |
| **E 11** | **Sub Area** | **Electronic Packaging materials (VSSC)** |
| **E 11.1** | **Development of Aluminium nitride ceramic tapes for space electronic packaging Applications (VSSC)**<br>AlN has good dielectric properties, high thermal conductivity, low thermal expansion and non reactive with normal semi conductor process chemicals and gases. Dense AlN tapes are at high demand for space electronic packaging applications. Tape casting process is identified for the fabrication of AlN green tapes of 200-300µ. The slurry and the sintering schedule will be optimized to obtain defect free green & sintered AlN tape | |
| **E 12** | **Sub Area** | **Dielectric Materials (VSSC)** |
| **E 12.1** | **Development of BaxSr1-xTiO3 Tunable Dielectric Thin Films Prepared by Pulsed Laser Deposition (VSSC)**<br>Barium strontium titanate (BST) is of particular interest for tunable devices, since it has high dielectric constant that can be tuned by applying an electric field, and relatively low loss at various frequencies. In the present fast growing semiconductor industry, miniaturizing the device fabrication is most important. For this application, the BST based high dielectric materials are fabricated in thin film forms. Therefore, it is very important to understand the relationship between the BST thin film material and microwave properties of the devices, in order to optimize the performance of BST-based components for tunable antennas. The key objective of this proposal is to develop BaxSr1-xTiO3 thin film (x between 0.4-0.7) and study the effect of process parameters (substrate temperature and oxygen pressure), film thickness and strain on dielectric properties of films grown by pulsed laser deposition method. | |
| **E 13** | **Sub Area** | **Structural Health Monitoring (VSSC)** |
| **E 13.1** | **Structural Health Monitoring of Composite Structures using Optical fibres with Bragg Grating Sensors (VSSC)**<br>Optical fibres with Bragg Grating sensors are the leading candidate technology for Structural Health Monitoring (SHM) since they have minimal mass penalty for extremely large numbers of sensors. There are many advantages like compatibility with the composites, low Electro Magnetic Interference (EMI), multiple sensing capabilities with a single fibre etc. This sensor technology will be highly useful in present as well as our future | |

| | | |
|---|---|---|
| | launch vehicle applications.<br><br>Scope: Supply of optical fibres with Fibre Bragg Grating (FBG) *sensors* inscribed at required locations. Support for embedment/surface bonding of sensors for subsurface/surface strain monitoring of composite components. Demonstration of strain and temperature sensing with data recording in a computer on specimen and component levels. Development of interrogation techniques for multiple Fibre Bragg Grating sensors embedded in a single fibre. | |
| **E 14** | **Sub Area** | **Development of Miniature Specimen (VSSC)** |
| **E 14.1** | **Development of Miniature Specimen Test Techniques (VSSC)**<br><br>Miniature specimen test techniques enable the evaluation of mechanical properties using extremely small volume of the material. For characterization of C/C composites and CNT based composites this method is to be adopted considering the cost involved in the realization of specimens. The reliability and accuracy of the parameters obtained by different miniature specimen test methods are established by modelling them. Finite Element analysis is used to convert the experimental load-deflection curves into stress-strain information, which in turn gives information on ductility, strength etc., (Data Inversion Technique). A complete simulation of these test techniques using Finite Element Modelling (FEM) helps to improve the accuracy and demonstrate the validity of these test methodologies. | |
| **E 15** | **Sub Area** | **Composites (VSSC)** |
| **E 15.1** | **Inelastic Finite Element Model of Multidirectional Carbon-Carbon Composites to predict the material characteristics and behaviours (VSSC)**<br><br>Multidirectional C-C composites (3D, 4D) are composite material wherein the reinforcing fibres act as reinforcement at various directions. 4D C-C composites has found successful applications in solid rocket nozzles especially as ITE's. The material behaviour of nD C-C composites is highly anisotropic and shows nonlinear elastic behaviour. Most of the work carried to assess the behaviour of multidirectional C-C composites is evaluated through destructive testing; hence limited data is generated for the mechanical properties. In this context few works are carried (especially by SAFRAN group) to theoretically predict the mechanical behaviour of the material and corresponding material properties associated with this class of material. Since at VSSC, nD C-C composites are envisaged to have application as SRM throat inserts and also as TPS material for certain applications, it is essential to initiate the micromechanical model studies to | |

| | |
|---|---|
| | theoretically predict the material behaviour vis-a-vis the mechanical properties. An elastoplastic finite element model, including homogenised mono-axial stiffness can predict the material properties as has been referred in many literatures. Presently available tested material properties can further aid to verify the model if developed for such studies. |
| **E 15.2** | **Mathematical model of Interaction of gas phase with carbon perform during Isothermal CVI process (VSSC)**<br><br>One of the most promising and common methods of fabrication of thinner Carbon-Carbon composites is through vapor phase densification of porous structure of carbon fibers acting as reinforcement. During CVI process, the vapors of the hydrocarbon namely methane, propane etc decomposes to produce the desired carbon matrix within the pores of the preform and thereby increases the density. The density aimed after the final densification is based on the targeted mechanical and thermal properties required for the specific use of application of the product. Practically, the major hindrance of realization of C-C products through CVI process is the long processing duration required to achieve the desired density. Furthermore the process must be intermediately interrupted to permit surface machining or heat treatment at high temperature in order to open the pores for further densification. Under this consideration, a comprehensive numerical modelling is essential to optimise the processing parameters to achieve the required density and also to reduce the long process duration. |
| **E 15.3** | **Study of defects in composites (VSSC)**<br><br>Study the effect of defects (determinations, de-bounce, voids, fiber separation etc.) and cut outs on strength and Stiffness properties of sandwich and laminate composites: Composite products are widely being used for satellite structural applications. The type of constructions range from laminate, stiffened laminates, Monocoque and sandwich. These products are autoclave cured and realized using prepregs. These composite parts are prone to defects during handling/movement between various work stations or due to processing. Also many a time cut outs are to be provided on these composite parts for various mechanical requirements. A study need to carried out to parameters ( in terms of location , geometry and size) the effect of these defects/ cut outs on the stiffness and strength of sandwich and laminate composites. |
| **E 15.4** | **Out of Autoclave Processing of Prepreg based fibres Reinforced Composites (VSSC)**<br><br>Conventionally composite products for satellite structure applications are realized by Autoclave curing Processes. The prepreg layup is completed on |

| | |
|---|---|
| | a tool/mould under room temperature conditions. The curing is completed under higher temperatures of the order of $175^0$c.The inherent disadvantage of this process is the likely curing stresses induced in the composite part. A suitable process need to be developed in which curing can be done outside autoclave by Developing prepregs based on resins which can cure under UV light or using conventional prepregs but curing outside autoclaves using more energy efficient methods. |
| **E 15.5** | **Effect of various curing parameters and procedures, tooling to composite interaction on the properties of sandwich and laminate composites (VSSC)**<br><br>Composite products for satellite structure applications are mostly realised by Autoclave curing Processes. The prepreg lay up is completed on a tool/mould under room temperature conditions. The curing is completed under higher temperatures of the order of $175^0$c.The product is cooled to room temperature before extracted. Various curing parameters like temperature, pressure, vacuum rate of heating/cooling ,various procedures being followed for monitoring and controlling these parameters .Tooling to composite interaction type of release medium used type of breather/bleeder material used , extent to resin bleed out etc. critically affects the properties of the realized composite part (sandwich and laminated composites). A study need to be carried out to characterise the influence of these factors on the properties of these composite parts. |
| **E 15.6** | **Nano meter level measurement and assessment of space composite structures (VSSC)**<br><br>An increasing demand for high-quality, low cost Earth imagery has led to the requirement for improved structural stability of the satellite instruments providing the imagery. This translates into camera structures capable of maintaining very high levels of dimensional stability order of few micron (<10μ) for a length of 1m over their lifetime. CFRP[1] have emerged as one of the best materials for dimensionally stable space structures. The "theoretical" zero CTE[2] is only approximated as well as the manufacturing precision allows. So in ultra stable structure where micron level dimensional stability is required, there is an obvious need for quantitative assessment of the magnitude of change in dimensions. We are in need of a nano meter level measurement setup with all associated analytical software and hardware fully integrated, meant for specimen level as well as assembly level evaluation of the payload and camera structure. |
| **E 16** | **Sub Area** — **Modelling (VSSC)** |
| **E 16.1** | **Geometric, Kinematic and Finite Element Modelling of Large** |

| | |
|---|---|
| | **Deployable/ Inflatable/Unfurlable Structures in Space (VSSC)**<br><br>Large antenna reflectors and other structures are being used in increasing numbers for satellite applications. The sizes range from dia.5.0m and upwards to 20.0m.During Launch phase these reflectors will be stowed so that launch envelope interfaces requirements are not violated. In space these structures get deployed by suitable mechanism of energy release like inflatables, Unfurlable , Unfoldables etc.<br><br>A suitable model need to be developed (a) To capture Geometry of these structures in space (0g condition) and in ground(1g condition) (b)To capture and model the kinematics of the members /linkages involved and (c)Finite element modelling of the structure to capture its dynamic, Static and Thermal distortion behaviour under space conditions. |
| **E 16.2** | **Composite process modelling – to capture warpage, shrinkage, spring back, and other moisture/curing induced deformations of Autoclave Cured - Prepreg based Fibre Reinforced Composites (VSSC)**<br><br>Composite products for satellite structure applications are mostly realized by Autoclave curing Processes. The prepreg lay up is completed on a tool/mould under room temperature conditions. The curing is completed under higher temperatures of the order of $175^0$c.The product is cooled to room temperature before extracted. The high temperature curing and the cool down back to room temperature induce curing stresses in the composite part. After extraction from the tooling these stresses along with the inherent anisotropy of the composite manifest itself in the form of warpage/shrinkage, spring back and other deformations of the composite part. A detailed model need to be worked out to capture and predict such behaviour - especially for regular geometries like Flat , Conical, Paraboloid , C shaped , L shaped & Tubular sections (round/square/ rectangular cross sections)- considering anisotorpy of the composite as well. |
| **E 17** | **Sub Area** — **Human in Space Programme & Mars Exploration (VSSC)** |
| **E 17.1** | **Development of Thermoplastic Elastometers for LCVG for Space Suit (VSSC)**<br><br>Liquid Cooling & Ventilation Garment (LCVG) of space suit requires a "wicking material" which allows one-way water transport. Material usually used is a block copolymer based on polyethylene oxide (PEO) soft segment and Polyether-ester block amide (PEBA) hard segment. The polymer should have high tear strength, toughness and water vapour transmission. |

| | | |
|---|---|---|
| E 17.2 | **Ceramic Supported Lithium Hydroxide (LiOH) For Human Space Flight Programme (VSSC)**<br>Lithium hydroxide is useful for the removal of carbon dioxide produced by human metabolism in the crew cabin of a manned spacecraft. For efficient absorption of carbon dioxide, surface area of LiOH particles should be maximum. This can be achieved by supporting LiOH particles on a highly porous ceramic material. | |
| E 17.3 | **Development of Catalysts for Splitting of Carbon Dioxide (VSSC)**<br>Atmosphere of Mars is reported to comprise mainly (95%) of carbon dioxide. It is suggested that oxygen for propulsion (for return flight to Earth) can be produced in Mars by catalytic splitting of carbon dioxide into carbon monoxide and oxygen. Another method is to reduce carbon dioxide using hydrogen (transported from Earth) to produce oxygen and methane. Development of catalysts for these reactions and optimisation of reaction conditions will go a long way in realizing Mars explorations. | |
| E 18 | **Sub Area** | **Polyurethanes (VSSC)** |
| E 18.1 | **Development of bio-based polyurethane coatings (VSSC)**<br>Polyurethane coatings are very common in space field. They are used for thermal control, conductive and other several applications. Currently, all PUs are based on petroleum based raw materials. Vegetable oil based PUs are attractive not only because of its bio-origin but also for good and comparable thermal stability to petroleum based PUs. Castor oil and other vegetable oils based PUs can find applications | |
| E 19 | **Sub Area** | **Metal Organic Frameworks (VSSC)** |
| E 19.1 | **Development of metal organic frameworks for the selective adsorption of gases like H2, CO2 and CO (VSSC)**<br>The work involves molecular modelling, synthesis and characterization of the MOF and evaluation performance. Academia should desirably be equipped with processing facilities such as pressure reactors and characterization facilities including BET surface area analyser, Single crystal XRD, FESEM, Electron Paramagnetic Resonance (EPR), $^{129}Xe$ Nuclear Magnetic Resonance | |
| E 20 | **Sub Area** | **Hybrid photovoltaics (VSSC)** |
| E 20.1 | **Development of perovskite based photovoltaic cells (VSSC)**<br>Development involves the synthesis and characterization (chemical, optical, | |

| | | |
|---|---|---|
| | photo physical and morphology) of the Perovskites having general formula ABX3 (A- alkyl ammonium cations, B-divalent metal and X-Halogens). The developed perovskites is to be evaluated as active layer on a scaffold in photovoltaic devices with an expected efficiency of 10-15%. Facilities including spin coating machine, muffle furnace are essential for device fabrication and solar simulator and source meter are desirable for photovoltaic evaluation. | |
| **E 21** | **Sub Area** | **Shape Fillers (VSSC)** |
| **E 21.1** | **Development of shape controlled inorganic fillers for thermal interface materials (VSSC)**<br>Thermal interface materials are very critical for the miniaturization of electronic components. In order to enhance the thermal conductivity of the interface thermal pad, conductive fillers like alumina and boron nitride are being use. The shape of fillers significantly contributes to the thermal conductivity. The objective is to synthesise the platelet and spherical shaped fillers and development of electrically insulated thermal pad . | |
| **F** | **Area** | **Tranducers and sensors (LPSC)** |
| **F1** | **Fibre optic sensors (LPSC)** | |
| **F2** | **$O_2$ & $CO_2$ gas sensors and development of graphene based sensors (LPSC)** | |
| **F3** | **Nano technology for pressure & strain sensors (LPSC)** | |
| **F4** | **Development of nano technology based Gas sensor (both presence & % quantity) (LPSC)** | |
| **G** | **Area** | **Structures and Fabrication (LPSC)** |
| **G1** | **Experimental evaluation of damping in fluid conveying pipelines immersed in fluid environment (Both theoretical empirical relation & Experiments) (LPSC)** | |
| **G2** | **Crack growth studies in propellant tanks through experiments & theoretical modelling (LPSC)** | |
| **G3** | **Electrical Discharge machining/ Die Sinking (EDM) (LPSC)**<br>Optimization of machining parameters for machining of following super alloys: Titanium Ti6Al4V, Inconel 600 / 718, Hynes-25, Molybdenum, Columbium 103. | |

| | | |
|---|---|---|
| G4 | **Optimization of machining parameters required for drilling of miniature holes of size less than dia 1.0mm with large L/D ratio of 100 in above super alloys (LPSC)** | |
| **H** | **Area** | **Avionics (VSSC)** |
| **H 1** | **Sub Area** | **Three phase motor driver (VSSC)** |
| **H 1.1** | **Direct Approach of generation for three phase motor driver by multi level inverter with reduced computational complexity (VSSC)**<br>This is a direct method for the generation of Space Vector Pulse Width Modulation (SVPWM) for any general *n-level* inverter. This method directly determines the switching states and coordinates of the switching vectors from the instantaneous amplitudes of the three phase reference signals. These direct relations emerge as a consequence of representing the reference vectors and switching vectors in the sixty degree coordinate framework. This also avoids fractional values as coordinates of the switching vectors. In this work a method is also proposed to compute the duration of the gating signals directly from the switching vectors without any mapping. The proposed method does not need any sector identification and can be used for any general *n-level* inverter. | |
| **H 2** | **Sub Area** | **ASIC Technology (VSSC)** |
| **H 2.1** | **Custom ASIC design of asynchronous RISC processor (VSSC)**<br>As the ASIC technology scaling continues, the effect of leakage and dynamic power consumption of the CMOS gets more consideration. Moreover the clock requirement for the new designs goes on increasing although the majority of the internal logic does not clock in the same speed. In such scenarios, the use of asynchronous circuit design gains importance. | |
| **H 2.2** | **Mixed signal ASIC (VSSC)**<br>A mixed signal IC combines analog and digital circuits on a single die. The analog portion involves ADCs, amplifiers, voltage reference and multiplexers, which are used to receive signals from the real world and convert them for interfacing with the digital logic in the IC. The digital logic usually consists of a microcontroller, which operates on the digital inputs and provides control outputs. The control outputs are fed to a DAC to obtain analog signals which complete the feedback loop. The microcontroller has internal memories and standard serial interfaces. | |
| **H 3** | **Sub Area** | **Floating Point Unit (VSSC)** |

| | | |
|---|---|---|
| H 3.1 | **Pipelined IEEE 754/ IEEE 854 compliant Floating Point Unit (VSSC)**<br>The FPU should capable of handling Single precision, double precision and Quad precision floating point numbers. It should be complaint to both IEEE 754 and IEEE 854. The pipeline feature is intented for high throughput computations which eliminates the pipeline processor stalls. It should handle all the special numbers specified in the standard and also generate the specified exceptions | |
| H 4 | **Sub Area** | **Indigenous FPGA (VSSC)** |
| H 4.1 | **Indigenous FPGA (VSSC)**<br>Due to the embargo issues it is required to design an Indigenous anti fuse FPGA in-house for the future ISRO missions. The design involves the following steps.<br>Universal logic cell design<br>Creating synthesis library<br>Programmable interconnect design<br>Modeling programmable interconnect<br>Place and route software tool development<br>FPGA fabrication<br>FPGA programmer hardware and software development | |
| H 5 | **Sub Area** | **On-board Computer (VSSC)** |
| H 5.1 | **Indigenous on-board computer VIKRAM1601 hardware accurate software model (VSSC)**<br>A faster hardware accurate software models for VIKRAM1601 is required for plugging into checkout systems for doing software validation (SIP) of integrated flight software. This eliminates the requirement of hardware packages during software testing. | |
| H 6 | **Sub Area** | **MEMS Acoustic Sensor (VSSC)** |
| H 6.1 | **Design, fabrication, testing and realization of a MEMS Acoustic Sensor (VSSC)**<br>This project aims to realize a MEMS acoustic sensor. The deliverables are realization of design, usage and optimization of processing technology, fabrication of functional devices, packaging and testing with requisite signal processing electronics. Specifications of the sensor are: | |

| | | |
|---|---|---|
| | • Structure : Bulk-micromachined<br>• Sensing technology : Piezoelectric<br>• Range (SPL) : 100dB – 180dB Sound Pressure Level<br>• Frequency response : Within ±2dB over 20Hz to 8kHz<br>• Linearity : ±1dB<br>• Operating temperature : -55 to +125°C | |
| **H 7** | **Sub Area** | **MEMS Accelerometer (VSSC)** |
| **H 7.1** | **Design, fabrication, testing and realization of a capacitive, MEMS Accelerometer (VSSC)**<br>This project aims to realize a MEMS accelerometer. The deliverables are realization of design, usage and optimization of processing technology, fabrication of functional devices, packaging and testing with requisite signal processing electronics. Specifications of the sensor are:<br>• Structure : Surface-micromachined<br>• Sensing technology : Capacitive<br>• Range : 5g<br>• Frequency response : DC-200Hz<br>• Linearity : < ±1%<br>• Control : Closed loop<br>• Operating temperature : -55 to +125°C | |
| **H 8** | **Sub Area** | **MEMS Shock Sensor (VSSC)** |
| **H 8.1** | **Design, fabrication, testing and realization of a MEMS Shock sensor (VSSC)**<br>This project aims to realize a MEMS Shock sensor. The deliverables are realization of design, usage and optimization of processing technology, fabrication of functional devices, packaging and testing with requisite signal processing electronics. Specifications of the sensor are:<br>• Structure : Bulk/Surface-micromachined<br>• Sensing technology : Piezoresistive<br>• Range : 1000g<br>• Frequency response : DC-8kHz | |

| | | |
|---|---|---|
| | • Linearity : 2%<br>• Control : Open loop<br>• Operating temperature : -55 to +125°C | |
| **H 9** | **Sub Area** | **Programmable Power Supply (VSSC)** |
| **H 9.1** | **Design, fabrication, testing and realization of Programmable High Voltage Power Supply (Programmable HVPS) (VSSC)**<br>The project aims at design and development of programmable High voltage power supply. The Programmable HVPS has 5V as input voltage. There is also a reference input which determines the output voltage. There must be multiple outputs and the voltages must be programmable from -5kV to 5kV and must vary proportionally with input reference voltage. Specifications of programmable HVPS are:<br>Voltage input : 5 V<br>Voltage output : -5kV to 5kV, multiple outputs but Proportional to input reference Voltage.<br>Reference input : 0 to 5V range<br>Power output : < 5W<br>Card Size : 80mm x 80mm approximately<br>Operating Temperature : -55°C to 125°C | |
| **H 10** | **Sub Area** | **On-board Flight Software (VSSC)** |
| **H 10.1** | **Formal Methods for Flight Software Specification and Verification (VSSC)**<br>Formal methods for software specification and verification are based on mathematical methods and offer a more rigorous approach for software development and verification. In order to ensure consistency of requirements and provide proof of correctness, formal methods are to be used to supplement the traditional techniques followed for specification and verification of flight software for launch vehicles. | |
| **H 11** | **Sub Area** | **Modelling of On-board Software (VSSC)** |
| **H 11.1** | **Model-based Software Development for Safety-critical systems (VSSC)**<br>Model-based approach to Software Development involves a mathematical | |

| | | |
|---|---|---|
| | and visual method of addressing problems associated with designing complex systems. It provides a common design environment for all development agencies, facilitates rapid proto-typing and early detection of errors as well as design re-use. One of the safety-critical elements of flight software is to be developed using the model-based software development paradigm, as a pilot project. | |
| **I** | **Area** | **Safety Engineering (SDSC-SHAR)** |
| **I 1** | **Design of Fire Alarm and detection system for hazardous building based on Smoke Modeling (SDSC-SHAR)** | |
| **I 2** | **Probabilistic Risk Analysis using safety management techniques for liquid propellant storage facilities (SDSC- SHAR)** | |
| **I 3** | **Consequence modeling : Analysis of failure of high pressure or high explosives systems and estimating the impact on other systems(SDSC- SHAR)** | |
| **I 4** | **Dispersion analyses of solid rocket motor exhaust gases (SDSC-SHAR)** | |
| **I 5** | **Dispersion analysis of liquid propellant leakage or spillage scenario (SDSC- SHAR)** | |
| **I 6** | **Study on failure mode of high pressure systems and its impact/effect on other systems (SDSC- SHAR)** | |
| **I 7** | **Study on failure mode of explosives/Propellant systems and its impact/effect on other systems (SDSC- SHAR)** | |
| **I 8** | **Study on inerting/neutralizing techniques for eliminating the pollution vapors from a system for making it safer for normal operations (SDSC- SHAR)** | |
| **I 9** | **Fire Detection Modeling studies (SDSC- SHAR)** | |
| **I 10** | **Analysis of smoke movements in high bay areas using computer models (SDSC- SHAR)** | |
| **I 11** | **Analysis of electrostatic hazards to rocket motor and high Explosive systems (SDSC- SHAR)** | |
| **I 12** | **Modeling and simulation studies on explosion and fire ball effects (SDSC- SHAR)** | |

| | | |
|---|---|---|
| I 13 | Fire Modeling using CFD (SDSC -SHAR) | |
| I 14 | Study of Maximum allowable RF and laser power in the vicinity of solid propellant with and without igniter (SDSC- SHAR) | |
| I 15 | Design and development of Indigenous Digital safety ohmmeter for launch vehicle Pyro measurements (SDSC- SHAR) | |
| J | Area | Gravity Gradiometer (IISU) |
| J1 | Design and Development of Gravity Gradiometer using atom interferometry techniques in a double MOT set up with laser cooled Rb atoms (IISU) | |
| K | Area | Precision Relative Navigation and Attitude reference System (IISU) |
| K 1 | High precision relative navigation and attitude reference system for space docking experiment (IISU)<br>Design, Development and Qualification of a Fully Autonomous Videometer based high precision relative navigation and attitude reference system for space docking experiment – system consisting of retro reflectors, illuminators, camera, complex image processing algorithms involving state observers, filtering algorithms, etc. for range, range rate, Line Of Sight (LOS), relative attitude determination. | |
| L | Area | Ultrasonic Motor (IISU) |
| L 1 | Design of compact ultrasonic motor for micro actuators (IISU) | |
| L 2 | Design of a micro manipulator which uses the ultrasonic motor (IISU) | |
| L 3 | Development of an ultrasonic motor including fabrication techniques, manufacturing, development of excitation electronics (IISU) | |
| L 4 | Assembly of the motor with the manipulator and demonstration of the same(IISU) | |
| M | Area | Smart PCBs - Stress Strain Sensitive Films (IISU) |
| M 1 | Design of multilayer PCB with integral stress/strain sensitive films (IISU) | |

| | | |
|---|---|---|
| M 2 | Development of the strain/stress sensitive film embedded PCB (IISU) | |
| M 3 | Demonstration of the insitu stress measurement during vibration of the randomly populated SMART PCB, in the vibration shaker (IISU) | |
| N | Area | Accelerometer (IISU) |
| N 1 | Design of compact microwave cavity resonator (IISU) | |
| N 2 | Design of compact microwave cavity resonator with One of the sides (wall) movable (IISU) | |
| N 3 | Design of the movable wall which is sensitive only to Acceleration. Acceleration induced changes in the dimension of the cavity alters the resonance frequency (IISU) | |
| N 4 | Design of microwave excitation and detection schemes for the above resonator (IISU) | |
| N 5 | Development of cavity resonator and microwave electronics (IISU) | |
| N 6 | Development of fabrication technology for realizing the microwave cavity resonator (IISU) | |
| N 7 | Development of compact electronics including microwave generator, and detector (IISU) | |
| N 8 | Assembly of microwave cavity resonator with the electronics (IISU) | |
| N 9 | Demonstration of accelerometer principle (IISU) | |
| O | Area | Vision Aided Inertial Navigation System - Image Processing (IISU) |
| O 1 | To extract Range, Range Rate & Angular Rate from Image Sequence for Autonomous Navigation using Vision Sensors (IISU) | |
| P | Area | Launch Vehicle Tracking System (SDSC-SHAR) |
| P 1 | Monopulse Feed with multi polarization for tracking Radars (SDSC-SHAR) | |
| P 2 | Pulse compression algorithms for signal processing in Radars (SDSC - SHAR) | |

| | | |
|---|---|---|
| **P 3** | **Doppler estimation algorithms to cater for very low velocity (5m/sec) to very high velocity (10 km/sec) targets and also acceleration of the order of 1km/sec/sec by using pulse compression (SDSC- SHAR)** | |
| **P 4** | **Shock waves in transonic zone effect on RF signals and its impact on Radar tracking (SDSC- SHAR)** | |
| **P 5** | **Extracting the signal information from IR video during cloudy and noisy environment (SDSC- SHAR)** | |
| **P 6** | **Application of Artificial Neural Networks for processing radar data- Noise estimation, Identification of processable segments based on signal strengths, Estimation of the trajectory from multiple radar track data (SDSC- SHAR)** | |
| **P 7** | **Electromagnetic testing of radome (radar dome) panels to estimate the loss & impedance matching at the junction of the panels (SDSC- SHAR)** | |
| **P 8** | **Knowledge-based Range safety aid using Simulated flight data (Track and Telemetry data) as well as previous flight data (SDSC- SHAR)** | |
| **P 9** | **Safety in using Laser Range Finder for launch vehicle tracking and also for personnel operation (SDSC- SHAR)** | |
| **Q** | **Area** | **Launch Pad (SDSC-SHAR)** |
| **Q 1** | **Residual life Assessment (RLA) of Launch Pedestal (LP) :- Estimation of residual life of the existing LP and validation of the results by using NDT(SDSC- SHAR)**<br>First Launch Pad at SDSC-SHAR was originally conceived and designed in mid eighties for the loads due to PSLV launch and has been in service since then. Subsequently, the same Launch Pad was used for GSLV launch also, due to which the Launch Pad was subjected to additional dynamic loads from t-3 seconds onwards due to strap-on firing. First Launch pad is operational since 1993. Now action is being initiated to realize a new Launch Pad. The remaining life of the existing Launch Pedestal has to be assessed | |
| **Q 2** | **Vibro Acoustics: Study on the acoustic induced vibrations on Launch Pad/ launch vehicle (SDSC- SHAR)** | |
| **Q 3** | **Light weight fast retractable cryo arms with highly reliable mechanisms to mount on movable Umbilical Tower (For Third Launch** | |

| | |
|---|---|
| | **Pad) (SDSC- SHAR)** |
| **Q 4** | **To study the methodology to establish effectiveness of launch pad Lightening Protection System in the Launch Complex Area (SDSC-SHAR)** |
| **Q 5** | **Analysis of Lightening discharge data of lightning protection systems (SDSC- SHAR)** |
| **Q 6** | **Acoustic Suppression System at Launch Pad: Prediction of Acoustics with water suppression on the launch Pad using CFD analysis (SDSC-SHAR)**<br>A theoretical model has to be developed with water suppression system for prediction of noise in the vicinity of launch vehicles with mobile launch pedestal, Umbilical tower and LVM3 launch vehicle<br>The effectiveness of the launch pad acoustic suppression system can be predicted virtually with the realized parameters and can also be validated during Vehicle lift off. |
| **Q 7** | **Acoustic Suppression System at Launch Pad: Characterization of Hydraulic transients/surges in hydraulic pipeline systems meant for Acoustic suppression system and validation (SDSC- SHAR)**<br>To study propagation of pressure waves occurring due to valve closure/opening, trip or any disturbance in the flow. Sizing of surge protection equipment to attenuate the pressure waves generated in the pipe flow. |
| **Q 8** | **Acoustic source localization using microphone array technique by employing beam-forming algorithm and finding the major jet noise sources during lift-off from launch pad (SDSC- SHAR)** |
| **Q 9** | **Strain gauge based structural health monitoring (SHM) of large structures like launch pedestal, umblical tower, VAB etc. (SDSC-SHAR)** |
| **Q 10** | **Experimental validation of Statistical energy analysis (SEA) for random vibration response of flight packages mounted on launch vehicle equipment bay deck (SDSC- SHAR)** |
| **Q 11** | **Multi-objective design optimization of launch pad for reducing the plume impingement load, acoustic load on the launch vehicle and construction cost of the launch pad (SDSC - SHAR)** |

| | | |
|---|---|---|
| **Q 12** | **Expert System for Launch Vehicle Preparation and Servicing (SDSC-SHAR)**<br>SDSC-SHAR has huge volumes of vital data on all fronts-process, raw materials, equipments, maintenance, qualification, clearances etc. are now available , in various report,document forms.But these data chunks are maintained in individual facilities , as soft copies,in stand alone mode.It will be very beneficial, if such rich storehouse of data is put into appropriate Expert System software package, so that the intelligence is accessible to process engineeers ,readily at hand.Such Intelligent tool will supplement the efforts of process Engineers and facilitate better process management. | |
| **Q 13** | **Launch Vehicle lift off Environment measurement system (SDSC-SHAR)** | |
| **Q 14** | **Ignition Over Pressure characteristics (IOP) during the launch vehicle lift-off and suppression (SDSC- SHAR)**:- Prediction of IOP. Effect of water addition on IOP suppression | |
| **Q 15** | **Computational Studies on Third Launch Pad Jet deflector configuration (SDSC- SHAR)** | |
| **R** | **Area** | **Testing of Liquid Propulsion Systems (IPRC)** |
| **R 1** | **Theoretical and Experimental studies on flow characteristics during changeover of flow from start-up tank to run tank during liquid rocket engine testing (IPRC)**<br>In a new cryogenic engine test facility, LH2 & LOX start-up tanks are used to simulate the engine start transient of flight for duration of 10s. During this phase, the start-up tanks will be at a pressure of about 0.4 MPa. Subsequently, the propellant feeding to Engine is changed over to run tanks having a pressure of about 0.7 MPa. | |

| | |
|---|---|
| | All the main run tanks are proposed to be installed in ground and engine is mounted at 10m level platform. Hence propellant feed circuits are run for long distances which lead for more pressure drop in feed circuit and higher MEOP of run tanks. But initial stagnant pressure in the upstream of facility isolation valve before opening shall be very close to the required engine inlet pressure to avoid any damage to the hardware. Considering this aspect, the feed circuits are sized accordingly and proposed start up tanks in the engine platform. Feed circuit piping systems are planned in such a way that feed circuits of start up tank and main run tank form a junction and are isolated by valves.<br><br>**Plan of feeding propellants for test**<br><br>During test, initially propellants will be allowed to flow from respective startup tanks. Once steady state is achieved, valve prior to the junction in main feed circuit will be opened and valve prior to junction in the startup feed circuit will be closed simultaneously. This will allow propellant to flow from main run tanks till end of the test.<br><br>**Problem**<br><br>Point to be noted here is that before opening the valve prior to the junction in main feed circuit, the stagnant pressure in the circuit is equal to MEOP of run tank which is higher than the static pressure of propellants flowing from startup tank to engine. When the above valve is opened to make the propellants to flow from main run tanks, there will be a chance of sudden surge in flow parameters in the piping segment between the junction and engine inlet. Hence, the flow characteristics have to be studied during this change over in terms of flow & pressure oscillations, temperature variations, effect on Engine performance etc. This would help in understanding the process and to program the flow control accordingly without affecting the engine performance. Analysis shall be carried out for different type of valve stems & Cvs and by considering different valve response time. For initial analysis, valve with size of DN150, globe pattern & Cv of 440 shall be considered for LH2 system while size of DN200, globe pattern & Cv of 760 shall be considered for LOX system |
| **R 2** | **Design, Analysis and Development of two stage Ejector for LOX tanks (IPRC)**<br><br>The LOX in run tanks have to be sub-cooled to a temperature of about 76 K for Engine testing. To achieve this temperature, the pressure in the ullage volume has to be brought down to a level of < 70 mbar. Presently single stage ejector is used by which a vacuum pressure of about 150 mbar only could be achieved. Hence, two stage ejectors need to be designed for achieving lower vacuum levels. |

| | |
|---|---|
| **R 3** | **Design, Analysis and Development of Nozzle Protection System (NPS) for sea level testing of CE20 Engine with A/R 100 (IPRC)**<br><br>The flight configuration of CE20 engine has an area ratio (A/R) of 100. Currently the CE20 Engine with A/R 10 is tested at Sea level while the acceptance testing of Engine with A/R 100 is planned in High Altitude Facility (HAT) mode at TCT-HAT facility. Since each flight Engine has to be acceptance tested for duration of 100 s, preparation of HAT facility for each test is economically not viable. Hence, it is planned to conduct the sea level testing of flight CE20 Engine with Nozzle Protection System (NPS). The NPS has to be designed, analyzed and developed considering the flow and dimensional features of CE20 Engine. |
| **R 4** | **Development of Data Management System for effective monitoring of various systems of large liquid rocket engine test facility (IPRC)**<br><br>A liquid rocket engine test facility consists of various fluid systems such as propellant fill, feed, drain systems, and Service fluid systems. All such system composed of various piping systems with flow components, pressure vessels, heat transfer equipments, safety equipments, instruments & gauges etc. Each fluid system has numerous numbers of flow components with specification for each component. For the test facility to be ready for testing and in serviceable condition all the above need to be maintained, tested and calibrated within the periodicity specified for the equipment/components concerned. Safety & ISO norms also insist this.<br><br>Considering voluminous data to be maintained & periodically updated and higher no. of equipments/ components at ICET, a user friendly **"Data management System"** for maintenance of records and for periodic updating of records is essential. This system shall have provision for data entry, edit, update, store, retrieve, presenting in the form report, print etc. Also, it shall have flexibility to add other test facility systems with similar features. |
| **R 5** | **Studies on establishment of collapse factor for different dwell periods of run tanks under pressure & expulsion (IPRC)**<br><br>- For CUS & CE20 Engine tests at ICET, the pressurization modes of tanks are different as follows.<br><br>- For CUS engine tests, the LOX & LH2 run tanks are pressurized with GN2 & GH2 respectively at 0.3 MPa and held for a period of approximately 2 hours (to carry out chilling of facility feed lines). Then at the same pressure, the expulsion of respective propellants is executed (for test) at requisite flow rates for a duration of 1000 s. |

| | |
|---|---|
| | - For CE20 engine tests, the tanks are pressurized to the same value & duration as in CUS engine tests during chilling and for test, the pressure is raised to 0.6 MPa and propellants are expelled for 800 s.<br><br>This variation in operational procedure calls for different assumption of saturation temperatures, pressurant temperature in ullage and thereby varying film temperatures. The variation in collapse factor considering the tank dimensions, propellant flow rates, dwelling period, pressurant temperature is to be studied for estimation of exact pressurant requirements. |
| **R 6** | **Establishment of polytrophic index for expansion of gas (GH2 & GN2) in storage cylinders during expulsion at high flow rate (IPRC)**<br><br>Pressurant gases such as GN2 & GH2 stored under high pressure in gas cylinders are withdrawn at various flow rates to pressurize the facility tanks. The pressurant flow rates vary depending upon the rate and duration of propellant expelled from the tank for the test at various phases of test operations. The expansion of gases in cylinders during these phases is neither isothermal nor isentropic and the index of expansion is to be established for understanding the expansion phenomena and for deriving the pressurant flow rates required for expulsion. |
| **R 7** | **Modeling, Analysis and Development of Double walled Jacketed type flame deflector for a liquid rocket test facility (IPRC)**<br><br>Lame deflector is an important element of a rocket engine test facility to protect the test facility structure and equipments from the high momentum and high temperature engine exhaust plume. Many types of flame deflectors are in use worldwide. In ISRO conventional dry plate heat sink deflector with external water spray is used. An attempt was taken to guide the flame through a water spray duct, which shows a better result. Based on literature survey, it is found that **Double walled Jacketed type flame deflector** will be more efficient, compact and cost saving**.** The constructional feature of this type of flame deflector is that it is of 'J' shape and the flame is made to hit at an appropriate angle vertical to the deflector. An annular space as jacket is formed between two mild steel plates. The entire deflector shall be made into many segments. Water enters into the jacket of each segment of the deflector at its bottom through pipes. At the top surface holes of appropriate size are drilled and distributed to ensure proper cooling of the deflector plate so that it will not distort during testing. During testing water will be supplied into the deflector and injected into the flame as fine spry through the minute holes. By doing this water is converted into super heated steam and act as a thermal barrier between the deflector and flame. |

| | |
|---|---|
| | The objective of this proposal is to finalize a deflector with suitable configuration, modeling and analysis for a given rocket engine parameters. The result of analysis shall include optimum impingement depth of jet, deflector size, segment size, total water flow rate, size of hole, total number of holes, hole distribution, water flow rate per hole, distribution pattern, temperature of plate without water cooling & with water cooling, annular space, thickness of top & bottom plates etc. A modular thermo structural analysis and proto type deflector testing with actual rocket exhaust shall be needed for implementation. |
| **R 8** | **$N_2O_4$ GEL elimination (IPRC)**<br>Satellite thrusters are being tested in HAT mode for performance evaluation. Normally $N_2O_4$ is used as oxidizer for testing purpose. N2O4 is always having a nature to form nitrosyl tetranitratoferrate (NTNF) in contact with stainless steel container (tanks). This is called as gel which will block the micro passage of the engine injector. A study on this subject for prevention will be useful. |
| **R 9** | **Design and development of dynamic pressure sensor (IPRC)**<br>Dynamic pressure measurements are essential to find and analyze the dynamic response of the propellant combustion under the operating condition of the Rocket/Spacecraft engines. The investigated results are correlated to combustion stability and engine efficiency. Presently, piezoelectric/piezo resistive water cooled dynamic pressure sensors are being used. These sensors are imported from the manufactures viz. PCB, kulite, keller etc. cooling of these sensors are mandatory during the measurements as the pressure port is in direct contact with the thrust chamber. Also, the piezoelectric type sensor gives only the dynamic pressure response, making it difficult to clear for the test as there is no ambient available.<br>The advanced technical approaches using fibre Optic, MEMS and nano technologies may be attempted to design suitable dynamic pressure sensors for our requirements. A better prediction of the level of combustion instability can be achieved with these types of sensors which can withstand higher temperatures also. A parametric study of the theoretical results as well as the comparison with the existing experimental data shall be carried out to qualify the designed sensor. |

| | |
|---|---|
| **R 10** | **Detection of hazardous environment and its mitigation using wireless sensor networks (IPRC)**<br><br>Earth storable hypergolic propellants are used for propelling the rocket and satellite engines at IPRC facilities. These propellants are highly toxic and hazardous. Hence, monitoring leakage of these propellants during the storage, transportation, filling and draining operations at the test stands and during the hot test activities is very much essential. As the remote storage facilities and test stands are not continuously manned, 24x7 monitoring is essential to correctly detect the leakages if any, and to mitigate the effects (fire, explosion etc), in the quickest possible time.<br><br>Wireless sensor networks supported by data fusion techniques can be employed to precisely determine the exact location and severity & the hazard without fear of any false alarm possibility. GIS (Geographical Information System) aids this scheme to identify the exact location of the incident and helps to alert the concerned personnel with the aid of GSM/GPRS message in real time. The mitigation activities depend on the severity of the incident and the facilities available/planned for the mitigation. |
| **R 11** | **Analysis of rocket propulsion test data using data fusion techniques (IPRC)**<br><br>A huge chunk of recorded data is available in the database for each engine. But data analysis is mostly carried out on individual subsystem or location wise and sometime it becomes difficult to correlate the performance with respect to other subsystems. A collective decision about the performance of the engine as a whole has to be arrived by analyzing the different parameters at different locations with the aid of data fusion techniques. This analysis will throw light into the engine performance as the failure or tending to fail of a particular subsystem or component influence the performance of another subsystem/component, during the course of the testing or series of tests. |
| **R 12** | **Thermo-Structural Analysis of 16 inch diameter, 130m long Liquid Oxygen pipe line during chill down process (IPRC)**<br><br>Semi cryo integrated Engine Test Facility is being established at IPRC for testing Semi cryogenic Propulsion Systems. During static testing of Engine, Liquid Oxygen is fed to engine from facility tanks through a feed circuit. Feed circuit consists of super insulated cryogenic pipe lines, fittings and vacuum jacketed valves. Feed line of size 16”, 40 Schedule made of |

| | |
|---|---|
| | Stainless Steel grade 304L is planned to feed Liquid Oxygen at the rate of 550 kg/s. Liquid Oxygen is to be fed to the engine precisely at a pressure of 0.7 MPa and temperature 90 K. To meet this requirement, the feed line is to be chilled from ambient condition to fluid temperature before feeding. Two modes of chilling are planned. Thermo-Structural analysis of pipe line during chill down is to be carried out for the both modes:<br><br>1. Chilling of feed line by allowing Liquid Oxygen at controlled flow rates into the feed line at one end and venting out vapors at other end. Liquid Oxygen in the feed line evaporates by taking heat from feed line and thereby temperature of feed line reduces. This process is continued until temperature of the feed lines reaches fluid temperature. This mode induces uneven stress distribution along the periphery of pipe due to the presence of low temperature liquid at bottom portion and vapor at relatively higher temperature at the top and causes thermal stresses & bowing effects in feed line. These effects are to be studied and method of chilling in controlled way is to be finalized by simulation & validation through experimental results<br><br>2. Provision is made for chilling of feed line by allowing low temperature gaseous Nitrogen in a controlled way. This mode will limit thermal stresses induced in feed line and bowing effects. This method is to be analyzed and method of chilling in controlled way is to be finalized by simulation & validation through experimental results. |
| **R 13** | **Design and Development of Stirling Cryogenic Cooler (IPRC)**<br><br>IPRC uses Liquid Nitrogen for pre cooling and Gaseous Nitrogen for inertization, media substitution and ejector operations. Liquid Nitrogen is stored in LIN storage Tank/Tankers of capacity 10 KL to 75 KL. The Boil off vapour in storage tank or in the Air Separation Units can be liquefied by incorporation of Stirling Cryogenic Cooler. Initially it is proposed to develop a cooler with cooling capacity of 500 W at 77K |
| **R 14** | **Rocket Engine Test Article Measurements of low Varying parameters using Wireless Sensor Networks (IPRC)**<br><br>Rocket motors use liquid fuel, Solid fuel, cryogenic and semi-cryogenic propellants depending upon the mission requirements and are designed for specific applications. Different instrumentation sensors used are pressure transducers strain gauges, thermocouple, RTDs, flow meters, accelerometers and micro phones. As per the requirement the sensors are selected and mounted on the rocket engine at specific locations. Right now these sensor's' data are transmitted to the control centre with a aid of hard-wired cables and lot of problem are faced in maintaining these cables to get |

| | |
|---|---|
| | error free data at the control centre.<br><br>The requirement of this project is to get rid of these cables which amount of 100s of kilometers in length altogether. These measurement data is to be acquired with the aid of wireless sensors and the new data/processed data only need to be transmitted to the control centre using wireless Ethernet, zig-bee or GSM technologies. We expect moderate data relates upto 2000 samples/parameter to get meaningful representation of the measured parameters suitable software to be developed to acquire, format out transmit test data, receive and strip the test data, process and analyze the test data etc. |
| **R 15** | **Data Processing and Analyzing of Earth Storable Liquid propulsion Rocket Engine Test data using Data Mining Techniques (IPRC)**<br><br>The performance of rocket engine can be examined through the processing of acquired test data, and the buildup of different parameter models. We have a good collection of Earth Storable Liquid propulsion rocket engine static test data. Data mining techniques can be adopted to analyze the test data. The technique may involve de-noising the parameter values without losing the useful information. Mathematical and statistical analysis to be carried out and the advantages of frequency domain and wavelet transformation to be exploited to arrive at a conclusion about the health and performance of the rocket engines in comparison with the similar hardware tested earlier. |

# 3.0 Satellite Communications Programme

| | | |
|---|---|---|
| **A** | **Area** | **SATCOM Technology (SAC)** |
| **A 1** | **Sub Area** | **SATCOM and SATNAV Architectures (SAC)** |
| **A 1.1** | **Studies related to NavIC (IRNSS) system (SAC)** | NavIC (Navigation Indian Constellation), Indian Regional Navigation Satellite System has been operationalized. With the above system there is a need to build up understanding on how best it can be leveraged to support existing and novel applications, and also to look ahead towards the future evolution of the system itself. This opens up a host of interesting problems for research and study, such as:<br>• Integration of IRNSS signals with existing GNSS signals at the receiver level to demonstrate the inter-operability.<br>• Use of IRNSS signals for navigation with “signals of opportunity” of terrestrial networks.<br>• Systems studies can be undertaken for autonomous satellite navigation, eliminating the need of ground support.<br>• The applicability of bandwidth efficient modulation schemes such as GMSK, APSK etc for satellite navigation systems.<br>• Development of simulation tools for situation awareness for navigation end users supporting their mission planning. Such tools will consider the complete navigation systems and provide the information about the system accuracy, availability, integrity and reliability for any operational situation. |
| **A 1.2** | **Systems simulation of advanced multibeam SATCOM systems (SAC)** | The simulation of multibeam satellite systems for broadband and mobile applications involves scenario definition, computation, and visualization challenges. The spatial variation of different parameters such as atmospheric conditions, receive and transmit antenna gain and traffic necessitate stochastic computation of satellite throughput. The simulation scenario definition involves the definition of coverage, antenna patterns, channel, and traffic conditions. In case of dynamic simulations, which offer a more realistic view of system behavior, one or more of the above given parameters vary with time, thus increasing simulation complexity manifold.<br>The different forms of throughput and capacity estimation also require computation over large number of geographic points across different |

| | |
|---|---|
| | scenarios, and subsequent optimization of payload configuration.<br>Research areas in this direction are:<br>• Spatio-temporal simulation of traffic and channel conditions such as rain fields<br>• Tools for computation and visualization of different performance parameters across coverage<br>• Incorporation of physical layers of different standards such as DVB-S2, DVB-S2X and DVB-RCS2, along with capacity optimization algorithms like Adaptive Coding and Modulation (ACM) and Dynamic Rate Adaptation (DRA.) |
| **A 1.3** | **Architectures and algorithms for AIS receivers onboard LEO and GEO platforms (SAC)**<br>The Automatic Identification System (AIS) is based on VHF radio transmissions of ships' identity, position, speed and heading, in addition to other key parameters. AIS, in its original form, are a terrestrial system. In space based AIS (SB-AIS), satellite receives AIS messages transmitted from the ships and relays the signals to the ground station. In terrestrial mode, AIS operates in Self Organized Time Division Multiple Access (SO-TDMA) scheme. The challenges involved in space based AIS are large number of SO-TDMA cells in satellite field of view and large number of uncoordinated messages from ships belonging to different SOTDMA cells in same time slots. It results in decrease in ship detection probability.<br>The research areas in this field include the algorithms development to improve the ship detection probability in presence of intra/inter system interference and miniaturization techniques for on-board hardware to meet the constraints for hosted payload. |
| **A 1.4** | **Algorithms and techniques for dynamic resource allocation in multibeam mobile and broadband satellites (SAC)**<br>Multibeam satellites offer the prospect of dynamic allocation of resources (power and bandwidth) across the coverage, based on geographical and temporal variation in demand. The demand variation may be a result of varying channel conditions (e.g. rain), or traffic variations. Similarly, the reuse plan may be made dynamic to accommodate varying frequency allocations.<br>Research areas in this direction include:<br>• Strategies for resource allocation while maintaining desired QoS across different beams. This includes consideration of increased |

| | |
|---|---|
| | interference to other beams while power/bandwidth in certain beams is increased.<br>• Use of resource allocation as a technique for fade mitigation in the EHF bands. This is an area of significant interest considering the tropical climate in the Indian region.<br>• Identifying and developing onboard technologies for enabling transfer of resources from one beam to another. Currently, technologies for power distribution, namely multiport amplifier and flexible TWTA are under investigation. Other options, for power and bandwidth flexibility can be explored. |
| **A 1.5** | **Investigation of channel models for S-band geo-mobile system (SAC)**<br>The link performance of conventional satellite systems is well established on the account of simple AWGN channel in line of sight communication. However, the development of geo-mobile system, with user services in urban, rural and metropolitan areas, shall require consideration of shadowing and multipath channels. Some models for L-band and S-band land mobile satellite (LMS) channels are available.<br>Research areas in this direction are:<br>• Channel modeling over Indian regions and desired frequencies. A comprehensive propagation model will allow accurate dimensioning of the payload system, thereby resulting in optimized implementation.<br>• Propagation characteristics for hybrid space/ground mobile system |
| **A 1.6** | **Hybrid Satellite Terrestrial Network (SAC)**<br>With satellites becoming capable of providing services to handheld terminals, it is envisaged that a hybrid network with terrestrial and satellite systems complementing each other shall be developed.<br>Research areas in this direction are:<br>• Investigation of possible satellite –terrestrial system architectures<br>• Handover strategies and related protocol modifications<br>• Physical layer design for simultaneous operation of satellite and ground component considering different channel characteristics |
| **A 2** | **Sub Area** — **Active RF and Microwave Circuits and Subsystems (SAC)** |
| **A 2.1** | **Development of temperature dependent models of PHEMTs, MHEMTs and InP HEMTs, their validity at cryogenic temperatures** |

| | |
|---|---|
| | **and application in design of LNAs for DSN in S, X and Ka-band (SAC)**<br>Presently limited data and models are available for simulation of active microwave circuits over temperature range including cryogenic temperatures. Circuits are designed at ambient and their response is studied practically at these temperatures. If proper models of basic devices are available over temperature and Ku frequency of operation, it will be helpful in designing circuits optimized for cryogenic temperatures. |
| **A 2.2** | **Design of GISAT transmit module in LTCC Technology (SAC)**<br>Advantages:<br>1) Hermetic sealing possible.<br>2) Number of feedthrus can be removed<br>3) Compact size and smallest weight of the module<br>4) Repeatability in the performance<br>5) Package with embedded RF Connectors<br>6) Cost effective due to bulk production (GISAT-2 onwards) |
| **A 2.3** | **Design of Digital Linearizer on ASIC (SAC)**<br>Advantages:<br>1) Universal Linearizer can be used in any frequency<br>2) Simple and easy to use<br>3) Can be use for any type of distortion (GaAS, GaN, TWT etc)<br>4) ASIC can be made outside based on our requirement to achieve better performance compared to present topology |
| **A 3** | **Sub Area** — **Passive Microwave Subsystems (SAC)** |
| **A 3.1** | **Flexible filters with in-orbit reconfigurability (SAC)**<br>Modern era is the age of dynamic evolution of satellite technologies. Satellites are becoming smarter day by day. A flexible satellite can be very useful from the application point of view in modern communication for which reconfigurable HW (amplifiers, filters, antennas, etc.) are highly desired since they allow real-time system adaptation and optimization to varying user demands in terms of bandwidth, coverage and frequency allocation. At present, one of the major bottlenecks in the development of reconfigurable payloads is the input and output filtering section, where filters of fixed centre frequency and bandwidth are employed. The utilization of reconfigurable IMUX/OMUX could allow substantial reduction |

| | | |
|---|---|---|
| | of mass, dimension and costs with respect to today's switched multiplexer solutions. Thus, the necessity to design a new filtering section whenever a new payload has to be developed could be reduced, while at the same time also last-minute changes in the development of a payload/system could be absorbed. Onboard tunable filters with a fast tuning speed, high quality factor and broad tuning range are key elements in reconfigurable systems. Tunable filters effectively utilize the frequency, bandwidth, suppress interfering signals and ease the requirement for oscillator phase noise and dynamic range. Universities/Research Institutes can considerably contribute in the field of RF-MEMS based filters, DR filters with MEMS based bimorph tuning element as well as stepper motor based tunable cavity filters. | |
| **A 4** | **Sub Area** | **Power Electronics (SAC)** |
| **A 4.1** | **Design of active input filter for switching power supply (SAC)**<br>An input filter is an essential and critical circuit element in DC/DC converters for payload equipments. It should be designed to achieve the required EMI compliance as per the conducted emission limits defined in the latest revision MIL-STD-461. The brute force passive filter designed to achieve the necessary compliance is usually very bulky and attributes for large space and size in the power converter package. An input filter with low mass and volume can be designed by inductor and capacitor values enhancement techniques using active devices. Also, impedance of the input filter must be designed to compensate for the negative input of power converter. A project on active input filter design shall be aimed at defining the filter requirements, synthesis of the filter circuit for the desired performance, developing the step by step design methods for realizing the input filter for given attenuation and impedance characteristics and practical verification of the design on a specific DC/DC Converter. | |
| **A 5** | **Sub Area** | **Optical Communications Systems (SAC)** |
| **A 5.1** | **Development of Microwave Photonics terminals for free space optical link design, simulation & analysis (SAC)**<br>It is anticipated that future trends in satellite communications will make it essential to implement very high bandwidth data links between different satellites. Examples would include LEO-GEO links for transfer of remote sensing data, GEO-GEO links for networking applications, internetworking of micro satellite clusters etc.<br>Optical Inter-satellite Links are now poised to grow rapidly in the coming years. There is a new surge of OISL-related interest projected applications are foreseen in many areas, including high bandwidth data relays, real- | |

| | | |
|---|---|---|
| | time transmission of earth observation data, internetworking of satellite constellations, military communications, signals intelligence and monitoring, and many others.<br><br>Microwave photonics is an integration of optoelectronics with microwaves. It offers very large bandwidth, high data rate, small size, low mass, low prime power, negligible interlink interface<br><br>and improved control mechanism. Some novel, opto-microwave devices are optical modulator, photo detectors, mixers, frequency converters, optical sources, optical amplifiers, laser terminal for operational inter satellite links. Design, simulation & analysis can be proposed for such type of components.<br><br>In this case, many new optical devices or optical technology applications will be needed. Bandwidths ranging into the gigabit region are envisaged by using the future optical transponders.<br><br>• To explore and develop in the core areas involved in the free space optical link design. Comparative link parameters have to be established for the optical transmitters and receivers for different optical links starting form short distances (100s of meters) to LEO to LEO or LEO to GEO etc with varying data rates. Accordingly hardware has to be developed for optical transmitters and receivers.<br><br>• A comparative study of different tracking mechanisms having the hardware suitable for working in space environments with sufficient power margins have to be envisaged. |
| **B** | **Area** | **SATCOM Applications (SAC/NESAC)** |
| **B 1** | **Sub Area** | **SATCOM Applications (SAC/NESAC)** |
| **B 1.1** | **Key Exchange algorithm for RS Receiver (SAC)**<br><br>NavIC (IRNSS) RS service involves encryption and to improve security, encryption keys are changed regularly to avoid brute force attack and cryptanalysis from unauthorized users. NavIC RS receivers deployed in field will have to be communicated with changed keys. ECC offers highest security and almost impossible to break the algorithm. Public Key exchange mechanism based on Elliptic Key Cryptography is to be developed for RS service. | |
| **B 1.2** | **Software defined radio based GNSS simulator (SAC)**<br><br>SDR is a novel concept and can be used for GNSS simulator applications. This requires high computation power to process 20 Mhz of signal in each | |

| | |
|---|---|
| | band for each satellite signal and involves huge data transfer from PC to DAC. Development of efficient algorithms to process and compute high bandwidth signals. Mechanisms to transfer high date rate transfer between FPGA and PC using ARM processor. |
| **B 1.3** | **NavIC (IRNSS) receiver with Mapping service integration (SAC)**<br>NavIC (IRNSS) receiver provides PVT and this should be integrated with other Google/NOKIA/Apple map services based on this PVT solution in Android/IOS/Windows8 environment. More services like showing best routes from one place to other places, tracking the fleet using NavIC (IRNSS) receiver kind of services are to be explored. |
| **B 1.4** | **Design, development and implementation of Lightweight authentication algorithm (SAC)**<br>Development of lightweight authentication protocols can be taken up as an activity which would be useful in NavIC (IRNSS) where authentication of some sort can provide security against spoofing kind of attacks. However, any kind of authentication mechanism should not incur too much overhead on NavIC (IRNSS) receiver for which it is must that the authentication algorithm should be resource efficient. Moreover, the implementation should be such that it is safeguarded against side channel kind of attacks. |
| **B 1.5** | **Study and Performance estimation of a Multi Carrier –Code Division Multiple Access System (SAC)**<br>Today, in parallel with multi-carrier transmission, the field of multi-carrier spread spectrum communications is considered to be an independent and important research topic. Multi-carrier spread spectrum is considered a potential candidate to fulfill the requirements of next-generation (4G) high speed wireless multimedia communications systems, where spectral efficiency and flexibility are considered as the most important criteria for the choice of the air interface.<br>The MC-CDMA technique is based on a serial concatenation of direct sequence (DS) spreading with multi-carrier modulation technique. It offers the advantage of both the proven technologies.<br>The DS-CDMA system is a multiple access technique that relies on spreading the data stream using an assigned spreading code for each user in the time domain. The capability of the system is given by the cross-correlation properties of the spreading codes helps in minimizing multiple access interference. Whereas the auto-correlation properties of the spreading codes provides the capability of distinguishing one component from others in the composite received signal in the case of severe multi-path propagation in mobile communications. However, The |

| | |
|---|---|
| | performance of a DS-CDMA system strongly depend on the number of active users, the channel characteristics, and the number of arms employed in the rake- receiver. The system capacity is limited by self interference and multiple access interference, which results from the imperfect auto- and cross-correlation properties of spreading codes.<br><br>The basic principle of multi-carrier modulation relies on the transmission of data by dividing a high-rate data stream into several low rate sub-streams. These sub-streams are modulated on different sub-carriers by using a large number of sub-carriers, a high immunity against multi-path dispersion can be provided since the useful symbol duration Ts on each sub-stream is much larger than the channel time dispersion. Hence, the effects of ISI are minimized. The main advantages of multi-carrier transmission are its robustness in frequency selective fading channels and, in particular, the reduced signal processing complexity by equalization in the frequency domain. OFDM, a multi carrier modulation system offers high spectral efficiency and effectively combats the problems with multipath propagation in mobile communications.<br><br>Thus the advantages of multi-carrier modulation on the one hand and the flexibility offered by the spread spectrum technique on the other hand have motivated for the Multi carrier –CDMA systems design.<br><br>Two different technologies called MC-CDMA (OFDM- CDMA) and MC-DS-CDMA have emerged as a combination of these two independent technologies. Thus the study and performance estimation of a MC-CDMA system in a multipath fading channel can be a very interesting and useful topic of research which can help in designing of an optimum MC-CDMA system for a fading channel. |
| **B 1.6** | **Tamper Proof Hardware Technology (SAC)**<br><br>NavIC (IRNSS) RS Receiver design and development is taken up at SAC. RS receiver is to be protected for the secret key and code inbuilt to the receiver in case of RS receiver is compromised by opening the unit. Tamper proof hardware technology will provide this protection to RS receiver. |
| **B 1.7** | **Development & Adaptation of GMR (Geo Mobile Radio)like standards & Technologies for seamless communication between Terrestrial & ISRO SATCOM networks (SAC)**<br><br>GEO-Mobile Radio Interface (GEO stands for Geostationary Earth Orbit), better known as GMR, is an ETSI standard for satellite phones. GMR standard is derived from the 3GPP-family terrestrial digital cellular standards and supports access to GSM/UMTS core networks. It is used by ACeS, ICO, Inmarsat, SkyTerra, TerreStar and Thuraya for high speed |

| | |
|---|---|
| | internet as well as audio and video services. Under this topic, it would be worthwhile to develop and implement standards that are similar to GMR or GMR itself for seamless communication between GSM and ISRO's MSS terminals. |
| B 1.8 | **Design for popular broadcast/communication standard like DVB-SH/DVB-RCS etc to facilitate satellite communication on the move. Efficient techniques for implementation of OFDM over satellite (SAC)**<br>DVB-SH is a published standard from ETSI for broadcast services using satellites to handheld devices. Under this topic, the development and implementation of techniques like DVB-SH in MSS band is expected. |
| B 1.9 | **Wideband Spectrum Sensing and Interference Cancellation techniques in Compressive Sensing Domain for next generation Broadband Satellite communication & efficient spectrum utilization (SAC)** |
| B 1.10 | **Design, Simulation and Implementation of PSK Modems with Higher order Coding to meet the communication requirements of LEO satellites and for Indian Data Relay Satellite System (SAC)**<br>The proposal could include building a Doppler compensated PSK MODEM for communication from a LEO platform to GEO platform. |
| B 1.11 | **Mixed signal ASIC: Design and Development of miniaturized, multiband (S, L, UHF band) Low Power transceiver ASIC for future SATCOM terminal (SAC)**<br>This proposal could include development of low power custom ASIC to support miniaturization of handheld and portable satcom terminals. |
| B 1.12 | **Low bit rate fast acquisition burst demodulator or Preamble-less/minimum preamble demodulation (SAC)**<br>The proposal of design and development could address techniques to improve the burst to burst gap and reduce the preamble size of low bit rate burst demodulator for Satcom applications. |
| B 1.13 | **Design & Development of RF-MEMS based monoscan converter for Single-channel Monopulse Tracking System (SAC)**<br>Monopulse tracking is used for precise pointing of onboard as well as ground station antennae. It is used in three configurations: Single-Channel, Two-Channel and Three-Channel. Single and two-channel configurations are commonly used in practice. Since single-channel configuration has advantage in terms of weight, size, power and phase-optimization, it is a preferred choice for most applications. But, the |

| | |
|---|---|
| | simplicity results in increased complexity at feed end, where three RF signals (Ka / Ku Band for example) need to be combined into one RF-signal using monoscan converter. It is also called autotrack modulator/combiner. The proposal could aim for developing RF-MEMS based (Ka / Ku Band) monoscan convertor technology, which should have potential to meet reliability requirements of onboard applications. |
| **B 1.14** | **Development multi-mode mobile terminal (SAC)**<br><br>Multimode smart phone is going to be future trend. The same phone will operate in different radio technologies and there is requirement of seamless transition between the networks. Media Independent Handover (IEEE 802.21) has been standardized for the seamless communication between different radio technologies. The proposal should aim for network design and mobile terminal development. |
| **B 1.15** | **Hybrid Terrestrial-Satellite DVB/IP Infrastructure for Triple-Play Services (SAC)**<br><br>With the advent of digital video broadcasting (DVB) technology and its exploitation over terrestrial links (DVB-T) along with its inherent characteristic to combine heterogeneous traffic into the same data stream (i.e., MPEG-2 and IP data), presents the possibility for the creation of a converged DVB/IP networking infrastructure, which is able to provide triple-play services within the broadcasting footprint. |
| **B 1.16** | **Design, Simulation and Implementation of electronic beam steering techniques for satellite mobile communication (SAC)**<br><br>Mobile satellites provide coverage over large regions. Large number of small beams is essential to cater the higher G/T requirements of small user terminals. In the conventional single feed per beam option, there are two major shortcomings:<br><br>i) It requires large number of feeds and ii) Higher complexity in de-pointing correction. Using digital beam-forming, a large number of beams can be formed using a relatively smaller number of feeds with the following advantages:<br><br>• Electronic steering of antenna beams is possible.<br>• Antenna miss-pointing error correction is possible without any physical movement of antenna parts, protecting sensitive antenna geometry.<br>• Reconfiguration of beams caters specific requirements including optimization for C/I, anti jamming capability etc. |

| | |
|---|---|
| B 1.17 | **Design of miniaturized low cost S-band antenna with near omnidirectional coverage for mobile hand held terminals (SAC)**<br>The requirement is to develop transmit only, receive only and transmit-receive antenna for different S-band MSS terminals & applications. An active antenna system will add value to receive only system. The proposal should preferably address all the above issues. |
| B 1.18 | **Design and development of RF transceiver ASIC for S-band handheld SATCOM terminals for MSS applications (SAC)**<br>This proposal should address development of low power custom RFIC for S-band transceiver to support miniaturization of handheld and portable satcom terminals. |
| B 1.19 | **Design and development of advanced pulse shaping techniques with lower roll off for efficient spectrum utilization(SAC)** |
| B 1.20 | **Design and development of robust and power & bandwidth efficient waveform for SATCOM services (SAC)** |
| B 1.21 | **Development of GPS based auto pointing system for 1.2m C-band antenna system(SAC)** |
| B 1.22 | **Local TEC model for NER through IRNSS + GPS + GAGAN Receiver (NESAC)**<br>Using current DF IRNSS + GPS + GAGAN Receivers, generation of local TEC model and characterization of Ionospheric Anomalies. This will provide reliable delay calculation which may lead to better positional accuracy. Earthquake induced TEC anomaly will be also tried to study so that any usable earthquake precursor may be identified and used for earthquake early warning. |
| B 1.23 | **ZIGBEE based Wireless Sensor Network for Landslide (NESAC)**<br>A multi column landslide sensor may be implemented for real time forecasting of landslides and dissemination of alerts in a wireless sensor network for centralized mitigation. |
| B 1.24 | **Wireless Communication Channel Noise Characterization for Hilly Urban areas like Shillong (NESAC)**<br>A study of the various noise effects impairing wireless communication in a hilly urban environment like Shillong is to be modeled and characterized. This may help in mobile tower location optimization and transmit power and modulation scheme optimization. |

| | | |
|---|---|---|
| **C** | **Area** | **Mechanical Engineering Systems (SAC)** |
| **C 1** | **Sub Area** | **Structural and Thermal Analysis (SAC)** |
| **C 1.1** | **Development of Reconfigurable reflectors using Smart materials and Smart structural systems (SAC)**<br><br>To develop Mechanically Active Antenna reflectors which can illuminate different land masses by Reconfiguring the skin of the reflector, by using Two-way Memory trained radial and circumferential strands of Shape Memory Alloy (SMA) wire Actuators as smart back up devices. Using this approach a DVM for 1.0M diameter C-band parabolic reflector is being developed for CATF testing after demonstrating successfully the Proof-of-concept on 0.4m diameter parabolic reflector.<br><br>This approach may have possible spin-off applications and may waive off the requirement of imported Antenna pointing Mechanism nowadays being used for achieving rigid body movements of the reflector for covering different land masses. | |
| **C 1.2** | **Usage of new materials for developing Light weight spacecraft reflectors (SAC)**<br><br>To develop Light weight Metalized Antenna reflectors using Contemporary light weight and low CTE 30% carbon reinforced Poly Ether Ether Ketone (P.E.E.K) / bare PEEK combinations using Vacuum Forming Technique as an alternative to conventional CFRP reflectors developed in Autoclaves using Co-curing techniques. A 0.4m diameter parabolic reflector using PEEK material is under development as a proof-of-concept.<br><br>This approach may make SAC stand alone in the field of developing reflectors without any external support. This approach may have possible spin-off applications in developing light weight SCATT. reflector in lieu of CFRP or Aluminum options. | |
| **C 1.3** | **Metallization of Fusion depositable materials, carbon composites / ceramics and development of segmented mirrors (SAC)**<br><br>Fusion deposited materials are emerging as a novel alternative for manufacturing precise and complex shapes for the future space industry and particularly for satellite components. While it has the advantages of producing virtually any shape that can be imagined, utilization of this manufacturing technique is limited to successful development of metallization and electroplating on the Fused Deposited Components. The work here involves developing Silver and Gold plating on Fusion Deposited ABS as per the space qualified procedures. | |

| | | |
|---|---|---|
| | Another research work in progress is the development of proof-of-concept of segmented telescopic mirror and its surface correction exercises are in progress using Piezoelectric Stacks and PZT Actuator devices. | |
| **C1.4** | **Analysis & development of RF MEMS based switches (SAC)**<br>The Structural analysis in the electrostatic field is supported in the precise displacement domain for 2 microns type of central deflection of the gold bridge of the RF-MEMS switch using the Coventorware Multi-physics software as per the detailed Boundary conditions and material properties to be furnished by the new FAB set-up at SCL Chandigarh. Two options of the switches are under taken for preliminary structural analysis and completed. Some modifications in design are in progress as per the recent visit to SCL FAB and the geometry is expected for analysis runs.<br>This approach will make SAC stand alone in the field of Analysis and RF design of RF MEMS based spacecraft switches. | |
| **C 2** | **Sub Area** | **Antenna System – Mechanical (SAC)** |
| **C 2.1** | **Development of Inflatable antenna for Space use (SAC)**<br>Inflatable antenna offers very light weight option i.e. very high ratio of size to stowed weight for large deployable spacecraft antenna. Material selection, Inflatable structure design, development of inflation system, fabrication techniques etc will be the area of technology development. | |
| **C 2.2** | **CFRP feed systems (SAC)**<br>Feeds are subjected to thermal loads and structural loads. Also present practice of using metallic feed result into weight penalty. CFRP feed system will provide light weight thermally & structurally stable solution for onboard system. | |
| **C 2.3** | **Development of Graphite mould for CFRP reflector (SAC)**<br>Presently CI mould is used for the fabrication of CFRP reflector. The advantage of Graphite mould is that it will be having CTE matching with CFRP material of reflector leading to better surface profile on reflector. Also the realization cycle time will be reduced in case of Graphite mould. | |
| **C 3** | **Sub Area** | **Optical Payloads – Mechanical (SAC)** |
| **C 3.1** | **Development of Nano-polishing technology for metal mirror (SAC)**<br>Metallic mirror machining by diamond turning process is being successfully used for precision surface profiling. Surface finish achievable is not adequate for the best performance of the instrument in visible wave | |

| | |
|---|---|
| | length range. It is required to develop the Nano-polishing process to achieve surface finish commensurate with similar mirror made out of ceramic material. |
| C 3.2 | **Development of High capacitance bad conductive lining material (SAC)**<br>High resolution telescope has very large aperture for incoming beam. It is challenging to take care of unwanted sun radiation intrusion, especially for GEO Imaging instruments, during dawn and dusk phase of orbit. It is required to develop polymers which do not conduct the heat across the thickness but it can withstand very high temperature. This would protect the metering structure from rise in temperature in any circumstances. |
| C 3.3 | **Development of precision sensors for feedback loop in auto focus system (SAC)**<br>Metering structure for large focal length telescope, required to provide very high dimensional stability under harsh thermal environment specially in GEO orbit. To compensate the thermo-structural behavior, auto-focusing mechanism is the way out. Linear dimension measurement sensor technology is required to be developed for giving the feed back to the focusing mechanism. It is required to be kept outside the field of regard as a parallel feedback system. |
| C 3.4 | **Shape Memory based actuation system for various deployment/ shutter mechanism (SAC)**<br>Different mechanisms will be required to be developed for payload operations. Development of shape memory alloy based mechanism will make simplified and reliable payloads. Special type of shape and programming technique is to be developed. |
| C 3.5 | **Embedded structural health monitoring system (SAC)**<br>Large dimensionally stable telescope structures required to be maintained strain free throughout the operational life. A SHM systems using many sensors like fiber Bragg Grating, Nano-accelerometer, Nano-temperature sensors etc, to be developed which can also be embedded into the composited structure. |
| C 3.6 | **Carbon fiber based efficient thermal strap development (SAC)**<br>Heat dissipation through conventional conductive material like Cu, is not adequate to handle the handle zone where high heat density heat dissipation exists. Carbon Nano-tube or carbon fiber strap can be used to transfer heat very efficiently with efficient weight saving. Technology also |

| | | |
|---|---|---|
| | can be developed to embed the fiber in printed wire board to diffuse the heat from high heat concentrated zones. | |
| C 3.7 | **Micro-heat pipe design and development (SAC)**<br>Research is required to design and develop optimized micro heat pipe, which can be efficiently used to maintain the temperature of certain components like detectors, of which performance is very much sensitive to temperature. | |
| C 4 | **Sub Area** | **Development of Space Qualified Reconfigurable Spacecraft Reflector (Ka Band) using Shape Memory Alloys - Smart Materials (SAC)** |
| C 4.1 | **Smart or intelligent materials / adaptive materials(SAC)**<br>Smart or intelligent materials / adaptive materials are the materials / smart structural systems, which have the capability to get adapted to the external load or stimuli. External stimulus can be in the form of vibration load, thermal load, pressure load etc.<br>Using smart materials and structural systems a Design Validation Model (DVM) of a typical Spacecraft Reconfigurable reflector has been envisaged to be developed which is able to change the shape and curvature of the reflecting surface using Shape Memory Alloys (SMA) Smart material. An innovative concept of smart backup beams will be developed for testing the re-configurability of the reflecting surface for satellite applications.<br>Reconfigurable reflector has been envisaged to be developed using new material called Poly Ether Ether Ketone (P.E.E.K) a light weight, Low Alpha material almost vying with properties of CFRP.<br>It has promising potential application in the field of developing futuristic reconfigurable reflectors. A 0.45 m dia. Ka-band MAA reflector (investigation for deflection of the reflector skin ) with re-configurability features has been proposed to be developed using contemporary Light weight flexible substrate material- Poly Ether Ether Ketone (P.E.E.K) sheets.<br>Reconfigurability is proposed to be obtained using SMA wire strands trained in Austenite & Martensite states.<br>Metalization of substrate material has been envisaged using hither to fore unexplored novel technique of Magnetron Sputtering / VDP after surface activation using Radio Frequency Plasma Etching for better adhesion properties at SAC / IPR Gandhinagar .<br>Challenging aspect is realization of the DVM of reconfigurable reflector | |

mechanically, structurally & electrically and the research element of the research problem is finalizing the most optimum configuration / geometric topology of the SMA Stiffeners after iterative process of analysis, to meet the Satellite specifications.

- The detailed work also includes Mechanical& Structural designs including Finite Element modeling and electrical / experimental investigations.
- Mould fabrication
- SMA & PEEK material characterization.
- The characterization of advanced reflector materials including high quality structural space adhesives,
- Space qualification tests e.g out-gasing properties viz, CVCM , TML etc, for the new materials.
- 8-10 microns thick copper metalization respectively for reflectivity of the flexible surfaces.
- The scope also includes space qualification of metalization process of the flexible material for the reflector surface.
- Development of the DVM.
- Electrical testing of the Reconfigurable antenna from the point of Reconfigurability at Compact Antenna Test Range (CATF) Facility SAC.

**Salient Features / Specifications**

| | |
|---|---|
| Diameter | 0.45 m dia. |
| Frequency | Ka-band |
| F/D | 0.4 |
| RMS (Structural) | 10 Microns |

This Technical Development Programme will lead to the development of design validation model for futuristic Re-configurable antenna reflectors are required for the following applications:

- For advanced applications such as Beam steering / Beam reshaping of spacecraft reflectors using in-house indigenous approach for covering different land masses on the Earth without using imported Antenna Point Mechanism. In future, this approach can also be used for altering the satellite coverage from India Coverage (IC) to Extended Coverage (EC) for

| | | |
|---|---|---|
| | futuristic GEOSAT satellites using high frequency small size spacecraft reflectors (Ka band) by Mechanically Active Means (MAA). Practically, along with MAA, electrically fine tuned adjustments can be achieved using phase shifters / Phase amplification approach.<br>• It will also help in compensating the thermal distortion related RMS error of flexible reflectors for futuristic Ka band reflectors. | |
| **C 5** | **Sub Area** | **Development of Space Qualified Ultra Light Weight Ka Band Spacecraft Reflector using PEEK (SAC)** |
| **C 5.1** | **Smart or intelligent materials / adaptive materials are the materials / smart structural systems, which have the capability to get adapted to the external load or stimuli. External stimulus can be in the form of vibration load, thermal load, pressure load etc (SAC)**<br>Using smart materials and structural systems a Design Validation Model (DVM) of a typical Spacecraft Light weight reflector has been envisaged to be developed which is made up of new material called Poly Ether Ether Ketone (P.E.E.K) a light weight , Low Alpha material almost vying with properties of CFRP. An innovative concept of light weight satellite reflector is envisaged which will cater to all the environment test specifications of the spacecraft.<br>It has promising potential application in the field of developing futuristic light weight reflectors. A 0.45 m dia. Ka band spacecraft reflector is envisaged to be developed.<br>Metalization of substrate material has been envisaged using hither to fore unexplored novel technique of Magnetron Sputtering after surface activation using Radio Frequency Plasma Etching for better adhesion properties.<br>Challenging aspect is realization of the DVM of light weight reflector mechanically & structurally and the research element of the research problem is finalizing the most optimum configuration / geometric topology of the Carbon reinforced PEEK stiffeners after iterative process of analysis, vibration testing to meet the Satellite specifications.<br>The scope of the work is as follows:<br>• The detailed work also includes Mechanical & Structural designs including Finite Element modeling and experimental investigations.<br>• Mould fabrication<br>• PEEK reflector bare skin and 30-34%-60% Carbon reinforced PEEK as structural stiffeners. | |

- The characterization of advanced reflector materials including high quality structural space adhesives,
- Space qualification tests e.g out-gasing properties viz, CVCM , TML etc, for the new materials.
- 8-10 microns thick copper metalization respectively for reflectivity of the flexible surfaces..
- The scope also includes space qualification of metalization process of the flexible material for the reflector surface .
- Development of the DVM .
- Mechanical testing of the Light weight antenna from the point of view of damping studies, frequencies and space qualification for sine, random & shock loads

Salient Features / Specifications

| | |
|---|---|
| Diameter | 0.45m dia. |
| Frequency | Ka-band |
| F/D | 0.4 |
| RMS (Structural) | 20 microns |

This Technical Development Programme will lead to the development of design validation model for futuristic Light weight antenna reflectors are required for the following applications:

- For advanced applications for high frequency light weight reflectors of U/V bands with stringent RMS & PE specifications

| | | |
|---|---|---|
| **D** | **Area** | **Electronics Support Services (SAC)** |
| **D 1** | **Sub Area** | **Microelectronics (SAC)** |
| **D 1.1** | **Film Bulk Acoustic Resonator based RF filters (SAC)** | Film Bulk Acoustic Resonator (FBAR) is used in high frequency RF filters because of its very high Q factor and low temperature coefficient. The scope of the research will include fabrication & modelling of FBAR and design of filter using FBAR. S-band filters are required for both space and ground application. |
| **D 1.2** | **RF SAW filters (SAC)** | Leaky Surface Acoustic Wave (LSAW) Resonator based RF filters offer |

| | |
|---|---|
| | several performance advantages in a compact size in the frequency range of 800 MHz to 3 GHz. One-port resonators acting as Impedance Elements are connected in ladder/lattice configuration to obtain filtering characteristics. The scope of the work shall include modeling and design of SAW resonators and RF filters based on these resonators. The deliverables shall include CAD tool for the synthesis and design of these filters. SAC, Ahmedabad shall extend fabrication support for these devices. |
| **D 1.3** | **Semiconductor device (GaAs PHEMT, MHEMT, InP & GaN based) modeling (linear, non-linear, noise) including statistical process variation and temperature dependence (SAC)**<br>Very few MMIC foundries give complete device models, which are required for simulation and design of MMICs, especially in non-linear simulations like frequency converter, frequency multiplier, gain control amplifier, voltage controlled oscillators. In most of the cases limited models are available from foundry. Scalable models including linear, noise, non-linear, statistical process dependence and temperature dependence needs to be developed which can be integrated with EDA software. |
| **D 1.4** | **Development of temperature dependent models of PHEMTs, MHEMTs and InPHEMTs, their validity at cryogenic temperatures and application in design of LNAs for DSN in S, X and Ka-band (SAC)**<br>Presently limited data and models are available for simulation of active microwave circuits over temperature range including cryogenic temperatures. Circuits are designed at ambient and their response is studied practically at these temperatures. If proper models of basic devices are available over temperature and frequency of operation, it will be helpful in designing circuits optimized for cryogenic temperatures. |
| **D 1.5** | **Non-linear stability analysis of multi-transistor MMIC (SAC)**<br>Though nonlinear stability is an established field, presently no microwave CAD software is available which can easily predict the stability of a nonlinear circuit and they do in linear case. For multi-transistor MMIC, presently few alternative methods like, convergence of harmonic balance simulator, S11 at all the active device points etc. are used, which are time consuming and empirical in nature. CAD software to easily predict nonlinear stability is desirable. |
| **D 1.6** | **Application of exact synthesis methods in design of microwave and millimeter wave non- linear circuits (SAC)**<br>Design of microwave circuits and components uses both non-synthesis |

| | |
|---|---|
| | and exact synthesis methods. Exact synthesis methods are generally used in filter and matching circuit designs. This design method is extended to linear active microwave circuit design where input and output of the active device is approximated by simple equivalent circuit.<br><br>There is a need to extend this powerful exact synthesis method to non-linear microwave circuit design, like mixer, modulator, frequency multiplier etc., which will lead to best optimized designs requiring less time for computer optimization. Use of non-uniform transmission lines in synthesis method may also lead to interesting solution. |
| **D 1.7** | **Wafer level packaging technology (SAC)**<br><br>Ka-band receiver MMIC SoC containing GaAs MEMS, as well as other MMIC and MEMS based devices (designed and developed by SAC) need wafer level packaging for maintaining performance and size advantage of chip. Heterogeneous integration and packaging at the MMIC wafer level is an attractive and enabling technology, following reference projects one such development. |
| **D 1.8** | **Development of Electron Beam / LASER Beam Sensitive Glass (SAC)**<br><br>This requires development of types of glasses that are sensitive to electron beam/ LASER Beam and upon exposure to these change their optical density (OD) or transmittance. The development will be useful in the development of optical elements like sinusoidal calibration targets for optical payload calibration, gratings, Fresnel lenses etc. using grey scale electron beam or LASER lithography. |
| **D 1.9** | **Development of nano structured magnetostrictive thin films for Surface Acoustic Wave device applications (SAC)**<br><br>Surface Acoustic Wave (SAW) devices are widely used in communications such as filters, delay line etc. Conventional SAW devices consist of metallic IDT on top of a piezoelectric film or substrates. Research involves the development of high quality thin films of giant magnetostrictive materials (e.g. Fe-Si) which exhibit high magnetostriction coefficient suitable for low insertion loss SAW devices. |
| **D 2** | **Sub Area** — **PCB Fabrication , wiring and assembly (SAC)** |
| **D 2.1** | **Defects Analysis of solder joints in Electronics Fabrication for space use & algorithm development (SAC)**<br><br>Fabrication data collection, compilation and methods can be developed to understand the cause of defect, quantification in various categories, impact of reviewed/reworked defects in solder joints under various |

| | |
|---|---|
| | environment conditions ,impact on life span long term space missions as well as on interplanetary missions, co-relation of that data in various orbits by preparing the samples, measuring relevant parameters. Subsequently, Algorithms development, Monitoring and improving PCB assembly quality by statistical optimization of processes and materials. |
| **D 2.2** | **Lead free soldering and surface finish (SAC)**<br><br>Solder materials used in assemblies pervade many forms of electronic platforms used by Space. Therefore, any change in soldering technology will have major implications for space operations. Lead-free soldering is fast becoming the norm for commercial applications. Before long, there will be a push for a similar switch to lead-free solder for high-reliability electronics, as is seen in Space applications. While lead-free solders are purported to reduce environmental and health risks, these solders present certain technical risks. Of concern, the reliability of most lead-free solders is not well known for high-reliability applications and the adverse environments of space.<br><br>• Identify, develop and qualify lead-free PCBs & solders to replace conventional tin-lead solders used in circuit card assemblies, connectors, and other electronics etc.<br><br>• Identify and develop lead free dummy components.<br><br>• Identify, develop and qualify environmentally acceptable replacements to surface finishes and RTV/conformal coatings currently used in circuit card manufacturing meeting out gassing requirements.<br><br>Finally, ensure the reliability issues surrounding lead-free electronics in high reliability applications. Objective is to generate comprehensive test data (including inspection requirements) on the reliability of circuit cards newly manufactured with lead-free solder and subjected to simulated high-reliability environmental conditions. |
| **D 2.3** | **3D packaging (SAC)**<br><br>For space borne system, electronic packaging plays an important role for deciding about the weight & volume of the overall electronic system/sub-system. Discrete component design moved on to integrated circuits which in term moved to programmable devices. Even packaging graduated from DIP type to SMD to BGA/CCGA to flip chip to direct die attachment on printed boards. Printed circuit board technology also graduated from single side PCB to double side and in turn to multi layer boards. Interconnection within PCB graduated from non plated through holes to plated through hole, blind via / buried via connectivity and to laser drilled |

| | |
|---|---|
| | micro vias. These still form the packing or interconnectivity in multiple boards as through conventional wired or though rigid flex boards. This needs a relook into packaging technology.<br><br>These different assembled boards can be moulded all together and the interconnection can be through patterning on these 3D structures. This will enable compactness of the packages and more electronics can be accommodated in the same volume or in the first volume is reduced, which will reduce overall size of the package. Following may be explored meeting the space usage requirements,<br><br>• Epoxy material suitable for such packaging<br>• High aspect ratio hole drilling<br>• 3D writing/structuring on moulded structure. |
| **D 2.4** | **Advanced Thermal Management Solutions on PCBs for High Power (SAC)**<br><br>With increasing power loss of electrical components, thermal performance of an assembled device becomes one of the most important quality factors in electronic packaging. Due to the rapid advances in semiconductor technology, particularly in the regime of high-power components, the temperature dependence of the long-term reliability is a critical parameter. Two main drivers in the space technology are miniaturization and reliability. Whereas there is a continuous improvement concerning miniaturization of conductor tracks (continuous reduction in lines/spaces), miniaturization of the circuit carrier itself has mostly been limited to decreased layer-counts and base material thicknesses. This can lead to significant component temperature and therewith to accelerated system degradation. Thus, enhancement of the system reliability is directly connected to an efficient thermal management on the PCB-level. Development of base materials with advanced thermal performance and use of innovative build-up concepts. |
| **D 2.5** | **Low temperature Soldering (SAC)**<br><br>Soldering of electronic components on printed boards generally takes place at temperatures of between 240 and 250°C. During soldering, the components and printed boards are exposed to thermal shock that affects their long-term. A reduction in the soldering temperature to about 180°C using low melting point solders is expected to for specific temperature sensitive components to reduce risk of components failure<br><br>Development of number of possible low temperature solders in combination with suitable low temperature flux without sacrificing reliability of solder joint. |

| | | |
|---|---|---|
| D 2.6 | **Electroless gold plating for space applications (SAC)**<br>Gold is used extensively in the electronics industry, particularly because of its exceptional electrical properties. Electroless gold plating process is a promising candidate for deposition of gold on high frequency circuits leading to the miniaturisation. Autocatalytic electroless gold deposition process is preferred as it ensures minimum 2 micron gold for wire bonding and solder ball joint applications for mounting ICs on soft substrates without any undercoat.<br>• Under this programme a technology need to be developed to deposit minimum 2 micron of soft gold on a patterned circuits on various high frequency laminates having 4 mil line and spacing. Deposited gold should be non porous and ductile, should withstand environmental tests prescribed for space applications and ensure long term reliability. | |
| D 3 | Sub Area | Surface Treatment Process Technology (SAC) |
| D 3.1 | **Process development to realize Electroforming process for Aluminum components (SAC)**<br>Electroforming is a technique used in fabrication of complex contoured components with high dimensional tolerances which are difficult to fabricate using conventional machining methodology. At present, electroforming process of copper components on Aluminum mandrels has been successfully realized at SAC. Copper has disadvantage of high density of 8.9 grams/cc.<br>Hence, efforts are invited to carry out in depth feasibility study to realize electroforming process of Aluminum components and develop detailed process & setup for the same. This process can be used for mm-wave components. | |
| D 3.2 | **Non-cyanide based Electroless Silver Plating process development (SAC)**<br>Silver plated components are widely used in RF systems of satellites. With miniaturization of mechanical assemblies and usage of higher frequency bands like K-band & Ka-band, dimensions have decreased to around 4 mm & lower. Also long waveguides of the length of 1.2 meters are being used with twists and turns in various planes, making it extremely difficult to silver plate inside surface of the cavity using the conventional electrolytic silver plating methodology.<br>Hence, proposals are invited in the area of non-cyanide based Electroless silver plating chemistry for plating aluminum 6061T6 alloy components | |

| | | |
|---|---|---|
| | with plating thickness of ≥2 microns of silver inside complex multi planar wave guides. | |
| **D 4** | **Sub Area** | **Environmental Test Technology (SAC)** |
| **D 4.1** | **Development of compact, liquid nitrogen based, close loop controlled, highly energy efficient thermal systems for direct use with existing thermal vacuum chambers as well as climatic test chambers (SAC)** | |
| **D 4.2** | **Development of non metallic, light weight, low loss cryogen transfer lines especially for efficient distribution of Liquid nitrogen (SAC)** | |
| **D 4.3** | **Development of compact, low cost Pulse Tube cryo-coolers to facilitate testing tiny devices at low temperature as well as for low cooling requirement of IR/CCD detectors (SAC)** | |
| **D 4.4** | **Development of acoustic coolers for small detector cooling application, handling high heat from the large heat sinks etc. (SAC)** | |
| **D 4.5** | **Development of thermoelectric cooling based compact climatic test chambers and thermal vacuum chambers (SAC)** | |
| **D 4.6** | **Development of mixed gas refrigeration based compact climatic test chambers and thermal vacuum chambers (SAC)** | |
| **D 4.7** | **Study and analysis of various forms of contaminations like surface & airborne particulates, surface and airborne molecular contaminants in and around thermo-vacuum chambers. Carryout in-depth measurement of such contaminants using APC, PFO, RGA, TQCM and CQCM available and carry out detailed process study as well as make recommendations in this regard for implementation (SAC)** | |
| **D 4.8** | **Study and analysis of Liquid Nitrogen consumption in Thermo-vacuum test facility with respect to different type of tests being carried out in different LN2 based thermo-vacuum chambers. Study and analyze transfer, static and flash losses taking place in various system elements during thermo-vacuum tests and carry out detailed process study as well as make recommendations in this regard for implementation (SAC)** | |
| **E** | **Area** | **Antenna (SAC)** |
| **E 1** | **Sub Area** | **Antenna (SAC)** |

| | |
|---|---|
| E 1.1 | **Electromagnetic Analysis of 3D geometries (SAC)**<br>This work includes the development of codes using suitable CEM techniques like FEM, FDTD, High frequency asymptotic techniques of PO/PTD, GO/GTD and hybrid techniques like FEM/BEM, GTD/MoM etc for analyzing the scattering and radiation parameters of antennas and its components. The developed codes should have also the capability to analyze the scattering properties of the 3D arbitrary objects by estimating RCS. The development of algorithm and computer codes for mesh generation for arbitrary boundary of 3D geometry with details of data-structure for co-ordinates of each node with respect to local and global coordinate system is the pre-requisite for the development of Electromagnetic codes. The computer code should be capable of generation of adaptive meshing depending on the geometry and field values at different parts of the geometry depending on the electromagnetic boundary conditions and electromagnetic computation based on the above cited CEM techniques. |
| E 1.2 | **Barium Strontium Titanate based Phased Array Antenna (SAC)**<br>Barium Strontium Titanate (BST) based tunable components falls under a category of Ferroelectric materials, possessing nonlinear dielectric constant which can be altered by application of external electric field, material composition ratio or with the changes in the ambient temperature. The tuning dielectric constant with bias voltage of BST find many applications such as antennas, varactors, phase shifters, non volatile memory etc. Due to its lesser impact time, high power handling capabilities, low losses at microwave frequencies BST is the most preferred choice in antenna reconfigurability. These phase tunable micro strip lines can be used at the inputs of the individual Patch Antenna elements in a Phased Array Antenna so as to electronically steer the radiation pattern in a desired direction. The study needs to be carried out for variation in RF properties due to change in material composition. |
| E 1.3 | **Characterization of Dielectric materials at High Frequency (SAC)**<br>Ferroelectric thin film can be used at its maximum potential for phased array antenna only when its material properties like dielectric constant, loss tangent, tunability are accurately characterized as a function of frequency, bias voltage applied, temperature at higher frequency setup. This requires the antenna material characterization for its dielectric properties and suitable techniques needs to be developed for the characterization. |
| E 1.4 | **Broadband Conjugate Matched Feed Horn for Offset Reflector** |

| | |
|---|---|
| | **Geometry (SAC)**<br><br>In radiometric applications or satellite communication, generally offset parabolic reflector antennas are preferred due to their inherent advantages of reduced aperture blockage, isolation between the reflector and the feed, lesser spurious radiation and suppressed side-lobes. But the performance of offset reflectors is satisfactory in terms of cross-polarisation components only when the larger F/D is selected. Space constraints limit the selection of large F/D. The concept of conjugate matched feed provides the solution for this contradicting requirement where low cross polarization can be achieved with smaller F/D. There is a need to design conjugate matched feed for 20 % bandwidth with cross polar performance better than -35 dB. SAC has already achieved 8 % bandwidth for the design of conjugate matched feed. |
| **E 1.5** | **FEM/BI method for Finite Frequency Selective Surface(FSS) Analysis (SAC)**<br><br>There is a requirement of analyzing finite FSS based on hybrid Finite element method (FEM) and Boundary Integral (BI) method. FEM used to solve the electric fields inside and on the boundaries of FSS (metal or dielectric based) by discretizing the FSS into finite number of tetradedral elements. The source used to excite the FSS can be corrugated feed horn or Gaussian source. The BI method is used solve the radiation characteristics of the FSS i.e. transmission and reflected radiation pattern by using the boundary fields solved by FEM. |
| **E 1.6** | **High frequency Substrate Integrated Waveguide (SIW) Antenna technology (SAC)**<br><br>Generally coplanar corporate feeder networks distributes the transmit/receive signal to the individual elements for less phase dispersion. At higher frequencies ohmic and dielectric losses of the connecting microstrip line dominates and results into undesired radiation. Among all transmission line hollow metallic waveguide feature extremely low losses up to very high frequencies but it is very bulky. Substrate integrated waveguide (SIW) technology provides a solution with ease of manufacturing and low cost of micro strip line and with the performance of the waveguide. LTCC, micromachining technique can be used for fabrication of SIW. The feeding mechanism needs to be developed using SIW technology for different antennas like planar cavity backed antenna, slot array antenna, Vivaldi antenna, horn antenna ,reflector antenna and planar micro strip antenna can be replaced by SIW. The system on chip and antenna on package may be studied in connection with this technology. |

| | |
|---|---|
| E 1.7 | **Estimate Measurement Uncertainty from Probed Quiet Zone Quality data (SAC)**<br>The analysis part includes the development of algorithm/computer code for estimating error in different antenna measurement parameters viz. Gain, Sidelobe, Radiation pattern from acquired raw probe data. It provides amplitude & phase vs. linear position data which are sufficient to characterize the volume of quiet zone. The quiet zone of an anechoic chamber is a defined volume within the chamber where a device under test (DUT) is to be placed for evaluation. |
| E 1.8 | **Accurate prediction of far field pattern using different topologies of near field data (SAC)**<br>This research problem involves the conversion of near field data, acquired using various scan geometries, into far field pattern. The objective of the study is to find out accurate and efficient near field to far-field conversion using various acquisition geometries as well as transformation scheme. Suitable interpolation techniques e.g. Optimal Sampling Algorithm, Bivariate Lagrange Interpolation etc. can be developed to convert the polar/spiral and other formatted data to rectangular grid using various interpolation schemes. Direct transformation techniques e.g. Jacobi-Bessel can also be explored to achieve accurate performance. |
| E 1.9 | **Analysis of Radomes on radar antenna performance (SAC)**<br>The efficient operation of delicate microwave antennas in the presence of adverse weather conditions requires in many circumstances the covering of the antenna by a radome. Radome is a protective cover for the antenna and is used extensively on terrestrial, weather radar systems, air traffic control, telemetry, satellite communications, satcom uplink and receive-only terminals. Radome structure is a framework structure (metal or dielectric) of interconnected columns (beams/seams). Foam and honeycomb cores are often added between inner and outer skins of the radome to function as low dielectric constant spacer material (reduced reflections) providing structural strength and rigidity. Investigations may be carried out for electromagnetic modeling of radome structure and the analysis to estimate the effects of radome on the antenna radiation characteristics may be carried out using suitable analysis techniques. |
| E 1.10 | **High Efficiency Dual polarized wideband slotted waveguide array Antenna (SAC)**<br>Waveguide slotted array antenna finds its application for its inherent advantages of good phase stability, low losses, high power handling capability and rugged structure. Open literature is available for narrow |

| | |
|---|---|
| | band waveguide slotted array like longitudinal shunt slot, series inclined slot and compound coupling and radiating slots. This investigation and design of slotted waveguide array intended at X & Ku band frequencies for technique to provide wide band width around 14-15 % with common antenna operating for dual linear polarization. The radiating aperture needs to be analyzed along with coupling slot feed array. |
| **E 1.11** | **Electronic band-gap antenna (SAC)**<br>Design and analysis of high efficiency/compact printed antenna array using electronic band gap structure such as mushroom type, fork type, unipolar type structure to improve the mutual coupling and making it suitable for wide angle scanning active phased array antenna. These structure can be integrated with microstrip antenna, waveguide slotted array antenna and horn array antenna to study the change in radiation properties. The electronic band gap structures integrated on intercostal structures has to be simulated for its RF transparency to improve the gain performance of the DGR antenna. |
| **E 1.12** | **Quasi-optical techniques for Millimeter-wave Antenna (SAC)**<br>This type of antenna system are of paramount use in millimeter wave (30-300 GHz) and Sub-millimeter wave (>300GHz) frequency bands. This type of antenna system has a reflector-antenna that transforms the wide received signal-beams into beams of intermediate width (intermediate gain) that pass through a train of reflectors or lenses before being focused into the low-gain feed-horns of the receivers. The research problem includes the formulation using different techniques like long Fourier optics, Physical optics and Geometric theory of diffraction to design the train of the reflectors so as to optimize the overall gain of the antenna. |
| **E 1.13** | **Multiband high efficiency feed antennas (SAC)**<br>Design, simulation and full wave analysis of multiband antenna structure such as sierpinski, appollian packaging monopole and koch geometry is required to estimate various antenna parameters like return loss, gain variation over frequency. These multiband geometries are being used for ground terminals for MSS type D, navigation satellite. Multifrequency operation of antenna feed can also be achieved by developing the common aperture feed catering dual/triple frequency and technique has to be developed so as to suppress the generation of higher order mode. Analysis and design of high efficiency antenna feed and its Orthomode Transducer, polarizer, diplexer etc are required for multiple beam antenna. Various types of feed horn catering different applications such as Trifurcated feed horn, Quasi integrated horn for high frequency application, horn with high power handling capability, Single aperture feed |

| | |
|---|---|
| | at C/Ku/Ka band for ground segment, profiled compact horn etc are to be designed. The navigational satellites will be radiating a composite signal covering the three bands simultaneously. There is a requirement to receive these three bands using a single compact ground terminal antenna covering L1, L% & S band. The common aperture antenna needs to be designed with single feed and it has to provide good axial ratio over large coverage angular extent up to 60-70 degree. The RESPOND investigator should study and demonstrate an optimum design for these requirements. |
| **E 1.14** | **Feed Array for reflector antennas (SAC)**<br>Feed array or multiple feeds illuminating reflector is required for multiple frequency or multiple polarization applications Effect of mutual coupling between focal array feeds and its effect on the antenna performance parameters like cross polarization, gain, beam width have to be studied. Beam shaping as well as the phase errors correction due to surface deformation may be accomplished by using cluster of feeds with proper beam forming network at the focal plane of the reflector. Investigation is needed to calculate the array excitation coefficients through the derivation of focal region fields for a shaped pattern or a reflector with deformed surface. |
| **E 1.15** | **Flexible coverage antenna (SAC)**<br>Various reconfigurable antenna systems for flexible coverage on the antenna need to be studied and designed. This requires design & study of multiple beam antenna, computation of excitation distribution to get the required beam shape and position. Development of various beam-forming algorithms and its implementation required to be explored. |
| **E 1.16** | **Antennas based on Micro-machined/Wafer- borne substrates (SAC)**<br>At mm-wave frequency ranges, antennas & feed may be realized on thin substrates and / or wafer-construction. The RESPOND investigators should study the various techniques and propose optimum fabrication methodology for such antenna systems for future linkage. |
| **E 1.17** | **Medium- or High-Gain UHF Antennas for Satellites (SAC)**<br>In recent times, the need for satellite-borne UHF antennas has emerged. Configurations for antennas with medium- or high-gain that may be mounted on satellites need to be studied and evolved. The investigator should undertake this study and propose optimum antennas for this requirement. Prototype demonstration may be included in the scope. |

| | |
|---|---|
| E 1.18 | **Conformal Antennas for Omni-directional Coverage Patterns (SAC)**<br>Due to upcoming space-science and inter-planetary missions, satellites need to carry antennas that are conformal to the cylindrical / arbitrarily-shaped satellite body. Also, pointing mechanisms may be expensive / unviable on such missions. Hence, investigators should develop antenna configurations that provide omni-coverage including the effect of the satellite body on the radiation pattern. |
| E 1.19 | **Ultra Wideband antenna at VHF band (SAC)**<br>Design and development of suitable compact antenna element at 10-50MHz with 150-200% band-width with the constraints of mass & volume for interplanetary mission of ISRO. |
| E 1.20 | **Soft computing techniques for shaped reflector antenna design (SAC)**<br>Different evolutionary techniques like back propagation algorithm, radial basis function and quantum/binary particle swarm optimization technique may be developed for shaped parabolic hyperbolic and elliptical reflectors to generate required secondary pattern and scattered pattern of sub-reflector at both. These techniques may also be studied for optimization of antenna performance parameter. |
| **F** | **Area** — **System Reliability (SAC)** |
| F 1.1 | **Stress Analysis & Life Estimation of Solder Interconnections based on Physics of Failure (PoF) Methodology (SAC)**<br>To gain insight into the failure mechanisms that come into play in a solder joint and its thermo-mechanical behaviour, towards estimating the life of any solder joint and a reliability figure.<br>This study will, in general, define a methodology to obtain the thermo-mechanical reliability of solder inter-connections in an electronic-package-assembly using solder joint fatigue models. This study will help to estimate the life and validate life-estimation models for the new package styles, i.e. column grid array & land grid array, QFN etc., and for high reliability long term space missions. This study will involve generation of geometrical models for the various package styles having different configurations of solder joints; stress analysis by applying cyclic temperature loading, for the individual package styles and solder joint design configurations; and extraction of failure parameters regarding fatigue & creep, from the cyclic stress-strain hysteresis loop. |
| F 1.2 | **Development of Co-axial Isolator / Circulators (SAC)** |

| | |
|---|---|
| | Co-axial Isolators/ Circulators of S, C, ext-C, and Ku-band frequencies are used in bulk for space hardware applications. At present, these components are being procured from international market. In order to get these components indigenously made with acceptable performance, academic institutions can take-up this project as a research & development activity and once developed technology can be transferred to any Indian industry for mass production.<br><br>Major Specifications:<br><br>Frequency Range :S , C, Ext C, Ku band<br><br>Insertion Loss :< 0.15 dB<br><br>Isolation :> 25.00 dB<br><br>VSWR :< 1.12<br><br>Operating Temperature Range:-20°C to +70°C |
| **F 1.3** | **Study on Effect of Long-term Storage on Tantalum Capacitors (SAC)**<br><br>To establish degradation in Tantalum capacitors and study usage life limitation (if any) with respect to application in satellite payloads<br><br>Classically shelf-life of Tantalum Capacitors has been considered to be limited due to effect of storage environment on the Tantalum oxide (various categories, typically pentoxide). With improved technology and techniques, such limitations are not spelt-out explicitly. However, no specific guidelines exist for shelf-life limitation and usage of tantalum capacitors for long mission life satellite applications after long storage.<br><br>A study is required on the effect of long storage on the dielectric properties (of Tantalum). |
| **F 1.4** | **Usage of LCP as Alternative to Conventional Hermetic Sealing Techniques for MMIC Die (SAC)**<br><br>Evaluate LCP packaging for hermetic sealing of MMIC<br><br>For Space usage, hermetic sealing of active die is necessary to prevent from environmental effects, before launch. Conventional techniques employ packaging using materials like Metals, ceramics and glass. However, the parasitics introduced due to conventional packages & packaging techniques severely deteriorate the performance of high frequency components including MMICs. Various alternative techniques for packaging the die, specifically MMICs are evolved. Such packaging results in components packaged in near hermetic package which can be directly assembled on to the circuits (stripline or microstrip). One of such techniques is, Packaging of MMIC in multilayer Liquid Crystal Polymer |

| | |
|---|---|
| | (LCP) substrates.<br><br>Liquid crystal polymer (LCP) package made from layers of thin-film LCP is an attractive alternative to traditional metal and ceramic hermetic packages. LCP is a near-hermetic material and its lamination process is at a relatively low temperature (285 deg C versus 800 deg C for ceramics).<br><br>LCPs offer a number of advantages in advanced printed wiring board and packaging applications including, low coefficient of thermal expansion, low moisture absorption, low moisture permeability, smooth surface, low dielectric constant and low dissipation at high frequencies and high temperature capability.<br><br>A study on effectiveness of die packaging using LCP for hermeticity will help establish alternatives for hermetic sealing of active components, specifically high frequency, necessary for Space payload applications. |
| **F 1.5** | **Development of EMI – RFI Gaskets (SAC)**<br><br>To develop EMI gasket to suppress unwanted electromagnetic, RF interface (RFI) and to provide environmental sealing.<br><br>The material of gasket shall be in the tape form. This material shall be made of expanded poly-tetra-fluoro-ethylene (ePTFE) filled with highly conductive carbon particles. Material used to manufacture EMI gasket shall be stable under atmospheric and high vacuum conditions. In order to get these gaskets indigenously made with acceptable performance, academic institutions can take-up the project as a research & development activity and once developed, technology can be transferred to any Indian industry for mass production.<br><br>Material Properties:<br><br>1) Material Composition : Carbon based PTFE<br><br>2) Operating temperature range: -40°C to 120 °C (with adhesive)<br>- 200°C to +200 °C (without adhesive)<br><br>3) Density : 340 kg/m3<br><br>4) Hardness : 45 (Shore A)<br><br>5) Volume resistivity : 1.5 X 106 ohm-cm<br><br>6) Shielding effectiveness: more than 45 dB. (Up to 40 GHz)<br><br>7) Outgassing properties : TML ≤ 1.0 % & CVCM ≤ 0.1 % |
| **F 1.6** | **Development of Microwave Absorber (SAC)**<br><br>To develop high loss microwave absorbers that attenuate electromagnetic |

| | |
|---|---|
| | interference.<br><br>Material shall be available in sheet form. It is used for reducing or eliminating cavity resonances, isolating components via insertion loss, reducing harmonics and terminating signals in waveguides.<br><br>Material Properties:<br><br>Frequency : 1 to 18 GHz<br>Base Material : Iron filled silicon rubber<br>Specific Gravity : 2.9 to 5.1<br>Hardness : 73 (Shore A)<br>Tensile Strength : 9.8 kg/ cm2<br>Elongation : 50 %<br>Reflectivity : -20 db at freq. between 1-8 GHz<br>TML : ≤ 1.0 %<br>CVCM : ≤ 0.1 %<br>Colour : Gray |
| **F 1.7** | **Development of Radiation Hardened Polymer Composite (SAC)**<br><br>To develop indigenous radiation hardened polymer composite for shielding application to replace Tantalum sheets.<br><br>Extensive applications of composites have emerged in space application in last few years. Durability issues like, long-term performance under radiation conditions needs to be studied. Polymers are generally non-conductive and transparent to radiation. So they are quite restricted for being used as shielding material in radiation environment. These drawbacks have led to the growth in the research for radiation-hardened polymers.<br><br>In this research work it is proposed to develop radiation-hardened epoxy resin by using different fillers and stabilizers to make polymer radiation-hardened shield with appropriate polymer with appropriate fillers and stabilizers. The comparative study shall be carried out to optimize the best composition among all prepared materials.<br><br>Tests like: Total Mass Loss (TML) and Collected Volatile Condensable Material (CVCM) & Radiation exposure levels up to 1Krad or more dosage to observe radiation effects on various properties of polymer need to be under taken. |

| | |
|---|---|
| F 1.8 | **Development of a Tool Setup to Evaluate the Effects of Single-Event-Upsets that Occur due to Radiation on Xilinx Devices (SAC)**<br><br>Development of a setup for evaluating Single Event Upset (SEU) effects in Xilinx FPGAs. SRAM based FPGAs are prone to temporary bit flipping due to high energy radiation particles in space (Single Event Upset). Depending on the design, SEU may affect functionality. Hence, identification of critical bits, which affect functionality, is required for effective mitigation. SEU mitigation techniques are then applied only on these identified critical bits.<br><br>Testing methods need to be devised that can allow the introduction of SEUs in the design and observation of their behaviour. Fault injection can be achieved either by intentionally programming an FPGA with an incorrect bit stream or partial dynamic reconfiguration. A combination of fault injection and gate-level simulation can prove very efficient for identifying SEU effects and mitigation techniques.<br><br>A setup is to be developed for fault injection in different FGPAs of Xilinx Virtex family, using test/gold vectors from QuestaSim. It is desired that the setup enables testing different designs, frequencies; injection of single bit/multiple bit upsets and the number of test signals.<br><br>The typical setup may comprise of three main parts:<br><br>a) Flexible FPGA-based Control Board, that can rule the fault injection procedure<br><br>b) DUT board that should contain the FPGA to be tested, e.g. Virtex 4 device; & Workstation. |
| F 1.9 | **Estimating Software Reliability (SAC)**<br><br>To predict/ estimate reliability of any software under development or under operations/ maintenance.<br><br>Software reliability estimates are used during development, to make the release decision; and after the software has been operationalised, as part of system reliability estimation, as a basis of maintenance recommendations and further improvement. It is required to study existing reliability estimation models and come out with workable solutions for adoption at SAC. |
| F 1.10 | **Relating Human Psychology to Software Quality (SAC)**<br><br>Towards prioritizing the QA efforts in a general perspective, it is required to understand human psychological perspectives of various stakeholders, including end-users & developers.<br><br>Human psychology relates to the software life cycle processes & end-user |

| | |
|---|---|
| | experience of the software. A research relating human psychological processes to the software development & quality assurance processes from the perspectives of various stake-holders will provide useful knowledge for addressing software quality throughout software life-cycle. |
| F 1.11 | **Mining Software Repositories for Software Process Improvement (SAC)**<br>To improve the overall efficiency of the process and people involved in different phases of software development.<br>The field of mining software archives, such as version archives like code repositories, bug reports, documents, mailing lists, etc., is concerned with the automated extraction, collection, abstraction and interpretation of events and artifacts created and recorded during software development. Based on mining these software repositories propose and develop empirical techniques to validate/ improve software development and quality assurance approaches. |
| **G** | **Area** — **Mission Development Area (ISAC)** |
| **G 1** | **Sub Area** — **Mission (ISAC)** |
| **G 1.1** | **To understand the different data sets, performance modeling, evaluations on a non-operational spacecraft and controlling (ISAC)** |
| **G 1.2** | **New tools and techniques for automation of multi satellite operations (ISAC)** |
| **G 2** | **Sub Area** — **Navigation (ISAC)** |
| **G 2.1** | **Navigation satellite autonomous maintenance (ISAC)** |
| **G 2.2** | **Design of data structure for minimizing time to first fix (ISAC)** |
| **G 2.3** | **Best data encryption algorithm design for hack free / secured data transfer (ISAC)** |
| **G 2.4** | **Broadcast signal Anti-Spoofing techniques (ISAC)**<br>- Design of Long PRN code (like GPS P(Y)) for secured application<br>- Design of different types of PRN codes for GNSS signals (Gold code, kasami)<br>- Message Authentication |
| **G 2.5** | **Explore the application of IRNSS satellite based navigation for** |

| | |
|---|---|
| | **common man (ISAC)** |
| **G 2.6** | **Design of network and message structure for disaster warning broadcast through satellite during Tsunami, cyclone and bad weather (ISAC)** |
| **G 2.7** | **Design of network for and message structure for weather forecast for army supply flight operation (ISAC)** |
| **G 2.8** | **Design of better transmitted data integrity like Forward Error Correction (FEC), Interleaving (ISAC)** |
| **G 2.9** | **Algorithm development of inter satellite ranging and onboard orbit estimation (ISAC)** |
| **G 2.10** | **Determination of Spacecraft orbit for Inter – Planetary Mission through Optical Navigation (LEOS)**<br>The Spacecraft will navigate autonomously by using optical data taken by on-board camera to determine its orbit and use this information to predict its future trajectory and make necessary corrections. The objective of the study is to develop a methodology to determine the spacecraft's position and velocity for intermediate cruise and target encounter phase. Intermediate cruise phase navigation is based on image celestial bodies (called beacons) through Line of Sight (LOS) measurements in the background of stars whose Helios Centric Positions are known in order to estimate the Spacecraft Position and Velocity.<br>Target encounter phase where the object (beacon) LOS measurements are made through image processing techniques either by computing Center of Mass (COM) for known image types, Centre of Brightness (COB) for unknown image types and limb measurement for the images than do not fit fully in FOV and estimate the Spacecraft Position and Velocity. The study involves systems design, Framing Camera Specifications, Image Processing, Navigation and Guidance and Software implementation. |
| **G 3** | **Sub Area** **Flight Dynamics (ISAC)** |
| **G 3.1** | **Orbit determination: Parameter estimation methods, including least squares and Kalman filtering. Attention should be paid to statistical aspects and data processing (ISAC)** |
| **G 3.2** | **Formation Flying: Orbital dynamics of formation satellites including Rendezvous and Docking experiments (ISAC)** |

| | | |
|---|---|---|
| G 3.3 | Orbital Motion: Models for orbital motion about irregular shaped bodies such as Comets, asteroids etc (ISAC) | |
| G 3.4 | 3-body Dynamics: Orbits in Libration points and their stability and station keeping (ISAC) | |
| H | Area | Communication and Power (ISAC) |
| H 1 | Sub Area | Communication (ISAC) |
| H 1.1 | PN Ranging Receivers (ISAC) | |
| H 1.2 | MMIC based TTC Transponders (ISAC) | |
| H 1.3 | Optical data communication (ISAC) | |
| H 1.4 | RF switches development for spacecraft application (ISAC) | |
| H 2 | Sub Area | Power (ISAC) |
| H 2.1 | Regenerative fuel cell technology development with an energy density of 420Wh/Kg. These are also called Reversible proton exchange membrane fuel cells where each cell is capable of operating both as a fuel and as electrolyser (ISAC) | |
| H 2.2 | Radio isotope thermo-electric generator. These are static in operation providing very high reliability and long life (ISAC) | |
| H 2.3 | Development of Gallium Nitride Solar Cell development (ISAC) | |
| I | Area | Integration and Checkout (ISAC) |
| I 1 | Sub Area | Integration (ISAC) |
| I 1.1 | Development of highly accurate (better than 0.05mm) 3D measurement System (Photogrammetry based) (ISAC) | |
| I 1.2 | Development of system capable of measuring the 3D co-ordinates of markers / 3D objects. The system should be capable of measuring the 3D co-ordinates of the markers on the object to be measured (ISAC) | |
| I 1.3 | Design and development of cable coupling analysis program (ISAC)<br>Satellite is made up of a large amount of harness carrying various types of signals, frequencies and power levels. The harness design should achieve Electro Magnetic Compatibility between the various functions and facilitate | |

| | | |
|---|---|---|
| | the functioning of the satellite system. As a first step in this direction it becomes incumbent to quantify the coupled signals. Once this is done measures can be taken to reduce the coupling. Software needs to be developed to quantify the quantum of coupling. | |
| I 1.4 | **Automation of Integration Testing (ISAC)**<br>Scope exists to automate satellite testing. Though the monitoring points are spread out, there exists scope to electronically switch, monitor and record the measured readings, wave forms etc. This is the subject matter of development. As a spin off, the data archiving, retrieval, data tagging follow. As a next step auto control of test equipment can be tried out. | |
| I 1.5 | **Design and development of Test equipment (ISAC)**<br>In addition to standard test equipment available in the market, a good number of dedicated test equipments get developed. Scope exists for universities or organizations to contribute to design and development of test equipments. | |
| I 1.6 | **Design & Development of antenna for ground testing and automation of EMC test setups (ISAC)** | |
| I 1.7 | **Mechanical Ground Support Equipment (ISAC)**<br>A large number of mechanical ground support equipment (viz., Satellite handling systems, panel handling systems, Satellite transportation containers, physical parameter measurement machines etc.,). Some of the parameters measured are Centre of Gravity, moment of Inertia. Measurement of Misalignments of sensors, actuators and payloads and applying corrections to meet the specifications is another area where scope for design and development exists. | |
| **J** | **Area** | **Mechanical Systems (ISAC)** |
| **J 1** | **Sub Area** | **Thermal (ISAC)** |
| **J 1.1** | **Novel thermal bus systems which can collect transport and provide heat for components (ISAC)** | |
| **J 1.2** | **Phase change materials / studies (ISAC)** | |
| **J 1.3** | **Thermo electric devices (ISAC)** | |
| **J 1.4** | **Development of super insulating material (ISAC)** | |
| **J 1.5** | **Development of thin film gas sensor, actuators and micro-heater** | |

| | |
|---|---|
| | **(ISAC)** |
| **J 1.6** | **Development of high emittance surfaces (ISAC)** |
| **J 1.7** | **Development of Alternate radiative surface (ISAC)** |
| **J 1.8** | **Alternate transparent conductive coating (other than ITO) (ISAC)** |
| **J 1.9** | **CNT based efficient thermal conductors (ISAC)** |
| **J 1.10** | **Engineering tool for thruster plume study (ISAC)** |
| **J 1.11** | **Thermochromic and Electrochromic materials (ISAC)** |
| **J 1.12** | **Continuous roll coating facility for thin film deposition on thin flexible polymeric sheets(ISAC)** |
| **J 1.13** | **Functional ceramic coating and carbon based films by PVD, CVD and plasma based techniques (ISAC)** |
| **J 1.14** | **Thermal control of microelectronics (at board and chip level) (ISAC)**<br>- Micro channels (single and two phase)<br>- Micro heat pipes and loop heat pipes (transport capacities can be in the range 1W to 100W) |
| **J 1.15** | **Process development for porous metal wicks (used in loop heat pipes) with complex shapes and their fluid / mechanical characterization (ISAC)** |
| **J 1.16** | **Computationally efficient algorithms / codes for view factor calculation including shadowing effects and directional / spectral surface properties (ISAC)** |
| **J 1.17** | **Radiative / flow / combustion model for prediction of heat flux on spacecraft surfaces from thruster plumes (ISAC)** |
| **J 1.18** | **Development of an advanced solver for coupled fluid flow and heat transfer with conduction, radiation (participative and non-participative) and convection (ISAC)** |
| **J 1.19** | **Contamination of optical surfaces due to material migration and deposition in a space environment (ISAC)** |
| **J 1.20** | **Degradation of spacecraft thermal properties (including contamination films) by high energy particles, atomic oxygen and UV** |

| | | |
|---|---|---|
| | **(ISAC)** | |
| **J 1.21** | **Development of flash techniques for thermal diffusivity measurement. (ISAC)** | |
| **J 1.22** | **Development of light weight stirling / Brayton engines for spacecraft application to generate power using waste heat (ISAC)** | |
| **J 1.23** | **Enhancement of heat transfer in fluids using electric / magnetic fields (ISAC)** | |
| **J 1.24** | **Variable emissivity coatings. Near unity emissivity with the ability to reduce emissivity by at least a factor of ten (ISAC)** | |
| **J 1.25** | **Test facility for atomic oxygen environment (ISAC)** | |
| **J 1.26** | **Suitable materials / surface engineering against atomic oxygen environment (ISAC)** | |
| **J 1.27** | **Radiation heat shield materials for ultra high temperature (beyond 2000°C) (ISAC)** | |
| **J 1.28** | **Alternative surface engineering for sun shield to achieve IR emittance < 0.02 and solar absorptance < 0.1 (ISAC)** | |
| **J 1.29** | **Passive thermal control techniques for Martian atmosphere (ISAC)** | |
| **J 2** | **Sub Area** | **Structures (ISAC)** |
| **J 2.1** | **Advanced composite materials having higher stiffness, higher strength and better hygroscopic properties (ISAC)** | |
| **J 2.2** | **SMART materials like piezo elastic, electrostrictive and magnetostrictive materials (ISAC)** | |
| **J 2.3** | **Shape memory alloys to actively control vibrations and shape control (ISAC)** | |
| **J 3** | **Sub Area** | **Mechanisms (ISAC)** |
| **J 3.1** | **Humanoid mechanism development (ISAC)**<br>The compact mechanism / actuation required for a humanoid (2 legged system) to accomplish movements in a stable manner is to be developed. | |
| **J 3.2** | **Gripper for end reflector (ISAC)**<br>Grippers for micro Robots to handle problem related to handling / | |

| | | |
|---|---|---|
| | operating different tools etc. to be developed. | |
| J 3.3 | **Analysis of large deployable membrane structure (ISAC)**<br>This involves non-linear FEM methods and required for large unfurlable / inflatable antennas which are mass efficient. | |
| **K** | **Area** | **Controls and Digital (ISAC)** |
| **K 1** | **Sub Area** | **Control Dynamics** |
| **K 1.1** | **Control algorithms for high pointing and stability for advanced remote sensing satellites (ISAC)** | |
| **K 1.2** | **Development of control algorithms for under actuated spacecraft's with high moment of inertia (ISAC)** | |
| **K1.3** | **Development of control algorithms for Autonomous station keeping single/ multiple satellites (ISAC)** | |
| **K 1.4** | **Modelling & simulation of multibody systems (ISAC)** | |
| **K 1.5** | **Control algorithms for high pointing and stability for advanced remote sensing satellites (ISAC)** | |
| **K 1.6** | **Structural Flexible Mode Control (ISAC)**<br>Large Structural Flexible Mode control (active /passive) using Adaptive Filters for large appendages vibrations | |
| **K 1.7** | **Smooth Trajectory Planning for Time-bound (Track to Track) Reorientation of Agile Spacecraft (ISAC)**<br>Present Guidance algorithm used in on-board Carto series is iteration based and changeover between maneuver and imaging is not smooth resulting in settling time requirement (Wait Phase) post reorientation. With development of non-iterative guidance, this problem can be avoided. The term Track to Track means both initial and final rates are non-zero | |
| **K 1.8** | **Guidance and Control algorithms for Rendezvous & docking/Formation flying etc (ISAC)** | |
| **K 1.9** | **Navigation Algorithms for Rover/Lander/Docking systems using vision based sensors and Laser Sensors etc (ISAC)** | |
| **K 1.10** | **Development of statistical based algorithms for providing Fault Detection Isolation and Reconfiguration using Unscented Kalman** | |

| | | |
|---|---|---|
| | **Filter (UKF) (ISAC)** | |
| **K 1.11** | **Development of real time Autonomous fuel optimal Guidance and Control algorithms for Soft landing missions(ISAC)** | |
| **K 1.12** | **Development of robust control system using Linear Matrix Inequality (LMI) concept for single / multiple satellites (ISAC)** | |
| **K 2** | **Sub Area** | **Control & Digital Electronics (ISAC)** |
| **K 2.1** | **64 bit processor development (ISAC)** | |
| **K 2.2** | **Advanced control systems for high resolution imaging satellites (ISAC)** | |
| **K 2.3** | **System on chip and mixed signal processing (ISAC)** | |
| **K2.4** | **Quad Redundant Fault Tolerant System Studies (ISAC)**<br>Study on systems, algorithms, fault tolerant logics for Quad redundant platforms | |
| **K 2.5** | **Active Microvibration control (ISAC)**<br>Studies related to measurement and control of micro-vibrations on Imaging sensors | |
| **K 2.6** | **Reconfigurable Hardware(ISAC)**<br>Studies related to Reliable, reconfigurable hardware systems | |
| **K 2.7** | **Image based navigation systems (ISAC)** | |
| **K 3** | **Sub Area** | **Digital Systems (ISAC)** |
| **K 3.1** | **1) New generation still image compression algorithm (lossy / lossless) for space application / Advanced Audio / Video coding, beyond the CCSDS wavelet image compression & H264 coding.**<br>**2) Advanced channel coding/decoding techniques beyond the LDPC & TCM techniques**<br>**3) Onboard image processing techniques for feature extraction, change detection etc. (ISAC)** | |
| **L** | **Area** | **Reliability and Components (ISAC)** |
| **L 1** | **Sub Area** | **Indigenization and Components Group (ISAC)** |

| | | |
|---|---|---|
| L 1.1 | **System-In package (SIP): Enabling Technologies viz. Multichip module with chip level stacking & embedded passives and MMIC based RF / Microwave modules to bring the SIP to a more complete functional system (ISAC)** | |
| L 2 | **Sub Area** | **Reliability (ISAC)** |
| L 2.1 | **Contamination modeling and kinetics studies (ISAC)**<br>To establish computer model for estimation of in-orbit contamination by taking into account the orbit parameters | |
| **M** | **Area** | **Systems Production (ISAC)** |
| M 1 | **Sub Area** | **Systems Engineering (ISAC)** |
| M 1.1 | **Automation test systems for various space conditions (ISAC)** Spacecraft electronic packages (simulation, Analysis) and data logging. | |
| M 2 | **Sub Area** | **PCB Design & Fabrication (ISAC)** |
| M 2.1 | **Advanced Chemical / materials development for fine hole plating and fine line etching in PCB application (ISAC)** | |
| M 2.2 | **Development of advanced photo lithography for high density interconnects (HDI) (ISAC)** | |
| **N** | **Area** | **VLSI Design (SCL)** |
| N 1 | **Sub Area** | **Specific R&D problem/issue for fabrication in 0.18µm CMOS process (SCL)** |
| N 1.1 | **Charge pump PLL frequency synthesizer design (SCL)**<br>Description: Design of low phase noise differential CMOS VCO<br>Differential change pump with CMFB(Common Mode Feed Back)<br>Basic specs: 5MHz to 65MHz<br>PLL output frequency required: input frequency*(28) | |
| N 1.2 | **Design of instrumentation amplifier (SCL)**<br>The brief specifications are:<br>Low noise:0.3µV p-p at 0.1 Hz to 10 Hz<br>Low nonlinearity 0.003%(G-1) | |

| | |
|---|---|
| | High CMRR: 120dB (G=1000)<br>Low offset voltage: 50μV<br>Low offset voltage drift: 0.5μV/OC<br>GBW product: 25 MHz |
| **N 1.3** | **Design of a current feedback amplifier (SCL)**<br>The brief specifications are:<br>High speed: 1650 Mhz (G = +1)<br>Low voltage offset : 0.7 mV<br>Low input bias current : 7μA<br>High O/p drive : 100 mA |
| **N 1.4** | **Design of low Noise amplifier (SCL)**<br>The brief specifications are;<br>To operate from 1.8V power supply<br>To give flat gain from 3 to 5 GHz<br>To deliver 21 dB power gain with only -15dB variation<br>Average noise figure to be 5.4 dB<br>Input and output reflection coefficients to be -13.3 and -19.5 dB |
| **O** | **Area** — **CMOS Process Technology (SCL)** |
| **O 1.1** | **Development of 1.8/5V 1/0 circuits (SCL)**<br>Development of 1.8/5V 1/0 circuits (Analog and Digital Pad Circuits with ESD) in 180 nm CMOS process is required. This work will be done subsequent to process integration for 5V-MOSFETs in the baseline process |
| **O 1.2** | **Development of accurate frequency dependant SPICE models for both active transistors and passive elements (SCL)**<br>The minimum-channel length MOSFETs SCL process (180nm CMOS technology) has Unity Current Gain frequency, Ft ~55 GHz. The existing device models supported by the technology are however valid up to baseband frequencies (one tenth of Ft of transistors) only. Development of accurate frequency dependant SPICE models for both active transistors and passive elements (Inductors & capacitors) in gigahertz range is required for rf-circuit designs capability in the existing process |

| | | |
|---|---|---|
| **P** | **Area** | **Development and Educational Communication (SAC)** |
| **P 1.1** | **Mapping Information and Communication Practices in the Tribal Areas specially focus to Rajasthan, Madhya Pradesh, Gujarat and Maharashtra states(SAC)** | |
| **P 1.2** | **A comparative study on Media Habits between Rural and Urban India(SAC)** | |
| **P 1.3** | **Community's Felt and perceived information needs in the agriculture sector(SAC)** | |
| **P 1.4** | **Community's Felt and perceived information needs in the health sector of Rural India(SAC)** | |
| **P 1.5** | **Impact Assessment of Edusat Network as supportive role in the field of formal education & teachers' training(SAC)** | |
| **Q** | **Area** | **Navigation Programme (ISAC/SAC)**<br>NavIC (Navigation Indian Constellation), Indian Regional Navigation Satellite System is operationalized. With the above system, the position accuracies can be achieved is better than 20 Meters in Indian Land Mass.<br>GAGAN is an Indian Satellite Based Augmentation System which provides improved position accuracy and integrity to Indian Civil aviation and other applications. GAGAN System has been certified for precision approach known as Approach Vertical Navigation Service (APV1). GAGAN system can provide position accuracy better than 3-5 meters.<br>With respect to the above, new areas of applications were identified and the product can be developed for the following applications. |
| **Q 1** | **Sub Area** | **NavIC & GAGAN Applications (ISAC/SAC)** |
| **Q 1.1** | **Non-civilian Applications (ISAC/SAC)** | |
| **Q 1.2** | **Location Based Services (ISAC/SAC)** | |
| **Q 1.3** | **Mobile applications (ISAC/SAC)** | |

| | | |
|---|---|---|
| Q 1.4 | BIG: Bhuvan, IRNSS and GAGAN integration (SAC/ISAC/NRSC) | |
| Q 1.5 | Mobile based navigation App for IRNSS (Android, Microsoft, blackberry, Mac OS) (ISAC/SAC) | |
| Q 1.6 | Development of Personal Safety mobile APP for individuals (For women safety or child) to track and monitor their location using IRNSS services (ISAC/SAC) | |
| Q 1.7 | Improvement of Public transport safety using IRNSS service (RTC Buses or Railways) (ISAC/SAC) | |
| Q 1.8 | Advanced algorithm for Driver less auto navigation (example : Driver less Car or automobiles ) (ISAC/SAC) | |
| Q 1.9 | NavIC in high dynamics systems: Rockets (ISAC/SAC) | |
| Q 1.10 | NavIC for Radio Occultation (ISAC/SAC) | |
| Q 1.11 | NavIC for LEO and MEO satellites position determination (ISAC/SAC) | |
| Q 1.12 | NavIC for Cartographic applications (ISAC/SAC) | |
| Q 1.13 | NavIC for Precise Time Transfer (ISAC/SAC) | |
| Q 1.14 | Fleet management (ISAC/SAC) | |
| Q 1.15 | Precision agriculture (SAC) | |
| Q 2 | Sub Area | Innovative Location Based Services: The following are the Innovation location based System that can be explored (ISAC/SAC/NRSC) |
| Q 2.1 | Vehicle collision avoidance and automatic driving using navigation and wi-fi services (ISAC/SAC) | |
| Q 2.2 | Tracking the trains and automatic managing the trains in a particular route (ISAC/SAC) | |
| Q 2.3 | Navigation for coal/underground mining applications (SAC/NRSC) | |
| Q 2.4 | Pocket Compatible receivers & Accessing from mobiles/tablets for sharing locations (SAC) | |
| Q 2.5 | Search & Rescue & Disaster Warning service (SAC/NRSC) | |

| | | |
|---|---|---|
| Q 2.7 | Guided Navigation (SAC/ISAC) | |
| Q 3 | Sub Area | Receiver Algorithms :The New algorithms for the precise user position computation can be developed in the following areas(ISAC/SAC) |
| Q 3.1 | Multimode Software Receiver for NavIC (ISAC/SAC) | |
| Q 3.2 | Advanced algorithm for Autonomous Navigation for NavIC (ISAC) | |
| Q 3.3 | ASIC Based NavIC receiver (ISAC/SAC) | |
| Q 3.4 | Miniaturization of NavIC receiver (ISAC/SAC) | |
| Q 3.5 | Signal Spoofing Mitigation Techniques (ISAC/SAC) | |
| Q 3.6 | Advanced Anti Jamming and Interference mitigation Algorithms (ISAC/SAC) | |
| Q 3.7 | Ionosphere prediction model using GAGAN & NavIC (ISAC/SAC) | |
| Q 3.8 | Error mitigation for precise positioning (ISAC/SAC) | |
| Q 3.9 | Long Code Generation and Encryption (ISAC/SAC) | |
| Q 4 | Sub Area | Modernization of NavIC (ISAC/SAC)<br>ISRO is planning to develop the next generation of Navigation System. With reference to the above, the following are the new areas of research interest are identified for the modernization of NavIC |
| Q 4.1 | Simulation and Analysis of Receiver Algorithms (ISAC/SAC) | |
| Q 4.2 | Minimizing Time to First Fix (ISAC/SAC) | |
| Q 4.3 | Tracking the target locations from remote place using satellites (ISAC/SAC) | |
| Q 4.4 | GNSS Processing Techniques and Tools (ISAC/SAC) | |

# 4.0 Earth Observations Programme

| | | |
|---|---|---|
| **A** | **Area** | **Mission Development and Remote Sensing Sensor Technology (SAC)** |
| **A 1** | **Sub Area** | **Electro-Optical Sensors (SAC)** |
| **A 1.1** | **Ultra-low power, High-speed analog front-end devices for processing of detector signals and interfacing devices (SAC)** | |
| **A 1.2** | **Miniaturization of electronics in the form of low power ASICS and Read Out Integrated Circuits (ROIC) (SAC)** | |
| **A 1.3** | **On board data processing, loss-less data compression and generating theme based data output using radiometric, spatial and spectral compression techniques (SAC)** | |
| **A 1.4** | **Analog, mixed signal and digital ASIC design, simulation, verification (SAC)** | |
| **A 1.5** | **Advanced PCB technology for miniaturization of high speed and high power front-end electronics including its thermal management (SAC)** | |
| **A 1.6** | **Onboard high speed data transfer, interfacing and networking (SAC)** | |
| **A 1.7** | **Extraction of very low signal from noise – Techniques (SAC)** | |
| **A 1.8** | **High power capacitance/inductance drivers with multilevel voltages (SAC)** | |
| **A 1.9** | **Modeling of special devices – Techniques (SAC)** | |
| **A 1.10** | **Modeling of devices for Cryogenic temperature operation (SAC)** | |
| **A 1.11** | **Mitigation techniques for radiation environment in space (TID/SEL/SEU etc) - Device level, System level (SAC)** | |
| **A 1.12** | **Topologies for High Speed design and digitization (SAC)** | |
| **A 1.13** | **Design of >30 bit Digitizer (SAC)** | |
| **A 1.14** | **Chip on board technology for space hardware (SAC)** | |
| **A 1.15** | **EMI susceptibility analysis for co-existence of low noise, high speed, high power analog/digital circuits (SAC)** | |
| **A 1.16** | **DSP based real /near real time data processing for signal analysis and** | |

| | | |
|---|---|---|
| | **image processing with emphasis on frequency and spatial domain (SAC)**<br>• Hardware and/or software with Image Based attitude determination electronics.<br>• Spacecraft docking system electronics<br>• Real Time decision making for Landing System | |
| **A 1.17** | **Onboard computer electronic system (including volatile, nonvolatile mass memories, processors, standard interfaces, RTOS etc.) for space environment supporting soft computing of complex algorithms and real time applications (SAC)** | |
| **A 1.18** | **Development of high power (100W) high efficiency (>90%) power amplifier working over unregulated raw bus for driving low impedance load ( < 4 Ω) (SAC)** | |
| **A 1.19** | **Algorithm to minimize jitter at cold tip of pulse tube cooler or sterling cycle cooler using close loop active vibration control (SAC)** | |
| **A 1.20** | **Development of algorithm or MATLAB model to estimate/optimize PID coefficient for optimum response based on overall close loop transfer function or any industry defined PID tuning method. Also, development of cooler transfer function based on empirical data or close loop response measurement (SAC)** | |
| **A 1.21** | **Very Low noise (≤1mV), Low power (<10W), highly efficient (>90%) space grade miniaturized (12W/in3) isolated power supply /module including advance features for protection and output control (SAC)** | |
| **A 2** | **Sub Area** | **Optics (SAC)** |
| **A 2.1** | **Compact optical systems (SAC)** | |
| **A 2.2** | **Studies and solution for gravity effect on large diameter light weight optics (SAC)** | |
| **A 2.3** | **Adaptive optical elements (SAC)** | |
| **A 2.4** | **Development of extremely thin and deformable mirrors (SAC)** | |
| **A 2.5** | **Metal mirror optics for VIS / NIR imaging (SAC)** | |
| **A 2.6** | **Interferometric sensing system (SAC)** | |
| **A 2.7** | **Optical butting to increase swath at higher resolution (SAC)** | |

| | | |
|---|---|---|
| A 2.8 | On-board focusing of optics (SAC) | |
| A 2.9 | Development of wedge/ strip filters (SAC) | |
| A 2.10 | Athermalization of optics using phase plate (SAC) | |
| A 2.11 | Studies on super resolution techniques (SAC) | |
| A 2.12 | Image quality analysis of catadioptric (Reflective and Refractive) systems (SAC) | |
| A 2.13 | Origami lenses (SAC) | |
| A 2.14 | Diffractive Optical Elements (DOEs) and development of hybrid lenses (diffractive + refractive)/Binary Optics (SAC) | |
| A 2.15 | Super Lenses (using meta-materials) (SAC) | |
| A 2.16 | Foveated Optics (SAC) | |
| A 3 | Sub Area | Detectors (SAC) |
| A 3.1 | Modelling of CCD based imaging sensor charge transfer scheme. (SAC) | |
| A 3.2 | Minimization of Charge of transfer efficiency degradation when irradiated with high energy radiation (SAC) | |
| A 3.3 | Mathematical simulation of Quantum Dot Infrared detector performance (SAC) | |
| A 3.4 | Development of Si photodiodes with high responsivity in blue and NIR spectral regions (SAC) | |
| A 3.5 | Surface treatment approaches for photodiode Quantum Efficiency improvement (NIR to Blue and/ or selected wavelength regions). Graded antireflection coating for minimization of reflection as a function of wavelength, in area array Si CCD (SAC) | |
| A 3.6 | Surface treatment for dark current minimization (SAC) | |
| A 3.7 | APD development (Si and InGaAs) (SAC) | |
| A 3.8 | Development of MCT based PV detector sensitive in the spectral region SWIR-LWIR regions (SAC) | |
| A 3.9 | Multiband (SWIR/MIR, MIR/SWIR - detector Infrared detector Development | |

| | | |
|---|---|---|
| | (including Quantum/ Type-II Strained layer type detectors) (SAC) | |
| A 3.10 | Development of Multi-band high quantum efficiency detector arrays. (SAC) | |
| A 3.11 | Hemi sphere/ flexible Focal plane arrays (SAC) | |
| A 3.12 | High speed high performance APS arrays (SAC) | |
| A 3.13 | Miniature gas sensors for CO, CO2, CH4, NH3, O2, N2O, SO2and other Greenhouse gases (SAC) | |
| A 3.14 | Optical Fiber based gas sensor (SAC) | |
| A 4 | Sub Area | Electro-Optical Systems (SAC) |
| A 4.1 | Fourier transform spectrometers for space (SAC) | |
| A 4.2 | Imaging spectrometer- VNIR and TIR (SAC) | |
| A 4.3 | Compressive sensing techniques (SAC) | |
| A 4.4 | Tera-Hertz imagers (SAC) | |
| A 4.5 | Compact optical systems (SAC) | |
| A 4.6 | Formation Flying EO systems (SAC) | |
| A 4.7 | Imaging Science – Modelling of complete imaging chain – simulation and advancements (SAC) | |
| A 4.8 | Miniaturization of EO sensors/imagers through use of MOEMS (SAC) | |
| A 4.9 | Space LIDAR/LADAR (SAC) | |
| A 4.10 | Precision calibration sources for ground and onboard use (SAC) | |
| A 4.11 | Precision scene simulators (SAC) | |
| A 4.12 | Fibre Optic based image relay system (SAC) | |
| A 4.13 | Studies on 360º imaging optical systems relevant to space based remote sensors (SAC) | |
| A 4.14 | Micro Mirror based scanners and imagers (SAC) | |
| A 4.15 | Inter-calibration of hyper-spectral sensors having different spectral | |

| | | |
|---|---|---|
| | **response (SAC)** | |
| **A 4.16** | **Development of models for radiometric and background radiation performance evaluation of Payloads (SAC)** | |
| **A 4.17** | **Identification of trace gases using mass spectrometry data (SAC)** | |
| **A 5** | **Sub Area** | **Micro Fabrication for Optics (LEOS)** |
| **A 5.1** | **Deformable mirror by micro fabrication for phase correction in adaptive optics (LEOS)**<br>Deformable Mirror (DM) is an important sub system of adaptive optical instrumentation which helps in improving the optical performance of an imaging system by actively correcting the measured wave font errors. The surface figure of a deformable mirror is actively controlled and modified such that it cancels out the measured surface error of system. It is made up a flexible Si wafer with thin film piezoelectric actuators fabricated on the back side using micro lithography techniques. This technology has multiple applications in improving imaging performance, optical communicated and ophthalmology. | |
| **A 5.2** | **Micro mirror array for wave front phase sensor (LEOS)**<br>Micro mirror array is an important optical device with multiple applications. Realizing the fabrication technology of this device will be a significant step in the development of more complex instruments such as Shack Hartman Sensor etc. | |
| **A 6** | **Sub Area** | **Spectroscopy instrumentation and application (LEOS)** |
| **A 6.1** | **Optical design and development of compact spectrograph for spectroscopy (LEOS)**<br>Aberration corrected spherical surface gratings for specific spectroscopy application can be designed and the groove pattern can be realized using direct-write electron beam lithography. It is possible to fabricated analog depth diffractive optics in thin films of polymethyl methacrylate. Diffractive optic fabrication on non-flat (to date convex spherical) substrates can be fabricated utilizing the large depth of filed inherent in E-beam lithography. Realization of this technology will help in realizing compact, high performance spectrograph with minimum number of optical components. | |
| **A 6.2** | **Raman spectroscopy based studies on optical materials and minerals (LEOS)**<br>It is now well established that most of the covalently bonded optical materials and minerals have their characteristic Raman spectrum which can be used to | |

| | | |
|---|---|---|
| | identify the compound. Proposal to do mineralogical study using Raman spectroscopy are useful to collect sufficient data and develop techniques to analyze and identify mineral compositions of any unknown minerals. These results and experience will help in future moon / mars mineralogy using Raman instrument. | |
| **A 6.3** | **Raman spectroscopy application in earth and planetary atmosphere studies (LEOS)**<br>The gaseous composition of earth and planetary atmospheres are required to be studied and analyzed on a regular basis to understand the climatic changes that are happening. LIDAR instrument based on Raman spectroscopy can give us valuable information on gaseous distribution along the attitude. Laboratory simulated atmosphere studies of gaseous planets and also experimental Raman LIDAR spectroscopy studies of earth atmosphere are of interest. | |
| **A 7** | **Sub Area** | **Electro- Ground Checkout Systems (SAC)** |
| **A 7.1** | **Embedded firmware for Real time Data processing, continuous data acquisition (data rate of up to 2 Gbps), Real time video streaming (@ 15fps of frame size 2560x2160) and real time Image display (SAC)** | |
| **A 7.2** | **Drivers for multi-core DSP system, with RTOS and algorithms for real-time object identification as well as tracking (SAC)** | |
| **A 7.3** | **General purpose graphics processing based systems for high speed real time image display (SAC)** | |
| **A 7.4** | **Very high speed Data acquisition of the order of 40Gbps sustained for about 2 TB volume (SAC)** | |
| **A 7.5** | **3-axis precisely controlled mounts for distortion free imaging (SAC)** | |
| **A 7.6** | **Extraction of finer spectral resolution information from Hyper-spectral Imagery, given a large number of relatively coarser resolution images with overlapping spectrums (SAC)** | |
| **A 7.7** | **Algorithm/software to create a super straddle of workstations towards effective utilization of computing resources for electro-optical payload development environment (SAC)** | |
| **A 7.8** | **Development of algorithms/software to generate 3D images using DMD based scanning of targets (SAC)** | |
| **A 7.9** | **Development of Mathematical Models for an Electro-Optical System (SAC)** | |

| | | |
|---|---|---|
| A 7.10 | Software to simulate the final image, with sensitivity to design parameter/system environment/onboard processing/viewing geometry (SAC) | |
| A 7.11 | Firmware for Baseband Reception of high speed serial data and real time extraction and dissemination of raw data from FEC coded/CCSDS formatted/Compressed/Encrypted data stream (SAC) | |
| A 8 | Sub Area | Integration and Testing (SAC) |
| A 8.1 | Space-borne electro-optical performance estimation models (SAC) | |
| A 8.2 | Automation of imaging system test setup (SAC) | |
| A 8.3 | Precision test setups (SAC) | |
| A 8.4 | Development of innovative techniques/methodologies for integration and testing (SAC) | |
| A 8.5 | Development of imaging system performance optimization and characterization techniques (SAC) | |
| A 8.6 | Development of In-orbit performance prediction models and performance evaluation techniques (SAC) | |
| A 8.7 | Development of methodologies and fast algorithms for analysis of large amount of test data (SAC) | |
| A 8.8 | Development of highly accurate (better than 0.05mm) 3D measurement System (Photogrammetry based) (ISAC) | |
| A 8.9 | Development of system capable of measuring the 3D co-ordinates of markers /3D objects. The system should be capable of measuring the 3D co-ordinates of the markers on the object to be measured (ISAC) | |
| A 9 | Sub Area | Sensor Electronics (SAC/ LEOS) |
| A 9.1 | Onboard intelligence (SAC) | |
| A 9.2 | Ultra-low power ASIC, mixed-signal ASIC (SAC) | |
| A 9.3 | Design of High speed FPGA (SAC) | |
| A 9.4 | DSP and embedded design (SAC) | |
| A 9.5 | Mixed-signal component characterization (SAC) | |

| | | |
|---|---|---|
| A 9.6 | **Miniaturized power supply (SAC)** | |
| A 9.7 | **HMC-based switching regulator (SAC)** | |
| A 9.8 | **UAV-compatible hardware (SAC)** | |
| A 9.9 | **High speed data acquisition and processing (SAC)** | |
| A 9.10 | **UAV-compatible hardware (SAC)** | |
| A 9.11 | **Space radiation modelling (SAC)** | |
| A 9.12 | **EMI/EMC analysis (SAC)** | |
| A 9.13 | **GP/GPU based software (SAC)** | |
| A 9.14 | **Miniature sensors for in-situ measurements (SAC)** | |
| A 9.15 | **Biochemical sensors (SAC)** | |
| A 9.16 | **On Orbit mounting estimation of star sensor (LEOS)**<br>Star Sensor Mounting Estimation using on orbit / in-situ measurements The star sensor provides attitude accurate to 10'' in measurement axes and 40" in bore-sight axis, leading the spacecraft pointing and control of 36" in body frame at about 4/8Hz update rate. The mounting / mechanical stability contributes to about 4-6'' uncertainty. Also due to various factors like thermal, effects of structural stability etc., the SS mounting varies by small amount cyclically in orbit/season.<br>Towards providing further improved attitude accuracy of about 10" (in all three axes in body frame), it is proposed for research studies the problem of estimating the star sensor mounting on orbit/in-situ, using star sensor measurements, so that mounting updated at every attitude solution cycle, can be delivered along with estimated attitude solution to AOCS for significantly improving the pointing control accuracies of spacecraft & location accuracies of imageries. | |
| A 9.17 | **On board star catalogue generation for a small field of view (FOV) star sensor. The database should contain inertial coordinates of selected stars. Star separation table in the form of indices of star (LEOS).** | |
| A10 | **Sub Area** | **Microwave Sensors (SAC)** |
| A 10.1 | **System Design and Configuration (SAC)**<br>High resolution, wide swath SAR system configurations using Digital beam-forming and SweepSAR; mm-wave atmospheric temperature and humidity | |

| | |
|---|---|
| | sounding; scatterometer systems; Ground-Penetration Radars (Stepped Chirp/CW-LFM/ Impulse-type Ultra wideband); Active Radar Calibrators; High accuracy Altimeter for Hazard Detection, Navigation and Guidance; GNSS-Reflectometry; MTI-SAR from spaceborne platforms, SAR Polarimetry and Polarimetric Interferometry, new algorithms for Polarimetric Decomposition using hybrid polarimetry, Precipitation Radars, Doppler Weather Radars, Mini, Micro & Nano SAR systems at RF & mm-wave, Advanced Microwave sensor Calibration techniques, Inverse SAR systems etc. |
| **A 10.2** | **Transmit-Receive Technology (SAC)**<br><br>Wideband, high power Miniaturized TR Modules and Pulsed TWTAs in L,S,C & X-bands, High Power MMIC Designs, compact Microwave Power Modules (c-MPM) & Combiner, High Efficiency Pulsed & CW SSPAs (MOS/GaAs FET, GaN HEMT/HBT) with associated thermal & power management, High power & low loss X-Band Ferrite Switch assemblies, ultra low noise & ultra high freq. (mm & sub-mm freq.) technologies like mHEMT/pHEMT/ Schottky/RF-CMOS for linear (LNAs/Gain Blocks), non-linear (mixers/multipliers/VCO) & control circuits (Phase shifters/ Attenuators/Switches), Multi Chip Module technologies (multi-layer soft substrates/LTCC/HTS), Highly stable & Coherent Phase Locked (VCO/DRO) compact Frequency Generators, Metamaterial structures, MMIC, RF MEMS and RF-CMOS Receiver Designs, etc. |
| **A 10.3** | **Power Supply Technology (SAC)**<br><br>Miniaturized & high efficiency, pulsed power supplies with higher current capabilities, Low Drop-Out Regulators (LDO) & Point Of Load (POL) Hybrid HMC/ASIC, soft switching DC-DC converters, Reconfigurable (FPGA/ Power ASIC based) Converters etc. |
| **A 10.4** | **Digital and Mixed Signal Technology (SAC)**<br><br>Mixed Signal ASIC Design & Development (8-14 bit ADCs & DACs @ 1.5 GSPS), Ultra-High Speed SERDES (>2.5 Gbps), SAR processor ASIC / SoC with huge on-chip Memory, Fault tolerant Reconfigurable 32/64-bit Microprocessors/DSPs/SoCs, Ultra-High speed/Capacity (>5 Tbits) Scalable Solid state mass storage, Wideband waveform synthesizer (>1GHz BW), Opto-electronics devices & Transceivers, Ultra-High Speed Serial/ Parallel Interfaces (wired/wireless), wireless active antenna Tile Electronics, Ultra High Speed (>1.5 GSPS) and Ultra-High Precision Data Acquisition Electronics (16-32 bits), Design of Radiation Hardened Cell libraries for 0.18µm SCL Foundry, Radiation Tolerant/Hardened Package design, SEL/SEU-Immune Designs, Soft & Hard IP developments for peripherals, Signal Processing modules, Interface modules etc.. |

| | | |
|---|---|---|
| A 10.5 | **Onboard Payload Data processing Technology (SAC)**<br>Real Time SAR Data Compression and Signal Processor, Real time signal processing for Radar Altimeter, Real time feature/hazard detection for planetary landing assistance, onboard Radar backscatter ($\sigma 0$) computation for Scatterometer, Multi-channel Complex Correlator for Synthetic Radiometer, Geometric and Radiometric calibration of microwave sensors, etc | |
| A 10.6 | **Signal and Image Processing Algorithms (SAC)**<br>SAR raw Data Compression using Compressed Sensing/Wavelet Transforms, Signal Processing and Tracker algorithms for Radar Altimeter for Navigation, Guidance & Control, Complex Correlation Algorithm for Synthetic Aperture Radiometer & Performance Analysis, Onboard SAR Processing algorithms, Linear & Hybrid Polarimetric Data Processing and Analysis, Interferometric SAR Data Processing and Analysis, Super Resolution Image Processing Algorithms, Feature Extraction Algorithms for Microwave Data, Extraction of Subsurface Dielectric properties for Ground Penetration Radar, GNSS- Reflectrometry & GNSS Remote sensing Receiver etc.. | |
| A 11 | **Sub Area** | **Mission (ISAC)** |
| A 11.1 | **New tools and techniques for automation of EO multi satellite operations (ISAC)** | |
| A 12 | **Sub Area** | **Flight Dynamics (ISAC)** |
| A 12.1 | **EO Satellite Orbit determination (ISAC)**<br>Parameter estimation methods, including least squares and Kalman filtering. Attention should be paid to statistical aspects and data processing | |
| A 13 | **Sub Area** | **Optical Thin Films (LEOS)** |
| A 13.1 | **Studies on transition metal oxide thin film coatings (LEOS)**<br>Transition metal oxide coatings are potential candidates for their applications as infrared detector sensing elements, switching devices, radio-frequency transparent thermal control coatings, etc. Studies on optical, electrical and thermal properties of the thin films will lead to development of devices for space applications. | |
| A 13.2 | **Laser damage threshold studies on optical thin film coatings (LEOS)**<br>The optical coatings such reflector coatings, antireflection coatings, interference filter coatings, etc have their applications in laser based instruments for ground as well as space applications. Based on the energy of the laser the coatings may be damaged. The studies on laser damage threshold of optical coatings | |

| | |
|---|---|
| | give an insight into the durability aspects of the coatings for laser applications. |
| A 13.3 | **Studies on hydrophobic/ dust repellent coatings (LEOS)**<br>Optical thin film coatings are essential for space based reflective/ refractive electro-optics systems. The front optical elements being exposed to space environment, they need to be protected from dust and condensable vapours which seldom detrimental to the performance of payloads. These coatings will also be useful in interplanetary missions during landing the instrument over the surface of the planet. Hence the study of hydrophobic/ dust repellent coatings find space applications |
| A 13.4 | **Infrared optical coating technologies for filters, Anti reflectance coatings etc for IR optics (LEOS)**<br>Space qualified optical coating technologies to produce filters and ARCs in different spectral bands in the near IR, SWIR and far IR for the imaging and spectroscopy instruments that are being envisaged in the future space programs are required to be developed. |
| A 13.5 | **Thin film solar cells and thin film batteries for satellite power requirement (LEOS)**<br>It is already recognized that Thin film solar cells based Cu-In-Ga-S (CIGS) materials coatings are highly advantageous for space power application as these panels have high specific power (Watts / Kg) and are highly radiation resistant. Development of this technology for space usage will help in significantly reducing the weight contribution due to solar power requirements. |
| A 13.6 | **Nano technology based optical / gas sensors (LEOS)**<br>Nano technology based rechargeable Thin film batteries which can be charged and store the power generated by solar cells are under development for space application. With this combination failures due to lack of power can be significantly reduced. |
| A 13.7 | **Optical material, coatings and components for NIR or Visible LASER development (LEOS)**<br>Indigenous development of LASER for space application in an ongoing process at LEOS which requires lasing materials, damage resistant coatings and Thin film based laser diodes etc., research and development in realizing these technologies can be very useful. |
| A 13.8 | **Ultra narrow band pass and notch filters for a single wavelength of a laser line (LEOS)**<br>These filters are required for Raman Spectroscopy Instrumentation where the |

| | | |
|---|---|---|
| | incoming laser should be spectrally stable with a very narrow band width and without any side lobes. This can be possible only with a very narrow band pass filters placed in front of the laser. Similarly the Rayleigh scattered radiation from a laser illuminated sample has the same wavelength as the laser. In order to observe the Raman Spectrum, this component needs to be filtered out completely using a very narrow band notch filter centered at the laser wavelength. Development of these filters will help in indigenous realization of Raman instrument for space application. | |
| **A 13.9** | **Glancing Angle Deposited optical films with unique optical properties and their applications (LEOS)**<br>Porous nano-engineered thin films fabricated using GLAD have a wide variety of optical applications. Helical films exhibit intriguing chiral optical properties, including circular Bragg effects and optical activity. GLAD films with grade index can be used for wide-band antireflection coatings exhibiting transmittance in excess of 99.7% over a 460 nm wavelength range, rugate filters with wide stopbands, spectral hole filters with narrow passbands, and even optical humidity sensors with superior performance response time and sensitivity to many commercial available sensors. The square spiral chiral film can be used to produce photonic crystals with a complete, three dimensional bandgap. | |
| **A 14** | **Sub Area** | **Fusion Algorithm for computation of Spacecraft Attitude with Multiple – Head Star Trackers (LEOS)** |
| **A 14.1** | **Development of optimized fusion algorithms and techniques to combine the images obtained from multiple heads, compensate for thermo-elastic distortions between heads and compute spacecraft attitude (LEOS)**<br>Higher attitude measurement accuracy is obtained by using the star image captured from multiple star tracker heads that are mounted with different relative orientations. The accuracy is improved with the availability of more number of stars from multiple heads and different orientations of star tracker heads that offset bore-sight errors. The difficulty in multiple heads configuration is the results may be affected by thermo - elastic distortions between the heads | |
| **A 15** | **Sub Area** | **Micro Aircraft for Mars-2 (LEOS)** |
| **A 15.1** | **Development of Unmanned Arial Vehicle (UAV) which can fly using solar power (LEOS)**<br>• It will have imaging payload and an RF link with the orbiter spacecraft.<br>• It should have adjustable propellers to fly forward as well as for hovering.<br>• It should be built with non-corrosive and light weight material.<br>The Mars is having lot of attention from the researchers for its exploration, | |

| | | |
|---|---|---|
| | related to existence of life. Typically the exploration is carried out in two phases.<br>• A spacecraft orbiting over Mars and taking images with very high resolution images, which are bulky to fine the area of interest. But this has limitations. The dust and clouds make a thick layer and make the visibility poorer for the attitude of a spacecraft.<br>• After finding the region of interest a rower is made to land on the surface and the rower does the soil study in very limited area.<br>• There can be one intermediate stage to find out area of interest on Mars surface by a low attitude Arial survey. Since Mars is having atmosphere an Aeroplane can fly over here. This plane should be solar powered, built with light weight non corrosive materials and carries small camera for surveillance and RF link with the satellite should have Mars upto 3 kg. It's propellers should be adjustable to front direction fly as well as for hovering.<br>The Aero plane is deployed from the satellite into the Mars atmosphere and the plane performs high resolution survey on a wide area with miniature cameras. In case the area is found to be unsuitable the plane can be made to hover at a different area. This makes the search very economical for the desired landing spot for a rover, since the higher resolution images can be obtained with a much smaller payload when a low attitude survey is carried out. | |
| **B** | **Area** | **Remote Sensing Image Processing and Software Development (SAC/NRSC/IIRS/NESAC)** |
| **B 1** | **Sub Area** | **Image Processing (SAC/ IIRS/ NESAC)** |
| **B 1.1** | **Advanced technique and algorithm development for in-flight Geometrical Calibration and its Standardization for Optical Remote Sensing payloads (SAC)**<br>In-flight geometric calibration exercises are carried out usually during initial phase of the mission and necessary algorithms and corresponding s/w are developed for each mission separately. Special efforts are put for conducting a large number of exercises and analysis of results. This makes the in-flight experiments purely mission dependent calling for s/w changes for any new mission. Further, different modelling approaches are available with the DP team. So a need for generalized s/w is felt based on the current experiences while giving scope for flexibility to extend the approach for new sensors like TDI and other high-resolution imaging modes. A scheme for standardization/generalisation of this activity is being evolved in terms of the following viz.<br>• Establishing necessary set of pre-identified test bed areas where | |

| | |
|---|---|
| | adequate number of accurate control points are available, for use by any mission<br>• Development of mission independent techniques/algorithms and necessary s/w to work with or without control.<br>• Provision to incorporate new techniques, various modelling options to work with/without control points, options for single sensor, stereo sensors, triple sensors, multi-strips, multi-bands, TDI sensor, imaging modes etc.<br>• Identifying a set of common in-flight geometric parameters for adjustment for any mission as well as mission specific features.<br>• Approach should be able to characterize interior and exterior orientation of the sensors.<br>• Standardization of definition, convention for in-flight geometric parameters and their use<br>• Estimation and separation of attitude biases from spacecraft alignment and payload alignment angles etc.<br>• Standardization of Input /Output file formats and contents<br>• Scope for adding any additional, new features pertaining to in-flight procedures.<br>This research aims at development of new procedures (both technology development as well as R&D work for development of algorithms and s/w) and standardization/generalization of the approaches for in-flight geometric calibration of the sensors onboard remote sensing satellites, which will result in high accurate data product realization at system level, apart from improving registration and mosaicking accuracies across missions for handling heterogeneous data sets. This can also give a future direction to the calibration procedures in terms of the requirements of some of the hardware onboard so that they can be useful in the future remote sensors (Cartosat-2C/2D, Cartosat-3, Cartosat-1A/1B, Chandrayaan-2 etc) of different configuration. |
| **B 1.2** | **Modelling for Multiple Satellite/Sensor/Strip/View data in block adjustment sense (SAC)**<br>The aim of this research is to develop approaches/techniques (both parametric and non-parametric) to model simultaneously data from multiple satellite/sensor/strips/Views from Cartosat-1/2/2A/2B and future missions to generate terrain corrected products with high accuracy. The scope of the proposal includes development of techniques for generation of Digital Elevation Models and Orthoimages without using the control points so that it can meet the Global requirements. This can be achieved by increasing the redundancy in the |

| | | |
|---|---|---|
| | datasets. Both Physical and RPC models will be built in block adjustment such a way, it can be easily adopted for planetary missions Chandrayaan-1 and Chandrayaan-2.<br><br>It is planned to make use of this approach with global missions like Quickbird, IKONOS, Worldview for available data sets. The proposed research will be able to handle and model full pass duration with limited control or no control and pave way for realizing highly accurate DEMs and good quality data products especially for future HR missions like Cartosat-2C/2D, Cartosat-3, & other upcoming carto series of satellites & other High resolution missions. | |
| **B 1.3** | **Automatic extraction of 3D city models using LIDAR/ Satellite data (IIRS/ NESAC)** | |
| **B 1.4** | **3D surface modelling and features capturing of UAV/UAS data (NESAC)** | |
| **B 2** | **Sub Area** | **Development of Image processing algorithms (NRSC/SAC)** |
| **B 2.1** | **Automatic Image Registration (NRSC)**<br><br>This should cater to multi-temporal, multi-resolution and multi-spectral imagery registration with a specified accuracy for each category with a sub-pixel accuracy | |
| **B 2.2** | **Hyper spectral Image analysis (NRSC/SAC)**<br><br>Development of techniques of hyper spectral analysis for EO and planetary applications | |
| **B 2.3** | **Bundle block adjustment of aerial/satellite imagery (NRSC)**<br><br>A technique development for operational bundle adjustment of large number of satellite imagery. This should cater to the multi-resolution and multi-resolution satellite imagery. Should make use of a distributed processing environment including the state of the art computer architecture | |
| **B 2.4** | **Cloud computing and virtualisation (NRSC)** | |
| **B 2.5** | **Algorithms for time series analysis of satellite data (NRSC)** | |
| **B 2.6** | **Advanced models for satellite data pre-processing methods (NRSC)**<br><br>Innovative high resolution image processing algorithms like image restoration, noise elimination, blur reduction and other quality improvements including advanced geometric correction models for satellite imagery | |
| **B 2.7** | **Development of Visualisation techniques for VR system (NRSC)** | |

| | | |
|---|---|---|
| **B 3** | **Sub Area** | **Data Simulation (SAC)** |
| **B 3.1** | **High resolution data simulation for future Cartosat series and HYSI mission (SAC)**<br><br>There is a need of data simulation towards understanding the TDI devices in terms optical butting (used to make swath larger), high bit depth (radiometric resolution) and spatial resolution (0.5 m or higher). Therefore TDI sensor data simulation will be taken up in near future by using the other TDI devices data already flown globally like IKONOS/Quick Bird etc. This simulation will help in calibration, and testing the data processing and data compression s/w of Cartosat-2C and 3. Data simulation is also required for HYSI sensors for testing of data processing algorithms, simulation of agile platform effects as well as testing of data compression algorithms. | |
| **B 3.2** | **Simulations for microwave sensors (SAC)**<br><br>There is a need of data simulation for testing effect of various sensor parameters like chirp bandwidth, slice bandwidth and resolution, SNR etc. on performance of pencil beam scatterometer. Simulations of wave-forms are required for deciding on optimum sensor parameters and tracking algorithms for spaceborne altimeter system. Simulations are required to develop robust phase unwrapping algorithms for SAR Interferometry techniques. Simulations to understand concept of SweepSAR for acquiring data over large area with better geometric resolution. Data simulation will also help in testing of data processing algorithms. | |
| **B 4** | **Sub Area** | **Data Visualisation (SAC)** |
| **B 4.1** | **An immersive satellite image navigator with human gesture recognition (SAC)**<br><br>This research may brandish a complete suite to visualize the image data with gesture recognition features. This kind of navigation will enable swift display and browsing of satellite image data with the help of no contact, gesture driven device (like Wii). Also, it can be used in discussion panels, exhibitions and presentations which intend to use this type of visualization as an approach for technology demonstration. | |
| **B 4.2** | **Development of Image fusion techniques (SAC)**<br><br>This research is aimed towards development of image fusion techniques by spatial and frequency domain methods for merging HR PAN & MX data as well as optical and microwave data. The scope includes<br><br>1. Development of Image fusion method to generate merged product of Cartosat-2C. | |

| | |
|---|---|
| | 2. Study & implementation of suitable algorithm and in-house software development from the existing approaches for HR data and<br>3. Development of Image fusion methods to generate merged products from various optical bands and microwave multi-polarised data acquired at different look angles.<br>Initially testing can be done by existing Cartosat-1, IRS-P6 and RISAT-1 data sets. |
| **B 4.3** | **Image Matching for DEM generation (SAC)**<br>One of the most important components of DEM generation from stereo/ multi-view imagery is the generation of high density match points and their structuring. Current version of CartoDEM based on Cartosat-1 stereo pair is based on advances in template matching to produce high density match points and structuring by TIN. Further research areas taken up in this include feature-based matching, better shadow and outlier detection, and improved DEM regularization/ conditioning for end-use. Another area of research in this field is development of robust algorithm for triplet matching, which will be enhancing the current version of Lunar DEM generated from Chandrayaan-1 TMC as well as for future Chandrayaan-2 TMC. R&D efforts are required to generate very high quality DEM from Aerial TMC stereo/triplet data sets by extending the above methods in terms of improvements in techniques/algorithms |
| **B 4.4** | **Image Quality Improvement (SAC)**<br>The image component of Data products are a result of correction for systematic errors/ variations in Radiometry and Geometry. Development of techniques for restoration (MTF correction) of high spatial resolution imagery (e.g. Carto-2 series), de-striping of narrow-band sensors like OCM, and spectral de-convolution of Hyper-spectral imagery are areas of research in this category. Currently operational MTF restoration for Cartosat series are based on techniques developed here. |
| **B 4.5** | **Quality Indices for quantifying Data Quality (SAC)**<br>R&D in terms of identifying suitable quality parameters for each sensor, development of algorithms for evaluating the parameters from data, and quantifying uncertainties in the process. |
| **B 4.6** | **Generation of quality flags for INSAT-3D products (INSAT-3D, INSAT-3DR) (SAC)**<br>A study on identification of quality flags for data products of Imager and Sounder is planned to be initiated. Quality flags will be formulated to capture end-to-end quality related to sensor performance, data processing approach and calibration quality, keeping in view quality requirements of climate quality |

| | |
|---|---|
| | data.<br><br>Some of proposed scene-wise quality flags for Level-1 products are a) Radiometric quality – visual, calibration accuracy, sensor noise and b) Geometric accuracy - navigation accuracy, channel mis-registration. Additional flags as per requirement may be identified. Effect of above quality flags on usability of geo-physical products (eg. SST, OLR, UTH, Atmospheric winds) on identified sites will be studied. Validation exercise with references/in-situ measurements is also planned to be carried out |
| **B 4.7** | **Identification of quality parameters for Hyper spectral Data (SAC)**<br><br>Quality parameters to quantify Geometric, Radiometric and Spectral quality of Hyper-spectral data are required to be identified. Quality aspects specific to Planetary or Land applications such as spectral signature identification for mineral mapping can be explored. Effect of basic data quality on usability and accuracy of higher level products generated for applications can be analysed.<br><br>Study area can be identified with available hyper-spectral data (Hyperion/AHYSI sensors), where sensor performance and data quality can be studied and validated with ground observations. |
| **B 4.8** | **Integrated Work bench for Quality Analysis of remote sensing images (SAC)**<br><br>A work bench for quality analysis is proposed to be developed that would support data visualization and quality evaluation of remote sensing images. The software should support visualization of different types of satellite images (Medium to High resolution, Multi/Hyper spectral, Optical/SAR) and geo-physical data products (SST/UTH/WV etc). It should have capability of overlaying Vector Layers (District/State boundaries), Ground Control Points (GCPS), Google-Maps available in public domain on images. Use of Open source libraries/GIS packages can be explored for implementation. Domain specific techniques for semi-automatic quality evaluation will be integrated with the proposed software. |
| **B 4.9** | **Post-launch Calibration of space-borne sensors (SAC)**<br><br>This is carried out for medium resolution optical land-imaging sensors' radiometry based on natural calibration sites, for narrow-band Ocean Colour sensors based on Moon-imaging, for high resolution sensor MTF based on artificial targets, and for SAR sensor geometry using corner reflectors and radiometry from natural sites. Development of suitable models for ground radiometry assimilation, Top-of-Atmosphere radiance generation, Moon-image irradiance modeling, target design and modeling for MTF evaluation, and for modeling of calibration parameter determination for SAR targets are areas of research in this category. In each aspect operational methods are based on |

R&D carried out here.

**SAR radiometric calibration** is one of the important aspect to characterize and maintain image quality throughout the mission and to provide stable, quantifiable image products to the users. This exercise is carried out throughout the mission in different manners.

- For SAR sensors, continuous monitoring of gamma naught and sigma naught on non-variant calibration sites like Amazon rainforest, Boreal forest is done to observe antenna pattern and consistency in gamma0
- Radiometric parameters like sigma0, speckle index and radiometric resolution are observed from other distributed targets for the data sets with same instrumental parameters (beam, polarization). This exercise is used to estimate noise equivalent sigma0 to ensure the data quality
- Scalloping and banding are the distortions needs to be quantified for ScanSAR mode
- Corner reflector based calibration is done to compute the impulse response parameters. A regular and systematic analysis helps to estimate the radiometric accuracy and stability using corner reflector based data
- Monitoring of SAR instrument subsystem components is used to study gain variations or linearity

A novel approach for **Data quality evaluation of Scatterometers** (OceanScat or upcoming mission ScatSat-1) is being worked out where one can relate the parameters available at different levels of product to geophysical parameters. In Scatterometer the vector wind is retrieved by combining several backscatter observations made from multiple viewing geometries.

From Level 0, Leve1 and Level 2 data products, behavior of each sensor parameter is studied and suitable flags are generated if any deviation is observed. Pre-requisite of this exercise is first to have proper understanding of the instrument and algorithm characteristics which gives an insight into the factors controlling data quality. This monitoring and stringent flagging of required parameters at each level ease the traceability in order to relate the end product with Level 0 or intermediate level of products.

Scatterometer calibration includes the monitoring of onboard calibration data to keep a check on transmitted power. Invariant sites like Amazon rainforest, Sahara Desert, Antarctic snow are required to be monitored regularly and time series of backscattered or brightness temperature can be generated to check the system behavior. Regular such feedbacks help data processing to fine tune the DP system in order to generate high accuracy data products.

| | | |
|---|---|---|
| B 4.10 | **Sensor Web Enablement (IIRS)**<br>Open Geospatial Consortium (OGC) has taken a major initiative towards the development of OGC SWE specification. The OGC's Sensor Web Enablement (SWE) standards enable developers to make all types of sensors, transducers and sensor data repositories discoverable, accessible and useable via the Web. Some of the key areas of SWE research are on Sensor Web Data Visualization, Sensor Web Data Uncertainty Management, Sensor Web Data Management (e.g., Indexing, Caching, Query & Processing), Sensor Web Data Discovery and Search and SWE Deployment for Real-world Applications. Also few areas like Convergence of GeoWeb, Sensor Web and Social Web and Interoperable Middleware Architectures for heterogeneous Sensor Networks/Sensor Web are in developmental stages. | |
| B 5 | Sub Area | Earth Observation Data Processing (SAC/ NRSC/ IIRS/ NESAC) |
| B 5.1 | **Advanced sensor models for optical & Microwave data Geo-referencing (SAC/ NRSC/ IIRS/ NESAC)** | |
| B 5.2 | **Techniques for multi-date data registration and mosaicing (SAC/ NRSC/ IIRS/ NESAC)** | |
| B 5.3 | **Techniques for Geospatial Data Analysis (SAC/ NRSC/ IIRS/ NESAC)** | |
| B 5.4 | **Atmospheric correction procedures implementation for Visible & NIR & HySI (SAC/ NRSC/ IIRS/ NESAC)** | |
| B 5.5 | **Data Processing for Smart Satellites (SAC)**<br>Carry out the Technology demonstration of complete Data processing on-board and disseminating products/Information. | |
| B 5.6 | **Cloud Avoidance Scheduling (NRSC)**<br>Payload programming makes the optimum use of satellite resources to satisfy User requirements. The various capabilities of the IRS satellites and its resources call for a meticulous planning. Payload programming is successful only when it results in acquisition which cater to user requirements in terms of data quality, correct area of coverage (targeting accuracy), timeliness (within the period of interest) and cloud free acquisition.<br>Cloud cover is one of the major problems in the acquisition of optical satellite remote sensing data and has a negative impact on the efficiency of data scheduling.<br>The necessary global cloud information (on a daily / hourly basis) derived from | |

| | |
|---|---|
| | meteorological satellites has to be incorporated in the planning system to improve the planning efficiency. |
| **B 5.7** | **Time Series Data Processing (SAC)**<br>Re-Processing all IRS, land and ocean data for generation of Atmospherically corrected ortho-rectified (water leaving radiance and ground reflectance) products, which can be used for Time Series analysis and generation of climate quality products |
| **B 5.8** | **LIDAR Data Processing: Space Based, Ground Based and Aerial LIDARS (SAC)** |
| **B 5.9** | **Data Processing for Atmospheric studies using space borne platforms (SAC)** |
| **B 5.10** | **INSAT-3DR, Resourcesat-2R, GISAT Improved Processing algorithms and techniques to support real time users requirements and generation of Atmospherically corrected Land Products (SAC)** |
| **B 5.11** | **Generalized Data Processing Software for Air-borne HySI Optical sensors (SAC)** |
| **B 5.12** | **Development of Advanced SAR Image Formation techniques including sweepsar, Polarimetric techniques for air-borne & space-borne payloads (SAC)** |
| **B 5.13** | **Development of general SAR processor to process C, X, L and S band data (SAC)** |
| **B 5.14** | **Development of techniques to process squint mode and spotlight mode SAR data (SAC)** |
| **B 5.15** | **Calibrated Climate Quality Products generation and global dissemination from Scatterometer & Altimeter type of Payloads (SAC)** |
| **B 5.16** | **Techniques for SAR interferometry and differential interferometry using SweepSAR repeat pass data (SAC)** |
| **B 5.17** | **Techniques for Sea Ice detection and kinematics of ice using SAR and scatterometer data (SAC)** |
| **B 5.18** | **Development of techniques for processing of synthetic aperture radiometer data (SAC)** |
| **B 5.19** | **Augmentation of analysis and applications packages for microwave** |

| | | |
|---|---|---|
| | Sensors (SAC) | |
| B 5.20 | New retrieval Algorithms – FSI (Full Spectrum Inversion) of ROSA data Processing (SAC) | |
| B 5.21 | Loss less data compression solutions for various levels of products of Airborne and space borne HYSI sensors (SAC) | |
| B 5.22 | Hybrid polarimetric modelling for scattering information retrieval from man-made and natural features (IIRS) | |
| B 5.23 | Snow depth and Snow Water Equivalent (SWE) estimation using SAR and ground based measurements in Himalayas (IIRS) | |
| B 5.24 | Semi-empirical modelling for forest biophysical characterization using PolSAR data (IIRS) | |
| B 5.25 | SAR calibration and attenuation measurement using triangular trihedral corner reflectors for RISAT-1 data (IIRS) | |
| B 5.26 | Characterization of opencast mining areas using various polarimetric decomposition techniques (IIRS) | |
| B 5.27 | Urban Feature/metallic extraction using fully polarimetric data (IIRS) | |
| B 5.28 | PolInSAR based semi-empirical modelling for forest aboveground biomass estimation (IIRS/ NESAC) | |
| B 5.29 | Space-borne three dimensional SAR tomography (IIRS) | |
| B 5.30 | Estimation and Correction of Tropospheric and Ionospheric Effects on Differential SAR Interferograms (IIRS) | |
| B 6 | Sub Area | Image Processing and Pattern Recognition (SAC) |
| B 6.1 | Relative Radiometric Normalization Techniques (SAC) | |
| B 6.2 | Advanced image Registration models/frameworks/software/libraries (SAC) | |
| B 6.3 | Image classification and intelligence (SAC) | |
| B 6.4 | Kernel based Learning/Machine Learning for Change detection analysis (SAC) | |
| B 6.5 | Super resolution Approaches for Remote Sensing Images (SAC) | |
| B 6.6 | Resolution enhancement approaches for scatterometer and radiometer | |

| | | |
|---|---|---|
| | **data (SAC)** | |
| **B 6.7** | **Automatic Feature Extraction and Labeling Techniques (SAC)** | |
| **B 6.8** | **Noise Modeling, Blur removal (SAC)** | |
| **B 6.9** | **Image Representation (SAC)** | |
| **B 6.10** | **Image Based Modeling and 3D re-construction (SAC)** | |
| **B 6.11** | **Techniques for Classification of Hyper spectral images (SAC)** | |
| **B 6.12** | **Techniques for Textural feature extraction from multi-spectral and hyper spectral images (SAC)** | |
| **B 7** | **Sub Area** | **Visualization, Cloud Computing & Software Architecture (SAC)** |
| **B 7.1** | Developing Advance Techniques for Earth & Planetary Data Visualization<br>➢ Real Time Visualization of robots<br>➢ Visualization of astronauts space walks<br>Identification of landing sites on other planets **(SAC)** | |
| **B 7.2** | **Immersive Data Visualization for Earth Observation Applications (SAC)** | |
| **B 7.3** | **Establishment of a Virtual reality and data/ Information visualization facility for earth and planetary missions (SAC)** | |
| **B 7.4** | **A private cloud infrastructure for Image processing and highly compute intensive applications so as enable designers/developers to dynamically use computing and storage resources in HPC environment (SAC)** | |
| **B 7.5** | **GRID enabled Global Data Processing Model (SAC)** | |
| **B 7.6** | **Parallel Processing approaches for real time data processing and re-processing in HPC environment and using GPGPU platforms as well as accelerators like Intel-5 (SAC)** | |
| **B 7.7** | **Consolidation of Software Library and adapting in SIPA Projects (SAC)** | |
| **C** | **Area** | **Satellite Data Reception and Ground Station (NRSC)** |
| **C 1** | **Sub Area** | **Design and Development of Antenna for data reception (NRSC)** |

| | | |
|---|---|---|
| C 1.1 | **Tri-Band dual Polarization (S/X/Ka) Concentric Feed System for Low Earth Orbiting (LEO) satellite ground station Antenna System (NRSC)** | |
| C 1.2 | **Very High Data rate (up to 2GBPS) demodulator & Bitsynchronizer Systems with programmability for Multiple modulation & encoding schemes. (NRSC)** | |
| C 1.3 | **Three axis azimuth-elevation-train (variable tilt axis) axis tracking pedestal for antenna system (NRSC)** | |
| C 1.4 | **Adaptive Servo Control Systems for Ka-Band data reception antennas (NRSC)** | |
| C 1.5 | **FPGA implementation of CCSDS standard DWT-based image decompression (NRSC)** | |
| C 2 | **Sub Area** | **Satellite image data compression & decompression (NRSC)** |
| C 2.1 | **Development of high speed CCSDS image compression / decompression technique (NRSC)**<br>The CCSDS has established a recommended standard for a data compression/decompression algorithm applied to two-dimensional digital spatial image data from payload instruments and to specify how this compressed data shall be formatted into segments to enable decompression at the receiving end.<br>The steps followed can be briefed as: performing an image de-correlating operation (DWT) and then encoding the coefficients in various stages in order to obtain the compressed image. The compressed image has to be decoded with the knowledge of the segment header. Rate regulation needs to be done in order to adjust the compression rate. The decoded coefficients are correlated back (inverse DWT) to get the reconstructed satellite image<br>All the future Cartosat missions follow the CCSDS image compression/decompression technique and there is a need for the high speed implementation of the same.<br>The requirement is the implementation of all the compression and decompression steps using General Purpose Graphics Processing Unit (GPGPU) and CUDA software. | |
| C 3 | **Sub Area** | **Error Correction Coding (NRSC)** |
| C 3.1 | **Reed Solomon decoding software development for satellite data(NRSC)**<br>• Satellite communication channels are subject to channel noise, and thus errors may be introduced during transmission from the source to a | |

| | | |
|---|---|---|
| | receiver. Error detection techniques allow detecting such errors, while error correction enables reconstruction of the original data. Reed Solomon decoding algorithm is one of the error correcting algorithms to correct the received data with errors. Different formats of RS decoding standard algorithms are available like (247,255), (223,255). These things work in two modes one in CCSDS format and the other in traditional standard mode.<br>• Because of huge volume of satellite data and large mathematical computation it is time consuming to decode the data by using the traditional methods of Reed Solomon decoding algorithm. Hence there is a need for the high speed implementation of the same. The requirement is the parallelism of the Reed Solomon algorithm in General Purpose Graphics Processing Unit (GPGPU) and by parallel approach in Central Processing Unit (CPU). | |
| **C 4** | **Sub Area** | **Distributed Workflow Management (NRSC)** |
| **C 4.1** | **Autonomous Multi agent Job Scheduling Algorithms for distributed systems (NRSC)**<br>Large scale processing and knowledge extraction from data requires execution of complex workflows in a distributed environment. A generic framework needs to be evolved for collaborative computing among the resources to obtain maximum throughputs from the systems<br>Development of (i) multi-agent system architecture for processing data in a distributed network environment (ii) models for a multi agent communication (iii) schemes for automatic configuration of agents based on the dynamics of the real time job scheduling and (iv) Resource optimization algorithms to improve the processing timelines | |
| **C 5** | **Sub Area** | **Data Mining (NRSC/ SAC/ NESAC)** |
| **C 5.1** | **Algorithms for Knowledge Extraction from Big Data (NRSC/SAC/NESAC)**<br>Large volumes of data that cannot be stored in normal relational databases are being generated every day from the remote sensing satellites. Many software elements extract information from the raw data generating information in unstructured form such as images, log files, user orders in pdf, word etc. There is a need for developing efficient data mining algorithms to tag the data sets for facilitating efficient build up of archival and retrieval.<br>• In general data mining algorithms work on data sets that are of reasonable size and cannot handle BIG data.<br>• Develop Parallel Algorithms for mining the classification rules to facilitate | |

| | | |
|---|---|---|
| | data archival in an optimal manner<br>• Develop mining algorithms that are Incremental and can learn and unlearn from the continuous satellite data acquisitions<br>• Develop algorithms for extracting meaningful trends in the customer ordering, build customer satisfaction index, predict the future sales or potential sensors or popular products etc., | |
| **C 6** | **Sub Area** | **Software Engineering (NRSC)** |
| **C 6.1** | **Software Reliability Modelling and Metrics (NRSC)**<br>There is a need to develop automated tools to extract different metrics from various software packages developed by ISRO to estimate their reliability and predict if possible the failure rates from the version history.<br>• Develop customized metrics for different types of software packages including real time, near real time, post processing, workflow software and distributed software<br>• Develop algorithms for estimating the software reliability numbers and predictive models for forecasting the failure conditions | |
| **D** | **Area** | **Earth and Ocean Sciences Applications (SAC/ NRSC/ IIRS/ NESAC)** |
| **D 1** | **Sub Area** | **Geosciences (SAC/ NRSC/ IIRS/ NESAC)** |
| **D 1.1** | **Himalayan Cryosphere (SAC)** | |
| | Improvements and development of snow melt run-off models<br>Applications of snow melt run off for irrigation and hydro-power requirements<br>Improvements and development of glacier mass balance models<br>Understanding glacier dynamics<br>Modeling snow and glacier depth<br>Development of algorithms for auto extraction of glacier features from multi-sensor satellite data with particular reference to Hyperspectral and thermal data<br>Microwave remote sensing for snow & glaciers including interferometry techniques<br>Comparative study of Himalayan glaciers with other mountain glaciers<br>Impact of climate change on Himalayan snow & glaciers (NESAC) | |

| | |
|---|---|
| | Snow and glacier hazards including avalanche forecasting, crevices detection and modelling burst of moraine dam lakes |
| **D 1.2** | **Marine Geosciences (SAC)** |
| | Development of techniques to retrieve gravity/geoid using satellite altimetry over oceans<br>Modelling marine lithosphere using gravity and other geophysical data<br>Understanding subsurface tectonics and associated processes<br>Tsunami Modelling<br>Hydrocarbon exploration in offshore regions.<br>Study of water quality parameters such as turbidity, Ph, etc using hyper spectral remote sensing data; Calibration of the remote sensing data using the field observations **(NRSC/ IIRS)** |
| **D 1.3** | **Coastal Processes (SAC)** |
| | Understanding Holocene and Quaternary coastal evolution<br>Understanding processes leading to coastal erosion and predicting shoreline changes<br>Sediment budgeting with reference to identification of sediment cells,<br>Coastal vulnerability models and risk assessment<br>Developing models for integrated coastal zone management plans |
| **D 1.4** | **Geo-Archaeology (SAC)** |
| | Developing approach to analyze multisensor satellite data (Radar and high resolution multispectral data in particular) for identifying hitherto unknown surface/buried archaeological sites<br>Validation using geophysical techniques such as GPR, pitting and trenching. |
| **D 1.5** | **Mineral exploration (SAC)** |
| | Methods to analyse multisensor satellite data (including Hyperspectral, RADAR, Thermal and Geophysical data of various spaceborne/airborne missions) for mineral exploration<br>Develop GIS based models to identify mineral prognostic zones by integrating geological, geophysical and geochemical data. |
| **D 1.6** | **Geology, Structure and Geomorphology (NRSC/ IIRS/ NESAC)** |
| | Hyper spectral response characterization of intimately mixed geological |

| | |
|---|---|
| | samples occurring in complex geological terrain **(NRSC)** |
| | Spectral library generation of rocks & archiving from various geological terrain in visible and thermal region **(NRSC/IIRS)** |
| | Sub-surface geo / archaeological features using GPR data sets **(NRSC)** |
| | Geophysical data collection and analysis for understanding the subsurface in some of the important geological province **(NRSC)** |
| | Active faults mapping using high resolution satellite data **(NRSC/IIRS/ NESAC)** |
| | Development of an automatic technique using satellite data and DEM for identification of landforms in different geomorphic provinces of India **(NRSC)** |
| | Numerical modelling for crustal deformation using GPS vectors **(NRSC/IIRS)** |
| | Mapping/ Updation of major Tectonics Grains in N. India using RISAT-1 Data **(IIRS)** |
| | Analysis of Geomorphic Indicators for studying Active /Current Tectonics **(IIRS/ NESAC)** |
| | Space borne geodetic techniques like gravity data processing & analysis, DINSAR and related Techniques **(IIRS)** |
| | Derivation of innovative sub-pixel mapping algorithms to identify rarely occurring class indicating mineralisation **(NRSC)** |
| | Implementation of algorithms to derive spectrometric parameters of each pixel of hyperspectral data **(NRSC)** |
| | Development of regional landslide early warning system based on rainfall threshold **(NRSC)** |
| | Automatic Identification of earthquake and landslide induced terrain changes from high resolution satellite data **(NRSC)** |
| | Correlation of landforms with mineral composition on planetary surfaces **(NRSC)** |
| **D 1.7** | **Vulnerability Profiling of Capital cities of NER (NESAC)**<br>Urban areas are susceptible to disasters (man-made or natural). It is the need of the hour to make a rapid vulnerability assessment of urban areas in order to understand what is required for building disaster resilience community. The potential impact of different parameters on urban services arising from the |

| | | |
|---|---|---|
| | geographical setting of a city; the nature, size and density of its settlements; and the existing coping capacity of its society and governance system can be studied to create vulnerable profile of urban areas. | |
| **D 2** | **Sub Area** | **Soil Resource Characterization, Land Use Planning and Watershed Management (IIRS/ NESAC)** |
| **D 2.1** | **Terrain Characterization in Hydrological properties of soils (IIRS)** | |
| **D 2.2** | **Spatial prediction of soil properties (IIRS)** | |
| **D 2.3** | **Expert knowledge & fuzzy logic in characterization of soil properties (IIRS)** | |
| **D 2.4** | **Soil & Nutrient Loss modelling at watershed scale (IIRS)** | |
| **D 2.5** | **Climate change Impact of soil erosion and soil quality (IIRS)** | |
| **D 2.6** | **Soil Quality Assessment and Monitoring using hyper spectral data (IIRS)** | |
| **D 2.7** | **Soil Nutrient Management for Precision Agriculture using hyper spectral data (IIRS)** | |
| **D 2.8** | **Soil Clay Mineral Identification and Mapping using hyper spectral data (IIRS)** | |
| **D 2.9** | **Microwave RS in Characterization of salt-affected soils and waterlogged area (IIRS)** | |
| **D 2.10** | **Soil carbon sequestration (IIRS)** | |
| **D 2.11** | **Impact of climate change on soil processes (IIRS)** | |
| **D 2.12** | **Satellite based Evapo-transpiration Estimation (IIRS)** | |
| **D 2.13** | **Land surface parameter estimation: Estimation of land surface albedo using radiative transfer principles (IIRS)** | |
| **D 3** | **Sub Area** | **Agriculture and agro-ecosystem (SAC/ IIRS/ NESAC)** |
| **D 3.1** | **Development of mathematical/matching algorithm in spectral library development using hyper spectral data (SAC)** | |
| **D 3.2** | **Integrated approach (including remote sensing inputs) for multi-crop assessment in sparse cropped regions (SAC)** | |
| **D 3.3** | **Ingestion of RS inputs/products in Climate change analysis/modelling of agro-ecosystems (SAC)** | |

| | | |
|---|---|---|
| D 3.4 | **Development of GHG models for agro-ecosystems under different conditions (SAC)** | |
| D 3.5 | **Algorithm development for agro-ecosystems product generation from geostationary platform (SAC)** | |
| D 3.6 | **Climate change impact on Crop Productivity (IIRS)** | |
| D 3.7 | **Energy Flux and carbon flux measurement and modelling in Agro-ecosystem (IIRS)** | |
| D 3.8 | **Carbon fluxes measurement and monitoring in Agro-ecosystem (IIRS)** | |
| D 3.9 | **Satellite based estimation of land surface energy (IIRS)** | |
| D 3.10 | **Satellite Derived Land Surface Parameters and Meteorological Variables (IIRS)** | |
| D 3.11 | **Understanding shifting cultivation as a driver of LULC change (NESAC)** | |
| D 4 | **Sub Area** | **Forest and Environment (SAC/NRSC/ IIRS/ NESAC)** |
| D 4.1 | **Forestry and Ecology- Biophysical parameters (NRSC)** | |
| | Sub pixel tree cover estimates using multi sensor IRS imagery | |
| | Observations on ecophysiological factors for tropical forests and parameterization of biome models for Indian forests | |
| | Feature recognition of tree and canopy objects in IRS pan and multi spectral imagery | |
| | Automated methods for estimation of tree allometry fine scale biomass and stand structure using laser measurements **(SAC/ IIRS)** | |
| D 4.2 | **Mapping at 1:10K or higher and identification of Eco-sensitive zones areas for conservation and management (NESAC)** | |
| D 5 | **Sub Area** | **Water Resources (IIRS)** |
| D 5.1 | **Future climate data downscaling using statistical methods and subsequent hydrological modelling (IIRS)** | |
| D 5.2 | **Precipitation estimation (for better understanding of the spatial and temporal distribution of precipitation which is critical to climatic, hydrologic, and ecological applications) (IIRS)** | |

| | | |
|---|---|---|
| D 6 | Sub Area | Oceanic sciences and climate (SAC/ NRSC/ IIRS/ NESAC) |
| D 6.1 | Retrieval of IPAR & PAR flam OCM-2 irregular basis and validation with measurements for different regions of tropical, sub tropical and Polar areas (NRSC) | |
| D 6.2 | Retrieval of sea surface salinity from satellite data and validation (NRSC) | |
| D 6.3 | Ocean surface characterization using SARAL Altika Data (NRSC) | |
| D 6.4 | Meso-scale ocean eddy scale analysis (NRSC) | |
| D 6.5 | Ocean wind, wave and current assessment in coastal waters (NRSC) | |
| D 6.6 | Satellite altimeter waveform analysis to improve geophysical parameters retrieval (NRSC) | |
| D 6.7 | Satellite altimeter Data assimilation in ocean models (NRSC) | |
| D 6.8 | Derivation of Ocean surface currents utilizing data from SARAL AltiKa and OSCAT. Combining geostrophic currents from SSHA (from Altimeters) and wind driven currents from wind velocities (from Scatterometer), the ocean surface currents can be obtained (NRSC) | |
| D 6.9 | Ocean state forecast with global and regional numerical dynamic models (SAC)<br>Ocean state forecast is being done by using Ocean general circulation model and wave models. As there are only a few observations are available over the ocean, there is large uncertainty in the initial condition. Assimilation of satellite data is an important component to generate the initial condition and the forcing field. This involves advance assimilation technique for ocean data assimilation. | |
| D 6.10 | Air sea interaction studies (SAC)<br>To understand some of the atmospheric and oceanic processes near ocean surface, air sea interaction study is very important. Because of scarcity of observed data over the ocean, it is important to understand these processes with the help of satellite data. This involves diagnostic studies of the processes with satellite data. | |
| D 6.11 | Ocean modelling (NRSC)<br>Investigation of the thermal inertia of the Indian Ocean. Ocean models can be used to investigate the thermodynamics of the oceans with emphasis on long term thermal evolution in the oceans. This would help in estimating the thermal inertia of the ocean, an indicator of effects on climate change. | |

| | |
|---|---|
| D 6.12 | **Development of bio-optical algorithms in CASE-2 waters (NRSC)**<br>With the availability of OCM-1 and 2 and for the future OCM-3 with more spectral bands a programme has been planned for reprocessing of ocean colour data sets for the development of ECV like chlorophyll-a, PAR and diffusive attenuation coefficient in coastal waters. Using large sets of in-situ underwater radiation measurements and associated bio-physical measurements coastal bio-optical algorithms has to be developed. Using this algorithm reprocessing of OCM data is to be planned. |
| D 6.13 | **Response of Coastal system due to climatic change and its long and short term implications (NRSC)** |
| D 6.14 | **Satellite based retrieval of geo-physical parameters for coastal processes assessment (NRSC)** |
| D 6.15 | **Eco-system change direction and responses due to coastal change using high resolution IRS-data sets (NRSC/ NESAC)** |
| D 6.16 | **In-situ studies of phytoplankton cultures to understand changes in the absorption spectrum in response to different environment variables for developing methodologies for satellite retrieval (NRSC)**<br>Retrieval of spectrum information of dominant phytoplankton groups from satellite ocean colour data especially for case 2 waters is complex and requires good amount of in situ studies from pure cultures to understand how this varies due to age of the culture, between different groups and also with nutrient manipulations. In recent years several methodologies have been develop to extract spectrum information from satellite ocean colour data however this requires important validation to make such techniques operational in the era of OCM. |
| D 6.17 | **Study of relationships between oxygen and C13 based primary productivity for Indian coastal waters to evaluate photosynthesis quotient for developing satellite based primary productivity model (NRSC)**<br>Changes in oxygen concentrations over time can be used to estimate the rates of photosynthesis and therefore primary productivity. Carbon assimilation rates based on oxygen evolution often assumes a ratio of one moles of O2 produced for every moles of CO2 assimilation however this number is highly variable in the environment. Studies can be undertaken to compare this classical techniques with modern C13 based primary productivity to understand the variability which can be used to develop satellite based PP model. |
| D 6.18 | **Measurement of particulate organic and particulate inorganic carbon in coastal and open ocean waters of northern Indian Ocean for development** |

| | | |
|---|---|---|
| | **of satellite based algorithm (NRSC)**<br>Particulate organic and inorganic (comprised of mainly cocolithophores) are important component of any oceanic system which influence the marine carbon cycle. Remote sensing measurements are now being used to characterise these component in basin scale due to its large spatial coverage however lack proper validation due less in-situ measurement. Both beam attenuation and in situ POC/PIC have been used to develop empirical relationship as early as 1988. Latest research suggests good relationship between oceanic POC concentrations vs. Rrs (443)/ Rrs (555). Opportunities are available for measuring POC/PIC by chemical or physical method (CTD, Beam Attenuation) for development and validation of satellite algorithm for Northern Indian Ocean. | |
| **D 6.19** | **Development of methodologies (statistical and numerical methods) for the generation of time series/ long period data base from the OCM sensors ( Chl, PAR and AOT ) over the North Indian Ocean in association with NRSC. (NRSC)** | |
| **D 6.20** | **Development of methodologies for generation of near real time ocean surface currents using satellite derived winds, Sea Surface heights/ anomaly, SST and salinity for the Indian ocean (NRSC)** | |
| **D 6.21** | **Development of bio-optical algorithms in CASE-II waters using Inherent optical parameters and propagation to the top of atmosphere using appropriate radiative transfers models (NRSC)** | |
| **D 6.22** | **Use of satellite observation in ocean general circulation model for understanding regional circulation and heat budget in the Indian Ocean (NRSC)** | |
| **D 6.23** | **Development of eddy-resolving meso scale ocean model and potential fishing zone predictability (NRSC)** | |
| **D 6.24** | **Assimilation of Satellite observation in Ocean general circulation model to reconstruct ocean state parameters (NRSC)** | |
| **D 6.25** | **Development of real time coastal ocean analysis system through ocean general circulation model coupled with ocean Biogeochemical Flux model (NRSC)** | |
| **D 6.26** | **Use of satellite observation for modeling and assessing regional carbon cycle for the Indian region (NRSC)** | |
| **D 7** | **Sub Area** | **Marine Biology related activities (SAC/ NRSC/ NESAC)** |
| **D 7.1** | **Development of coastal algorithm for ocean colour remote sensing (SAC)** | |

| | | |
|---|---|---|
| | Development of Case-2 geophysical algorithms for Indian coastal waters, Atmospheric correction models for turbid waters, Development of CDOM and TSS algorithms and Bathymetry estimation in optically shallow waters. | |
| D 7.2 | **Coastal Carbon Dynamics in Oceans (SAC)**<br>Bio-geo-chemistry of the coastal oceans, Study of various components of the carbon cycle, Nitogen cycle and phytoplankton blooms, Fish stock assessment, Primary and New production modeling. | |
| D 7.3 | **Marine Living Resource Management (SAC )**<br>GIS based marine resource living management systems, Species specific fisheries forecast , conservation for engendered marine organism | |
| D 7.4 | **Atmospheric Aerosol Research (SAC/ NESAC)**<br>Algorithms for atmospheric aerosols using satellite over plain & hilly land and oceans, Aerosol transportation and climate studies. | |
| D 7.5 | **Simulation of Methane distribution and visualization in MARS Atmosphere (SAC/NRSC)**<br>Indian MARS mission will be carrying MSM (Methane Sensor for MARS) to map the methane sources and deriving concentration in MARS atmosphere by ppb accuracy. Simulations are planned using other MARS orbiter data like MGS etc. considering the specification of Indian MSM for visualization and understanding the data. This simulation is to be carried jointly with the help of Principal Investigator of MSM. | |
| **E** | **Area** | **Aerial Remote Sensing (NRSC/ NESAC)** |
| **E 1** | **Sub Area** | **Automatic feature extraction from aerial images (NRSC)** |
| **E 1.1** | **Automatic feature extraction from aerial images (NRSC)**<br>The objective of this study would be to explore the possibilities of automatic feature extraction through the fusion of high resolution aerial digital camera images and DSM either from Lidar technology or from photogrammetry. As per the literature, the fusion of DSM from Lidar scanners and image data from digital cameras showed promising results. The data from these two sources is complimentary to each other and hence make a great combination | |
| **E 2** | **Sub Area** | **Automatic mapping methods (NRSC)** |
| **E 2.1** | **Automatic extraction mapping features from high resolution (better than 50cm) orthorectified images (NRSC)** | |

| | | |
|---|---|---|
| E 2.2 | **Automatic Quality check tools for mapping (Misclassification, Polygon closure, Snapping error detection, Contour crossing errors) (NRSC)** | |
| E 3 | **Sub Area** | **Segmentation of Aerial / satellite data (NRSC)** |
| E 3.1 | Segmentation becomes more important with increasing spatial resolution of imagery. Texture in high-resolution aerial and high resolution satellite images requires substantial amendment in the conventional segmentation algorithms. The potential applications of this segmentation process are (1) Automatic 3D model generation (2) automatic DEM generation from DSM (3) Automation in Quality Checking of vector maps and many more. | |
| E 4 | **Sub Area** | **Aerial Data Compression (NRSC)** |
| E 4.1 | **Development and incorporation of lossless compression algorithm(s)/ technique(s) (NRSC)**<br>Development and incorporation of lossless compression algorithm(s)/ technique(s) for better handling, archival, effective usage and time critical data processing of aerial analog and digital data. The compression algorithm must meet the requirement of aerial compression system for storage and operation time. The compression techniques must reduce operation memory, and accelerate the processing speed without any data loss. | |
| E 5 | **Sub Area** | **Radiometric Calibration LiDAR Waveform (NRSC)** |
| E 5.1 | **Radiometric calibration (NRSC)**<br>Radiometric calibration refers to the statistical process of deriving physically well-defined radiometric quantities from the sensor's raw measurements. Waveform LiDAR system provides detail information about the backscattering properties of the observed targets by recording complete return signal. Even though waveform measurements have high content of information, data acquired during different flight campaigns cannot be directly compared without a proper radiometric calibration. Model waveform Radiometric calibration requires formulation of LiDAR equation. This model may be useful for the retrieval of higher level data products. | |
| E 6 | **Sub Area** | **LiDAR/Digital Camera data analysis (NRSC)** |
| E 6.1 | **Automatic detection of tree height, leaf area index, canopy etc. for biomass estimation (NRSC)** | |
| E 6.2 | **Tree species detection from LiDAR waveform data (NRSC)** | |
| E 6.3 | **Building height extraction methods & Texture draping for 3D city** | |

| | | |
|---|---|---|
| | **modelling (NRSC)** | |
| **E 7** | **Sub Area** | **Photogrammetry (NRSC)** |
| **E 7.1** | **Automatic conversion of Digital Surface Model to Terrain Model (NRSC)** | |
| **E 7.2** | **Multiray photogrammetry for block adjustment (NRSC)** | |
| **E 7.3** | **Correspondence methods for automatic conjugate point identification (NRSC)** | |
| **E 7.4** | **Automatic cutline generation for ortho mosaic generation (NRSC)** | |
| **E 8** | **Sub Area** | **Aerial data acquisition and instrumentation (NRSC)** |
| **E 8.1** | **Development of Gyro stabilized mounts for airborne applications (up to 100 kg payload) (NRSC)** | |
| **E 8.2** | **Development of GPS-IMU integration methods (NRSC)** | |
| **E 8.3** | **Unmanned aerial systems for long range (~100 km) (NRSC)** | |
| **E 8.4** | **Mobile mapping systems for rapid 3D city modelling (NRSC)** | |
| **E 9** | **Sub Area** | **Aerial Remote Sensing using UAV (NESAC)** |
| **E 9.1** | **Design & assembly of UAV components-payloads, communication components etc., UAV data acquisition, processing, 3D feature capturing, construction of 3D surface model/DEM, automatic object or pattern recognition (NESAC)** | |
| **F** | **Area** | **Earth and Climate Sciences (NRSC)** |
| **F 1** | **Sub Area** | **Atmosphere and Climate Sciences (NRSC)** |
| **F 1.1** | **Regional monitoring of Trace and Green house gases (NRSC)**<br>Trace and green house gases in earth atmosphere are important as they affect both air quality and radiation balance of the earth atmosphere system. Anthropogenic activities influence abundance of many of these gases in the atmosphere. In view of this, it is necessary to have continuous monitoring of these gases and changes in their concentrations over different regions to understand anthropogenic impacts on global climate change. | |
| **F 1.2** | **Retrieval of green house gases using satellite data (NRSC)**<br>By realizing the impacts of trace and greenhouse gases in air quality and radiation budget, it is necessary to have measurements of these gases with | |

| | |
|---|---|
| | sufficient spatial coverage. Satellite remote sensing enables retrieval of trace and greenhouse gases over large regions to estimate their effects on earth atmosphere and contribution in climate change. Spatial distribution of abundance of these gases can be used to identify their major source regions and also to estimate long term trends in their concentration. |
| F 1.3 | **Transport of chemical constituents of atmosphere using WRF chemical transfer modelling (NRSC)**<br>Atmospheric dynamics lead to dispersion and transport of chemical constituents in atmosphere from their source regions to distant locations. In order to understand effects of chemical constituents in earth atmosphere, their transport from source regions to other locations has to be examined. Transport of chemical constituents in atmosphere can be investigated in detail using models such as WRF. |
| F 1.4 | **Study of Boundary Layer dynamics (NRSC)**<br>Atmospheric Boundary Layer (ABL) is the lowest part of troposphere, which is directly influenced by earth surface and responds to surface forcing with a time scale of an hour or less. Structure of ABL and associated dynamics are important to understand weather, climate, pollution dispersion and exchange processes between surface and atmosphere. |
| F 1.5 | **Aerosol characterization and its impact on solar radiation (NRSC/ NESAC)**<br>Atmospheric aerosols, one of the major climate forcing agents, affect earth atmosphere radiation balance through aerosol radiation interactions and aerosol cloud interactions. Despite the efforts being carried out for past few decades, atmospheric aerosol remains one of the major sources of uncertainty in climate forcing estimates. Better understanding of aerosol impacts on weather and climate demands adequate incorporation of aerosol parameters in climate models, which needs accurate measurements of aerosol characteristics. |
| F 1.6 | **Surface energy budgeting using remote sensing (NRSC)**<br>Surface energy budgeting assumes importance as the surface energy balance is one of the major factors affecting hydrostatic stability and mixing of atmospheric constituents such as pollutants in lower atmosphere. Remote sensing can be used for surface energy budgeting over large spatial extends to understand changes in surface energy balance and related effects in earth atmospheric boundary layer characteristics and associated processes |
| F 1.7 | **Impact of aerosol on agricultural productivity (NRSC/ NESAC)**<br>Atmospheric aerosols alter energy balance of the earth atmosphere system |

| | |
|---|---|
| | through scattering and absorption of radiation and also by modifying cloud properties. Through scattering and absorption, atmospheric aerosols reduce surface reaching solar radiation, which in turn affect agricultural production. In addition aerosols affect large scale circulation systems such as Indian summer monsoon and associated rainfall. Changes in rainfall will have significant effect on agricultural production. |
| F 1.8 | **Retrieving vertical profile of temperature and humidity using Radio Occultation (RO) data (NRSC/ NESAC)**<br>Vertical profiles of atmospheric temperature and humidity are important parameters in atmospheric research, especially for weather forecast and climate change studies. Radio Occultation technique is an effective method to retrieve these profiles by receiving radio signals from GPS navigation satellites. The method makes use of the fact that degree of refraction of radio waves while passing through the atmosphere depends on gradients in air density which in turn depends on temperature and humidity. |
| F 1.9 | **Urban heat fluxes - quantification of surface energy processes, urban weather, urban heat distribution and heat fluxes (IIRS)** |
| F 1.10 | **Transport of chemical constituents of atmosphere using WRF chemical transfer modelling (NRSC/ NESAC)** |
| F 1.11 | **Study of Boundary Layer dynamics (NRSC/ NESAC)** |
| F 1.12 | **Surface energy budgeting using remote sensing (NRSC)** |
| F 1.13 | **Retrieving vertical profile of temperature and humidity using Radio Occultation (RO) data (NRSC)** |
| F 1.14 | **Atmospheric Transport (role in determining the distributions of chemical species in the atmosphere, understanding process, circulation, vertical transport, atmospheric stability, turbulence etc) (IIRS/ NESAC)** |
| F 1.15 | **Particulate matter monitoring (understanding air quality standards, classification of particulate matter, evolution, transportation, processes, measurements analysis and modelling) (IIRS/ NESAC)** |
| F 1.16 | **Climate Change Impact assessment (NRSC/ NESAC)**<br>Anticipated/Ensuing climate change is expected to alter the water resources availability, demand and use patterns. Many uncertainties remain about the extent of these climatic changes, as well as about their societal implications. Assessment of vulnerability and resulting risk to water resources due to climate-change impacts is necessary to work out appropriate adaptation and mitigation |

| | | |
|---|---|---|
| | strategies | |
| F 1.17 | **Polar ice dynamics studies (SAC)**<br>To study the impact of climate change on polar ice cover, satellite data are used for monitoring the ice cover over the Polar Regions. Research is being done for identifying different type of ice cover using various satellite measured parameters. | |
| F 1.18 | **Trace gases measurement and monitoring (understanding trace gases, evolution, transportation, processes, measurements analysis and modelling) (IIRS/ NESAC)** | |
| F 1.19 | **Aerosol Optical Thickness and Atmospheric Correction over Land (SAC/IIRS/ NESAC)**<br>Calibration and radiometric normalization is the key issue in future remote sensing activities related with biophysical parameter retrieval and climate change. Atmospheric correction of the satellite data is a challenge. Most important input for atmospheric correction involved estimation of Aerosol optical thickness (AOT) either from network of ground observations or satellite data. Retrieval of AOT sensors like Resourcesat series is a challenge. There is need to develop simplified correction approach including AOR inputs using dark dense vegetation approach. There is further need to develop instrumentation with capability of polarized measurements and LIDAR sensing. | |
| F 2 | **Sub Area** | **Agriculture and Agro-ecosystem studies(SAC/NRSC)** |
| F 2.1 | **Integrated approach (including remote sensing inputs) for multi-crop assessment in sparse cropped regions (NRSC)** | |
| F 2.2 | **The remote sensing techniques of crop assessment in hilly terrains/ high altitudes (NRSC)** | |
| F 2.3 | **RS based indices/techniques for agro-ecosystems characterization / evaluation (NRSC)** | |
| F 2.4 | **Ingestion of RS inputs/products in Climate change analysis/modelling of agro-ecosystems (NRSC)** | |
| F 2.5 | **Development of GHG models for agro-ecosystems under different conditions (NRSC)** | |
| F 2.6 | **Parameter retrieval techniques with Hyperspectral data (NRSC)** | |
| F 2.7 | **Algorithm development for agro-ecosystems product generation from** | |

| | | |
|---|---|---|
| | **geostationary platform (NRSC)** | |
| **F 2.8** | **Concepts of multidate/multisensor fusion of different scales and resolutions and uncertainty analysis in relation to agro-ecosystems (NRSC)** | |
| **F 2.9** | **Newer tools and techniques development for quick assessment of temporal dynamics of crops/vegetations using Indian multi temporal satellite data (NRSC)** | |
| **F 2.10** | **Development of mathematical/matching algorithm in spectral library development using hyperspectral data (NRSC)** | |
| **F 2.11** | **Modelling soil carbon sequestration in relation to cropping systems and climate change (NRSC)** | |
| **F 2.12** | **Development of farming systems models with RS inputs/products (NRSC)** | |
| **F 2.13** | **Applications of RS/GIS in horticulture studies (NRSC)** | |
| **F 2.14** | **Technical development of geometrics (NRSC)** | |
| **F 2.15** | **Geostationary data utilization in crop assessment (NRSC)** | |
| **F 3** | **Sub Area** | **Environment Sciences and Hydrological Modeling (SAC/ NRSC/ IIRS)** |
| **F 3.1** | **Sensor System Studies for Environmental studies (SAC)**<br>Sensor system studies involve feasibly experiments and radiative modeling activities to arrive at suitable sensor parameters for monitoring earth and planetary objects. Development of spectral library, ground based experimentation in field of agriculture, forest and other ecosystem are required to propose suitable spatial, spectral and radiometric resolution of satellites. Modeling codes such 6S code, MODTRAN etc are used to study the sensitivity of surfaced and atmospheric parameters. It is needed to carry simulation experiments to propose optimum sensor parameters and develop retrieval algorithms for geophysical parameters from future Resourcesat series, NEMO-AM, ENVSAT Series and GISAT satellites for environmental applications. | |
| **F 3.2** | **Forestry and Ecology- Biophysical parameters (NRSC)** | |
| **F 3.3** | **Sub pixel tree cover estimates using multi sensor IRS imagery (NRSC)** | |
| **F 3.4** | **Observations on ecophysiological factors for tropical forests and parameterization of biome models for Indian forests (NRSC)** | |

| | |
|---|---|
| F 3.5 | **Feature recognition of tree and canopy objects in IRS pan and multi spectral imagery (NRSC)** |
| F 3.6 | **Automated methods for estimation of tree allometry fine scale biomass and stand structure using laser measurements (IIRS)** |
| F 3.7 | **Green House Gases Estimation (SAC/ NESAC)**<br>One of the recent trends in remote sensing understands the climate change trough space measurements. Atmospheric Green house gases concentration and measurements of flux are important research Area. Currently available sensor system includes GOSAT, ENVISAT-SCIAMACHY, MOPITT etc. India has plans to launch such mission (ENVSAT Series) in future with other countries (OCO of USA, GOSAT-2 of Japan). There is need to develop radiative transfer scheme to model and retrieve the gases concentration. There is need to in situ measurement of $CO_2$, $CH_4$, $N_2O$ etc fluxes for validation of satellite products. |
| F 3.8 | **Regional monitoring, mapping and inventory analysis of Trace and Green house gases (NRSC/ NESAC)** |
| F 3.9 | **Retrieval of green house gases using satellite data (NRSC/ NESAC)** |
| F 3.10 | **Aerosol Optical Thickness and Atmospheric Correction over Land (IIRS/ NESAC)**<br>Calibration and radiometric normalization is the key issue in future remote sensing activities related with biophysical parameter retrieval and climate change. Atmospheric correction of the satellite data is a challenge. Most important input for atmospheric correction involved estimation of Aerosol optical thickness (AOT) either from network of ground observations or satellite data. Retrieval of AOT sensors like Resourcesat series is a challenge. There is need to develop simplified correction approach including AOR inputs using dark dense vegetation approach. There is further need to develop instrumentation with capability of polarized measurements and LIDAR sensing. |
| F 3.11 | **Hydrological Modeling (SAC)**<br>Hydrological modeling at Basin as well as India level is needed to understand the distribution and balance of water balance components. The projecting the water requirements in the future climate scenario are another area of important research. SAC has initiated hydrological modeling activities related with role of forest ecosystem in influencing the hydrological component over a large region using satellite and ground based measurements. There is need to develop model to retrieve hydrological variables (rainfall, Soil Moisture, Evapotranspiration) using satellite data. Snow and glacier hydrology is an |

| | |
|---|---|
| | important thrust area of research. Inland waters level monitoring using altimeter data. |
| F 3.12 | **Forest Meteorology and Ecosystem Modeling (SAC)**<br><br>Forest plays an important role in governing the energy and mass exchange over a region. Quantification of energy fluxes helps in modeling regional climate. SAC is involved in development of 24 Micrometeorological station network in India which are taking continuous measurements in agriculture and natural vegetation system. There is need to develop land surface process models to quantify the fluxes with reference to surface and atmospheric forcing. Most of the biogeochemical modeling depends on phenological understanding of different vegetation types. There is need to carry out ground experimentation as well as satellite modeling to estimate the phenological matrices of different vegetation types. Such efforts would lead to develop the forest growth simulation models.<br><br>Modeling NPP using satellite measurements such as INSAT-CCD is an important future thrust area. There is need to develop process based model to quantify the net primary productivity and ecosystem level productivity. Network of annual biomass measurements are needed to validate the NPP products.<br><br>It is known that biomass modeling is limited with optical measurements due to saturation of optical light in denser canopy. Radar based approaches provide improved assessment. It is proposed to develop LIDAR based modeling to account the height of the forest in the estimation of forest biomass.<br><br>Detection of forest fire and development of fire alarm system based on bioclimatic indices is an important research area which will be carried out using INSAT-3D satellite data. |
| F 3.13 | **Alpine Ecosystem and Climate Change Studies (SAC)**<br><br>Alpine ecosystems exist in low temperature region and are very sensitive to changing patterns of temperature (global warming). Sensitive alpine tree line species are found responding to already changing climate scenarios. SAC has carried out benchmark studies in mapping the alpine tree line and modeling responses of tree line species to climate change scenarios. There is need to create permanent monitoring stations for continuous observation of on sensitive ecotones. Moreover high altitude lakes freeze thaw cycle is an also important indicators of such changes. SAC has made atlases of high altitude lakes however there is need to study the physico-chemical properties of these lakes in relation to climate change scenarios. |
| F 3.14 | **Mangrove ecosystem analysis and its role in climate change (SAC)**<br><br>Mangrove ecosystem and its important in costal environmental studies is well recognized. Satellite based mapping and modeling the photosynthesis response |

| | | |
|---|---|---|
| | is an important area of research presently being carried out at SAC. It is needed to develop network of experimental sites to quantify the biophysical characteristics of mangrove and develop model to predict the effect of climate change on mangrove system. | |
| F 3.15 | **Coral Reef Mapping and Modeling (SAC)**<br>Coral reef is known as important indication of climate change. Satellite plays an important role in mapping the coral reef habitat regions. There is need to develop hyperspectral remote sensing techniques to detect different types of corals. Modeling is required to assess the effect of SST on coral bleaching observed at different regions. | |
| F 3.16 | **Wetland Ecosystem (SAC)**<br>Wetlands mapping has been carried out by SAC at 1:50,000 scale for India. There need to develop scheme to map the wetlands using improved and integrated approach involving microwave and optical data. Wetland eutrophication needs to be studied using temporal high resolution optical sensors. Efforts on modeling Methane Emission from Wetlands is an important future thrust area. | |
| F 3.17 | **Advanced and Hybrid data assimilation in NWP models to simulate heavy precipitation events over NER of India (NESAC).** | |
| F 3.18 | **Assimilation of DWR/ SONDE/ AWS/ SODAR data in NWP models (NESAC)** | |
| **G** | **Area** | **Disaster Management (SAC/ NRSC/ IIRS/ NESAC)** |
| **G 1** | **Sub Area** | **Geo-hazards (SAC /NRSC /IIRS/ NESAC)** |
| **G 1.1** | **Earthquake Precursor Analysis for moderate to high magnitude earthquakes in India for understanding the spatio-temporal likelihood of earthquakes (SCA /NRSC /IIRS/ NESAC)** | |
| **G 1.2** | **Modelling geodynamics (SAC/ NRSC)** | |
| **G 1.3** | **Early warning of landslides (SAC/IIRS/NRSC/NESAC)** | |
| **G 1.4** | **Logistic regression based method for landslide hazard zonation (IIRS)** | |
| **G 1.5** | **2D Flood Inundation Modelling - Simulation of flood inundated areas for a given discharge using DEM and other inputs from satellite data (NRSC/ NESAC)**<br>To explore the applicability of hydro-dynamic equations in various conditions of overland flood wave propagation on different floodplain topographies. Inter | |

| | |
|---|---|
| | comparison of different DEM products for 2 dimensional hydraulic simulations. |
| G 1.6 | **Flood Early Warning System (FLEWS) (NESAC)**<br>Calibration and validations of all distributed river/tributary models in Brahmaputra and Barak river valleys with available hydro-logical and river geometry datasets. Sensitivity analysis of various model parameters to understand the hydrologic response of various types of river catchments in the said study area. |
| G 1.7 | **Flood Hazard zonation and risk assessment in major riverine and urban flood prone catchments (NESAC)**<br>Applicability of various approaches of flood hazard zonation such as flood frequency based hydraulic simulations, inundation occurrence based FHZ and NESAC developed multi-criteria analysis in both riverine and urban flooding conditions. |
| G 1.8 | **Integration of satellite based inputs along with DEM for forecasting a flood discharge and to provide early warning (NRSC/ NESAC)** |
| G 1.9 | **Simulation of inundation in urban environment using hydrologic and hydraulic models (NRSC)** |
| G 1.10 | **Assessing the possibility of cloudburst using INSAT images (NRSC)** |
| G 1.11 | **Automated detection of landslide using AWIFS and Cartosat-1 derived DEM (IIRS/ NESAC)** |
| G 1.12 | **Debris flow modelling and risk assessment (IIRS)** |
| G 1.13 | **Thunderstorm Now-casting (NESAC)** |
| G 1.14 | **Tsunami modelling (NRSC)** |

# 5.0 Space Sciences Programme

| | | |
|---|---|---|
| **A** | **Area** | **Investigation on Near Earth Environment (PRL)** |
| **A 1** | **Sub Area** | **Thermosphere – Ionosphere System (PRL)**<br>Thermosphere and ionosphere are mutually coupled System with neutral and plasma affecting each other with different time scales. In addition, this part of atmosphere/ionosphere also gets affected from the forcing above by sources of solar origin and also from lower atmosphere. Thus comprehensive studies using various techniques are needed. |
| **A 1.1** | **Thermospheric Airglow and their processes (PRL)** | |
| **A 1.2** | **Plasma and neutral dynamics in Thermosphere-Ionosphere system (PRL)** | |
| **A 1.3** | **Coupling of High-low latitude Thermosphere-Ionosphere system (PRL)** | |
| **A 1.4** | **Effects of solar eclipse, earthquake on ionosphere (PRL)** | |
| **A 1.5** | **Waves and instabilities in ionosphere (PRL)** | |
| **A 1.6** | **Geomagnetism: Ionospheric, magnetospheric and solar wind induced Variable and transient (pulsations) phenomena (PRL)** | |
| **A 1.7** | **Ionospheric modification (PRL)** | |
| **A 1.8** | **Study of height profiles of electron density, electric field, and neutral wind in the equatorial F region (PRL)** | |
| **A 1.9** | **Linking the thunderstorm related dynamical forcing on the upper atmosphere (PRL)** | |
| **A 1.10** | **Measurements of upper mesospheric temperature and winds (PRL)** | |
| **A 1.11** | **Whole atmosphere coupling through wave forcing through observations and modeling (PRL)** | |
| **A 1.12** | **Three dimensional simulation of Rayleigh Taylor instability (PRL)** | |
| **A 1.13** | **Modelling of equatorial electrojet (PRL)** | |
| **A 2** | **Sub Area** | **Study of low latitude ionosphere (PRL)** |

| | | |
|---|---|---|
| A 2.1 | **Study of low latitude ionosphere applied to satellite based communication and navigation systems (PRL)** | |
| A 2.2 | **Ionospheric phenomena using TEC by GPS and other parameters (PRL)** | |
| A 2.3 | **GNSS based ionospheric retrieval under Equatorial Spread F events (PRL)** | |
| A 2.4 | **GNSS observations and ionospheric forecasting for Quiet geomagnetic conditions (PRL)** | |
| A 2.5 | **Study of space weather events and geomagnetic storms in nearly same longitude zone to evaluate the latitudinal ionospheric response in the same local time zone. Similarly, study of longitudinal differences in such response (PRL)** | |
| A2.6 | **Study of Electro-dynamical and thermospheric processes leading to positive and negative ionospheric storms in low latitudes (PRL)** | |
| A 3 | **Sub Area** | **Magnetosphere Processes (PRL)**<br>The understanding of the magnetic environment of the earth is important as it protects from high energetic solar wind particles and cosmic rays. Geo effective disturbances are important to be investigated not only to understand the modification of magnetosphere but also to protect earth orbiting satellites. |
| A 3.1 | **Plasma instability processes (PRL)** | |
| A 3.2 | **Micro plasma process in magnetic reconnection region (PRL)** | |
| A 3.3 | **Triggering of sub storms and impact on global ionosphere (PRL)** | |
| A 3.4 | **Relationship between geomagnetic storm and sub-storm (PRL)** | |
| A 3.5 | **Investigation on plasma waves and their propagation characteristics.**<br>**Turbulence: MHD Turbulence, Compressible Turbulence (PRL)** | |
| A 3.6 | **Wave particle interaction (PRL)** | |
| A 4 | **Sub Area** | **Impact of Space Weather (PRL)**<br>Disturbances in the sun, their propagation in the interplanetary medium, interaction of solar wind with magnetosphere decides the effectiveness of the solar |

| | | |
|---|---|---|
| | | disturbances that impact the near Earth environment. |
| A 4.1 | Physics of Shocks (PRL) | |
| A 4.2 | Identification of structures and turbulence in solar wind plasma (PRL) | |
| A 4.3 | Interaction between solar wind and magnetospheric boundary (PRL) | |
| A 4.4 | Impact of space weather processes in ionosphere, thermosphere system (PRL) | |
| A 4.5 | Distortion of radiation belt and plasma sphere during extreme space weather events (PRL) | |
| A 4.6 | Interplanetary scintillations (PRL) | |
| B | Area | Atmospheric dynamics and coupling (NARL) |
| B 1 | Sub Area | Observations, Modelling and Simulations (NARL) |
| B 1.1 | Modelling of atmospheric tides (NARL) | |
| B 1.2 | Generation and propagation of atmospheric wave modes (NARL) | |
| B 1.3 | Numerical simulations of stratospheric sudden warming and their global influence (NARL) | |
| B 1.4 | Gravity wave-tidal -mean flow interactions (NARL) | |
| B 1.5 | Simulations of QBO, SAO and Intra-Seasonal Oscillation (NARL) | |
| B 1.6 | Influence of lateral wave forcing on tropical weather and climate (NARL) | |
| B 2 | Sub Area | Mesosphere-lower thermosphere system along with lower ionosphere (D and E-regions) (NARL)<br>This region acts as a buffer between upper atmosphere and lower atmosphere where wave activities are more. The region which filters out a lot of wave modes is not yet understood due to lack of systematic measurements. |
| B 2.1 | Winds and wave activities in mesosphere (NARL) | |
| B 2.2 | Mesospheric Airglow and their processes (NARL) | |
| B 2.3 | Propagation of VLF waves in the D region of ionosphere and their relation to Earth-quake (NARL) | |

| | | |
|---|---|---|
| B 2.4 | E-region of ionosphere-electrojet and associated plasma waves (NARL) | |
| B 2.5 | Lower and upper atmosphere coupling (NARL) | |
| B 2.6 | Effects of dusty plasma (NARL) | |
| C | Area | Sun and Solar System (PRL) |
| C1 | Sub Area | Planetary atmospheres (PRL)<br>With the advent of various missions to various planets it is necessary to understand the planetary atmospheres and ionospheres. Formation of planetary magnetosphere in the presence of intrinsic magnetic field of the planet is yet another interesting problem to pursue. |
| C 1.1 | Formation of ionospheric layers in Mars and other planets (PRL) | |
| C 1.2 | Effect of dust in Martian and other planetary atmospheres (PRL) | |
| C 1.3 | Formation of planetary magnetospheres (PRL) | |
| C 1.4 | Planetary Aurora and Airglow (PRL) | |
| C 1.5 | Lightning phenomenon on other planets (PRL) | |
| C 1.6 | Non-linear effects in orbital mechanics (PRL) | |
| C1.7 | Aeronomy of other planets and comparison with that of the earth (PRL) | |
| C 2 | Sub Area | Study of Comets (PRL)<br>Comets represent pristine solar nebular matter and hence studying comets is very important to understand the early solar system itself. |
| C 2.1 | Composition of dust and plasma tails (PRL) | |
| C 2.2 | Dust formation, distribution and characterization of dust tail (PRL) | |
| C 2.3 | Plasma processes in plasma tail (PRL) | |
| C 2.4 | Processes involving dusty plasma (PRL) | |
| C 3 | Sub Area | Solar Physics (PRL/ISAC)<br>Being the energy source for solar system objects, Sun directly controls various physical phenomena in the Solar |

| | | |
|---|---|---|
| | | system. Sun is also closest star and hence offers opportunity to study various stellar phenomena at an unprecedented spatial resolution. |
| C 3.1 | **Origin of Sun and Solar system (PRL)** | |
| C 3.2 | **Transient Phenomena: Flares, Coronal Mass Ejections (PRL)** | |
| C 3.3 | **Surface Phenomena: Granules, Super granules, Sun spots (PRL)** | |
| C 3.4 | **Atmosphere: Chromospheres Phenomena, Coronal Plasma Phenomena (PRL)** | |
| C 3.5 | **Radiation: Thermal and non-thermal radiation processes (PRL)** | |
| C 3.6 | **Magnetic field and Velocity mapping (PRL)** | |
| C 3.7 | **Solar cycle variation, prediction of activity cycle (PRL)** | |
| C 3.8 | **Multi-wavelength studies (PRL)** | |
| C 3.9 | **Solar dynamo, Magneto-Convection region (PRL)** | |
| C 3.10 | **Helio –seismology (PRL)** | |
| C 3.11 | **MHD simulations for Solar and Stellar Atmospheres (ISAC/PRL)** | |
| C 3.12 | **Polarized Radiative Transfer modeling through solar atmospheres (ISAC/PRL)** | |
| C 3.13 | **Forward modeling for UV spectroscopy (ISAC/PRL)** | |
| C 3.14 | **Development of inversion codes for Chromospheric and Coronal studies (ISAC/PRL)** | |
| C 3.15 | **Study of dynamical events for Space weather using archival data (ISAC/PRL)** | |
| C 4 | **Sub Area** | **Planetary Sciences (NARL /ISAC)** |
| C 4.1 | **Saturn's upper atmosphere (NARL)**<br>Plasma in the Saturn's upper atmosphere, magnetosphere, radiation belts, interaction with its rings and moons, the rotation period of Saturn | |
| C 4.2 | **Investigations on the problem of Methane on planetary atmospheres: Mars and Pluto (NARL)** | |

| | | |
|---|---|---|
| C 4.3 | **Development of an algorithm to compare and correlate IR spectroscopy data of minerals with X-ray fluorescence spectra using laboratory experiments and modelling (ISAC)** | |
| C 4.4 | **Modelling of terrestrial planetary evolution and surface chemistry (ISAC)** | |
| C 4.5 | **Comparative studies on the surface chemistry of inner planets compare to Earth (ISAC)** | |
| C 4.6 | **Radiative transfer modelling of planetary atmospheres (ISAC)** | |
| C 4.7 | **Planetary atmospheric composition using archival data like vertical profiling and solar wind interaction with outer atmosphere (ISAC)** | |
| C 4.8 | **Study of particles interaction with planetary magnetospheres and related dynamics (ISAC)** | |
| **D** | **Area** | **Astronomy and Astrophysics (PRL)** |
| **D 1** | **Sub Area** | **Galactic Astronomy, Extra-galactic Astronomy and Cosmology.** |
| **D 1.1** | **Interstellar medium (PRL)**<br>Star formation in giant molecular clouds. Disks and Jets around low/high mass proto-stars. Cluster identification, classification and characterization.<br>Proto Planetary nebulae, Chemically peculiar Planetary Nebulae. Asymmetric Planetary nebulae<br>Extinction curves and their modelling in various wavelength regions: infrared and far –Ultra-violet. Origin of 217.5 nm feature. Polycyclic Aromatic Hydrocarbon molecules and their contribution to interstellar extinction. | |
| **D 1.2** | **Astro-biology and Astro-chemistry (PRL/ISAC)**<br>Formation of pre-biotic molecules in interstellar matter origin of life. Formation of interstellar giant molecules in star forming clouds.<br>Experiments of astrobiological importance to detect most important biomolecules and their precursors that would provide clues on the origin of life | |
| **D 1.3** | **Dust formation in Stellar Ejecta Modelling of Circum-stellar matter (PRL)** | |
| **D 1.4** | **Star spots: Photometric and spectroscopic variability studies (PRL)** | |
| **D 1.5** | **Chemically Peculiar Stars: stars with abundances different from solar abundances (PRL)** | |

| | | |
|---|---|---|
| D 1.6 | Astro-seismology: Variability in spectral line profiles at high resolution (PRL) | |
| D 1.7 | Extra-Solar-Planets: Transit observations using a small facility (PRL) | |
| D 1.8 | Binary Star Phenomena: Novae, Supernovae Type-I, Cataclysmic variables, X-ray binaries with Black Hole and Neutron Star companions. Transient phenomena Quasi-Periodic oscillation in X-ray binaries (PRL) | |
| D 1.9 | Ultra-luminous X-Ray Sources, Micro-quasars. Study of environments of Black Holes of different masses: $10^5$ Solar mass to Stellar mass (PRL) | |
| D 1.10 | Studies on the Galactic centre (PRL) | |
| D 1.11 | Studies on Elliptical and Spiral Galaxies. ISM in external galaxies. Star formation and evolution in external galaxies (PRL) | |
| D 1.12 | Investigation of Active Galactic Nuclei. Star-burst galaxies. Intergalactic medium (PRL) | |
| D 1.13 | Multi-Wavelength observations using Ground-based and/or Space-borne facilities: X ray, UV, Visible, Infrared, Sub-millimeter, Millimeter and Radio regions (PRL) | |
| D 1.14 | Theoretical and Observational studies on Dark Matter and Dark Energy. Theoretical and Observational Cosmology (PRL) | |
| D 1.15 | Data mining and processing techniques with applications to astronomical data (PRL) | |
| D 1.16 | Development of thin X-ray windows (pin hole free, few micron thick, made of low Z materials) (Energy of interest 200 eV to 2000 eV) for x-ray detector applications (ISAC) | |
| D 1.17 | Development of thin film windows for the transmission of charged particles, especially particles of higher charge (ISAC) | |
| D 1.18 | Laboratory characterization of poly capillary x-ray optics (ISAC) | |
| **E** | **Area** | **Space Instrumentation (PRL)** |
| **E 1** | **Sub Area** | **Ionosphere/Thermosphere (PRL)** |
| E 1.1 | Plasma Measurements, Airglow emissions experiments (PRL)<br>1. Magnetometer | |

| | | |
|---|---|---|
| | 2. Electric Field<br>3. Electron/ Ion Density & Temperature<br>4. Imagers/Photometers/Spectrometers<br>5. Winds and temperature (neutral)<br>6. Drift Meter, Composition measurements<br>7. Radio Beacon and Occultation | |
| **E 2** | **Sub Area** | **Earth's Lower/Middle Atmosphere (PRL)** |
| **E 2.1** | **Aerosols, minor constituents & Trace Gases Experiments (PRL)**<br>1. Optical Photometers<br>2. Infrared Photometers<br>3. Infrared Spectrometer<br>4. Visible photometer for lightening<br>5. Active Experiments like Lidar, SAR, Scatterometer | |
| **E 3** | **Sub Area** | **Planetary Exploration (PRL)** |
| **E 3.1** | **Atmosphere Experiments (PRL)**<br>1. Charge particle measurements<br>2. Composition (Mass Spectrometer)<br>3. Vertical distribution of Electron Density<br>4. Vertical distribution of Species | |
| **E 4** | **Sub Area** | **Planetary Atmosphere (PRL)** |
| **E 4.1** | **Surface measurements (Elemental composition) Experiments (PRL)**<br>1. X ray Spectrometer<br>2. Laser induced breakdown spectroscopy<br>3. Surface & Subsurface Temperature<br>4. Dust and surface charging<br>5. Microwave radar | |
| **E 5** | **Sub Area** | **Astronomy (PRL)** |
| **E 5.1** | **Instrumentation for Ground-based and Space-borne facilities (PRL)**<br>1. Visible & Infrared Photometers, Polarimeters and Spectrometers for | |

| | | |
|---|---|---|
| | ground-based and space-based facilities.<br>2. Ultra-violet spectro-photometers and spectrometers for space-based facilities.<br>3. X- ray instrumentation for space-based facilities (Imaging and Spectra and polarization)<br>4. Gamma Ray Spectrometer for space-borne platforms<br>5. Space telescopes.<br>6. Active and Adaptive optics for diffraction limited imaging.<br>7. Detector arrays for UV, Visible, IR and X-ray regions. | |
| **E 6** | **Sub Area** | **Astronomical Instrumentation (ISAC)** |
| **E 6.1** | **Development of any hardware element or testing of Alkali Halide Photo Cathode for gas based photomultipliers (ISAC)** | |
| **E 6.2** | **Acousto-Optic Tunable Crystal development for spectroscopy (ISAC)** | |
| **E 6.3** | **Liquid Crystal development for Near Infra red spectroscopy (ISAC)** | |
| **E 6.4** | **Development of square profile filters for narrow band astronomy applications (ISAC)** | |
| **E 6.5** | **Development of Fibre bundles for high dynamic studies of solar eruptive events (ISAC)** | |
| **E 6.6** | **Development of Low atomic number X-ray transmission filters for use with soft X-ray detectors (ISAC)** | |
| **E 6.7** | **Multilayer coated mirror characterization for X-ray optics (ISAC)** | |
| **E 6.8** | **Development of X-ray gratings for high resolution X-ray spectroscopy (ISAC)** | |
| **E 6.9** | **Development of compact X-ray tubes for X-ray generation for use in laboratories (ISAC)** | |
| **E 7** | **Sub Area** | **Solar Studies (PRL)** |
| **E 7.1** | **Charge Particle & Radiation Flux in X, UV, Optical & IR wavelengths Experiments (PRL)**<br>1. Optical Photometers/ Spectrometers<br>2. Infrared Photometers/ Spectrometers | |

| | | |
|---|---|---|
| | 3. Charge particle energy & flux measurements | |
| **E 7.2** | **Active and Adaptive optics for diffraction limited imaging (PRL)** | |
| **E 8** | **Sub Area** | **X-ray transients (ISAC)** |
| **E 8.1** | **Timing and spectral studies of X-ray transients (ISAC)**<br>Timing and spectral studies of X-ray transients like Cataclysmic variables, searching for new QPOs and coherent pulsations in X-ray binaries using archival data. Some of the scientific problems that can be addressed under these studies are:<br>Estimation of the mass of compact objects in binaries<br>Modeling the complex emission mechanisms from accretion disk around Galactic and extragalactic X-ray sources | |
| **E 9** | **Sub Area** | **Exo-planets: Exo-planet studies with archival data (ISAC /PRL)** |
| **E 9.1** | **Statistical analysis correlating properties of exoplanets with their host stars (ISAC/PRL)** | |
| **E 9.2** | **Detection of new exoplanets using archival data from Kepler (ISAC/PRL)** | |
| **E 9.3** | **Modeling the atmosphere of exoplanets from the available data (ISAC/PRL)** | |
| **E 9.4** | **Experiments to detect biosignatures of planetary / exoplanetary systems (ISAC/PRL)** | |
| **F** | **Area** | **Remote sensing data analysis from planetary exploration missions (PRL/SAC/IIRS/SPL)** |
| **F 1** | **Sub Area** | **Moon (PRL/ SAC/ IIRS/ SPL)** |
| **F 1.1** | **Development of MHD model for solar wind interaction with moon (SPL)** | |
| **F 1.2** | **Chemical, mineralogical and morphological studies (PRL)** | |
| **F 1.3** | **Lunar Surface Sciences (SAC)**<br>The main research themes for research includes Lunar Surface composition, Lunar morphology, Hyperspectral data analysis for Lunar Surface, Thermal Remote Sensing of the Moon, Spectral characterization of Lunar analogues, Lunar surface dating and lunar volcanism. | |

| | | |
|---|---|---|
| F 1.4 | **Polarimetric modelling of Lunar surface characterization (IIRS)** | |
| F 1.5 | **Lunar Gravity and Crustal thickness studies (SAC)**<br>Using the surface elevation and satellite tracking data lunar gravity can be deduced and this gravity data can be further modelled using gravity reduction methods to find out the lunar crustal thickness, which provide information about the lunar interior processes. The main research themes include Lunar gravity modelling, inversion modelling for crustal thickness and lunar interior. | |
| F 2 | **Sub Area** | **Mars (PRL/ SAC/ NRSC)** |
| F 2.1 | **Surface and atmospheric processes on Mars (PRL)** | |
| F 2.2 | **Records of aqueous activities on Mars (PRL)** | |
| F 2.3 | **Solar interaction and atmospheric loss processes (PRL)** | |
| F 2.4 | **Studies related to Martian surface and Polar Ice (SAC/ NRSC)**<br>Major research themes are Characterization of Martian analogues rocks in India, Hyperspectral analysis of Mars data, Thermal remote sensing of Mars, Martian Atmosphere. Surface composition of mars Remote Sensing for Trace gases. | |
| F3 | **Sub Area** | **Planetary Data Processing (SAC)** |
| F 3.1 | Vision_based horizontal velocity estimation of lander craft using optical flow methods - which will involve study of algorithms and development of software for vision based horizontal velocity computation, useful for soft landing of lander craft (Chandrayaan-2). | |
| F 3.2 | DTM generation from terrestrial stereo images & Path guidance algorithm development for rover instrument:<br>This calls for (i) study and understanding the methodology/techniques and related software development for deriving DTM from terrestrial stereo images using close range photogrammetry concepts (for Chandrayaan-2 Rover camera) and (ii) Derivation of optimum path between two points using the terrain information over moon surface | |
| F 3 | **Sub Area** | **Minor Solar System Objects (PRL)** |
| F 3.1 | **Meteorite asteroid connection- Comparison of reflectance spectra (PRL)** | |
| F 4 | **Sub Area** | **Astronomical Data Processing and Analysis (SAC)** |

| | | |
|---|---|---|
| F 4.1 | **Autonomous Spacecraft navigation using Pulsars (SAC)**<br>To evaluate the usability of fast spinning and strongly magnetized neutron stars, also known as pulsars, in defining and external reference system suitable for deep space navigation.<br>To propose a methodology that can be used in deep space navigation for operational purpose | |
| F 4.2 | **Study of Anomalous X-Ray Pulsars (SAC)**<br>The objective of this study is to review and add understanding of recent observation as well as analysis of Anomalous X-Ray Pulsars with an emphasis on timing, variability, and spectra. This study should contribute in deeper understanding of AXP in terms of its high and variable magnetic field, its evolution and its importance in life cycle of a star. Astrosat Data will be used for study and other contemporary satellites data will be used for validation | |
| G | Area | Laboratory study of Astromaterials (PRL) |
| G 1 | Sub Area | Meteorites from asteroids (PRL) |
| G 1.1 | Early solar system processes and time scales (PRL) | |
| G 2 | Sub Area | Moon and Mars Meteorites (PRL) |
| G 2.1 | Composition, evolution and chronology (PRL) | |
| H | Area | Study of terrestrial analogues of Moon and Mars (PRL) |
| H 1 | To understand surface properties and aqueous processes on Mars (PRL) | |
| I | Area | Payloads for upcoming planetary missions (PRL) |
| I 1 | Experiments based on EM radiation, particle irradiation and nuclear reactions can be devised to understand surface and subsurface composition and the equipment can be realized in a miniaturized space qualified form (PRL) | |

# 6.0 Meteorology

| | | |
|---|---|---|
| **A** | **Area** | **Weather and Climate (NARL/ SAC/ NRSC/ IIRS/ NESAC)** |
| **A 1** | **Sub Area** | **Modelling and computer simulations for weather prediction(NARL/ SAC)** |
| **A 1.1** | **Parallelization/Optimization of weather and climate Models (NARL)** | |
| **A 1.2** | **Use / development of remote sensing techniques for high resolution real time monitoring of convective systems (thunderstorms, cyclones etc) (NARL)** | |
| **A 1.3** | **Development of advanced techniques for conventional and satellite based data assimilation in weather and climate models (NARL)** | |
| **A 1.4** | **Satellite weather image processing (NARL)** | |
| **A 1.5** | **Development of techniques for Data mining and Processing (NARL/SAC)** | |
| **A 1.6** | **Impact (socio-economic) Analysis of long term climate change predictions under different scenarios (NARL)** | |
| **A 1.7** | **Observational Campaign for understanding of convective systems (NARL)** | |
| **A 1.8** | **Seasonal to centennial scale Climate modeling (NARL)** | |
| **A 1.9** | **Now casting and short range weather prediction of convective systems (NARL)** | |
| **A 1.10** | **Numerical weather prediction with general circulation models (SAC/ NESAC)**<br>Real time weather forecast is an essential component during satellite launches from the launch pad as the launch vehicle is exposed to weather 2-3 days before the launch. Short range weather prediction is made using numerical weather prediction model and assimilation of satellite data. The same technique is also used for All India weather forecast in 5 km resolution. This involves dynamic modelling, physical parameterization and assimilation of satellite data. | |
| **A 2** | **Sub Area** | **Atmospheric sciences and climate (SAC/ NESAC)** |

| | |
|---|---|
| A 2.1 | **Retrieval of geophysical parameters from satellite data (SAC/ NESAC)**<br>ISRO has planned for launching a number of meteorological and oceanographic satellites in near future. It has already INSAT-3D, Megha-Tropiques and SARAL satellites in the orbit. In near future it has planned to launch GISAT. It is a challenging work to retrieve geophysical parameters from the sensor data of these satellites. This involves Radiative Transfer modelling and the Inverse modelling techniques. |
| A 2.2 | **Diagnostic studies for Monsoon (SAC/ NESAC)**<br>For better prediction of Indian Monsoon, it is necessary to understand the physical mechanism of convective processes. For this purpose, a lot of diagnostic studies are being carried out using satellite data like vertical profiles of atmospheric temperature and humidity. These profiles help to understand the stability of the atmosphere |
| A 2.3 | **Cyclone track and intensity prediction using satellite data and numerical models (SAC/ NESAC)**<br>Cyclone track and intensity prediction is very important activity as there is huge damage occurred due to cyclones. Improvement of cyclone track is being done by using numerical models and satellite data. Satellite data is used to determine the present location of the cyclone when it is over the ocean and away from the coast. The exact determination of the current and past location is useful for prediction of its future movement and intensity prediction. This involves both empirical and dynamic modelling and assimilation techniques. |
| A 2.4 | **Climate prediction with coupled Atmosphere-Ocean-Land-Ice models (SAC/ NESAC)**<br>For long term prediction of climate, Coupled model of Atmosphere, Ocean, Land and Ice is very important component. In these models, coupling is an important area of research as different components have different spatial and temporal variability. This involves balancing the fluxes at the interface boundaries of each component of the model. |
| A 2.5 | **Advanced system study for new sensor definition (SAC)**<br>For new measurements of atmospheric and Oceanic parameters, new advance sensors have to be defined for future satellites. System study is being done with the help of Radiative transfer models to define the appropriate frequency and bandwidth of new sensors. |
| A 2.6 | **Atmospheric sounding (measurement and understanding of vertical distribution of physical properties of the atmospheric column such as** |

| | | |
|---|---|---|
| | **pressure, temperature, wind speed and wind direction, pollution and other properties using remote sensing and in situ observation) (IIRS/ NESAC)** | |
| **A 3** | **Sub Area** | **Convection/Precipitation/Boundary layer (NARL)** |
| **A 3.1** | **Understanding dynamical characteristics of Mesoscale Convective Systems and their association with energetics of the atmosphere (NARL)** | |
| **A 3.2** | **Understanding the link among surface fluxes, atmospheric boundary layer and clouds (NARL)** | |
| **A 3.3** | **Understanding the rain processes (both at macroscale and microscale) at a regional level (NARL)** | |
| **B** | **Area** | **Radiation, Aerosols and Trace gases (NARL/IIRS/NRSC)** |
| **B 1** | **Sub Area** | **Instrumentation/Observations/Scientific problems/Modelling (NARL/ IIRS/ NRSC)** |
| **B 1.1** | **Development of low cost nephelometer (NARL)** | |
| **B 1.2** | **Development of OH analyzer (NARL)** | |
| **B 1.3** | **Study of cloud-aerosol interaction in fog/cloud chamber (NARL)** | |
| **B 1.4** | **Chemistry of minor and trace constituents that are precursors to ozone chemistry (NARL)** | |
| **B 1.5** | **Aerosol and radiative effects affecting the climate (NARL)** | |
| **B 1.6** | **Atmospheric Modelling (IIRS/ NESAC)**<br>Pixel based Aerosol Optical Depth (AOD) estimation by radiative transfer modelling using TOA radiance and validation with field instruments.<br>Development of image based aerosol retrieval techniques over satellite imagery. | |
| **B 1.7** | **Aerosol characterization and its impact on solar radiation (NRSC)** | |
| **C** | **Area** | **Microwave atmospheric studies (SPL)** |
| **C 1** | **Sub Area** | **Microwave Radiative Transfer (RT) code developments and inversions of geophysical parameters (SPL)** |

| | | |
|---|---|---|
| C 1.1 | Developing microwave Radiative transfer codes and inversion techniques for retrieving geophysical parameters including atmospheric hydrometeors are essential for satellite and ground based microwave /mm and sub millimeter wave proofing (SPL) | |
| D | Area | Signal and Data processing (NARL/ NESAC) |
| D 1 | Sub Area | Parameter retrieval algorithm developments (NARL/ NESAC) |
| D 1.1 | Lidar signal inversion methods (NARL) | |
| D 1.2 | Retrieval of temperature and minor constituents in the atmosphere from the satellite based radiance measurements (NARL) | |
| D 1.3 | Retrieval of electron density from GPS occultation measurements (NARL) | |
| D 1.4 | Radar signal processing (NARL) | |
| D 1.5 | Radar Data processing (NARL) | |
| D 1.6 | Improvements in satellite rain retrievals using advanced statistical or physics based algorithms (NARL) | |
| D 1.7 | Polarimetric DWR data processing and retrieval of precipitation/hail/wind (NESAC) | |
| E | Area | Radar and Lidar instrumentation for atmospheric probing (NARL) |
| E 1 | Sub Area | Development of Radar and Lidar accessories/techniques (NARL) |
| E 1.1 | Time dependent attenuator for Lidar signal (NARL) | |
| E 1.2 | Development of a Fiber optic based IF filter for lidar to solve the problem of temperature dependence of filters (NARL) | |
| E 1.3 | Digital up-converters (NARL) | |
| E 1.4 | Digital synthesizer for radar exciter (NARL) | |
| E 1.5 | Networking of radar subsystems (NARL) | |
| E 1.6 | Digital receiver for radar system (NARL) | |

| | | |
|---|---|---|
| E 1.7 | Digital beam forming techniques (NARL) | |
| E 1.8 | Clutter removal techniques (NARL) | |
| E 1.9 | Radar imaging techniques (NARL) | |
| E 1.10 | Dual-polarized patch antenna for radar applications (NARL) | |
| E 1.11 | Design and development of Solid state TR modules for radar applications (NARL) | |
| F | Area | Meteorology Facility for Launching Vehicle (SDSC-SHAR) |
| F 1 | Extended range prediction of Tropical cyclone genesis over Bay of Bengal (SDSC-SHAR) | |
| F 2 | Now casting of severe convective activity over southeast India using ground based meso-network of observations (SDSC-SHAR) | |
| F 3 | Thunderstorm predictors and their forecast skill for the southern peninsular India (SDSC-SHAR) | |
| F 4 | Study of Sub-Tropical Westerly Jet in winter over southern Peninsular India (SDSC-SHAR) | |
| F 5 | Development of more capable local numerical weather forecast systems tailored to operational requirements (SDSC-SHAR) | |

------x------