# RESPOND BASKET


RESPOND & AI
Capacity Building Programme Office
ISRO HQ, Bengaluru

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# Introduction

ISRO is embarking upon many new areas of Science and Technology by taking up challenging technological assignments incessantly. In this significant task of National Importance, ISRO is looking for wider participation and contributions from academia in a focused manner for timely accomplishment of its goals.

In this regard, Capacity Building Programme Office of ISRO HQ has brought out a "RESPOND BASKET" comprising of around 150 urgent and most important research areas with a brief write up about the topic, for the participants to select and prepare detailed proposals on a priority basis. For each identified project under RESPOND Basket, a Co-Principal Investigator has been identified from the respective centre for any further clarification and coordination while preparing the proposals and during the tenure of the project.

The projects have been identified ISRO/ DOS centre wise and the faculty/researcher may select a suitable topic/problem, prepare the proposal and submit to the concerned centre/unit for consideration. The proposals may be submitted to the Director of concerned centre as given in **Annexure 1.** For queries related to proposal, please contact our RESPOND co-ordinators at each centre (**Annexure 2).**

The proposal submission formats and other necessary details are available in the ISRO website under the link www.isro.gov.in/research-and-academia-interface/submission-of-research-proposal.

For any queries please contact:

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| VSSC - 001 | | |
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| 1 | **Name of ISRO Centre/Unit** | Vikram Sarabhai Space Centre (VSSC), Thiruvananthapuram |
| 2 | **Title of the research proposal** | Development of robust algorithm for CFD simulation of supersonic and hypersonic flows around complex geometries on unstructured meshes |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri Aaditya Chaphalkar |
| 4 | **Contact Address of CoPI and Phone Number** | CFDD/ADSG, Aeronautics Entity<br>Vikram Sarabhai Space Centre<br>Thiruvananthapuram, Kerala<br>Phone: 0471-2564810<br>e-mail: aaditya_chaphalkar@vssc.gov.in |
| 5 | **Area of Research** | Computational Fluid Dynamics |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>Supersonic and hypersonic flows around complex geometries of launch vehicles and re-entry vehicles are of interest to VSSC as it forms an important part of characterization of launch vehicles. An unstructured finite volume 3D RANS solver is under development in VSSC. This solver has popular upwind scheme such as AUSM, Roe etc. with SA and SST turbulence models. Explicit as well as implicit time integration schemes are available. Currently, some issues are observed in convergence of supersonic and hypersonic flows while simulating flows at higher altitudes with low pressure and density.<br><br>**Scope of the work:**<br><br>As part of this project, a robust algorithm is to be developed to simulate supersonic and hypersonic flows in particular, that can be implemented in the in-house finite volume solver. The algorithm should be demonstrated on an unstructured grid finite volume 3D RANS solver that is either open-source or developed by the Principal Investigator. Convergence of the simulations using this algorithm should be shown on a generic launch vehicle geometry for various free-stream conditions including those with low pressure and density (higher altitudes). The algorithm should be able to work with upwind schemes such as AUSM, Roe etc. and popular turbulence models like SA and SST in both explicit and implicit time integration. Details of the algorithm can range from changing the values of closure coefficients in the turbulence model, update in the flux difference splitting schemes to development of a separate module that modifies the cell updates based on certain criterion. The project can be divided in two parts: 1. Algorithm for supersonic flows $2.0 < M \leq 4.0$ and 2. Algorithm for hypersonic flows $4.0 < M \leq 8.0$. Separate algorithm can be developed for these two or one algorithm can be developed that suites both these regimes.<br>**Deliverables:** Details of the algorithm developed along with the implementation details. | |

| VSSC - 002 | | |
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| 1 | **Name of ISRO Centre/Unit** | Vikram Sarabhai Space Centre (VSSC), Thiruvananthapuram |
| 2 | **Title of the research proposal** | Lattice-Boltzmann methods |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri M Gopalasamy |
| 4 | **Contact Address of CoPI and Phone Number** | CFDD/ADSG, Aeronautics Entity<br>Vikram Sarabhai Space Centre<br>Thiruvananthapuram, Kerala<br>Phone: 0471-2564258<br>e-mail: gopalsamy_muthiah@vssc.gov.in |
| 5 | **Area of Research** | Computational Fluid Dynamics |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>In recent years, the Lattice Boltzmann (LB) method has been developed as an alternative method of Computational Fluid Dynamics (CFD). This method originates from kinetic theory and has several advantages in modeling fluid flows in complex geometries and multiphase flows. In addition, the explicit and local interaction makes it amenable for parallel realizations in large scale simulations. The utilization of lattice-Boltzmann has been focused on incompressible flow since the deviations of the many lattice-Boltzmann model are proportional to the square of Mach numbers. The effort to recover the Navier-Stokes equations of compressible flow has become successful for flows with medium Mach numbers near one using the Hermite polynomials as the expansion basis. In the early development the equilibrium distribution function is chosen to be a small-Mach number expansion containing a few coefficients. This approach has achieved great success for the continuity and momentum equations. The effort of recovering the energy equation has met some difficulties due to numerical instability. There are some models that aim to simulate Euler and Navier-Stokes equations and are recovered by the finite difference LB method.<br><br>**<u>Scope of the work:</u>**<br><br>The focus of the work would be towards development of a parallel and efficient algorithm for simulating single-phase, multiphase fluid flows for supersonic flows (M > 1.0) with finite Knudson Number.<br><br>**<u>Deliverables</u>:**<br><br>The LBM code along the detailed documentation on the implementation. | |

| VSSC - 003 | | |
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| 1 | **Name of ISRO Centre/Unit** | Vikram Sarabhai Space Centre (VSSC), Thiruvananthapuram |
| 2 | **Title of the research proposal** | Jet noise field for an supersonic under-expanded jet |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri B Venkata Subrahmanyam |
| 4 | **Contact Address of CoPI and Phone Number** | ACD/ADSG, Aeronautics Entity<br>Vikram Sarabhai Space Centre<br>Thiruvananthapuram, Kerala<br>Phone: 0471-2564810<br>e-mail: b_subrahmanyam@vssc.gov.in |
| 5 | **Area of Research** | Vibro-Acoustics |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>Jet noise is one of the primary factors that induces dynamic load on vehicle structures during lift-off of launch vehicle. The high level of vibration produced during lift-off can lead to malfunction of electric/electronic packages, control system components and fatigue failure of light weight structures. Further, the noise specifications in the crew module are also governed by the jet noise. Hence, the transmission of the jet noise is an essential technology to be developed for efficient design of the crew module and associated systems. The jet noise distribution (PSD and spatial correlation) is used as a forcing function to compute the transmitted noise along a structure.<br><br>**<u>Scope of the work</u>:**<br><br>Large Eddy Simulations using either a new developed code or open-source code for an ideally expanded supersonic jets to be carried out and the jet noise results are to be validated. LES simulations for a free jet ($M_e$=2.8, $P_e/P_{inf}$=2.4) have to be carried out and the jet noise field (temporal PSD and spatial correlation) has to be characterized in both near and farfield. Development of a simplified model for computing the noise characteristics for this jets at different regions is also encouraged.<br><br>**<u>Deliverables:</u>**<br><br>LES code along with the details of the implementation and jet noise field for the free jet. | |

| VSSC - 004 | | |
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| 1 | **Name of ISRO Centre/Unit** | Vikram Sarabhai Space Centre (VSSC), Thiruvananthapuram |
| 2 | **Title of the research proposal** | Investigation of launch vehicle base flow-field in presence of supersonic under expanded multijet |

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| | | environment at various external free stream flow conditions |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri Vinod Kumar |
| 4 | **Contact Address of CoPI and Phone Number** | CFDD/ADSG, Aeronautics Entity<br>Vikram Sarabhai Space Centre<br>Thiruvananthapuram, Kerala<br>Phone: 0471-2565809<br>e-mail: vinodkumar_g@vssc.gov.in |
| 5 | **Area of Research** | Aerodynamic Design and Analysis |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>The highly underexpanded jet in multijet environment causes significant upstream influence. This results in changes in pressure distribution on the core as well as strap-on boosters.<br><br>**<u>Scope of the work</u>:**<br><br>Experimental investigation of change in pressure distribution on core and strap-on boosters of typical launch vehicle configuration for various jet pressure ratios ranging from 1 to 100.<br><br>**<u>Deliverables: Response surface Model for</u>**<br><br>1. Coefficient of pressure distribution on core and strap-on for various pressure ratios<br>2. Change in force and moment coefficient for various pressure rations for core and strap-ons. | |

| **VSSC - 005** | | |
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| 1 | **Name of ISRO Centre/Unit** | Vikram Sarabhai Space Centre (VSSC), Thiruvananthapuram |
| 2 | **Title of the research proposal** | Development of a compact, lightweight regenerable adsorbent for carbon dioxide capture |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr Deepthi Sivadas |
| 4 | **Contact Address of CoPI and Phone Number** | ASD / PCM<br>Vikram Sarabhai Space Centre<br>Thiruvananthapuram, Kerala<br>Phone: 0471-2564919<br>e-mail: deepthi_sivadas@vssc.gov.in |
| 5 | **Area of Research** | Gas Absorbent Materials |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>Re-generable carbon dioxide capture system is vital for environmental control and life support system in long duration manned space missions. The proposal | |

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| | envisages to identify promising re-generable systems for selectively capturing carbon dioxide from the air.<br><br>Number of materials namely, solid amines, zeolites, molecular sieves, etc. have been reported for their high efficiency to selectively remove carbon dioxide and chemical contaminants as well as their chemical inertness and non-flammable properties. Furthermore, these sorbent materials can be readily regenerated via either thermal swing adsorption (TSA) or pressure swing adsorption (PSA), and therefore, are reported to be suitable for the removal of carbon dioxide and trace contaminants.<br><br>These re-generable adsorber systems do not have to be replaced during a space mission, and can be smaller and lighter than the disposable adsorber beds. Currently, packed beds of sorbent pellets are mostly used in the adsorption systems; however, recent studies have shown that these materials can be easily fluidized and/or eroded, due to both thermal cycling and mechanical vibration, and can generate fine particulates that bypass the downstream mesh filters. This results in particulates buildup in downstream pumps, blowers, and other components, and has been problematic in some aerospace applications. Furthermore, these packed beds of pellets create a large pressure drop across the adsorption system.<br><br>In view of the above, it is imperative to develop alternative approaches to packed bed systems, where the suitable adsorbent material should be coated on metal mesh elements (substrate consists of a series of ultra-short-channel-length) or monoliths which can effectively adsorb / capture carbon dioxide and trace contaminants. The study should aim at developing the regenerable adsorbent material having selective carbon dioxide adsorption efficiency of minimum 8% by weight. |

| **VSSC - 006** | | |
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| 1 | **Name of ISRO Centre/Unit** | Vikram Sarabhai Space Centre (VSSC), Thiruvananthapuram |
| 2 | **Title of the research proposal** | Evaluation of mixed mode fracture toughness of high strength aerospace materials |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri G Sudarsana Rao |
| 4 | **Contact Address of CoPI and Phone Number** | MCD,MME<br>VSSC, Thiruvananthapuram, Kerala<br>Phone: 0471-2562235<br>e-mail: g_sudarshan@vssc.gov.in |
| 5 | **Area of Research** | Material Characterisation |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>Structures commonly experience mixed mode fracture in real engineering applications. Mode I fracture properties are significantly used in engineering | |

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| | calculations since it is worst case scenario. However, knowledge of mixed mode fracture characteristics of materials will enable designers to decide the actual margins in actual engineering applications.<br><br>The scope of the study is as follows:<br><br>a) Evaluate Mode I and Mode II, Mode I and Mode III stress intensity factors with different ratios.<br><br>b)Evaluate Pure Mode I, Mode II using novel specimen and fixture technique. If possible, pure Mode III also can be evaluated.<br><br>c) Study the influence of mixed mode using classical and FEM models and that of the experimentally evaluated.<br><br>d)Make scientific/Engineering assessment and correct the FEM by appropriate factors based on experimental data (if applicable)<br><br>e) The material proposed to study are Maraging steel (M250) and ESR15CDV6 both parent and weld. Material and welded coupons for the study will be provided by VSSC.<br><br>f) Responding agency is requested to use minimum quantity of material as it is scarce.<br><br>g) Specimen design, fabrication, fixture design and fabrication, testing, data evaluation, metallurgical analyses are in the scope of responding agency. |

| **VSSC - 007** | | |
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| 1 | **Name of ISRO Centre/Unit** | Vikram Sarabhai Space Centre (VSSC), Thiruvananthapuram |
| 2 | **Title of the research proposal** | Noble metal coating over Carbon-Carbon composites |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri Jhon Paul |
| 4 | **Contact Address of CoPI and Phone Number** | CCDD, Composites Entity<br>Vikram Sarabhai Space Centre<br>Thiruvananthapuram, Kerala<br>Phone: 04712569608<br>e-mail: jhon_paul@vssc.gov.in |
| 5 | **Area of Research** | High Temperature Materials |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>Carbon-Carbon Composite materials are coated with SiC to protect from oxidation when the applications temperature is higher than 400$^{o}$C. However due to numerous applications of the material above 1700$^{o}$C, development program to coat Carbon-Carbon Composite with Noble Metals is initiated. Also during thermo-structural applications which demands leak tightness of C-C products like C-C combustion chamber, coating of Iridium on C-C composite is considered to be an ideal solution. | |

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| | Iridium (Ir) is considered as promising candidate for oxidation resistant materials at elevated temperature due to its high melting point (2430$^{o}$C), good chemical stability, low oxygen permeability, impermeability to gases, good chemical compatibility and low carbon solubility below the eutectic temperature of 2100–2300$^{o}$C. Considering the various merits offered by electrodeposition (ED) method for coating, it is proposed to develop the coating of Iridium (Ir) on Carbon-Carbon (C-C) Composite through ED. Also to overcome the problem of CTE mismatch between C-C and Ir, interlayer coating of Rhenium shall be provided through the same methodology.<br><br>Development of Iridium Coating will enable induction of C-C Composites based thrusters for Spacecrafts.<br><br>**Scope of Work:**<br><br>• Development of Coating Methdology of Iridium on Carbon-Carbon Composite Samples through electro deposition<br><br>• Development of Interlayer Coating of Rhenium through electro deposition<br><br>• Microstructural & Compositional Characterisation of Coating<br><br>• Demonstration of the process on various geometries (Conical & rectangular).<br><br>The deliverable would be the technology/methodology for coating over C-C Composite materials. |

| **VSSC - 008** | | |
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| 1 | **Name of ISRO Centre/Unit** | Vikram Sarabhai Space Centre (VSSC), Thiruvananthapuram |
| 2 | **Title of the research proposal** | Development of thermoplastic liners for helium gas bottle |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr R.S.Rajeev |
| 4 | **Contact Address of CoPI and Phone Number** | PSCD/PCM<br>Vikram Sarabhai Space Centre<br>Thiruvananthapuram, Kerala<br>Phone: 0471-2565041<br>e-mail: rs_rajeev@vssc.gov.in |
| 5 | **Area of Research** | Thermoplastic Polymers |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>At present, liners of helium gas bottles are fabricated using titanium alloy. Titanium alloy based liners attract large production delay, high cost and fabrication difficulties. In order to save time and cost in realizing such liners, it is proposed that the liners can be fabricated using suitable thermoplastic materials. Two important criteria for selecting the thermoplastic polymer for such applications are the helium gas barrier property and linear elasticity in the range of 10-20%. The thermoplastic | |

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| | polymers of choice are high density polyethylene, polyetherether ketone, nylon etc. In order increase the gas barrier properties, the polymer needs to be reinforced with platelet type fillers (nanoclay, graphene etc) in such a way that the helium leak rate of 10 E-8 mbar lit/sec/cm2 or better is achieved. The processing of layered material incorporated thermopolastic liners can be optimized using twin screw extrusion followed by injection molding of the two halves to get spherical liners. The plastic welding process also needs to be optimized so that there is no leakage of helium gas through the weld area and only maximum 5% drop in strength due to welding.<br><br>**Scope of the project:**<br>The scope of the project includes developing a dispersion method for the effective dispersion of layered nanomaterials (nanoclay, graphene etc) in thermoplastic matrix (HDPE, Nylon, PEEK etc) so as to find out the percolation threshold for effective gas barrier (helium leak rate 10E-7 mbar l/s/cm2 or better). The scope also includes development of proper plastic welding process so that the leak rate through the welded region is same as that through the other parts of the composite (helium leak rate of 10E-6 or better).<br><br>**The expected deliverables are:**<br>1. Thermoplastic polymer-nanoclay compositions with helium leak rate 10E-7 mbar l/s/cm2 or better<br>2. Thermoplastic polymer-graphene compositions with helium leak rate 10E-7 mbar l/s/cm2 or better<br>3. Method for proper dispersion of nanomaterials in thermoplastic matrix and optimization of process parameters and nanomaterial loading to achieve the above leak rate properties.<br>4. A method of plastic welding so that there is no specific leak of helium gas through the weld joint. |

| **VSSC - 009** | | |
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| 1 | **Name of ISRO Centre/Unit** | Vikram Sarabhai Space Centre (VSSC), Thiruvananthapuram |
| 2 | **Title of the research proposal** | Inelastic finite element model of multidirectional Carbon-Carbon composites to predict the material characteristics and behaviours |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri Jhon Paul |
| 4 | **Contact Address of CoPI and Phone Number** | CCDD, Composites Entity<br>Vikram Sarabhai Space Centre<br>Thiruvananthapuram, Kerala<br>Phone: 04712569608<br>e-mail: jhon_paul@vssc.gov.in |
| 5 | **Area of Research** | Carbon-Carbon Composites |
| 6 | **Summary of the proposed research and expected deliverables** | |

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| | 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 are 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 limited work has been carried 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 planned to initiate the micromechanical model studies to theoretically predict the material behaviour vis-a-vis the mechanical properties. Scope of work includes development of an elastoplastic finite element model, including homogenised mono-axial stiffness that can predict the material properties as has been referred in literature and, available tested material properties. |

| **VSSC - 010** | | |
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| 1 | **Name of ISRO Centre/Unit** | Vikram Sarabhai Space Centre (VSSC), Thiruvananthapuram |
| 2 | **Title of the research proposal** | Process optimization of Isothermal CVI process |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri Jhon Paul |
| 4 | **Contact Address of CoPI and Phone Number** | CCDD, Composites Entity<br>Vikram Sarabhai Space Centre<br>Thiruvananthapuram, Kerala<br>Phone: 04712569608<br>e-mail: jhon_paul@vssc.gov.in |
| 5 | **Area of Research** | Carbon-Carbon Composites |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>One of the most promising and common methods of fabrication of thinner Carbon-Carbon & Carbon-Silicon Carbide Composites is through vapor phase densification of porous structure of carbon fibers acting as reinforcement. During CVI process, the hydrocarbon gases or vapors of silanes decomposes to produce the desired carbon /Silicon carbide 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 realisation of C-C/ C-SiC 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 | |

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| | for further densification. Scope of work includes development of a comprehensive numerical modelling to simulate and optimise the processing parameters to achieve the required density and also to reduce the long process duration. |

| **VSSC - 011** | | |
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| 1 | **Name of ISRO Centre/Unit** | Vikram Sarabhai Space Centre (VSSC), Thiruvananthapuram |
| 2 | **Title of the research proposal** | Development of C-SiC composite through CVI using Mono-Methyl-Silane |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri Jhon Paul |
| 4 | **Contact Address of CoPI and Phone Number** | CCDD, Composites Entity<br>Vikram Sarabhai Space Centre<br>Thiruvananthapuram, Kerala<br>Phone: 04712569608<br>e-mail: jhon_paul@vssc.gov.in |
| 5 | **Area of Research** | Carbon-Carbon Composites |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>Carbon-Silicon Carbide is considered as an ideal material for future Thermo-Structural applications, considering the various advantages offered by the material. SiC matrix is derived presently using Methyl-Trichlo-Silane, having drawbacks in due to high corrosive nature of the chemical and by-products of chlorides which are formed during the process. To meet the future requirements of C-SiC composites and also to provide SiC coating over Carbon-Carbon Composite products for various space applications, it is envisaged to use Mono Methyl Silane (MMS) as precursor for Chemical Vapour Infiltration/Deposition method. MMS is considered to be advantageous compared to other MTCS and Silane precursors, considering the chemical nature (Low Molecular Weight), processing under low temperature (~800 0C) and being less hazardous, non corrosive and non toxic.<br><br>The scope of work in this program includes the following:<br>• Development of process Technology to provide SiC coating on C-C product through CVD using MMS as a process precursor.<br>• Development of process technology to densify Carbon preform with SiC matrix through CVD using MMS as a process precursor.<br>• Evolve details of storage, handling and usage of MMS for CVI and CVD processes. | |

| **VSSC - 012** | | |
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| 1 | **Name of ISRO Centre/Unit** | Vikram Sarabhai Space Centre (VSSC), Thiruvananthapuram |
| 2 | **Title of the research** | Solidification behavior and grain refinement of cast |

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| | **proposal** | superalloys |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr Govind |
| 4 | **Contact Address of CoPI and Phone Number** | Head, FTD, MME<br>Vikram Sarabhai Space Centre<br>Thiruvananthapuram, Kerala<br>Phone: 0471 2562291<br>e-mail: govind@vssc.gov.in |
| 5 | **Area of Research** | Physical Metallurgy |
| 6 | **Summary of the proposed research and expected deliverables:**<br>Superalloys 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 ageing characteristics for the Ni-base and Ni-Fe base superalloys.<br>The project deliverables would be optimized process parameters for grain refinement. | |

| **VSSC - 013** | | |
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| 1 | **Name of ISRO Centre/Unit** | Vikram Sarabhai Space Centre (VSSC), Thiruvananthapuram |
| 2 | **Title of the research proposal** | Effect of processing parameters on cryo impact properties of cast alloys |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr Govind |
| 4 | **Contact Address of CoPI and Phone Number** | Head, FTD, MME<br>Vikram Sarabhai Space Centre<br>Thiruvananthapuram, Kerala<br>Phone: 0471 2562291<br>e-mail: govind@vssc.gov.in |
| 5 | **Area of Research** | Physical Metallurgy |
| 6 | **Summary of the proposed research and expected deliverables**<br>Many alloys are used in form of castings at cryo temperatures. Under this project proposal, it is envisaged 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. Materials (04X and 08X) shall be provided by VSSC in the form of test bar.<br>The deliverables would be process parameters at which cryo impact properties will be met. | |

| VSSC - 014 | | |
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| 1 | **Name of ISRO Centre/Unit** | Vikram Sarabhai Space Centre (VSSC), Thiruvananthapuram |
| 2 | **Title of the research proposal** | Optimization of heat treatment parameters & characterization of super alloys |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr Govind |
| 4 | **Contact Address of CoPI and Phone Number** | Head, FTD, MME<br>Vikram Sarabhai Space Centre<br>Thiruvananthapuram, Kerala<br>Phone: 0471 2562291<br>e-mail: govind@vssc.gov.in |
| 5 | **Area of Research** | Physical Metallurgy |
| 6 | **Summary of the proposed research and expected deliverables**<br>Various cast super alloys (XH43, IN 718, XH62, and XH67) are being used in our space programme. It is necessary to take up extensive studies on characterization of these super alloy and optimization of heat treatment parameters and compositions for better performance. Material for heat treatment studies shall be provided by VSSC in the form of test bar.<br>The project deliverables would be the heat treatment cycles/parameters that would meet specified properties and test results. | |

| VSSC - 015 | | |
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| 1 | **Name of ISRO Centre/Unit** | Vikram Sarabhai Space Centre (VSSC), Thiruvananthapuram |
| 2 | **Title of the research proposal** | Simulation of SLM (Selective laser melting) process for prediction of defects and parametric control in printing of components |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr Govind |
| 4 | **Contact Address of CoPI and Phone Number** | Head, FTD, MME<br>Vikram Sarabhai Space Centre<br>Thiruvananthapuram, Kerala<br>Phone: 0471 2562291<br>e-mail: govind@vssc.gov.in |
| 5 | **Area of Research** | Physical Metallurgy |
| 6 | **Summary of the proposed research and expected deliverables**<br>Selective Laser Melting is process for making complex shaped components in very less time. Process optimization and modeling is very important for improving reliability of the process. Models should be based on thermal imaging of the melting | |

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| | passes and should be able to predict the effect of parameters on discontinuities in the product.<br><br>The deliverables would be software model and simulated data / test results, for laser melting process. |

| VSSC - 016 | | |
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| 1 | **Name of ISRO Centre/Unit** | Vikram Sarabhai Space Centre (VSSC), Thiruvananthapuram |
| 2 | **Title of the research proposal** | Development of space radiation resistant materials |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr SVS Narayanamurthy |
| 4 | **Contact Address of CoPI and Phone Number** | MCD,MME<br>Vikram Sarabhai Space Centre<br>Thiruvananthapuram, Kerala<br>Phone: 0471-2563628<br>e-mail: narayanamurty_susarla@vssc.gov.in |
| 5 | **Area of Research** | Material Characterisation |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>Exposure of critical and vital components of spacecrafts to external radiation leads to degradation of the properties of the structural and electronic materials, thereby jeopardizing the flightworthiness of the spacecrafts. Hence it is critical for the identification of significant property changes induced as a result of the radiation exposure in the aforementioned materials. The purpose of this project is to develop and understand the radiation effects on the physical, mechanical, thermal and optical properties of materials (metallic and composite).<br><br>The deliverable would be the technology and process to make radiation resistant materials for use in deep space long duration missions. | |

| VSSC - 017 | | |
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| 1 | **Name of ISRO Centre/Unit** | Vikram Sarabhai Space Centre (VSSC), Thiruvananthapuram |
| 2 | **Title of the research proposal** | Development of Ultrasonic technique for locating casting defects |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr Govind |
| 4 | **Contact Address of CoPI and Phone Number** | Head, FTD, MME<br>Vikram Sarabhai Space Centre,<br>Thiruvananthapuram, Kerala<br>Phone: 0471 2562291<br>e-mail: govind@vssc.gov.in |

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| 5 | **Area of Research** | Physical Metallurgy |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>Many critical components are made through casting route. Complex castings get few unacceptable defects which are to be repaired through welding. It is necessary to locate the defect precisely in the wall of the casting to avoid unnecessary gouging. Ultrasonic technique can be very effective in this regards. But due to cast structure low frequency probes only can be used. Also response of the cast material is not good to Ultrasonic testing. Considering these limitations a suitable technique/procedure is to be developed for defect detection using UT.<br><br>The deliverables would be the detection technique/methodology and relevant documentation. | |

| IPRC - 001 | | |
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| 1 | **Name of ISRO Centre/Unit** | ISRO Propulsion Complex (IPRC), Mahendragiri |
| 2 | **Title of the research proposal** | Design and development of ANFIS controller for optimized control in Cryogenic High Altitude Test facility of IPRC |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Ms. Chrystella Jacob |
| 4 | **Contact Address of CoPI and Phone Number** | AISE<br>ISRO Propulsion Complex (IPRC)<br>Mahendragiri, Tamil Nadu<br>Phone: 04637-281289<br>e-mail: chrysjacob@iprc.gov.in |
| 5 | **Area of Research** | Algorithms for Controllers |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>Cryogenic HAT facility in IPRC is comprised of Vacuum System, Diffuser System, Cooling System and Ejector System along with Propellant Filling /Feed Circuits, Structural Components, Safety Systems and Instrumentation systems for the Static testing and Qualification of Cryogenic Engines. The major components of the Vacuum System are the Vacuum Chamber inside which the test specimen is mounted and the Ejector for chamber evacuation. This ejector has a clustered nozzle configuration for admitting constant $GN_2$ into the chamber through the Pneumaticlines, Field Elements (Electro pneumaticvalves and Control valves) and Sensing devices for process parameter monitoring. A single input based Closed-loop Proportional Integral Derivative (PID) controller is deployed for the control valve in order to attain the required flowrate with theoretically estimated static set point. The Proportional, Integral and Derivative coefficients are determined offline.<br><br>PID is an error based control approach without direct knowledge of the process and is suitable for well defined and static process. Also overshoots, oscillations and noise amplification are associated with the PID based control approach. An ANFIS (Adaptive Neuro based Fuzzy Inference System) is an integrated Neuro-Fuzzy system with a knowledge based approach for a Process control. Artificial Neural Networks (ANN) are adaptive systems that can be trained and tuned from a set of trials whereas Fuzzy Inference Systems (FIS) have the ability to represent and execute reasoning using fuzzy rules. ANFIS controllers can cater to the process needs with decisions based on more than one process parameter and can handle dynamic or changing process conditions. Hence it is proposed to design, develop and deploy ANFIS controller. The neural network can be implemented with the available process data and the necessary algorithms for control has to be developed and deployed on an independent controller that can be interfaced to existing data repositories using standard interface protocols for real time decision and control. | |

| IPRC - 002 | | |
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| 1 | **Name of ISRO Centre/Unit** | ISRO Propulsion Complex (IPRC),Mahendragiri |
| 2 | **Title of the research proposal** | Development of high entropy alloythermal barrier and wear resistancecoatings for rocket engines |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr.S.G.K.Manikandan |
| 4 | **Contact Address of CoPI and Phone Number** | EAIE<br>ISRO Propulsion Complex (IPRC)<br>Mahendragiri, Tamil Nadu<br>Phone: 04637-281289<br>e-mail:manikandan.sgk@iprc.space.gov.in |
| 5 | **Area of Research** | Materials, Surface Engineering |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>High-entropy alloys (HEAs) are presently of great research interest in materials science and engineering. Unlike conventional alloys, which contain one and rarely two base elements, HEAs comprise multiple principal elements, with the possible number of HEA compositions extending considerably more than conventional alloys. The concept of high entropy introduces a new path of developing advanced materials with unique properties, which cannot be achieved by the conventional micro-alloying approach based on only one dominant element. Up to date, many HEAs with promising properties have been reported, e.g., high wear-resistant HEAs, Co1.5CrFeNi1.5Ti and Al0.2Co1.5CrFeNi1.5Ti alloys; high strength body-centered-cubic (BCC) AlCoCrFeNi HEAs at room temperature, and NbMoTaV HEA at elevated temperatures. Furthermore, the general corrosion resistance of the Cu0.5NiAlCoCrFeSi HEA is much better than that of the conventional 304- stainless steel. In addition, HEAs have excellent specific strength, superior mechanical performance at high temperatures, exceptional ductility and fracture toughness at cryogenic temperatures, superparamagnetism, and superconductivity. Due to their considerable structural and functional potential as well as richness of design, HEAs are promising candidates for coating applications, which warrants further studies. Thermal-spray (TS) technology to fabricate coatings of the NixCo0.6Fe0.2-CrySizAlTi0.2 HEAs was developed. These sprayed particles are accumulated on the substrate by cooling and building up one by one into a cohesive structure. Thus, coatings are formed. The results also indicate that the hardness of the HEAs prepared by the TS in combination with annealing at 1100°C/10 h is significantly increased to that of the as-cast state (1045 HV). These samples exhibited excellent coarsening resistance, resulting from the Cr3Si and several unidentified phases. NixCo0.6Fe0.2CrySizAlTi0.2 alloy system does precipitate during casting, which isquite different from many other HEAs. The literature survey confirmed that phase formation and final microstructure of HEAs are strongly dependant on the processing conditions. A low-cost HEA coating with a nominal composition of | |

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| | 6FeNiCoCrAlTiSi was prepared by laser cladding. This technique normally results in a metallurgical bond that has the superior bond strength over TS. The resultant coating is dense with no voids or porosity. One of the advantages of the laser-cladding process is the laser beam which can be focused and concentrated to a very small area and keeps the heat affected zone of the substrate very hallow. This feature minimizes the chance of cracking, distorting, or changing the metallurgy of the substrate. Additionally, the lower total heat minimizes the dilution of the coating with materials from the substrate. The coating prepared by laser cladding has a simple BCC solid solution with high micro-hardness, high resistance to softening, and large electrical resistivity. After being annealed at T < 750°C, the coating shows high thermal stability, and its resistivity slightly decreases, but the micro-hardness almost remains unchanged. After annealing at T > 750°C, the microhardness of the coating slowly decreases with increasing the decomposition rate of the BCC solid solutions. A suitable high entropy alloy system and coating process need to be developed for the rocket engines to make the HEAs coating more uniform and with high cohesion with substrates. |

| **IPRC - 003** | | |
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| 1 | **Name of ISRO Centre/Unit** | ISRO Propulsion Complex (IPRC), Mahendragiri |
| 2 | **Title of the research proposal** | Processing and properties of High-Entropy Ultra-High temperaturecarbides |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr.S.G.K.Manikandan |
| 4 | **Contact Address of CoPI and Phone Number** | EAIE<br>ISRO Propulsion Complex (IPRC)<br>Mahendragiri, Tamil Nadu<br>Phone: 04637-281289,<br>e-mail:manikandan.sgk@iprc.space.gov.in |
| 5 | **Area of Research** | Material Development |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>Ultra-High Temperature Ceramics (UHTC's) are a limited and select set of carbides, nitrides and borides of the group IV and V transition metals, which are typically defined as having melting temperatures more than 3300K; with HfC exhibiting the highest known melting point of all materials (4232 ± 84 K). UHTC's also display high hardness, elastic modulus and resistance to thermal shock and chemical attack. These materials represent the only suitable class of materials available to make or protect components that are placed under the most extreme of operating environments. As these developing technologies become more advanced and more demanding, UHTC's are coming under increasing pressure to perform under more diverse operating conditions. A greater selection of UHTC's that exhibit a much broader range and combination of physical, chemical and mechanical properties are | |

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| | therefore required to meet these demands. Bulk equiatomic (Hf-Ta-Zr-Ti)C and (Hf-Ta-Zr-Nb)C high entropy Ultra-High Temperature Ceramic (UHTC) carbide compositions shall be processed through optimized route for the (Hf-Ta-Zr-Nb)C composition to produce a high purity, single phase, homogeneous, bulk high entropy material (99% density); revealing a vast new compositional space for the exploration of new UHTCs. Mono/binary carbides need to be developed with hardness (36.1 ± 1.6 GPa,) compared to the hardest monocarbide (HfC, 31.5 ± 1.3 GPa) and the binary (Hf- Ta)C (32.9 ± 1.8 GPa). |

| **IPRC - 004** | | |
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| 1 | **Name of ISRO Centre/Unit** | ISRO Propulsion Complex (IPRC), Mahendragiri |
| 2 | **Title of the research proposal** | Multi-material additive manufacturingof Metamaterials with Giant, Tailorable Negative Poisson's Ratios |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr.S.G.K.Manikandan |
| 4 | **Contact Address of CoPI and Phone Number** | EAIE<br>ISRO Propulsion Complex (IPRC)<br>Mahendragiri, Tamil Nadu<br>Phone: 04637-281289<br>e-mail:manikandan.sgk@iprc.space.gov.in |
| 5 | **Area of Research** | Additive Manufacturing |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>Materials with designed threedimensional micro-architectures offer multiple beneficial properties such as low weight, high stiffness and strength, negative poisson ratio and energy absorptions and can open up a myriad of material by design applications from flexible armor, responsive materials to bio-mimetic materials. Ultimately, one would like to 3D print functional device or components that incorporate multiple material constituents without the requirement of excessive assembling procedures such as gluing, aligning, fitting, and welding. Apart from enhancing spatial resolution and printing speed, achieving this goal requires the ability to incorporate an array of different material properties within a manufacturing platform. In analogy to typical 2D color printers that can integrate multiple colors from mixing a few colors (magenta, cyan, yellow), a three-dimensional fabrication platform should not only be able to integrate multiple colors, but also be capable of spatially integrating encoded material properties and compositions from mixing only a limited number of feedstock materials. A strategy to achieve unusual mechanical properties through coupling variable elastic moduli from a few GPa to below KPa within a single tissue to be evolved. The ability to produce multi-material, threedimensional (3D) micro-architectures with high fidelity incorporating dissimilar components has been a major challenge in man-made materials. The multi-modulus metamaterials whose architectural element is comprised of encoded | |

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| | elasticity ranging from rigid to soft. In contrast to ordinary architected materials whose negative Poisson's ratio is dictated by their geometry, these types of metamaterials are capable of displaying Poisson's ratios from extreme negative to zero, independent of their 3D microarchitecture. The resulting low density metamaterials is capable of achieving functionally graded, distributed strain amplification capabilities within the metamaterial with uniform micro-architectures. Simultaneous tuning of Poisson's ratio and moduli within the 3D multimaterials could open up a broad array of material by design applications ranging from flexible armor, artificial muscles, to actuators and bio-mimetic materials. |

| **IPRC - 005** | | |
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| 1 | **Name of ISRO Centre/Unit** | ISRO Propulsion Complex (IPRC), Mahendragiri |
| 2 | **Title of the research proposal** | Thermodynamic and microstructuralstudy of $Ti_2AlNb$ oxides at 800°C |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr.S.G.K.Manikandan |
| 4 | **Contact Address of CoPI and Phone Number** | EAIE<br>ISRO Propulsion Complex (IPRC)<br>Mahendragiri, Tamil Nadu<br>Phone: 04637-281289,<br>e-mail:manikandan.sgk@iprc.space.gov.in |
| 5 | **Area of Research** | Material Characterization |
| 6 | **Summary of the proposed research and expected deliverables**<br>$Ti_2AlNb$-based alloy, sometimes referred to as orthorhombic alloy, is a class of highly promising lightweight high-temperature materials. This type of alloy is considered to partially substitute the high-density ($\rho$ = 8~8.5 g/cm$^3$) Ni-based superalloys in the aerospace industry due to its low density, high strength, superior plasticity, high fracture toughness and excellent creep resistance at elevated temperatures. In such applications, the operating temperatures could go beyond 600– 650°C, leading to severe oxidation of the alloy surface. There are three potential approaches to improve high-temperature oxidation resistance: alloying, preoxidation and coating. A two-step voltage-controlled microarc oxidation (MAO) method can be used to produce ceramic coatings on a $Ti_2AlNb$-based alloy. However, after a prolonged exposure to air at elevated temperatures, intermetallics exhibit oxygen induced embrittlement characteristics such as low ductility and brittle fracture. Thus, an understanding of high-temperature oxidation mechanisms is essential for improving the oxidation resistance of materials. A $Ti_2AlNb$ based alloy is observed to exhibit fairly good oxidation resistance below 750°C. After reaching 800°C, the oxidation resistance decreased dramatically. Thus, the oxidation behavior and mechanisms are to be investigated at a higher temperature of 800°C and above. | |

| IPRC - 006 | | |
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| 1 | **Name of ISRO Centre/Unit** | ISRO Propulsion Complex (IPRC), Mahendragiri |
| 2 | **Title of the research proposal** | Super-strong materials fortemperatures exceeding 2000°C |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr.S.G.K.Manikandan |
| 4 | **Contact Address of CoPI and Phone Number** | EAIE<br>ISRO Propulsion Complex (IPRC)<br>Mahendragiri, Tamil Nadu<br>Phone: 04637-281289<br>e-mail:manikandan.sgk@iprc.space.gov.in |
| 5 | **Area of Research** | Materials |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>Ceramics based on group IV-V transition metal borides and carbides possess melting points above 3000°C, are ablation resistant and are, therefore, candidates for the design of components of next generation space vehicles, rocket nozzle inserts, and nose cones or leading edges for hypersonic aerospace vehicles. As such, they will have to bear high thermo-mechanical loads, which makes strength at high temperature of great importance. While testing of these materials above 2000°C is necessary to prove their capabilities at anticipated operating temperatures, literature reports are quite limited. Reported strength values for zirconium diboride ($ZrB_2$) ceramics can exceed 1 GPa at room temperature, but these values rapidly decrease, with all previously reported strengths being less than 340 MPa at 1500°Cor above. The strength of $ZrB_2$ceramics was increased to more than 800 MPa at temperatures in the range of 1500–2100°C. These exceptional strengths are due to a core-shell microstructure, which leads to *in-situ* toughening and subgrain refinement at elevated temperatures. The development of such materials those are superstrong at ultra-high temperatures are proposed. | |

| IPRC - 007 | | |
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| 1 | **Name of ISRO Centre/Unit** | ISRO Propulsion Complex (IPRC), Mahendragiri |
| 2 | **Title of the research proposal** | The effect of reduced gravity oncryogenic nitrogen boiling and pipechill down |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr.S.G.K.Manikandan |
| 4 | **Contact Address of CoPI and Phone Number** | EAIE<br>ISRO Propulsion Complex (IPRC)<br>Mahendragiri, Tamil Nadu<br>Phone: 04637-281289<br>e-mail:manikandan.sgk@iprc.space.gov.in |

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| 5 | **Area of Research** | Heat Transfer |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>Manned deep space exploration will require cryogenic in-space propulsion. Yet, accurate prediction of cryogenic pipe flow boiling heat transfer is lacking, due to the absence of a cohesive reduced gravity data set covering the expected flow and thermodynamic parameter ranges needed to validate cryogenic twophase heat transfer models. The proposed work provides a wide range of cryogenic chilldown data aboard an aircraft flying parabolic trajectories to simulate reduced gravity. Liquid nitrogen is used to quench a 1.27 cm diameter tube from room temperature. The pressure, temperature, flow rate, and inlet conditions are reported from 10 tests covering liquid Reynolds number from 2,000 to 80,000 and pressures from 80 to 810kPa. Corresponding terrestrial gravity tests were performed in upward, downward, and horizontal flow configurations to identify gravity and flow direction effects on chilldown. Film boiling heat transfer was lessened by up to 25% in reduced gravity, resulting in longer time and more liquid to quench the pipe to liquid temperatures. Heat transfer was enhanced by increasing the flow rate, and differences between reduced and terrestrial gravity diminished at high flow rates. The new data set will enable the development of accurate and robust heat transfer models of cryogenic pipe chilldown in reduced gravity. | |

| **IPRC - 008** | | |
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| 1 | **Name of ISRO Centre/Unit** | ISRO Propulsion Complex (IPRC), Mahendragiri |
| 2 | **Title of the research proposal** | Superelasticity and cryogenic linearshape memory effects of $CaFe_2As_2$ |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr.S.G.K.Manikandan |
| 4 | **Contact Address of CoPI and Phone Number** | EAIE<br>ISRO Propulsion Complex (IPRC)<br>Mahendragiri, Tamil Nadu<br>Phone: 04637-281289<br>e-mail:manikandan.sgk@iprc.space.gov.in |
| 5 | **Area of Research** | Metallury, Shape Memory Alloys |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>Shape memory materials have the ability to recover their original shape after a significant amount of deformation when they are subjected to certain stimuli, for instance, heat or magnetic fields. However, their performance is often limited by the energetics and geometry of the martensiticaustenitic phase transformation. An unique shape memory behavior in $CaFe_2As_2$, which exhibits superelasticity with over 13% recoverable strain, over 3 GPa yield strength, repeatable stress–strain response even at the micrometer scale, and cryogenic linear shape memory effects near 50K. These properties are achieved through a reversible uni-axial phase | |

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| | transformation mechanism, the tetragonal/orthorhombic-to collapsed- tetragonal phase transformation. The proposed work is for developing cryogenic linear actuation technologies with a high precision and high actuation power per unit volume for deep space exploration, and more broadly, suggest a mechanistic path to a class of shape memory materials, $ThCr_2Si_2$-structured intermetallic compounds. |

| **IPRC - 009** | | |
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| 1 | **Name of ISRO Centre/Unit** | ISRO Propulsion Complex (IPRC), Mahendragiri |
| 2 | **Title of the research proposal** | Development of mechanical metamaterials at the theoretical limit ofisotropic elastic stiffness |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr. S.G.K.Manikandan |
| 4 | **Contact Address of CoPI and Phone Number** | EAIE,<br>ISRO Propulsion Complex (IPRC)<br>Mahendragiri, Tamil Nadu<br>Phone: 04637-281289,<br>e-mail:manikandan.sgk@iprc.space.gov.in |
| 5 | **Area of Research** | Materials Characterization |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>A wide variety of high performance applications require materials for which shape control is maintained under substantial stress and that have minimal density. Bio-inspired hexagonal and square honeycomb structures and lattice materials based on repeating unit cells composed of webs or trusses, when made from materials of high elastic stiffness and low density, represent some of the lightest, stiffest and strongest materials available today. Recent advances in 3D printing and automated assembly have enabled such complicated material geometries to be fabricated at low (and declining) cost. These mechanical metamaterials have properties that are a function of their mesoscale geometry as well as their constituents, leading to combinations of properties that are unobtainable in solid materials; however, a material geometry that achieves the theoretical upper bounds for isotropic elasticity and strain energy storage (the Hashin–Shtrikman upper bounds) has yet to be identified. Here we need to evaluate the manner in which strain energy distributes under load in a representative selection of material geometries, to identify the morphological features associated with high elastic performance. Using finite-element models, supported by analytical methods, and a heuristic optimization scheme, material geometry shall be identified that achieves the Hashin–Shtrikman upper bounds on isotropic elastic stiffness. The advantageous properties of low density mechanical metamaterials are: their mesoscale geometry can facilitate large crushing strains with high energy absorption, optical bandgaps and mechanically tunable acoustic bandgaps, high thermal insulation, buoyancy, and fluid storage and transport. | |

| IPRC - 010 | | |
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| 1 | **Name of ISRO Centre/Unit** | ISRO Propulsion Complex (IPRC), Mahendragiri |
| 2 | **Title of the research proposal** | Observational study: microgravitytesting of a phase-change referenceon the International Space Station |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr. S.G.K.Manikandan |
| 4 | **Contact Address of CoPI and Phone Number** | EAIE<br>ISRO Propulsion Complex (IPRC)<br>Mahendragiri, Tamil Nadu<br>Phone: 04637-281289<br>e-mail:manikandan.sgk@iprc.space.gov.in |
| 5 | **Area of Research** | Materials Characterization under Microgravity |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>Orbital sensors to monitor global climate change during the next decade require low-drift rates for onboard thermometry, which is currently unattainable without onorbit recalibration. Phase-Change Materials (PCMs), such as those that make up the ITS-90 standard, are seen as the most reliable references on the ground and could be good candidates for orbital recalibration. Development on miniaturized phasechange references capable of deployment on an orbital blackbody is mandatory. The objective of the proposed work is on the improvement of orbital temperature measurements for long duration earth observing and remote sensing.<br><br>This proposal needs certain microgravity research either in space or in a lab level is required to determine whether and how microgravity will affect the phase transitions. There will be a need for orbital temperature knowledge to support infrared radiance measurements with 0.1-K uncertainty over a period of at least 10 years. As temperature uncertainty is only one of the contributors to the desired 0.1-K uncertainty, the goal for on-orbit temperature knowledge must be smaller (in the range of 0.01K) to leave margin for other uncertainties in the calibration chain. Onboard references utilizing phase transitions have been identified as the most likely means for realizing International System of Units (SI) traceability for temperature measurements in orbit. TheITS-90 identifies several phasechangematerials (PCMs) withreliable fixed points that can bereproduced and used as referenceswith submilli-kelvin absoluteuncertainties for ground-basedcalibrations. Three PCMs with fixedpoints in the range required tocalibrate Earth-observing sensors areGallium (Ga), water, and mercurywith melt points of 302.9146k,273.16K, and 234.3156K,respectively. However, the ITS-90description of procedures andapparatuses does not translate easilyinto a design for an automatedorbital implementation. ITS-90describes fixed-point cells that usefragile materials such as plastic orglass to contain PCMs and requiresensors to be placed in re-entrant wells within relatively large volumesof 250 ml or more of the PCM. | |

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| | Thedescribed procedures do not applydirectly to *in situ* sensor calibrationssuch as those that will be requiredon an orbital blackbody.In early 2006, the suitability of Gaand its various binary eutectics wereinvestigated at the All RussianInstitute for Opto-PhysicalMeasurements (VNIIOFI) in Moscow, Russia under a subcontract withSpace Dynamics Laboratory (SDL) inLogan, UT, USA. The purpose ofthese studies is to significantlyreduce the size and volume ofqualified containers and identifyPCMs within the range of 273–303 Kthat could be used as calibrationstandards aboard Earth-observingsatellites. This study will becharacterizing several suitableeutectics to fill the gap in the ITS-90temperature scale between thetriple point of water and the meltingpoint of Ga. Independent orbitalstudies that included phase changesof various materials have shown thatcrystallization structures in materialsolidified in the absence of gravitycan differ from solids formed at 1g.Because the basis of these priorinvestigations was not temperaturecalibration or repeatability of fixedpoints, no accurate temperaturedata were recorded. Thetemperature of phase transitions isunlikely to be affected by gravity,but there was a lack of evidence tosupport that hypothesis. |

| **IPRC - 011** | | |
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| 1 | **Name of ISRO Centre/Unit** | ISRO Propulsion Complex (IPRC), Mahendragiri |
| 2 | **Title of the research proposal** | Numerical study on the porousinjector concept for throttling of liquid rocket engine |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr. Ganesh P |
| 4 | **Contact Address of CoPI and Phone Number** | ICET<br>ISRO Propulsion Complex (IPRC)<br>Mahendragiri, Tamil Nadu<br>Phone: 04637-281804<br>e-mail: pganesh@iprc.gov.in |
| 5 | **Area of Research** | Liquid Propulsion |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>In liquid rocket engines, the injector design has influence on the combustion stability, combustion chamber durability, overall all engine performance and greatly on the throttling capabilities of the engine. Presently co-axial injectors are used in LOX/H2 or LOX/CH4 liquid propellant rocket engines. Advanced injector design which is insensitive to the varying injection conditions is required for applications specifically for throttling capability. One of the promising candidates for the development of throttleable injector shall be the porous injector for the cryogenic rocket engines. For example, in order to increase in the contact surface between fuel and oxidizer, the oxidizer (Liquid Oxygen, LOX) injected through many small tubes in a parallel showerhead configuration and the fuel in this case, | |

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| | hydrogen/methane shall be injected through a porous faceplate. The main advantages is that of throttling the engine by reducing the propellant mass flow, which in this case has minor influence on the atomization and mixing characteristics. In addition, very low combustion roughness can be achieved even at very low pressure drops across the injector. Another advantage are the potentially lower manufacturing costs based on the simple design.<br>**Expected deliverables:**<br>1. Numerical modeling of flow through porous media and atomization characteristics of the porous injector.<br>2. Parametric studies to understand the impact of the operating conditions and the porous geometry on the performance of the injectors.<br>3. A model, incorporating numerical and analytical approaches to predict the mixing efficiency and throttling capabilities of porous injectors in cryogenic engines<br>4. Experimental validations of the numerical study through cold flow spray characterization and hotfire tests. |

| **IPRC - 012** | | |
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| 1 | **Name of ISRO Centre/Unit** | ISRO Propulsion Complex (IPRC), Mahendragiri |
| 2 | **Title of the research proposal** | Modeling and simulation of microchannel reactor for Sabatier reactionfor methane synthesis from carbondioxide |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr. Ganesh P |
| 4 | **Contact Address of CoPI and Phone Number** | ICET<br>ISRO Propulsion Complex (IPRC)<br>Mahendragiri, Tamil Nadu<br>Phone: 04637-281804<br>e-mail: pganesh@iprc.gov.in |
| 5 | **Area of Research** | Interplanetary Missions & Process Engineering |
| 6 | **Summary of the proposed research and expected deliverables**<br>In the view of Mars exploration missions and human space missions, Sabatier reaction plays a vital role in order to convert the carbon-dioxide into the useful products. Sabatier reaction involves the methanation reaction of CO2 using hydrogen to produce methane and water. For human spacecraft, CO2 removal from the crew-cabin is accomplished by engaging the catalytic reactor. In the same way, CO2 from the Mars atmosphere shall be converted to the propellant - methane (CH4) as a concept of in-situ resource utilization. In the view of space qualified product development, it requires a compact and light weight catalytic reactor to | |

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| | convert the CO2 into the useful methane and water. One of the viable options shall be the micro-channeled reactor and in order to configure the light weight & compact system which needs a fundamental research on the modeling and simulation of micro reactor for efficient operation of the methanation process.<br>**Expected deliverables:**<br>o CFD modeling of the micro reactor with reaction kinetics to design the reactor for the maximum conversion.<br>o Process dynamics and simulation of process parameters to optimize the process intensification.<br>o Experimental validation of micro-reactor for Sabatier reaction.<br>o Uncertainty analysis of designed reactor for different operating conditions. Process model which includes the reactor, Heat Exchanger, recycle loop for furtherdesign of a full-scale process. |

| **IPRC - 013** | | |
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| 1 | **Name of ISRO Centre/Unit** | ISRO Propulsion Complex (IPRC), Mahendragiri |
| 2 | **Title of the research proposal** | Solar Photovoltaic based sensing |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr. S.Murugan |
| 4 | **Contact Address of CoPI and Phone Number** | AISE<br>ISRO Propulsion Complex (IPRC)<br>Mahendragiri, Tamil Nadu<br>Phone: 04637-281299<br>e-mail: mur.gan@iprc.gov.in |
| 5 | **Area of Research** | Energy for Deep Space Mission |
| 6 | **Summary of the proposed research and expected deliverables**<br>Heat flux is measured based on the Thermopile technology which involves and multi metal junctions integrated in the sensing element. Also, the solar cells convert the irradiated energy into electrical energy this work is towards converting the solar/photovoltaic cell for Heat flux sensing and measurement. The solar cells provide the output voltage/current proportional to the irradiated light energy. It is possible to correlate the irradiated energy spectrum vs heat flux. Hence the solar cell/Photovoltaic can be converted for measurement of Heat flux. Explorative experimental investigations are essential for the development of photovoltaic based heat flux sensing. In this process the IV Generation of solar cells i.e. Pervoskite solar cells are to be studied for conversion efficiency on Visible, IR, UV and Dark energy conversion etc to tune the photovoltaic cells for Heat sensing applications. | |

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| | The work is to be extended towards the efficiency improvement of the photovoltaic cells. And to, enhance the dark current generation in photovoltaic generators. This finds application as power generators in deep space missions where the space probes are engulfed in the e.m. waves. The major work involves theoretical estimate of the e.m. energy spectrum. Hence this work involves a) fabrication of Solar Cells (I, II, III or IV) generation solar cells b) study the conversion efficiency c)theoretical study on the sensing linked to Heat flux d) fabrication of proto version of solar cell/Photovoltaic based heat flux sensor. |

| **IPRC - 014** | | |
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| 1 | **Name of ISRO Centre/Unit** | ISRO Propulsion Complex (IPRC), Mahendragiri |
| 2 | **Title of the research proposal** | Solid cryogenic green propulsion system |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri R. Perumal Pillai |
| 4 | **Contact Address of CoPI and Phone Number** | DAG, TSE<br>ISRO Propulsion Complex<br>Mahendragiri, Tamil Nadu<br>Phone: 04637- 281635 |
| 5 | **Area of Research** | Cryogenic Engineering |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>Cryogenic propellants offers the highest energy efficiency for rocket engines because of the low molar mass of their combustion products, high combustion temperature hence maximum specific impulse can be obtained. The complex feed system required either with turbo-pumps and regenerative cooling is disadvantaging the cryogenic propulsion systems. Solid propellant rocket motors are simple because they not have the complex feed system and solid propellant insulates the combustion chamber walls from the hot gases so there is no need of cooling. The performance of solid rocket motors (in termsof Isp) is substantially lower than of cryogenic liquid engines and the mass of the combustion chamber is substantially higher than the mass of the liquid propellant tanks. The advantage is that the demonstrated reliability of solid rocket motors is higher than that of liquid engines and the cost of a solid motor is only a meagre portion of a liquid engine for the same total impulse. Present solid rockets propellants are not the eco friendly chemicals.<br><br>The advantages of solid and cryogenic liquid propulsion systems shall be combined to develop an eco friendly solid cryogenic green system is an extremely attractive solution for heavy thrust rocket boosters. The theoretical feasibility and lab level experimental study to demonstrate the prospects of using solid cryogenic green rocket engines, which could lead to substantial improvement in efficiency, eco | |

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| | friendly and reduction in launch costs in addition to improving the launch reliability. |

| IPRC - 015 | | |
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| 1 | **Name of ISRO Centre/Unit** | ISRO Propulsion Complex (IPRC), Mahendragiri |
| 2 | **Title of the research proposal** | Numerical modeling of vapour liquid interaction in cryogenic systems |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri R. Perumal Pillai |
| 4 | **Contact Address of CoPI and Phone Number** | DAG,TSE<br>ISRO Propulsion Complex<br>Mahendragiri, Tamil Nadu<br>Phone: 04637- 281635 |
| 5 | **Area of Research** | Cryogenic Engineering |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>In cryogenic systems, pressure measurement is carried out using pressure sensors which are designed to work at ambient temperature. To avoid the low temperature exposure of the sensing elements of these pressure sensors, lengthy canalisation tubes are used for warming up the cryogenic fluid. Because of this arrangement a large thermal gradient along the length of a vapour filled column which is closed at the warm end creates oscillations in pressure measurement. Those typical cryogenic oscillations include the thermal acoustic oscillations, the “Geyser” oscillations, gasification oscillations, and those oscillations under the periodic heat load from the wall of bare (Non-insulated) canalisation lines. The thermal acoustic oscillations occur when cryogenic liquid and vapour interacts each other. The warm gas in the column contracts due to the thermal interaction between the vapour liquid interactions. The gas expands at the other end due to the thermal interaction between the ambient through the canalisation walls. The inertia of the gas moving away from the warm section creates a low pressure in the warm section. This is aggravated by the high density and therefore high mass of the gas in the cold section which is being pushed away from the warm section. At low temperatures, the viscosity of the gas decreases; therefore there is a slug of high density gas, with low viscosity acting like a mass attached to a spring. In the two-phase fluid interactions subject to pressure variation in the cryogenic liquid flow, the compressibility of the vapour bubbles act as a spring with an asymmetric non-linear characteristic. The volume of the vapour bubbles increases or decreases differently if the pressure fluctuations are compressing or expanding. Aim of this work is to develop numerical model to simulate the pressure oscillations focus on the effect of diameter, wall thickness, length and material of the canalisation line on the formation of pressure oscillations and to develop the methodology to bias or eliminate the effects of pressure oscillation. | |

| IIRS - 001 | | |
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| 1 | **Name of ISRO Centre/Unit** | Indian Institute of Remote Sensing (IIRS), Dehradun |
| 2 | **Title of the research proposal** | Utilization of satellite data for tropical cyclone forecasting using the NWP model over the Indian Ocean |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr. Sanjeev Kumar Singh |
| 4 | **Contact Address of CoPI and Phone Number** | Marine & Atmospheric Sciences Department<br>Indian Institute of Remote Sensing<br>4, Kalidas Road<br>Dehradun-248001<br>Uttarakhand<br>Dehradun-248001<br>Phone: 0135-2524228<br>e-mail: sksingh@iirs.gov.in |
| 5 | **Area of Research** | Tropical Cyclone; Remote sensing data assimilation in the Numerical Weather Prediction model; Numerical Weather Prediction |
| 6 | **Summary of the proposed research and expected deliverables**<br>With the increased infrastructure and amount of people living along the Indian coastline, it is vital to improve the accuracy of India Ocean tropical cyclone track and intensity forecasts. Accurate prediction of the tropical cyclones in the tropical region, particularly over the Indian subcontinent is a challenging task due to its complex geographical location, having Indian land region surrounded by Bay of Bengal (BOB) in East, Arabian Sea (AS) to the West and the Indian ocean in south. During the post and pre-monsoon seasons, the Indian subcontinent is more or less every year hit by tropical cyclones, which forms either of the seas situated in the East and West of the Indian land region. Even though currently tropical cyclone forecasting using NWP model has improved our understanding over many process of tropical cyclone, there is scope to utilize the various types of satellite data in the NWP model for improving the forecasting of tropical cyclone. Over the oceanic region very less number of conventional observations are available. So, satellite data plays an important role to monitor the tropical cyclone formation to dissipation. Therefore, in this project, it is proposed to utilization of satellite data and evaluation of its impact on tropical cyclone forecasting such as track, intensity and rainfall during landfall using NWP model over the Indian Ocean. | |

| IIRS - 002 | | |
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| 1 | **Name of ISRO Centre/Unit** | Indian Institute of Remote Sensing (IIRS), Dehradun |

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| 2 | **Title of the research proposal** | Analysis of extreme rainfall events based on numerical models and satellite observations |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Ms. Charu Singh |
| 4 | **Contact Address of CoPI and Phone Number** | Marine and Atmospheric Science Department<br>Indian Institute of Remote Sensing<br>4, Kalidas Road<br>Dehradun-248001<br>Uttarakhand<br>Phone: 0135-2524183<br>e-mail: charu@iirs.gov.in |
| 5 | **Area of Research** | South Asian monsoon system: inter-annual, intra-seasonal variability, extreme rainfall events, numerical weather prediction, aerosols and its impact on weather and climate, retrieval of rainfall from remotely sensed observations |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>Extreme rainfall is one of the serious challenges that society has to face under changing climate. Indian subcontinent is highly vulnerable for increasing tendencies of these climatic events. It is noted based on the recent studies (Menon et al., 2013; Goswami et al., 2006; Rajeevan et al., 2008) that the frequency and intensity of such an extreme events are anticipated to increase under a warming environment. Therefore, numerical modeling with the aid of remotely sensed observations and ground based measurements may be carried out to forecast such an extreme events well in advance. Extreme rainfall events are associated with meso-gamma scale processes, which are difficult to simulate with the presently available set of the numerical models. It is proposed that the inclusion of the remotely sensed observations in high resolution model simulations would be helpful in developing a customized forecasting system for the prediction of extreme rainfall events. | |

| **IIRS - 003** | | |
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| 1 | **Name of ISRO Centre/Unit** | Indian Institute of Remote Sensing (IIRS), Dehradun |
| 2 | **Title of the research proposal** | Applications of satellite data sets for Indian summer monsoon studies |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Ms. Charu Singh |
| 4 | **Contact Address of CoPI and Phone Number** | Marine and Atmospheric Science Department,<br>Indian Institute of Remote Sensing,<br>4, Kalidas Road<br>Dehradun-248001 |

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| | | Uttarakhand<br>Phone No. – 0135-2524183<br>e-mail: charu@iirs.gov.in |
| 5 | **Area of Research** | South Asian monsoon system: inter-annual, intra-seasonal variability, extreme rainfall events, numerical weather prediction, aerosols and its impact on weather and climate, retrieval of rainfall from remotely sensed observations |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>Rainfall during the summer monsoon season is one of the most important factors in deciding the fate of the economy in tropical region. Livelihood of people specifically in Indian subcontinent region largely depends on agriculture yield, which is considerable modulated by amount of rainfall during a monsoon season. Prediction of the seasonal total rainfall have notably been improved in recent years based on present set of global circulation models (GCMs), however still there is a substantial scope of further research in modeling and forecasting the intra-seasonal variability of Indian summer monsoon. Intra-seasonal variability of the monsoon is defined in terms of the active and break periods during principal rainy season. In country, like India where major agriculture practices are based on rain fed agriculture, development of suitable methods for the forecasting of active and break spells of monsoon well in advance are of utmost importance. Satellite based data sets have been proved to be useful in delineating the active and break rainfall spells in several previous studies (Hoyos et al., 2007; Singh et al., 2016; Singh et al, 2017; Singh and Dasgupta, 2017). It is proposed to study the intraseasonal variability of Indian summer monsoon based on satellite data sets, which will be helpful in developing the understanding of physical mechanism behind this variability. Such a study would be a value addition to the ongoing studies in this context and may prove to be helpful in developing a method for identification of active and break rain spells and their spatial-temporal characteristics. | |

| **IIRS - 004** | | |
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| 1 | **Name of ISRO Centre/Unit** | Indian Institute of Remote Sensing (IIRS), Dehradun |
| 2 | **Title of the research proposal** | Modeling of dust aerosols and its impact on weather and climate |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Ms. Charu Singh |
| 4 | **Contact Address of CoPI and Phone Number** | Marine and Atmospheric Science Department,<br>Indian Institute of Remote Sensing<br>4, Kalidas Road<br>Dehradun-248001<br>Uttarakhand |

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| | | Phone: 0135 2524183<br>e-mail: charu@iirs.gov.in |
| 5 | **Area of Research** | South Asian monsoon system: inter-annual, intra-seasonal variability, extreme rainfall events, numerical weather prediction, aerosols and its impact on weather and climate, retrieval of rainfall from remotely sensed observations |
| 6 | **Summary of the proposed research and expected deliverables**<br>Dust is one of most important sources of aerosol burden (by mass) across the globe; about 80% of contribution to the global aerosol loading comes from dust (Ginoux, 2012). The low latitude deserts of Africa and Asia also known as the dust belt are the major sources of the dust for the entire world consists of the Sahara, arid and semiarid regions of Arabia and central Asia, Taklamakan and Gobi in East Asia (Pokharel et al., 2017; Prospero, 2002; Washington et al., 2003). Dust emanated over the distant source regions enters in the Indian subcontinent region through long range transport, and substantially modulate the weather pattern and air quality of the region through its direct and indirect impact on the atmosphere. In recent years several researchers (Vinoj et al., 2014; Jin et al., 2015; Solmon et al., 2015; Singh et al., 2017 a, b) focused on the impact of dust in modulating weather and climate patterns in South Asian region at various scales ranging from climate to short term (about 2 weeks or so). However, our present understanding of interlinking of dust with weather and climate have been improved substantially, nevertheless, concrete efforts are required to quantify the impact of dust on weather and climate. Such efforts may be employed based on synergistic use of satellite, ground based data sets and model simulations. | |

| **IIRS - 005** | | |
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| 1 | **Name of ISRO Centre/Unit** | Indian Institute of Remote Sensing (IIRS), Dehradun |
| 2 | **Title of the research proposal** | Backscatter analysis using Multi-Temporal, multi-frequency & multi-Polarization SAR data in the context of flooded regions and partially submerged vegetation |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri C.M.Bhatt |
| 4 | **Contact Address of CoPI and Phone Number** | Disaster Management Studies Department<br>Indian Institute of Remote Sensing,<br>4, Kalidas Road<br>Dehradun-248001<br>Uttarakhand<br>Phone: 0135-2524345<br>e-mail: cmbhatt@iirs.gov.in |

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| 5 | **Area of Research** | Flood hazard & risk vulnerability analysis, Flood inundation modelling, SAR based assessment of backscattering for inundation mapping urban flooding |
| 6 | **Summary of the proposed research and expected deliverables**<br>In recent years the quantity and quality of satellite products available to stakeholders during and after an event has greatly improved. The Sentinel series of satellites is a prime example of this, producing data with high spatial and temporal resolutions that is free to download. The strength of the radar return is dependent on a number of factors, notably surface roughness, dielectric properties, and local topography in relation to the radar look angle. Despite the operational advantages of SAR compared to optical systems, there are challenges in identifying flooded areas. Roughening of the water surface, created by heavy rainfall or wind, can cause backscattering of the radar signal, increasing the possibility of underestimation of inundated areas. Also mixing of flood signature in arid regions especially sand due to low backscatter and therefore leading to overestimation. SAR systems are side looking and, depending on the incidence angle, terrain features can produce radar shadow, overlaying, and foreshadowing. Identification of flooding can also be problematic in areas where other structures protrude the water surface and interact with the radar signal. Therefore, in this project, it is proposed to utilize of multi-temporal,multi-frequency & multi-polarization SAR data in the context of flooded and partially submerged vegetation in different scenarios to assess the backscatter response and also optimize the threshold in case for flood delineation for rapid emergency response. | |

| **IIRS - 006** | | |
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| 1 | **Name of ISRO Centre/Unit** | Indian Institute of Remote Sensing (IIRS), Dehradun |
| 2 | **Title of the research proposal** | Flash flood risk assessment using satellite images, GIS tools and hydrological modeling |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri M.Bhatt |
| 4 | **Contact Address of CoPI and Phone Number** | Disaster Management Studies Department<br>Indian Institute of Remote Sensing<br>4, Kalidas Road<br>Dehradun-248001<br>Uttarakhand<br>Phone: 0135-2524345<br>e-mail: cmbhatt@iirs.gov.in |
| 5 | **Area of Research** | Flood hazard & risk vulnerability analysis, Flood inundation modelling, SAR based assessment of backscattering for inundation mapping urban flooding |

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| 6 | **Summary of the proposed research and expected deliverables**<br><br>Flash flood is one of the devastating natural disaster in the mountainous region of India. Floods in mountainous environment because of their quick hydrological response as well as their considerable power make mountain streams highly hazardous and events therein difficult to forecast such that they cause large amounts of losses and fatalities worldwide. Floods in mountain basins are often flashy, and therefore differ from most other fluvial floods in that the lead time for warnings is generally very limited. In these environments, direct current meter measurements are often impossible to conduct during flood peaks for safety and technical reasons. It is impossible to avoid risks of floods or prevent their occurrence, however it is plausible to work on the reduction of their effects and to reduce the losses which they may cause. Flash flood mapping to identify sites in high risk flood zones is one of the powerful tools for this purpose for planners, risk managers and disaster response or emergency services during extreme and intense rainfall events. Therefore, in this project, it is proposed to utilize hydraulic modeling, geomorphic, and hydrologic data, DEM, thematic data, meteorological data, socio-economic data to model and map flood risk vulnerable areas to flash floods. |

| **IIRS - 007** | | |
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| 1 | **Name of ISRO Centre/Unit** | Indian Institute of Remote Sensing (IIRS), Dehradun |
| 2 | **Title of the research proposal** | Rapid flood inundation mapping using social media, remote sensing and topographic data |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri C.M.Bhatt |
| 4 | **Contact Address of CoPI and Phone Number** | Disaster Management Studies Department<br>Indian Institute of Remote Sensing<br>4, Kalidas Road<br>Dehradun-248001<br>Uttarakhand<br>Phone: 0135-2524345<br>e-mail: cmbhatt@iirs.gov.in |
| 5 | **Area of Research** | Flood hazard & risk vulnerability analysis, Flood inundation modelling, SAR based assessment of backscattering for inundation mapping urban flooding |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>Flood events cause substantial damage to urban and rural areas. Monitoring water extent during large-scale flooding is crucial in order to identify the area affected and to evaluate damage. During such events, spatial assessment of flood water may be derived from satellite or air borne sensing platforms. Meanwhile, an increasing | |

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| | availability of smartphones is leading to documentation of flood events directly by individuals, within formation shared in real-time using social media. Topographic data, can be used to determine where floodwater can accumulate. Therefore, in this project, it is proposed to integrate information derived from multiple sources to aid in the estimation of flood inundation extent and identifying hot spots. |

| **IIRS - 008** | | |
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| 1 | **Name of ISRO Centre/Unit** | Indian Institute of Remote Sensing (IIRS), Dehradun |
| 2 | **Title of the research proposal** | Terrain Modelling |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr. Ashutosh Bhardwaj |
| 4 | **Contact Address of CoPI and Phone Number** | Photogrammetry and Remote Sensing Department<br>Indian Institute of Remote Sensing<br>4, Kalidas Road<br>Dehradun-248001<br>Uttarakhand<br>Phone: 0135-2524117<br>e-mail: ashutosh@iirs.gov.in |
| 5 | **Area of Research** | Terrain Modelling for Earth and other planets |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>Terrain Modelling is an important aspect in various application and phenomenon taking place on earth and other planets, moon or extra-terrestrial objects.<br><br>To study various natural – manmade phenomenon on earth and applications like IBP, flood, city planning, hazard zonation, and atmospheric modelling require highly accurate topography of terrain for correct decision making. A large number of methods (as applicable) have evolved for terrain modelling such as photogrammetry (satellite/aerial/terrestrial), SAR Interferometry, Radargrammetry, LiDAR (satellite/aerial/terrestrial) or a combination of these for example, ALTM-DC. These methods can be appropriately utilized with GNSS for an effective and accurate input to models used in various applications. Accessibility to high computational power has opened the ground for utilization of HR and VHR datasets.<br><br>The target will be to use the latest methods for generation and utilization of an improved topography. | |

| **IIRS - 009** | | |
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| 1 | **Name of ISRO Centre/Unit** | Indian Institute of Remote Sensing (IIRS), Dehradun |

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| 2 | **Title of the research proposal** | Various machine leaning algorithms for earth observation data processing |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr. Anil Kumar |
| 4 | **Contact Address of CoPI and Phone Number** | Photogrammetry and Remote Sensing Department<br>Indian Institute of Remote Sensing,<br>4, Kalidas Road,<br>Dehradun-248001<br>Phone: 0135-2524114<br>e-mail: anil@iirs.gov.in |
| 5 | **Area of Research** | Machine Learning |
| 6 | **Summary of the proposed research and expected deliverables**<br>Artificial Neural networks (ANN) is a generic name for a large class of machine learning algorithms, most of them are trained with an algorithm called back propagation. In the late eighties, early to mid-nineties, dominating algorithm in neural nets was fully connected neural networks. These types of networks have a large number of parameters, and so do not scale well. But convolutional neural networks (CNN) are not considered to be fully connected neural nets. CNNs have convolution and pooling layers, whereas ANN have only fully connected layers, which is a key difference. Moreover, there are many other parameters which can make difference like number of layers, kernel size, learning rate etc. While applying Possibilistic c-Means (PCM) fuzzy based classifier homogeneity within class was less while observing learning based classifiers homogeneity was found more. Best class identification with respect to homogeneity within class was found in CNN output, as shown in the figure. With this it gives a path to explore various deep leaning algorithms in various applications of earth observation data like; self-learning based classification, prediction, multi-sensor temporal data in crop/forest species identification, remote sensing time series data analysis. | |

| **IIRS - 010** | | |
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| 1 | **Name of ISRO Centre/Unit** | Indian Institute of Remote Sensing (IIRS), Dehradun |
| 2 | **Title of the research proposal** | Hydrological modeling and water balance studies using ground and Space based inputs |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr. S. P. Aggarwal |
| 4 | **Contact Address of CoPI and Phone Number** | Water Resources Department<br>Indian Institute of Remote Sensing<br>4, Kalidas Road<br>Dehradun– 248001<br>Uttarakhand<br>Phone : 0135 2524162 |

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| | | e-mail: spa@iirs.gov.in |
| 5 | **Area of Research** | Hydrological Modeling |
| 6 | **Summary of the proposed research and expected deliverables**<br>The water balance or quantification of hydrological cycle components of an area or watershed/basin can only be done with the help of hydrological models, and is one of the most common and important inputs for any water resources management activity. The hydrological models can be estimated using monthly to annual simple water balance based methods, using lumped semi-empirical models working at watershed scale, semi-distributed physical models with working at hydrological response unit (HRU) scale and fully distributed physical grid based models. In all these hydrological models, remote sensing and GIS plays an essential role by providing information on rainfall, land use land cover (LULC), soil, digital elevation models, and land surface temperature. Most of the hydrological models also need ground based hydro-meteorological data such as precipitation, temperature, water level and discharge for simulation, calibration and validation of hydrological models. The present project envisages development and validation of hydrological models at different climate and topographical regions of India, with integration of ground and space based datasets, so that improvements in overall hydrological prediction and assessment can be done. | |

| **IIRS - 011** | | |
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| 1 | **Name of ISRO Centre/Unit** | Indian Institute of Remote Sensing (IIRS), Dehradun |
| 2 | **Title of the research proposal** | Hydrological Parameters Retrieval using Remote Sensing (Evapotranspiration ET, Soil Moisture SM, Surface Runoff SR, Snow Physical Parameters, Glacier Facies, Glacier Velocity, Snow/glacier melt, change in Terrestrial Water Storage ΔTWS) |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr. Praveen Kumar Thakur |
| 4 | **Contact Address of CoPI and Phone Number** | Water Resources Department<br>Indian Institute of Remote Sensing<br>4, Kalidas Road<br>Dehradun– 248001<br>Uttarakhand<br>Phone : 0135 2524166 |
| 5 | **Area of Research** | Hydrological Parameters Retrieval |
| 6 | **Summary of the proposed research and expected deliverables**<br>The hydrological parameters such as Precipitation, Evapotranspiration (ET), Soil Moisture (SM), Surface Runoff (SR), Snow Physical Parameters, Glacier Facies, | |

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| | Glacier Velocity, Snow/glacier melt, change in Terrestrial Water Storage (ΔTWS) are essential for water balance and hydrological quantification of any river basin or watershed. The traditional ground based methods of hydrological parameters estimation are mostly point based, and very good temporal resolution, but lack spatial coverage. The large spatial variation in hydrological parameters such as rainfall, SM, ET, Snow Water Equivalent (SWE) and (ΔTWS) can be easily overcome by remote sensing based hydrological parameters retrieval methods. The temporal variation of some of these parameters can be at sub-daily to hourly time scale, and some of the remote sensing satellites working in constellation mode can easily address such issues.<br><br>The present project can be used develop and validate the remote sensing based hydrological parameters retrieval techniques with ground truth from existing and future planned set of ground instruments/observations for Indian conditions. The derived hydrological parameters can be used in data assimilation mode for improving the prediction and assessment capability of hydrological models.<br><br>The main deliverable from this project will be time series of hydrological parameters derived from various remote sensing based satellites, sensors and validated with ground based observations. |

| **IIRS - 012** | | |
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| 1 | **Name of ISRO Centre/Unit** | Indian Institute of Remote Sensing (IIRS), Dehradun |
| 2 | **Title of the research proposal** | Water level estimation in inland water bodies and river discharge estimation using Remote Sensing and GIS |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr. Arpit Chouksey |
| 4 | **Contact Address of CoPI and Phone Number** | Water Resources Department<br>Indian Institute of Remote Sensing<br>4, Kalidas Road, Dehradun<br>Phone : 0135 2524167 |
| 5 | **Area of Research** | Hydrological Parameters Retrieval |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>The important role of water level in the inland water bodies and rivers along with river discharge in the hydrological cycle is well known. Estimation of water levels in the water bodies and flow discharge of major streams is essential for both scientific and operational applications related to water resource management and flood risk prevention. Despite the awareness of the importance of water level and discharge information, many basins are still not monitored and, in recent decades, monitoring stations around the world have decreased. In recent years, the availability of new | |

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| | and freely accessible data sources from satellite sensors is steadily increasing. Several studies have already addressed the possibility of retrieving water level of inland water bodies and discharge from major stream using space based inputs, demonstrating their feasibility and great potential for difficult-to-monitor sites. Therefore, based on the above insights, multi-sensor approach for water level, velocity and discharge estimation is required. In this project methodology/algorithms will be developed and tested for estimation of water level and discharge using multi-sensor remote sensing based approach.<br><br>Deliverables of this project will be:<br><br>Water level at different inland water bodies and reaches of rivers in the basin.<br><br>Flow velocity and discharge at reaches of rivers. |

| **IIRS - 013** | | |
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| 1 | **Name of ISRO Centre/Unit** | Indian Institute of Remote Sensing (IIRS), Dehradun |
| 2 | **Title of the research proposal** | Remote sensing based reservoir sedimentation and downstream flood risk assessment |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr. Vaibhav Garg |
| 4 | **Contact Address of CoPI and Phone Number** | Water Resources Department<br>Indian Institute of Remote Sensing<br>4, Kalidas Road,<br>Dehradun– 248001<br>Uttarakhand<br>Phone : 0135 2524165 |
| 5 | **Area of Research** | Hydrological & Flood Studies |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>Reservoir sedimentation is the major problem, due to it every year the reservoir capacity is lost to considerable amount. This loss in capacity also instigates hydrological extremes viz. flood and/or drought in the downstream area. Surveying for assessment of the reservoir by conventional approach is time and money consuming. Geospatial technology provides ample opportunity in this field through the availability of high resolution satellite data from the sensors (active/passive) on board Satellites. Till date mostly optical data is used to calculate the water spread area of the reservoir. However, due to presence of cloud in most of the optical data during onset of monsoon, the water spread at the lowest reservoir level could not be mapped. In turn the revised capacity or sedimentation is generally assessed between either below full reservoir level (FRL) or above maximum draw down level (MDDL). Nowadays, the synthetic aperture radar (SAR) data at reasonable spatial | |

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| | resolution is available freely in public domain. Moreover, microwave data has capability to penetrate cloud and the information below cloud can easily be retrieved. To overcome the issues related to optical data, in the present study, the reservoir sedimentation can also be estimated using SAR data. Once the capacity of the reservoir is estimated, the study can be extended to analyse the flood risk downstream of reservoir using suitable hydrodynamic modelling incorporating space based inputs. |

| **IIRS - 014** | | |
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| 1 | **Name of ISRO Centre/Unit** | Indian Institute of Remote Sensing (IIRS), Dehradun |
| 2 | **Title of the research proposal** | Retrieval of Geophysical parameters related to Water Resources (Soil Moisture, Snow Depth, Water Level, PWV) using GNSS/IRNSS signals |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr. Bhaskar R. Nikam |
| 4 | **Contact Address of CoPI and Phone Number** | Water Resources Department<br>Indian Institute of Remote Sensing<br>4, Kalidas Road, Dehradun<br>Phone : 0135 2524164 |
| 5 | **Area of Research** | IRNNS/GNSS data utilization |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>Traditional GNSS signals are utilized for positional and navigational applications, however, GNSS has also been regarded as a powerful emerging space-borne technology for non-positioning applications. Since last two decades attempts have been made to utilize GNSS signals (direct or reflected) for retrieval of various geophysical parameters viz. soil moisture, water level, snow depth, crop height, Percipitable Water Vapour, etc. The ground-based GNSS-MET is proved to be complementary to the conventional sounding means of PWV due to its real-time, all-day and all-weather capabilities and high temporal resolutions. In the past few years new GNSS space constellations other than GPS and GLONASS have emerged. Along with GPS, GLONASS, BeiDou Navigation Satellite System (BDS), Galileo, QZSS, India has it's own regional navigation system; IRNSS. In this study, the change in the reflected signals of IRNSS (NavIC) constellation with change in nature/state of the reflecting surface will be analysed to develop models for retrieval of these surface parameter i.e. change in soil moisture, snow depth and water level. Also the direct signals from IRNSS and other GNSS satellites will be utilized for retrieval PWV. The derived products from these projects can be utilized for validation of other remote sensing based products and calibration/validation of modeling based products. | |

| IIRS - 015 | | |
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| 1 | **Name of ISRO Centre/Unit** | Indian Institute of Remote Sensing (IIRS), Dehradun |
| 2 | **Title of the research proposal** | Flood prone area mapping, Modeling/Forecasting & risk assessment using Geospatial tools |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri Pankaj R. Dhote |
| 4 | **Contact Address of CoPI and Phone Number** | Water Resources Department<br>Indian Institute of Remote Sensing<br>4, Kalidas Road<br>Dehradun – 248001<br>Uttarakhand<br>Phone : 0135 2524169 |
| 5 | **Area of Research** | Flood Studies |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>Flooding during the monsoon season is a recurring problem in many parts of India. Different Indian states, especially North West Himalayan (NWH) states (J&K, HP and UK) have experienced large number of hydro-meteorological disasters such as high intensity precipitation and subsequent flooding in downstream areas in the last few years. Few major flood disasters associated with high intensity rainfall are Kerala flood 2018, Manali flood 2018, Leh flood 2010, Manali and Uttarkashi flash floods of 2012, Ukhimath flash floods and mud slides of 2012. The floods in entire Uttarakhand, part of Himachal and GLOF at Kedarnath during 15-17 June 2013 are worst ever for NWH region. Flood events leads to extensive socio-economic damages, as happened in Kedarnath area during 15-17 June 2013.<br><br>Therefore, scientific study of such flood prone areas will help to reduce vulnerability form such hazards and also enhance the disaster management capacity of various disaster management agencies of this region. Expected deliverables of proposed research will be:<br><br>□ Use of Indian and other remote sensing satellite data as well as ground data for flood studies<br><br>□ Flood hydrographs generation for extreme events using hydrological modelling<br><br>□ Flood inundation mapping for extreme flood events using hydrodynamic modelling<br><br>□ Historical flood events inundation mapping using remote sensing data<br><br>□ Identification of probabilistic flood-prone area<br><br>□ Flood risk assessment using integrated approach of hydrological modelling and geospatial technique. | |

| IIRS - 016 | | |
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| 1 | **Name of ISRO Centre/Unit** | Indian Institute of Remote Sensing (IIRS), Dehradun |
| 2 | **Title of the research proposal** | Improving performance of irrigation system using ground based and Space based inputs |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr. Bhaskar R. Nikam |
| 4 | **Contact Address of CoPI and Phone Number** | Water Resources Department<br>Indian Institute of Remote Sensing<br>4, Kalidas Road<br>Dehradun – 248001<br>Uttarakhand<br>Phone : 0135 2524164 |
| 5 | **Area of Research** | Irrigation Water Management |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>The share of agricultural sector is utilization of fresh water is around 80%. The efficiency of irrigation systems utilization this share of water is around 35-40% against the expected/designed value of 65%. The scenario is grave in case of larger surface water irrigation project. Increase in irrigation water efficiency along with increasing area under irrigation is on the top priority Government of India. As per conservative assessment around 14 million hectare land can be brought under irrigation by improving irrigation project performance by 10%. However, the main hurdle in direction is vast size of irrigation project and non-availability of spatial data. Multi-sensors remote sensing inputs can be utilized for mapping and monitoring of irrigation projects. The temporal remote sensing inputs can be used for crop acreage mapping, estimation of irrigation water requirement, performance evaluation irrigation projects at divisional level. The challenging task of irrigated area mapping can only be achieved using temporal remote sensing data. The land degradation problems due to irrigation can also be assessed using multi-spectral and Hyperspectral remote sensing inputs.<br><br>In this research the temporal and multi-resolution remote sensing data will be utilized along with ground based data for performance evaluation of irrigation projects. The critical areas of performance degradation will be identified for and alternate operational strategies including conjunctive water planning, deficit irrigation, water reuse will be proposed for improving performance and agricultural returns from the project. | |

| IIRS - 017 | | |
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| 1 | **Name of ISRO Centre/Unit** | Indian Institute of Remote Sensing (IIRS), Dehradun |

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| 2 | **Title of the research proposal** | Online spatial data analysis and algorithm development for geo-scientific applications |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr. Harish Chandra Karnatak |
| 4 | **Contact Address of CoPI and Phone Number** | Geoweb Services, IT & Distance Learning Department<br>Indian Institute of Remote Sensing<br>4, Kalidas Road<br>Dehradun – 248001<br>Uttarakhand<br>Phone: 0135-2524332<br>e-mail: harish@iirs.gov.in |
| 5 | **Area of Research** | Online Spatial Data Analysis and Processing |
| 6 | **Summary of the proposed research and expected deliverables**<br>Availability of geospatial data from online data repositories and geoportals are increasing with rapid pace. For better utilization of these heterogeneity data sets, it is required to give more attention to develop web based algorithms as well as geocomputation model that allows high-level information extraction from distributed nature of geodata. The proposed research topic will develop a software framework for online spatial modelling and algorithm development based on user defines parameters. The main objective of proposed study is to develop and implement a web services and REST API based geo-processes and analysis approach for online Image processing and algorithm development. | |

| **IIRS - 018** | | |
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| 1 | **Name of ISRO Centre/Unit** | Indian Institute of Remote Sensing (IIRS), Dehradun |
| 2 | **Title of the research proposal** | Software framework development for GIS and image processing based online Virtual Laboratory |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr. Harish Chandra Karnatak<br>Shri Ravi Bhandari |
| 4 | **Contact Address of CoPI and Phone Number** | Geoweb Services, IT & Distance Learning Department<br>Indian Institute of Remote Sensing<br>4, Kalidas Road<br>Dehradun – 248001<br>Uttarakhand<br>Phone: 0135-2524332<br>e-mail: harish@iirs.gov.in<br>ravi.bhandari@iirs.gov.in |
| 5 | **Area of Research** | Software Framework development for GIS and Image Processing |

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| 6 | **Summary of the proposed research and expected deliverables**<br><br>The concept of virtual laboratory for RS&GIS based lab experiments is very important and critical for best utilization of hardware and software resources. This approach will help to the learners to understand the practical aspects of RS &GIS during their online courses. The virtual lab needs to be developed for various RS&GIS based scientific lab exercises. Various cyber security guidelines, performance issues and data storage and sharing system needs to be designed and developed. |

| **IIRS - 019** | | |
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| 1 | **Name of ISRO Centre/Unit** | Indian Institute of Remote Sensing (IIRS), Dehradun |
| 2 | **Title of the research proposal** | An astrobotany cultivation system capable of growing multiple food crops for long space flight missions. |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri Ashutosh Kumar Jha |
| 4 | **Contact Address of CoPI and Phone Number** | GID<br>Indian Institute of Remote Sensing<br>4, Kalidas Road,<br>Dehradun – 248001<br>Uttarakhand |
| 5 | **Area of Research** | Payloads for Human Space Program |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>In future deep space manned missions packaged food products may conquer a major part in payload allotment, this problem can be countered by having an inbuilt food crop cultivation unit which may provide the vyomanauts with required fresh food by implementing seed to seed cultivation technique. Also growing plants helps in increasing the O2 composition by absorbing CO2 within the cabin. They also have psychological impact on human being.<br><br>Considering these we will prototype a astroculture systems capable of growing plants in space environment.<br><br>*Objective: -*<br><br>To design a compact plant growth facility with low power consumption and optimal plant growth area, able to accommodate various experiments dealing with diverse food crops and variant growth techniques to increase the outcome of on-board food crop cultivation.<br><br>*Subobjective:*<br><br>1. Development of a Module should have | |

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| | a.plant growth system irrigation and reliable root zone moisture control for microgravity-based systems.<br>b. development of the illumination system with control for plant growth chamber.<br>c. Atmosphere management system with temperature and humidity control and to some degree carbon dioxide regulation<br>d. Process control and observation unit along with timely result recording<br>2. Categorized the crop based on the area/volume of space required to grow.<br>3. Suggest the best condition of growth of these plants. |

| **IIRS - 020** | | |
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| 1 | **Name of ISRO Centre/Unit** | Indian Institute of Remote Sensing (IIRS), Dehradun |
| 2 | **Title of the research proposal** | Remote sensing based estimation of carbon stock of bamboo resources of northeast India using machine learning algorithms |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr. Subrata Nandy |
| 4 | **Contact Address of CoPI and Phone Number** | Forestry & Ecology Department<br>Indian Institute of Remote Sensing<br>4, Kalidas Road<br>Dehradun – 248001<br>Uttarakhand<br>e-mail: nandy@iirs.gov.in<br>Phone: +91-135-2524175 |
| 5 | **Area of Research** | Forestry and Ecology |
| 6 | **Summary of the proposed research and expected deliverables**<br>Bamboo is an important non-timber forest product (NTFP) of subsistence and meets several commercial, social, environmental and economical perspectives. Especially in South East Asia, where it is known variously as the ‘poor man’s timber’, the ‘cradle-to-coffin’ plant and ‘green gold’, bamboo has and still provides the materials needed for existence. Recently, Govt. of India has kept bamboo out of the provision of Indian Forest Act 1927, and declared it as grass. Hence now it possible for the communities and state governments to harvest, transport and sell bamboo across the country. In spite of bamboo’s importance, the statistics on its spatiotemporal distribution and carbon stock is rather scarce and inconsistent which can hamper their sustainable development.<br>Bamboo forests play an important role in the global carbon sink due to their colossal carbon stock. Using the field inventory based methods, it is difficult to map the spatial distribution of carbon stocks of bamboo resources over a large area. Remote sensing, which enables spatial and temporal assessment of land and vegetation, | |

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| | can effectively address this issue. By integrating satellite and field inventory data, the carbon stock of the bamboo forests can be effectively estimated. The spectral and texture variables, derived from satellite data can be related to the field measured carbon using machine learning algorithms for carbon stock estimation. In recent years, machine learning algorithms have been widely used for carbon storage estimation. These algorithms give better estimation of carbon stocks.<br><br>Hence, the present study will aim to map the spatial distribution of bamboo resources as well the carbon stock of bamboo forests of northeast India. |

| **IIRS - 021** | | |
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| 1 | **Name of ISRO Centre/Unit** | Indian Institute of Remote Sensing (IIRS), Dehradun |
| 2 | **Title of the research proposal** | Soil quality/Fertility assessment using satellite remote sensing data and GIS |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri Justin George K |
| 4 | **Contact Address of CoPI and Phone Number** | Agriculture and Soils Department<br>Indian Institute of Remote Sensing<br>4, Kalidas Road<br>Dehradun-248001<br>Uttarakhand<br>Phone: 0135-2524141<br>e-mail: justin@iirs.gov.in |
| 5 | **Area of Research** | Soil quality, fertility assessment, digital terrain analysis, digital soil mapping, modeling soil properties, soil property prediction |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>Soil quality indicates the capacity of the soil to perform the various ecosystem services and by far it is the central element which determines the long term sustainability of any agricultural production system (Karlen et al., 2003).<br><br>Spatial assessment of soil quality as well as fertility parameters is vital for planning and adoption of various management strategies aimed at more efficient resource utilization for maximizing food production with minimal adverse impact on environment in these times of changing climate. Satellite remote sensing data provides continuous and wide coverage of various agroecosystems, which help in assessment of soil quality parameters. Remote sensing data can provide vital information regarding the various soil forming factors such as vegetation, climate, topography etc that can be used for assessing soil quality/fertility as well as development of various prediction models for spatial mapping of different soil quality indicators (Chagas et al., 2016; Dharmurajan et al., 2017; Jeong et al., 2017). | |

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| | Remote sensing can also aid us in identifying the drivers of soil quality on a long time scale such as land use and cropping system changes, cropping by using various approaches (Liu et al., 2015; Nabiollahi et al., 2018). |

| **IIRS - 022** | | |
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| 1 | **Name of ISRO Centre/Unit** | Indian Institute of Remote Sensing (IIRS), Dehradun |
| 2 | **Title of the research proposal** | High Biomass agricultural crops monitoring using Synthetic Aperture Radar (SAR) microwave remote sensing data |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr. Dipanwita Haldar |
| 4 | **Contact Address of CoPI and Phone Number** | Agriculture & Soils Department<br>Indian Institute of Remote Sensing<br>4, Kalidas Road<br>Dehradun-248001<br>Uttarakhand<br>Phone: 0135-2524139<br>e-mail: dipanwita@iirs.gov.in |
| 5 | **Area of Research** | Microwave Remote sensing data ; High biomass crops, Crop biophysical parameters monitoring, crop yield modeling |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>In the monsoon season availability of the optical data is a critical issue and coincides with the fast growth so multitemporal dual-polarised/ fully polarimetric data of moderate swath and resolution seem viable. Use of various frequency SAR data for different crops has been demonstrated globally (Haldar et al. 2012,2014,2018, Maity et al.2004, McNairn et al.,2002, Dave, Haldar et al., 2017 , Chauhan et al., 2018). Acreage and condition assessment in paddy, cotton, jute, and groundnut has been demonstrated. But the high biomass crops need to be addressed with higher wavelength facilitating better penetration for crop parameter study. Land preparation, sowing, vegetative phase, panicle initiation and maturity in grain crops, tillering and growth phase in sugarcane/ vegetative crops are the main stages to affect the specific backscatter. The studies with X- and C band report saturation beyond 5 kg/m2 of fresh biomass and entails difficulty in discrimination and biophysical parameter retrieved. Therefore, in this project, it is proposed for utilization of lower frequency satellite data (C/S/and L band) and evaluation of its response to crop biophysical parameter monitoring. Additional response information in the lower frequency domain is expected. | |

| IIRS - 023 | | |
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| 1 | **Name of ISRO Centre/Unit** | Indian Institute of Remote Sensing (IIRS), Dehradun |
| 2 | **Title of the research proposal** | Differential Interferometric SAR technique for groundwater depletion and mining induced land subsidence analysis |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr. R.S. Chatterjee |
| 4 | **Contact Address of CoPI and Phone Number** | Geosciences Department<br>Indian Institute of Remote Sensing<br>4, Kalidas Road<br>Dehradun-248001<br>Uttarakhand<br>Phone: 0135-2524156<br>e-mail: rschatterjee@iirs.gov.in |
| 5 | **Area of Research** | Microwave SAR, InSAR & DInSAR data processing; Mining and groundwater depletion induced land subsidence analysis |
| 6 | **Summary of the proposed research and expected deliverables**<br>Groundwater depletion and mining are two important anthropogenic causes responsible for land subsidence at various places of the country. Differential interferometric SAR is a proven spaceborne technique, which can be successfully used for detection and monitoring of land subsidence much before the damage. Spaceborne DInSAR based analysis needs to be supplemented with ground-based measurements and in-situ observations for validation and characterization of land subsidence. Time series analysis and predictive modelling based on the causative factors would be beneficial to understand the nature of the deformation and scenario analysis. | |

| IIRS – 024 | | |
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| 1 | **Name of ISRO Centre/Unit** | Indian Institute of Remote Sensing (IIRS), Dehradun |
| 2 | **Title of the research proposal** | Study of glacier change in the Himalaya and its climatic implications using remote sensing |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr. Pratima Pandey |
| 4 | **Contact Address of CoPI and Phone Number** | Geosciences Department<br>Indian Institute of Remote Sensing<br>4, Kalidas Road<br>Dehradun-248001<br>Uttarakhand<br>Phone: 0135-2524159 |

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| | | e-mail: pratima@iirs.gov.in |
| 5 | **Area of Research** | Glacier dynamics, Glacier geomorphology, Glacial Hazards |
| 6 | **Summary of the proposed research and expected deliverables**<br>The direct and indirect impact of glacier response to climate change affect society and mankind and hence makes it important to assess the changes of Himalayan glaciers to climate change. Assessment of glacier changes to climate change is necessary for preparation of countermeasures for glacier variation and related impacts. Despite the importance of the study, very few report are available on the vulnerability of Himalayan glaciers. Under rising temperature and changing precipitation scenario, rapidly retreating glaciers are giving rise to glacial lakes and accelerating the growth of existing glacial lakes. Sudden discharge of water associated with loose debris from these lakes known as the Glacial Lake Outburst Flood (GLOF) causes catastrophe in the downstream. Every country in the Himalayan region is affected by GLOF events. Further, the ice, snow, rock avalanche and mass movement from glaciers pose serious threat to people living in the high mountain region. It is therefore important to study and address the problem in totality using Remote Sensing, GIS and allied space technology. | |

| **IIRS - 025** | | |
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| 1 | **Name of ISRO Centre/Unit** | Indian Institute of Remote Sensing (IIRS), Dehradun |
| 2 | **Title of the research proposal** | Land surface deformation monitoring by Microwave SAR data analysis in the Coal Mines of Chhattisgarh |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr. R.S. Chatterjee |
| 4 | **Contact Address of CoPI and Phone Number** | Geosciences Department<br>Indian Institute of Remote Sensing<br>4, Kalidas Road<br>Dehradun-248001<br>Uttarakhand<br>Phone: 0135-2524156<br>e-mail: rschatterjee@iirs.gov.in |
| 5 | **Area of Research** | Microwave Remote Sensing application in coal mine monitoring |
| 6 | **Summary of the proposed research and expected deliverables**<br>Typically, coalmine subsidence occurs due to extraction of coal by underground mining. Besides, land surface deformation occurs in and around opencast mines and overburden dump areas, which lead to severe mass wasting and slope failure.<br>The common traditional techniques for measuring land surface deformation by | |

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| | ground-based measurement techniques using precise levelling, total station and global navigation satellite system (GNSS), can yield point-based measurements. Spaceborne SAR (Synthetic Aperture radar) interferometric technique provides spatially continuous measurement of land surface deformation over a large area at centimetre to sub-centimetre level precision. This research will focus on spaceborne differential interferometric SAR (DInSAR) data analysis for monitoring land surface deformation due to extraction of coal by underground and opencast mining techniques and their impact assessment. |

| **IIRS - 026** | | |
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| 1 | **Name of ISRO Centre/Unit** | Indian Institute of Remote Sensing (IIRS), Dehradun |
| 2 | **Title of the research proposal** | Predictive modelling and characterization of land subsidence due to groundwater and petroleum extraction in and around Mehsana, Gujarat |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr. R.S. Chatterjee |
| 4 | **Contact Address of CoPI and Phone Number** | Geosciences Department<br>Indian Institute of Remote Sensing<br>4, Kalidas Road<br>Dehradun-248001<br>Uttarakhand<br>Phone: 0135-2524156<br>e-mail: rschatterjee@iirs.gov.in |
| 5 | **Area of Research** | SAR Interferometry |
| 6 | **Summary of the proposed research and expected deliverables**<br>It is of ongoing concern that continuous on-shore oil and gas extraction as well as groundwater mining in the area, may contribute to the subsidence of the Mehsana Block of North Cambay basin. Our project will investigate land subsidence in the exploration oilfields due to hydrocarbon extraction in the Mehsana Block of ONGC and land subsidence in the Mehsana basin due to groundwater withdrawal in the region. Land subsidence will be investigated using DInSAR time series to map the land subsidence and to confirm the deformation source. Modelling of land subsidence in relation to groundwater withdrawal and petroleum extraction and consequent mass deficit will help to simulate future land subsidence scenario and to recommend preventive measures. | |

| **IIRS - 027** | | |
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| 1 | **Name of ISRO Centre/Unit** | Indian Institute of Remote Sensing (IIRS), Dehradun |

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| 2 | **Title of the research proposal** | Urban spatial growth modelling |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri Sandeep Maithani |
| 4 | **Contact Address of CoPI and Phone Number** | Indian Institute of Remote Sensing<br>4, Kalidas Road<br>Dehradun-248001<br>Uttarakhand<br>e-mail: maithani@iirs.gov.in<br>Phone:01352524189 |
| 5 | **Area of Research** | Urban spatial growth modelling |
| 6 | **Summary of the proposed research and expected deliverables**<br>The recent thrust on urban growth modelling using geospatial data and techniques are- i) to implement cellular automata (CA) based models to simulate urban growth in Indian cities, ii) to evaluate the efficacy of Artificial Neural Networks (ANN) in formation of transition rules for CA based modelling and its comparison with the traditional Multi-Criteria Evaluation (MCE) based CA model, iii) to investigate the effects of different neighbourhood sizes and neighbourhood types in calibration of CA based models, iv) to evaluate the performance of CA based models using Moran, Percent Correct Match and Shannon's Entropy and v) to generate ANN based urban growth zonation maps depicting zones of urban growth potential. | |

| **IIRS - 28** | | |
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| 1 | **Name of ISRO Centre/Unit** | Indian Institute of Remote Sensing (IIRS), Dehradun |
| 2 | **Title of the research proposal** | Thermal Remote Sensing for Urban Areas and Understanding of UHI Phenomena |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Sandeep Maithani |
| 4 | **Contact Address of CoPI and Phone Number** | Indian Institute of Remote Sensing<br>4, Kalidas Road<br>Dehradun-248001<br>Uttarakhand<br>e-mail: maithani@iirs.gov.in<br>Phone: 01352524189 |
| 5 | **Area of Research** | Land surface temperature |
| 6 | **Summary of the proposed research and expected deliverables**<br>Urban expansion involves land conversions from vegetated moisture-rich to impervious moisture deficient land surfaces. With growing urbanization, the local weather and climatic conditions of the area are varying considerably. Thermal remote sensing is a powerful tool to study the causes of changing land use pattern | |

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| | and the Urban Heat Island (UHI) effects. The thermal infrared data is useful for studying UHI over urban areas and plan the open spaces, accordingly. |

| IIRS - 029 | | |
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| 1 | **Name of ISRO Centre/Unit** | Indian Institute of Remote Sensing (IIRS), Dehradun |
| 2 | **Title of the research proposal** | Urban seismic risk assessment |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri Sandeep Maithani |
| 4 | **Contact Address of CoPI and Phone Number** | Indian Institute of Remote Sensing<br>4, Kalidas Road<br>Dehradun-248001<br>Uttarakhand<br>e-mail: maithani@iirs.gov.in<br>Phone: 01352524189 |
| 5 | **Area of Research** | Urban Hazards |
| 6 | **Summary of the proposed research and expected deliverables**<br>Urban areas are growing at a rapid pace, as a consequence, urban areas have encroached upon areas not suitable for urban growth. There is an urgent need to quantify the urban risk due to seismic activity in terms of damage to buildings, infrastructure etc. These analysis will provide an input into the disaster preparation process. | |

| IIRS - 030 | | |
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| 1 | **Name of ISRO Centre/Unit** | Indian Institute of Remote Sensing (IIRS), Dehradun |
| 2 | **Title of the research proposal** | Urban micro and meso-scale climate modelling and urban canopy parameters estimation |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Kshama Gupta |
| 4 | **Contact Address of CoPI and Phone Number** | Indian Institute of Remote Sensing<br>4, Kalidas Road<br>Dehradun-248001<br>Uttarakhand<br>Phone:0135-2524329 |
| 5 | **Area of Research** | Urban Climate |
| 6 | **Summary of the proposed research and expected deliverables**<br>Urban climate refers to climatic conditions in an urban area that differ from | |

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| | neighbouring rural areas, and are attributable to urban development. Temperatures are higher in cities than the surrounding rural areas— which is popularly manifested as Urban Heat Island (UHI). Urban climate is an effective issue on the local and global climates which is influenced by several factors such as urban morphology and density, the properties of urban surfaces and vegetation cover. The urban built-form due to its dense development, high-rise character and increase in impervious, absorptive surfaces is responsible for the trapping of heat and reduction in evaporative cooling due to decrease in vegetated, soft, pervious surfaces in urban areas. The study of urban climate is gaining further importance in the scenario of climate change. Research is ongoing for the generation of 3D urban database, urban parameterization in numerical weather models, urban canopy parameters estimation and understanding the micro and meso scale urban climate phenomenon. Currently, the emphasis is given to development of urban parameterization and micro and meso scale modelling. It will be further extended to the simulation of urban growth vis-à-vis urban climate. |

| **IIRS - 031** | | |
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| 1 | **Name of ISRO Centre/Unit** | Indian Institute of Remote Sensing (IIRS), Dehradun |
| 2 | **Title of the research proposal** | 3D Modelling of arban areas/ 3D city modelling |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Kshama Gupta |
| 4 | **Contact Address of CoPI and Phone Number** | Indian Institute of Remote Sensing (IIRS)<br>4, Kalidas Road<br>Dehradun-248001<br>Uttarakhand<br>Phone: 135-2524329 |
| 5 | **Area of Research** | 3 D modeling and visualization |
| 6 | **Summary of the proposed research and expected deliverables**<br>The 3D models of urban areas assist in better visualization of urban areas as well can be useful for building typologies, landscape morphological characteristics, urban climate studies and many more applications for urban planners. This involves review and development of algorithms for automatic extraction of buildings, reconstruction of building planes and construction of 3D model using LiDAR and high-resolution stereo pair data. Currently, emphasis is given to develop methods for generating the 3D models using high-resolution stereo satellite data and Laser scanner based data. | |

| **IIRS - 032** |
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| 1 | **Name of ISRO Centre/Unit** | Indian Institute of Remote Sensing(IIRS), Dehradun |
| 2 | **Title of the research proposal** | Utilization of remotely sensed data for species and vegetation health assessment and development of indices for Urban Green Spaces |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Kshama Gupta |
| 4 | **Contact Address of CoPI and Phone Number** | Indian Institute of Remote Sensing<br>4, Kalidas Road<br>Dehradun-248001<br>Uttarakhand<br>Phone: 135-2524329 |
| 5 | **Area of Research** | Urban Vegetation studies |
| 6 | **Summary of the proposed research and expected deliverables**<br>Objective assessment of urban green spaces for planning purposes is necessary for optimal distribution of urban green spaces. This involves development of easy to use comprehendible indices for the assessment of urban green spaces using remote sensing derived parameters. Further, availability of high-resolution multi-band data can also assist in identification of vegetation species as well as assessment of plant stress in urban areas. | |

| **IIRS - 033** | | |
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| 1 | **Name of ISRO Centre/Unit** | Indian Institute of Remote Sensing (IIRS), Dehradun |
| 2 | **Title of the research proposal** | GNSS data processing for geodynamics study |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri Suresh Kannaujiya |
| 4 | **Contact Address of CoPI and Phone Number** | Geosciences Department<br>Indian Institute of Remote Sensing<br>4, Kalidas Road,<br>Dehradun-248001<br>Uttarakhand<br>Phone: 0135-2524155<br>e-mail: skannaujiya@iirs.gov.in |
| 5 | **Area of Research** | GNSS, Crustal deformation, strain budget, the Himalayas |
| 6 | **Summary of the proposed research and expected deliverables**<br>The overall aim is to shed light on the tectonics and kinematics of the Himalayan region by investigating crustal deformations and to delineate the crustal strain pattern of the region using GNSS measurements and geophysical methods.<br>The project will use advanced earth observation resources for characterization of | |

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| | vulnerable earthquake zones by modelling of GNSS data to find out the stress/strain in the Northwest Himalaya. Successful modelling of stress/strain using numerical simulation has a direct linkage with seismicity of the area. The aim of the study is to monitor crustal deformation, seasonal strain, correlation with hydrological loading and to constrain strain accumulation as a measure of condition that facilitates fault movement and resultant earthquake. The algorithm of the project will be used with the current constellation of GNSS/IRNSS satellites for earthquake hazard assessment in the Himalayan region. |

| PRL - 001 | | |
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| 1 | **Name of ISRO Centre/Unit** | Physical Research Laboratory (PRL), Ahmedabad |
| 2 | **Title of the research proposal** | Understanding the initiation of solar eruptions through numerical modeling |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Ramit Bhattacharyya |
| 4 | **Contact Address of CoPI and Phone Number** | Udaipur Solar Observatory<br>Physical Research Laboratory, Bari Road<br>Udaipur, Rajasthan 313001<br>Phone: 02942457216<br>e-mail: ramit@prl.res.in |
| 5 | **Area of Research** | Solar Physics, Computational Physics |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>The near-Earth space weather: the time varying conditions of the space including the magnetosphere, ionosphere, thermosphere and exosphere is partiallydriven by the transient magnetic activities of the Sun and can directly harm spacecraft electronics, maintenance of satellite orbits and satnav among others. The solar transients relevant to space weather are mainly energetically large solar flares and coronal mass ejections (CMEs). Standardly, rearrangementsof magnetic connectivity, or magnetic reconnections (MRs), localized at active region corona are believed to onset the transients. A contextual exploration of the physics of MRs is then of utmost importance to better understand the space-weather. In absence of reliable measurements of solar coronal magnetic field, the project proposes to explore the coronal MRs using state of the art computer simulations. Specifically, the numerical work will focus on extrapolating coronal magnetic fields from photospheric fields measured by various satellites and generating three - dimensional magnetic maps. The maps will further be used in constructing magnetic field lines which are believed to traceplasma loopsthreading the solar corona. A morphological study of the magnetic field lines will identify locations in active regions which are prone to magnetic reconnections and hence, will directly relate to the flare productivity of the region. Additionally, identification of coherent twisted field lines—known as magnetic flux ropes—will provide partial information regarding the CME productivity of the region. Overall, the project will provide details of solar transients which drive the space weather and help to better understand it. | |

| PRL - 002 | | |
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| 1 | **Name of ISRO Centre/Unit** | Physical Research Laboratory (PRL), Ahmedabad |
| 2 | **Title of the research proposal** | Study of flares in regular and isolated active regions |

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| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr. Rohan Eugene Louis |
| 4 | **Contact Address of CoPI and Phone Number** | Udaipur Solar Observatory<br>Physical Research Laboratory, Bari Road<br>Udaipur, Rajasthan 313001<br>e-mail: rlouis@prl.res.in<br>Phone: 0294 2457217 |
| 5 | **Area of Research** | Solar Physics |
| 6 | **Summary of the proposed research and expected deliverables**<br>Monitoring and predicting solar eruptions is critical for technological assets operating in the near-Earth space environment. While flares are predominantly (although not universally) associated with complex active regions, they can also occur in the vicinity of regular, simple active regions. The motivation of this work is to ascertain the processes that lead to flares in alpha- and beta-type active regions and the conditions that enable or prevent them from evolving into CMEs. The data from NASA's Solar Dynamics Observatory (SDO) is comprehensive, spanning Cycle 24 since 2010 and is ideal for this investigation. | |

| **PRL - 003** | | |
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| 1 | **Name of ISRO Centre/Unit** | Physical Research Laboratory (PRL), Ahmedabad |
| 2 | **Title of the research proposal** | Observational studies of solar photospheric and chromospheric activities |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri Shibu K. Mathew |
| 4 | **Contact Address of CoPI and Phone Number** | Udaipur Solar Observatory<br>Physical Research Laboratory, Badi Road<br>Udaipur, Rajsthan – 313001<br>Phone: 0294-2457212 |
| 5 | **Area of Research** | Solar Physics |
| 6 | **Summary of the proposed research and expected deliverables**<br>With the installation of new Multi-Application Solar Telescope (MAST) and associated back-end instruments it is now possible to obtain high quality solar observations. A narrow band imager and a polarimeter along with adaptive-optics system can provide simultaneous spectro-polarimetric observations in solar photosphere and chromosphere. These observations can be used for deriving the magnetic and velocity fields and thus could be used understanding various solar activities. | |

| PRL - 004 | | |
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| 1 | **Name of ISRO Centre/Unit** | Physical Research Laboratory (PRL), Ahmedabad |
| 2 | **Title of the research proposal** | Automatic detection of solar features such as sunspots, filaments and extraction of their attributes |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Prof. Nandita Srivastava |
| 4 | **Contact Address of CoPI and Phone Number** | Udaipur Solar Observatory<br>Physical Research Laboratory, Badi Road<br>Udaipur, Rajsthan – 313001<br>Phone: 0294-2457211<br>e-mail: nandita@prl.res.in |
| 5 | **Area of Research** | Solar Physics |
| 6 | **Summary of the proposed research and expected deliverables**<br>The Global Oscillation Network Group (GONG) instrument has been recording full disk images of the Sun since more than 20 years. This gives an opportunity to understand the long-term behavior of the Sun at least for 2 solar cycles. This project is aimed at developing an automatic detection technique for implementation on solar full disk images, extraction of features like sunspots and filaments and also estimating their attributes in consecutive images. This would help understanding the temporal evolution of the solar activity both on transient phenomena leading to eruptions and also on long term. | |

| PRL - 005 | | |
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| 1 | **Name of ISRO Centre/Unit** | Physical Research Laboratory (PRL), Ahmedabad |
| 2 | **Title of the research proposal** | Study of vertical distribution of atmospheric water vapor, temperature and stratosphere-troposphere exchange using Lidar |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr. Som Kumar Sharma |
| 4 | **Contact Address of CoPI and Phone Number** | Physical Research Laboratory<br>Navrangpura, Ahmedabad-380009, Gujarat<br>Phone: 079-26314554<br>e-mail: somkumar@prl.res.in |
| 5 | **Area of Research** | Atmospheric Sciences |
| 6 | **Summary of the proposed research and expected deliverables**<br>Atmospheric water vapour is a major greenhouse species and its distribution shows high regional andseasonal variability. It plays vital role in cloud formation, radiation balance, chemistry, dynamics, and consequently impacts the weather and | |

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| | climate system. Variability in water vapor predominantly modulates fluxes oflong wave (infrared) radiation and can thereby influence the temperature in the Troposphere - Stratosphere system. To delineate the influence of water vapour onTroposphere- Stratosphere exchange (STE) processes, it is needed to have in depth investigations. Human-induced climate forcing is one of the major causes of warming in the lower atmosphere, cooling of the stratosphere, rise of tropopause height, weakening oftropical circulation patterns and modulations in tropical precipitation. Quantitative investigations of vertical distribution of water vapor, temperature and dynamics of boundary layer are very much needed. Further, these parameters form an important set of inputs for the regional weather and climate models. A Lidar is a state of the art instrument that provides the required information with high vertical and temporal resolutions. It provides vertical distribution of atmospheric water vapour, temperature, and boundary layer which are essential in quantifying several atmospheric processes. In this study a Lidar based investigations of the atmospheric water vapour, temperature and dynamics of boundary layer and their interdependence in the Indian sub-tropical and tropical regions will be proposed. Simultaneous measurements of these parameters will provide an appropriate dataset to address the above stated science goals. Further, these high temporally and vertically resolved measurements will help inimproving model outputs over Indian region. |

| **PRL - 006** | | |
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| 1 | **Name of ISRO Centre/Unit** | Physical Research Laboratory (PRL), Ahmedabad |
| 2 | **Title of the research proposal** | Space weather |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr. Dibyendu Chakrabarty |
| 4 | **Contact Address of CoPI and Phone Number** | Space and Atmospheric Sciences Division<br>Physical Research Laboratory<br>Navrangpura, Ahmedabad-380009, Gujarat |
| 5 | **Area of Research** | 1. Space weather<br>2. Ionosphere ‑ thermosphere system<br>3. Magntosphere ‑ ionosphere coupling<br>4. Geomagnetic storms<br>5. Magnetospheric substorms<br>6. Solar wind processes |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>Space weather changes when solar disturbances (like solar flare, interplanetary coronal mass ejections or ICME, Solar energetic particles) or interplanetary disturbances (like corotation interaction region or CIR) travel through the interplanetary medium and hit the terrestrial magnetosphere and ionosphere. During | |

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| | space weather events, radiation, energetic particles and electric field perturbations affect the near-earth geo-space. During geomagnetic storm under the influence of southward interplanetary magnetic field, the global magnetosphere and ionosphere undergo drastic changes. This alter the neutral and plasma dynamics, changes neutral composition and wind patterns and also generates plasma irregularities in the uppermost plasma layers of the earth. In addition, violent reorganization of the nightside magnetosphere also release enormous energy into the magnetosphere-ionosphere system. This is known as substorm. The relationship between storms and substorms, the impact of these processes on the near earth geospace are a few important research topics that need critical attention. These scientific issues are also pertinent in the context of navigational and other technological applications in space.<br><br>Expected deliverables include critical understanding on the plasma and neutral dynamical processes in the ionosphere-thermosphere system and electro-dynamical coupling between magnetosphere and ionosphere during geomagnetic storms and magnetospheric substorms. |

| **PRL - 007** | | |
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| 1 | **Name of ISRO Centre/Unit** | Physical Research Laboratory (PRL), Ahmedabad |
| 2 | **Title of the research proposal** | Quantum sensors and Quantum Metrology |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr. R.P. Singh |
| 4 | **Contact Address of CoPI and Phone Number** | AMOPH,<br>Physical Research Laboratory (PRL)<br>Ahmedabad– 380009, Gurarat<br>Phone:079-26314959 |
| 5 | **Area of Research** | Singular Optics and Quantum Optics |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>Entangled photons can be used for supersensitive sensing of many physical parameters of a system as well as for their precise measurements.<br><br>We would be producing higher dimensional multi-photon entangled states in our laboratory and apply them for supersensitive sensing and precision metrology.<br><br>As deliverables, we would be demonstrating supersensitive measurement of angular displacement of an object. | |

| NRSC - 001 | | |
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| 1 | **Name of ISRO Centre/Unit** | National Remote Sensing Centre (NRSC), Hyderabad |
| 2 | **Title of the research proposal** | Using Virtual Reality to control rovers remotely and mapping the remote environment |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Aarathi Ramesh M |
| 4 | **Contact Address of CoPI and Phone Number** | DPPA&WAA/G&WGS/BPM<br>National Remote Sensing Centre (NRSC)<br>Hyderabad, Shadnagar, Ranga Reddy, Telangana<br>Phone : 04023884588 |
| 5 | **Area of Research** | Virtual Reality, Remote Navigation |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>Remote controlled Rovers can be used in environments where it is not possible for humans to enter, places where the remote location is inaccessible or too dangerous for humans. For such cases, it is better to send remote controlled rovers. To control the rover remotely, it is required to map the rover environment and control the navigation precisely.<br><br>The rover's objective is to navigate in the desired environment and map the environment.<br><br>The rovers can be used as rescue rovers during disaster scenarios and also for mapping tourist places / archeological places. The output map to be published in Bhuvan.<br><br>**Deliverables:**<br><br>1. Hardware and software resources for developing virtual reality environment.<br>2. Sensors and controllers to help recognize the desired output from the human who is controlling the rover.<br>3. Hardware and software to detect sensor inputs and translate it to the rover navigation input.<br>4. Communication between rover and device to send navigation inputs and receive feedback and rover environment map.<br>5. Software to map the total rover environment.<br>6. The final output maps should be VR ready and can be navigation. | |

| NRSC - 002 | | |
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| 1 | **Name of ISRO Centre/Unit** | National Remote Sensing Centre (NRSC), |

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| | | Hyderabad |
| 2 | **Title of the research proposal** | Monitor and Assess the Air Pollution using IoT technology |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri Mahesh Pathakot |
| 4 | **Contact Address of CoPI and Phone Number** | Earth and Climate Science Area (ECSA)<br>National Remote Sensing Centre (NRSC),<br>Hyderabad ,Shadnagar, Ranga Reddy, Telangana<br>Phone:08542225460<br>e-mail:mahesh_p@nrsc.gov.in |
| 5 | **Area of Research** | Atmospheric Chemistry and Remote Sensing |
| 6 | **Summary of the proposed research and expected deliverables**<br>• The proposed work is aimed to real time monitoring of urban air quality interms of qualified pollutants using simple and efficient internet of things (IoT) technology with high spatial and temporal resolution in the urban areas.<br>• Air quality monitoring network (AQMN) is established using AWiFS satellite based sensor information.<br>• Thus, information on pollutants in different classes of study region (eg: Industries, Traffic and transport region, and residential zone) will be addressed.<br>• Ground truth IoTdata can be utilized to improve the satellite derived air quality parameters and better simulation of model output.<br>• IoT data on pollution can be integrated with micro meteorological observations to track the movement of pollutants.<br>• Create a dashboard tool that displays pollutants levels and their significance on air quality in real time.<br>• Link the real time data to NICES Bhuvan portal<br>**Progress through Outreach**<br>• Engage students with their environment.<br>• Train teachers, engage students to build air quality IoT sensors, deploy sensors, collect data, interpret and share results, identify causes of local air pollution.<br>• Easy of collecting large data with high spatial and temporal resolution.<br>• Real time feedback system on Air Pollution further helps to take decisions and identifying the problems.<br>• Leads for bettermonitoring/management of the environment.<br>Therefore, it is particularly important to set up a real-time air quality monitoring | |

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| | system (AQMS) to assess the micro level air pollution providing the prevailing information to the public. |

| NRSC - 003 | | |
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| 1 | **Name of ISRO Centre/Unit** | National Remote Sensing Centre (NRSC), Hyderabad |
| 2 | **Title of the research proposal** | Study of coastal aquifer system and seawater intrusion dynamics using High Resolution satellite image and ground geophysics through GPR Survey |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr. I C Das |
| 4 | **Contact Address of CoPI and Phone Number** | HGS, Geosciences Group<br>National Remote Sensing Centre<br>Hyderabad, Shadnagar, Ranga Reddy, Telangana<br>Phone: 040-23884227 |
| 5 | **Area of Research** | Ground water and Sea Water Intrusion |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>India has a very long coast line of 7516 km length. Around 10% of India's population lives in the area closer to the coast line. In this area, the freshwater aquifers are highly vulnerable to seawater intrusion and anthropogenic activities like aqua culture, salt pans etc. Fresh groundwater present in the shallow aquifers in these areas is the only source of drinking, domestic and irrigation uses. Effect of seawater intrusion in coastal aquifers is a major challenge for sustainability of these fresh water sources. Detailed characterization of the unconfined coastal aquifers is essential for prevention of sea water intrusion and remediation.<br><br>High resolution satellite images are useful to delineate the features of geomorphic importance in coastal areas. Ground Penetrating Radar (GPR) is the non-invasive geophysical technique that provides the high resolution profile of subsurface than any other geophysical techniques. GPR with deferent frequencies have the capability to detect water table as well as various layers present in the subsurface. Based on the penetration capacity it can also detect the saltwater/freshwater interface zones. 3D model can be generated using GPR data to understand the manifestations of subsurface layers as well as the dynamics of seawater intrusion in the coastal areas.<br><br>NRSC has successfully carried out GPR based shallow aquifer mapping in coastal Andhra Pradesh as a part of National Rural Drinking Water Program (NRDWP) of Ministry of Drinking Water and Sanitation (MoDWS), Govt. of India. | |

| NRSC - 004 | | |
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| 1 | **Name of ISRO Centre/Unit** | National Remote Sensing Centre (NRSC), Hyderabad |
| 2 | **Title of the research proposal** | Urban flood modelling |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr. K H V Durga Rao<br>Dr. Manjusree |
| 4 | **Contact Address of CoPI and Phone Number** | National Remote Sensing Centre<br>Hyderabad, Shadnagar, Ranga Reddy, Telangana<br>Phone: 040-23884541 |
| 5 | **Area of Research** | Hydrological modelling, flood forecasting, spatial modelling |
| 6 | **Summary of the proposed research and expected deliverables**<br>It is to develop spatial flood inundation simulation models for an identified urban area for providing flood forecast advisories. | |

| NRSC - 005 | | |
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| 1 | **Name of ISRO Centre/Unit** | National Remote Sensing Centre (NRSC), Hyderabad |
| 2 | **Title of the research proposal** | Algorithm development for automated extraction of flood inundated area using SAR images in real-time. |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr. K H V Durga Rao |
| 4 | **Contact Address of CoPI and Phone Number** | National Remote Sensing Centre<br>Hyderabad-500037, Shadnagar, Ranga Reddy, Telangana<br>Phone: 040-23884541; 08542225420<br>9440583027 |
| 5 | **Area of Research** | Disaster Management, Hydrological modelling |
| 6 | **Summary of the proposed research and expected deliverables**<br>In real-time flood monitoring and mapping activity turnaround time is very important. To minimise human interventions it is proposed to develop automated procedure for mapping of floods in near real-time and dissemination to the users. | |

| NRSC - 006 | | |
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| 1 | **Name of ISRO Centre/Unit** | National Remote Sensing Centre (NRSC), |

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| | | Hyderabad |
| 2 | **Title of the research proposal** | Development of SDSS tools for addressing emergency/disaster management |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr. K Rama Mohana Rao |
| 4 | **Contact Address of CoPI and Phone Number** | National Remote Sensing Centre<br>Hyderabad-500037, Telangana<br>Phone: 08542225413 |
| 5 | **Area of Research** | Disaster Management |
| 6 | **Summary of the proposed research and expected deliverables**<br>In disaster management decision making during relief and rescue operations is very crucial activity. To support this, customised GUI based DSS tools with the input of multi-scale database, near real-time data input from the field facilitate good decision making power for the disaster relief commissioners. | |

| **NRSC - 007** | | |
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| 1 | **Name of ISRO Centre/Unit** | Regional Remote Sensing Centre (RRSC) - East, NRSC, Kolkata |
| 2 | **Title of the research proposal** | Prediction of land cover change and future trends using time series satellite data: A Data Mining Approach |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri Niraj Priyadarshi |
| 4 | **Contact Address of CoPI and Phone Number** | Regional Remote Sensing Centre (RRSC) -East, (NRSC)<br>Dept. of Space, Govt. of India<br>Plot: BG-2, Action Area-1B, New Town<br>Kolkata – 700156, W.B.<br>Mob: 9007847769<br>Ph(O): 033-23410031<br>e-mail: nirajpriyadarshi007@gmail.com<br>niraj_p@nrsc.gov.in |
| 5 | **Area of Research** | Land cover change studies & monitoring |
| 6 | **Summary of the proposed research and expected deliverables**<br>Remote sensing data consisting of satellite observations of the land surface, biosphere, solid Earth, atmosphere and oceans, combined with historical climate records and predictions from ecosystem models, offer new opportunities for understanding how the Earth is changing, for determining what factors cause these changes and for predicting future changes. Data mining and knowledge discovery | |

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| | techniques can aid this effort by efficiently discovering patterns that capture complex interactions between ocean temperature, air pressure, surface meteorology and terrestrial carbon flux. There are a number of problems in the Earth science domain that have a data mining requirement due to the unique challenges posed by the types of data encountered in the domain.<br><br>Ecosystem-related observations from remote sensing data offer huge potential for understanding the location and extent of global land cover change. Hence, quantification of land cover change and its impact on ecosystem need to studied scientifically that influence by local climate, radiation balance, biogeochemistry, hydrology and the diversity and abundance of terrestrial species.<br><br>1) To develop prediction model as framework for land cover change and future trends based on parameters using time series satellite data.<br><br>2) To develop robust algorithms for change detection using data mining that is effective and can scale up to handle the large size of time series satellite data.<br><br>3) To develop algorithm for spatio-temporal event identification and characterization of land cover changes. |

| **NRSC - 008** | | |
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| 1 | **Name of ISRO Centre/Unit** | Regional Remote Sensing Centre - East, NRSC, ISRO |
| 2 | **Title of the research proposal** | Change prediction and modelling of dynamic natural Eco-system using remotely sensed image data |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr. (Mrs) Tanumi Kumar |
| 4 | **Contact Address of CoPI and Phone Number** | Regional Remote Sensing Centre - East, NRSC<br>Dept. of Space, Govt. of India<br>Plot: BG-2, Action Area-1B, New Town<br>Kolkata – 700156, W.B.<br>Mobile: 9674954068 |
| 5 | **Area of Research** | Image Processing and Machine Learning of Remotely Sensed Data, Study area/ ecosystem: Sundarban mangroves |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>The natural ecosystem is highly dynamic and exhibits a non-linear nature. The main objective of this research is to detect and analyze the changes of a coastal ecosystem within a time frame and develop a model that predicts the dynamics of the system and its biodiversity. The model will predict the eco-dynamics of the area through sub-pixel analysis of time series remotely sensed imagery and machine | |

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| | learning algorithms.<br><br>The objective is to approach this problem through nonlinear probability modeling, where prior knowledge is required to define a sensible state representation, together with parametric forms of transition and observation probabilities. In this research, the aim is to introduce a new approach to learning nonlinear dynamic systems and show that it performs well on rather high-dimensional time series datasets compared to standard models such as Hidden Markov Models or linear predictors.<br><br>From literature survey, it can be deducted that the dynamics of natural ecosystems have only been studied through physical monitoring and ground surveys. Predicting the outcome of competitive interactions between components of a natural ecosystem from satellite data in general (and from hyperspectral imagery in particular) can greatly overcome the limitations of ground surveys. The obtained results, verified through field visits, will illustrate that the proposed approach can interpret the dominance of certain classes and provide insights about their state of equilibrium or disequilibrium over a fixed time frame.<br><br>The developed prediction model (deliverable) will thus help to adopt a proper preventive, restoration and utilization measure of natural resources and can also be proposed on case-specific basis which would lead to sustainable management of the pristine natural ecosystem. |

| **NRSC - 009** | | |
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| 1 | **Name of ISRO Centre/Unit** | Regional Remote Sensing Centre- East, NRSC, Kolkata |
| 2 | **Title of the research proposal** | Water quality mapping along the Indian coasts: An integrated approach using remote sensing and *in-situ* observations |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr. Ch.V.Chiranjivi Jayaram |
| 4 | **Contact Address of CoPI and Phone Number** | Regional Remote Sensing Centre - East, NRSC<br>Dept. of Space, Govt. of India<br>Plot: BG-2, Action Area-1B, New Town<br>Kolkata – 700156, W.B<br>Phone: 033-23410022 (O), 8583039252 (M) |
| 5 | **Area of Research** | Oceanography |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>Coastal regions are complex and sensitive ecosystems and highly productive areas of the global oceans that are often exposed to various natural and man-made hazards. Changing climate, unplanned urbanization and exploitation of the coastal | |

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| | resources are dominant forces that induce fluctuations in these fragile ecosystems. Thus, it is imperative to establish robust water quality monitoring systems to provide reliable status of the coastal waters for their better management.<br><br>In situ observations provide the evolution of water quality parameters at very small scale both spatially and temporally, thus limiting the knowledge to a specific location and at the same time it is labour intensive. Whereas, remote sensing data provides information on a larger region at higher temporal resolution, economically. An integrated approach involving these two sources will improve the monitoring mechanism in the space-time domain of a specific area especially the Indian coasts. However, a comprehensive framework to monitor and assess the coastal water quality is lacking. Thus, the proposed study aims develop a framework for water quality monitoring using *in situ* and remote sensing products. |

| **NRSC - 010** | | |
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| 1 | **Name of ISRO Centre/Unit** | National Remote Sensing Centre (NRSC), Hyderabad |
| 2 | **Title of the research proposal** | Web enabled Data Analytics Tools for Geospatial Database of rural assets using Open Source tools |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr G S Pujar / Dr Stutee Gupta |
| 4 | **Contact Address of CoPI and Phone Number** | RDWMD, LRUMG, RSAA<br>National Remote Sensing Centre<br>Hyderabad-500037, Telangana |
| 5 | **Area of Research** | Big Data Analytics |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>Spatial analytics form critical part of understanding the patterns of governance investments, done through creation of development assets, especially in rural areas through flagship projects such as WDC-PMKSY, GEOMGNREGA & RKVY. Scale of the database is of the order Diversity of assets covering various aspects such as soil and water conservation, planting activity, developing fallow lands, flood control measures etc needs to be comprehended, in terms of spatial and temporal implementation as well as asset durability. Intrinsic patterns of asset database, need to be furnished through open source based online tools, addressing various stakeholders to realize the worth of or gaps in data, in turn to be used for future planning and maintenance of assets. Developing a pilot understanding of interaction of various spatial themes ranging from land use land cover to climate change themes is also essential to assess asset durability. In view of this requirement, development of open source based analytic framework needs to be developed and placed through bhuvan for consistent and clear rendition, feedback collection as well as quality flagging of information. The framework should address standard | |

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| | spatial analytical approaches covering spatial relations of assets within and across above mentioned themes, envelope based overlays of multiscale nature, creation of quality flags with respect to average data abundance/quality especially in a regionalized context. Open source tools such as R connected to web based processes through python programming need to be explored for design and development of the analytic product. Process adopted need to be furnished, as easy to comprehend capacity building module, so as to strengthen User Ministry stakeholders for long term utilization and internalization of technological approach in open source based spatial analytics. |

| **NRSC - 011** | | |
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| 1 | **Name of ISRO Centre/Unit** | National Remote Sensing Centre (NRSC), Hyderabad |
| 2 | **Title of the research proposal** | 3D mapping of soil properties |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr. K. Sreenivas |
| 4 | **Contact Address of CoPI and Phone Number** | Head, SLRAD, LRUMG, RSA<br>National Remote Sensing Centre<br>Hyderabad-500037, Telangana<br>Phone: 040-2388-4217<br>Mobile: 9246551206<br>e-mail: sreenivas_k@nrsc.gov.in |
| 5 | **Area of Research** | Remote Sensing Applications |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>Soil-landscape relation is quite complex in real world scenario and vary continuously in the space-time continuum. Soils and parent material show gradual variations in the horizontal and vertical planes forming 3D bodies that are commonly anisotropic. Till recent, the 2-D based soil mapping using visual as well as digital techniques are in vogue. Subsequently digital mapping methods are used to map one or a few soil properties spatially. Similarly the continued development of airborne remote sensing, geophysics and infrared measurement now provide tools that can assist in the mapping of soil structure and properties rapidly in 2D, 3D and even 4D.<br><br>The need of the hour is to map the soil properties three dimensionally using geo-statistical approaches like radial basis function (RBF), krigging or data mining tools such as neural networks, Cubist, random forests, etc. or a combination of both. Besides, the 3-D visualization of soil properties using open source tools like openGL with geo-spatial querying will provide a new dimension to the way the soils are looked at. Such information will form a base line to develop 3D process based | |

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| | models involving pedo-transformations. |

| NRSC - 012 | | |
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| 1 | **Name of ISRO Centre/Unit** | National Remote Sensing Centre (NRSC), Hyderabad |
| 2 | **Title of the research proposal** | Object-based approach for Mapping & Monitoring land degradation |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr. K. Sreenivas |
| 4 | **Contact Address of CoPI and Phone Number** | Head, SLRAD, LRUMG, RSA<br>National Remote Sensing Centre<br>Hyderabad-500037, Telangana<br>Phone: 040-2388-4217 (o)<br>Mobile: 9246551206<br>e-mail: sreenivas_k@nrsc.gov.in |
| 5 | **Area of Research** | Remote Sensing Applications |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>Hitherto, land degradation (LD) is being mapped using visual interpretation approaches on multi-temporal satellite data. The main problem in such approach is lack of consistency in the outcome especially, when complex logic of multi-season satellite data interpretation is involved. Digital techniques through provide limited accuracy but greater spatial consistency in deriving information. For implementation of land degradation action plan, very large scale maps are required. Generating such information using normal visual techniques for entire country could attract huge time and cost. As an alternative for this type of visual interpretation technique, the digital extraction of land degradation classes from fine spatial resolution satellite imagery is required. So, there is a need to develop a suitable and efficient object oriented method to map and monitor land degradation processes so as to generate action plans to achieve the land degradation neutrality.<br><br>The study will address, development of automatic object based land degradation information retrieval using multi-temporal high resolution remote sensing data along with ancillary data. The study is anticipated to develop software tools using open source object based classification algorithms or to develop new object based classification techniques to map land degradation on 1:10000 to 1:5000 scale. | |

| NRSC – 013 | | |
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| 1 | **Name of ISRO Centre/Unit** | Regional Remote Sensing Centre- South<br>NRSC, Bengaluru |

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| 2 | **Title of the research proposal** | Nutrient modeling of soil for assessing the soil health and sustenance of soil fertility |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr. S. Rama Subramoniam |
| 4 | **Contact Address of CoPI and Phone Number** | RRSC-S, NRSC,<br>ISITE Campus, Karthik Nagar<br>Outer ring road<br>Bengaluru, Karnataka<br>Landline: 08023026039<br>Mobile: 9481379482 |
| 5 | **Area of Research** | Agriculture and Soils |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>Decline in soil fertility does not get the same public attention as that of floods, droughts, pest infestation *etc.*, since it is a gradual process and not associated with catastrophes and mass starvation and therefore largely invisible. This necessitates a regular monitoring of changes in soil fertilitythat occurs in the soil**.** For understanding the role of different process a budgetary approach offers good toolthrough analyzing the turnover of nutrients in the soil-plant system at different spatial scales. Nutrient balances can provide an early indication of potential problems arising from a nutrient surplus or a deficit, increasing the risk of toxicities or deficiencies, respectively, both of which reduce crop yields. This project is being proposed to give solutions by identifying the root cause and assessing the nutrient inflows and outflows from the system i.e at field level, farm level and regional level. This will be done in a holistic manner by using nutrient budgeting model viz. NUTMON, etc in terms of nutrient stocks / flows as an crop / cropping system and farm as a whole and also as a district /regional level to know about the status of their soils and the strategies needed to sustain the fertility besides explore the possibilities for increasing the crop productivity in a environmentally sustainable way. High resolution data like CARTOSAT and LISS IV may be used in this study. Spatial variability of soils and nutrients availability is major components of this proposed study.<br><br>**Expected Deliverables:**<br><br>➢ A Model / Decision Support System will be developed for assessing the soil nutrient balance by considering all ways and means of inflow and outflow from the agro ecosystem<br><br>➢ Nutrient balance assessment at plot, crop activity and regional level will be a useful tool at the hands of policy makers, researchers and soil testing personnel to evolve strategic decision on policy interventions<br><br>➢ DSS will assist the farming community to achieve economic and social prosperity through Best Farm Management Practices. | |

| NRSC - 014 | | |
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| 1 | **Name of ISRO Centre/Unit** | National Remote Sensing Centre (NRSC), Hyderabad |
| 2 | **Title of the research proposal** | Estimation of the incoming long wave radiation under cloudy sky condition |
| 3 | **Name of Co PI from ISRO Centre/Unit** | NidhiMisra<br>Anurag Mishra |
| 4 | **Contact Address of CoPI and Phone Number** | WRG/RSAA<br>National Remote Sensing Centre (NRSC)<br>Balanagar, Hyderabad-500037, Telangana<br>Phone: 040-23884549 |
| 5 | **Area of Research** | Remote Sensing |
| 6 | **Summary of the proposed research and expected deliverables**<br>Estimation of net long wave radiation is important for the surface radiation budget calculation, which controls the evapotranspiration from the earth surface. Incoming longwave (4-100µm) radiation(ILR) depends on meteorological parameters i.e. air temperature and dew point temperature. Changes in the atmospheric conditions are mainly responsible for the change in air temperature and dew point temperature of the surface. The effective incoming longwave radiation to the earth surface becomes less in comparison to the clear sky condition as the cloud and aerosols present in the atmosphere absorb or reflect back some amount of radiation. The objective of this study is to estimate the incoming longwave radiation under the influence of the cloud and aerosol particles present in the atmosphere. Remote sensing techniques can calculate the aerosol particle concentration and cloud conditions present in atmosphere from satellite derived datasets. Atmospheric condition state can be integrated with the current meteorological conditions for the ILR estimation.Various studies consider the cloud effect and estimated ILR based on cloud classification. First cloud type can be identified and proportionally ILR estimates can be obtained based on the in situ observations. The objective of this study is to include the cloudy conditions and estimate the instantaneous / daily incoming long wave radiation. Appropriate methods needs to be adopted for cloud classification from satellite derived datasets. Including the effect of aerosol and cloud ILR product is proposed to be estimated in this study.Further the generated ILR for all sky condition data sets can be validated with theground observations of the instantaneous /daily incoming long wave radiation of all sky conditions. | |

| NRSC - 015 | | |
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| 1 | **Name of ISRO Centre/Unit** | National Remote Sensing Centre (NRSC), |

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| | | Hyderabad |
| 2 | **Title of the research proposal** | Technique development for Snow Depth and Snow Water Equivalent retrieval from passive microwave sensors over Indian Himalayan region |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri. B Simhadri Rao |
| 4 | **Contact Address of CoPI and Phone Number** | WRAD, WRG,<br>National Remote Sensing Centre<br>Balanagar, Hyderabad-500037, Telangana<br>Phone: 040-23884551 |
| 5 | **Area of Research** | Snow Hydrology |
| 6 | **Summary of the proposed research and expected deliverables**<br>• Snow cover extent is one of the Essential Climate Variable (ECV). Snow cover and related parameters (Snow Depth and Snow Water Equivalent) are critical inputs for snowmelt runoff estimation. Operational retrieval of SD & SWE at medium-fine resolution scale enhances the accuracy of the snowmelt runoff quantification and forecasting.<br>• SD &SWE products (~25km resolution) are currently generated from passive microwave sensors such as AMSR2 (G-COM) at global level.<br>• The study proposes to develop an operational algorithm for snow parameters retrieval over Indian Himalayan region. Using passive MW data. Further, downscaling algorithms will be developed to generate medium to fine (5km to 1km) resolution products integrating terrain characteristics from DEM, Snow persistence, etc. Calibration & validation protocols will be developed.<br>• Expected Deliverables:<br>1. Technique development for deriving SD and SWE from passive microwave sensors<br>2. Downscaling algorithms for generating medium to fine (5km to 1km) resolutionSD & SWE products.<br>3. Calibration & Validation protocols. | |

| **NRSC- 016** | | |
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| 1 | **Name of ISRO Centre/Unit** | National Remote Sensing Centre (NRSC), Hyderabad |
| 2 | **Title of the research proposal** | Downscaling of Satellite Data/Model Derived Soil Moisture and EvapotranspirationProducts |
| 3 | **Name of Co PI from ISRO** | Saksham Joshi |

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| | **Centre/Unit** | Nidhi Misra |
| 4 | **Contact Address of CoPI and Phone Number** | WRG/RSAA<br>National Remote Sensing Centre (NRSC)<br>Balanagar, Hyderabad-500037, Telangana<br>Phone: 040-23884529 |
| 5 | **Area of Research** | Hydrological Modeling |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>Soil moisture (SM) and Evapotranspiration (ET) arethe key hydrologic state variable for understanding hydrologic processes, including runoff, infiltration, drought, crop growth, and many other phenomena. Their estimation at a finer grid resolution is essential for water resource planning and irrigation scheduling. These data can be obtained in several ways, including in-situ measurements, remote sensing techniques, soil moisture/ET accounting models and hydrological models. Satellite remote sensingis considered as the reliable measurement to monitor SM and ET conditions on a regional scale. One major challenge in using satellite estimated data is their coarse spatial resolution and inability to resolve sub-grid scale variability. To overcome these limitations, various statistical approaches have used a downscaling framework to achieve a higher spatial resolution data. A number of studies have attempted to downscalemicrowave soil moisture and ET products with help of vegetation cover and surface temperature information obtained from optical andthermal sensors. On the basis of land surface temperature and vegetation index triangular feature space a downscaling factor is estimated which is in turn used to improve the spatial variability of the coarse resolution parameters from either satellite or model derived. The notable advantagesof this type of methods are the multi-data sources and long-term records of the optical/thermal data. This study is expected to deliver fine resolution soil moisture and evapotranspiration data considering land surface parameters and columnar soil moisture profile up to root depth. This method of downscaling has strong implication and potential for obtaininghigh-resolution soil moisture with the use of all available soil moisture products such as AMSR-E, SMOS, SMAP, and ASCAT. To achieve the actual water budgeting or planning for the field size in India this study of downscaling ET can make significant changes which is closer to the actual field condition. | |

| NESAC - 001 | | |
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| 1 | **Name of ISRO Centre/Unit** | North Eastern Space Applications Centre (NESAC), Shillong |
| 2 | **Title of the research proposal** | Mapping elevation using Autonomous UAVs in Swarm with field acquisition and resolution control- A simulation |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr. Dibyajyoti Chutia |
| 4 | **Contact Address of CoPI and Phone Number** | North Eastern Space Applications Centre (NESAC)<br>Shillong<br>Umiam- 793 103<br>Megahalya<br>e-mail: d.chutia@nesac.gov.in<br>Phone: 9436100493/0364-2306714 |
| 5 | **Area of Research** | Autonomous flying of UAVs in swarm, artificial intelligence, object tracking and recognition |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>The idea of having personal assistant UAVs is inspired by currently available digital assistants on smartphones such as Google Assistant, Siri, Bixby and Cortana. These assistants are limited to the functionalities of the smartphone and can only perform some tasks that are a part of the flow (of native applications installed). The same idea can be extended to UAV hardware for applications in security, surveillance, asset tracking, agritech, pisciculture tracking, region mapping along with personal use cases such as hands-free photography, navigating, VR streaming, advertisement, etc. Current implementations involve sophisticated approaches that also involve satellites for high altitude imagery.Challenges to be met:<br><br>1. Redundancy needed in data acquisition<br>2. Improvement in resolution of acquired imagery<br>3. Loss due to hardware failure is to be recovered<br>4. Contingency in case of interruption in LOS/ signal loss<br>5. Provision target mapping mechanism<br>6. Provision for artificial intelligence and dynamic overlapping mechanism for image stitching<br><br>**Deliverables:**<br><br>A 3D simulation of image acquisition using dynamic number of drones considering following factors. | |

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| | • Dynamic number of drones<br>• Optimal path planning and higher capture area with flying ad-hoc networks<br>• Redundancy in images<br>• Multiple level/resolution images with terrain based resolution control<br>• Server connection at relay points / relay times to route new commands<br>• Auto mapping of area and entire area coverage evenif some drone fails ( if fuel/battery allows)<br>• Utilisation of partial failure drones in case of camera failure. i.e. to use drone as only relay point and not image acquisition drone.<br>• Consideration of elevation and out-of-range problem.<br>• Consideration of environmental factors such as wind.<br>• Reusable and modular python code for actual deployment. |

| NARL - 001 | | |
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| 1 | **Name of ISRO Centre/Unit** | National Atmospheric Research Laboratory(NARL), Gadanki |
| 2 | **Title of the research proposal** | Design and development of a temperature insensitive fiber optic infrared narrow bandpass filter |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr. Y. Bhavani Kumar |
| 4 | **Contact Address of CoPI and Phone Number** | National Atmospheric Research Laboratory<br>Gadanki 517112, Pakala Mandal, Chittoor District<br>Andhra Pradesh<br>Phone: 9908835611<br>e-mail: ypbk@narl.gov.in |
| 5 | **Area of Research** | Development of lidars for atmospheric studies |
| 6 | **Summary of the proposed research and expected deliverables**<br>It is proposed to design and develop a temperature insensitive fiber optic infrared narrow bandpass filter with the following requirements.<br>1. The temperature insensitive filter response will consider using a no core fiber in the filter design and can be operated for a wide range of temperatures.<br>2. The filter design considers a high transmission with steep edges is required. | |

| NARL - 002 | | |
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| 1 | **Name of ISRO Centre/Unit** | National Atmospheric Research Laboratory ( NARL), Gadanki |
| 2 | **Title of the research proposal** | Estimation of upper atmospheric (70-100 km height region) eddy dissipation rates using Doppler Medium frequency radar (2-3 MHz) for the safe reentry of space capsules/shuttles carrying astronauts |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr. T. K. Ramkumar |
| 4 | **Contact Address of CoPI and Phone Number** | National Atmospheric Research Laboratory<br>Gadanki 517112, Pakala Mandal, Chittoor District<br>Andhra Pradesh<br>Phone: 9393601996<br>e-mail: tkram@narl.gov.in |
| 5 | **Area of Research** | Middle Atmospheric Dynamics |
| 6 | **Summary of the proposed research and expected deliverables**<br>The dissipating atmospheric waves can cause highly-varying intense turbulent layers surrounding space capsules/shuttles while reentering the atmosphere from | |

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| | space with high mach speeds in the height region of 70-100 km. High time (few minutes) and spatial (few kilometers in horizontal and fraction of kilometers in the vertical) resolution measurement of wind velocities in this height region is a must to determine with less errors the atmospheric eddy dissipation rates, which is possible with medium (2-3 MHz) frequency Doppler radars. |

| **NARL - 003** | | |
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| 1 | **Name of ISRO Centre/Unit** | National Atmospheric Research Laboratory (NARL), Gadanki |
| 2 | **Title of the research proposal** | The role of Himalayan mountain generated atmospheric waves in the shrinking of glaciers and generating of ionospheric plasma turbulences |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr. T. K. Ramkumar |
| 4 | **Contact Address of CoPI and Phone Number** | National Atmospheric Research Laboratory<br>Gadanki 517112, Pakala Mandal, Chittoor District<br>Andhra Pradesh<br>Phone: 9393601996<br>e-mail: tkram@narl.gov.in |
| 5 | **Area of Research** | Middle atmospheric dynamics |
| 6 | **Summary of the proposed research and expected deliverables**<br>Variation in the wind flows, associated with latitudinal drifts of subtropical westerly jets due to Rossby waves overthe topography of the Himalayan mountains particularly in the western region of Himalayas (Jammu and Kashmir),causes generation of plethora of spectra of atmospheric waves that can easily reach to the ionosphere and modulate the ionospheric plasma characteristics leading to large disturbances of radio wave communication between the ground and space. A suite of atmospheric experimental facilities to measure wind and temperature in the whole height region from the troposphere to lower thermosphere over the Jammu and Kashmir can shed light on the role of various atmospheric processes in the fast shrinking of Himalayan glaciers and the generation mechanism of various kind of ionospheric plasma irregularities. | |

| **NARL - 004** | | |
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| 1 | **Name of ISRO Centre/Unit** | National Atmospheric Research Laboratory ( NARL), Gadanki |
| 2 | **Title of the research proposal** | Algorithm development for retrieving parameters from the space-borne radiance measurements |

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| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr. S. Sridharan |
| 4 | **Contact Address of CoPI and Phone Number** | National Atmospheric Research Laboratory<br>Gadanki: 517112, Pakala Mandal, Chittoor District<br>Andhra Pradesh<br>Phone: 9441981312<br>e-mail: susridharan@narl.gov.in |
| 5 | **Area of Research** | Atmospheric dynamics, energetic and coupling |
| 6 | **Summary of the proposed research and expected deliverables**<br>The vertical temperature profile and the vertical distribution of all the constituents determine the radiance emerging from the atmosphere and reaching the satellite sensor. Multichannel infrared radiometers on board meteorological satellites measure the radiances through limb or nadir viewing. Hence the temperature and minor constituents in different layers of the atmosphere can be retrieved using radiative transfer algorithm which uses set of integro-differential equations. The solutions for these equations can be obtained in terms of deriving source function (absorption or scattering) in the atmosphere. | |

| **NARL - 005** | | |
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| 1 | **Name of ISRO Centre/Unit** | National Atmospheric Research Laboratory (NARL), Gadanki |
| 2 | **Title of the research proposal** | Influence of photochemistry on middle atmospheric gravity waves |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr. S. Sridharan |
| 4 | **Contact Address of CoPI and Phone Number** | National Atmospheric Research Laboratory<br>Gadanki: 517112, Pakala Mandal, Chittoor District<br>Andhra Pradesh<br>Phone: 9441981312<br>e-mail: susridharan@narl.gov.in |
| 5 | **Area of Research** | Atmospheric dynamics, energetic and coupling |
| 6 | **Summary of the proposed research and expected deliverables**<br>Gravity waves play a major role in determining thermal structure, mean circulation and distribution of chemical constituents of the atmosphere. In the middle atmosphere, the basic processes include photochemical, dynamical and radiative processes. This study aims to understand the role of photochemical heating on the middle atmospheric gravity waves. Using a linear diabatic gravity wave model, whether photochemistry damps or destabilizes or enhances gravity waves can be understood. The temperature dependency can also be studied. | |

| URSC - 001 | | |
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| 1 | **Name of ISRO Centre/Unit** | U R Rao Satellite Centre (URSC), Bengaluru |
| 2 | **Title of the research proposal** | On-board Image Processing techniques for estimation and correction of spacecraft jitter to improve the geometric performance of satellite images |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri Singh Khoral |
| 4 | **Contact Address of CoPI and Phone Number** | MDG,<br>U R Rao Satellite Centre<br>Bangalore – 560 017, Karnataka<br>Phone : 080-25082655<br>e-mail : jsk@isac.gov.in |
| 5 | **Area of Research** | Image Processing / Robotics |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>High resolution satellite images obtained from linear array CCD sensor have been widely used in surveying and mapping. For satellites equipped with CCD linear array sensorsthe attitude jitter, refers to the instability and distortion of satellite attitude, could deteriorate the mapping accuracy of high resolution satellites in both plane and height. For the majority of remote sensing satellites currently in use, the attitude information is estimated by interpolating the measurement data of star-tracker and gyros sampled at a relatively low frequency. As the frequency of satellite jitter is higher than the sampling rate of attitude data, the geometric processing of imagery would be affected by the undetected and uncompensated attitude distortions. Moreover, the requirement of attitude stability will become more and more severe with increasing spatial resolution of remote-sensing missions. Therefore, it is necessary to estimate and correct the spacecraft attitude jitter information accurately with additional methods in order to improve the geometric performance of satellite images.<br><br>**1. Jitter compensation at ISRO**<br><br>Currently, the attitude jitter is estimated and corrected on ground. This is proceeded by a campaign to calibrate the on-board gyros & star trackers. However, as noted earlier these methods are post-facto and make a significant contribution to the data product turnaround time. | |

| URSC - 002 | | |
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| 1 | **Name of ISRO Centre/Unit** | U R Rao Satellite Centre (URSC), Bengaluru |

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| 2 | **Title of the research proposal** | Integrated optics for Microwave photonics |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri Yogesh Prasad K R |
| 4 | **Contact Address of CoPI and Phone Number** | CSG<br>U R Rao Satellite Centre<br>Bangalore – 560 017, Karnataka<br>e-mail : kryogesh@isac.gov.in<br>Phone: 080-25083338 |
| 5 | **Area of Research** | Integrated Optics, Power Electronics |
| 6 | **Summary of the proposed research and expected deliverables**<br>**1. Introduction:**<br>The technology of electronic integrated circuits has shown rapid development over the past few decades and has led to complex and powerful electronic devices. Integrated Optics is a field that is inspired by these developments. Integrated Optics (IO) refers to the technology that enables fabrication of Integrated Optical Devices or Planar Light wave Circuits. The circuits can comprise of several optical components, active as well as passive, that are integrated to fulfil a given requirement. Integrated Optics can be used to fabricate miniaturized optical components such as Waveguides, Filters, Electro-optic Amplitude and Phase Modulators, Optical amplifiers, Lasers, Photodetectors etc.<br>**2. Microwave Photonics based approach at URSC:**<br>Experiments demonstrating generation of microwave carriers by optical heterodyning, electro-optic modulation etc are already in progress at URSC. | |

| **URSC - 003** | | |
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| 1 | **Name of ISRO Centre/Unit** | U R Rao Satellite Centre (URSC), Bengaluru |
| 2 | **Title of the research proposal** | Use of Artificial Intelligence (AI) / Expert Systems (ES) / Machine Learning (ML) in Mission operations |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri Singh Khoral |
| 4 | **Contact Address of CoPI and Phone Number** | MDG<br>U R Rao Satellite Centre<br>Bangalore – 560 017, Karnataka<br>e-mail: jsk@isac.gov.in<br>Phone: 080-25082655 |
| 5 | **Area of Research** | Artificial Intelligence, Expert Systems, Machine |

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| | | Learning, Neural Networks, Fuzzy Logics, Natural Language Processing, Genetic Algorithms, Robotics. |
| 6 | **Summary of the proposed research and expected deliverables**<br>**1. Introduction:**<br>With increase in launch frequency, a large number of spacecraft with varying configurations, orbital slots, payloads, applications have to be maintained in peak operating conditions with very low or nil downtime for the duration of their useful mission lifetimes (ranging from months to decades). This trend demands a high degree of automation of on-board and ground operations, and this is where use of techniques from artificial intelligence for spacecraft health monitoring and anomaly handling is really beneficial. The applications of AI include expert systems, Neural Networks (NN), Fuzzy Logics (FL), Natural Language Processing (NLP), Genetic Algorithms, robotics and machine learning. Spacecraft operations broadly classify into two categories namely Health Monitoring & Anomaly Management and Planning and Execution of routine planned activities.<br>**2. Mission Operations automation at MDG/URSC**<br>Virtual satellite operation is planned to optimise the utilization of the ground segment resources, viz. infrastructure and human. Towards this, an expert system based Health Monitoring and Anomaly Management is being developed. The automation of Planning and Execution of routine operations is also in progress. | |

| **URSC - 004** | | |
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| 1 | **Name of ISRO Centre/Unit** | U R Rao Satellite Centre (URSC), Bengaluru |
| 2 | **Title of the research proposal** | Design and development of miniaturized atomic frequency standard |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri J. John |
| 4 | **Contact Address of CoPI and Phone Number** | Head, MEMS Section<br>LEOS, Blore – 560 058, Karnataka<br>e-mail: jjohn@leos.gov.in<br>Phone: 080-22685252 |
| 5 | **Area of Research** | Optics, Atomic Physics, Micro Fabrication, Electronics. |
| 6 | **Summary of the proposed research and expected deliverables**<br>**1. Introduction:**<br>High accuracy frequency standards are the heart of many advanced space applications. Some typical examples include satellite navigation systems and | |

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| | precision clocks for high speed communication networks. In addition, many scientific missions also need high accuracy timing that is not possible to be achieved using conventional crystal oscillators. Present day atomic frequency standards for space applications are complex systems that comprise of gas filled cells and discharge lamps. These systems are bulky and power hungry and also seen leaking of the gas from the cells. They are based on 'Optical Pumping' technique that involve the use of a microwave cavity where the frequency of the microwave signal is locked to selected ground state hyperfine level via feedback through a resonant optical absorption. The atomic system is that of an alkali metal vaporform($Rb^{87}$ or $CS^{133)}$. These devices cannot be miniaturized beyond a limit due to the minimum size constraint of microwave cavity.<br><br>In Coherent Population Trapping (CPT) based standards, there is no requirement of an external microwave field, the interrogation technique is all optical. With the availability of compact semiconductor laser that can be modulated, miniaturization of atomic frequency standards has become a practical reality. One of the key components of the frequency standards or clock is the vapor cell that holds the alkali vapor in a gaseous state. MEMS based technologies are now being used to develop miniaturized vapor cells.<br><br>**2. Vapor Cell Development in LEOS:**<br><br>LEOS has initiated developmental work towards the realization of alkali vapor cells fabricated using MEMS technology. The main facilities required for cell fabrication are lithography, silicon Deep Reactive Ion Etching (DRIE) and anodic bonding. Processes for cell fabrication, insertion of alkali compound pill and into the cell, sealing and activation are being developed in LEOS. |

| **URSC - 005** | | |
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| 1 | **Name of ISRO Centre/Unit** | U R Rao Satellite Centre (URSC), Bengaluru |
| 2 | **Title of the research proposal** | Verification and validation of satellite onboard software (AOCE, TCP, BDH, SSR, SPS) using Model Checking |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Ms.Manoja J, |
| 4 | **Contact Address of CoPI and Phone Number** | RQAG,<br>U R Rao Satellite Centre<br>Bangalore – 560 017, Karnataka<br>e-mail: daffini@isac.gov.in<br>Phone: 080-25083629/3757 |
| 5 | **Area of Research** | Software Engineering, Embedded Systems, Software Quality Assurance |

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| 6 | **Summary of the proposed research and expected deliverables**<br><br>**1. Introduction:**<br><br>Model Checking is a particular formal method which takes in "a finite model of the system" and "a formally written property" and verifies whether the system satisfies the property by making an exhaustive search for counter-examples. Models addresses the system behaviour and the properties prescribe what the system should do / should not do.<br><br>For the verification and validation of Satellite Onboard software, the code written in ADA language needs to be converted into abstract model and the system/software specifications to be converted to properties understandable by the model checker. Once the system is modeled, the model checker explores the systems state space in order to determine satisfaction or violation of property.<br><br>**2. Model Checking at URSC:**<br><br>✓ It is proposed to make a system that will automatically generate abstract model from the ADA implementation of code and extract properties from the system specification and should automatically generate test cases/test scripts which can be executed in the in-house developed Software in Loop Simulator(SILS).<br><br>✓ On-board Software Quality Assurance Division(OSQD), URSC has done **a pilot project on the applications of Model Checking on AOCS software verification**. Modelling and analysis was done on Mars Orbiter Mission (MOM) software. It was demonstrated that early detection of bugs is possible.<br><br>✓ **Presently** the model checking technique is being **applied in the V&V of Chandrayaan2 NGCE Vikram Autonomy Software.** |

| **URSC - 006** | | |
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| 1 | **Name of ISRO Centre/Unit** | U R Rao Satellite Centre (URSC), Bengaluru |
| 2 | **Title of the research proposal** | Development of a Micro Heat Pipe for Electronics Cooling |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri J. John |
| 4 | **Contact Address of CoPI and Phone Number** | Head, MEMS Section,<br>LEOS, Bangalore – 560 058, Karnataka<br>e-mail: jjohn@leos.gov.in<br>Phone: 080-22685252 |
| 5 | **Area of Research** | Thermal Engineering, Micro Fabrication |

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| 6 | **Summary of the proposed research and expected deliverables**<br><br>**1. Introduction:**<br><br>Heat pipe is one of the efficient examples of thermal management systems. It operates by taking the advantage phase change.Conventional heat pips are larger in size and not suitable for transferring heat from localised hot spots in electronics. Hence an attempt is being made at LEOS to develop Micro heat pipe based upon MEMS architecture.<br><br>MEMS based heat pipes have the advantage of fabricating channels and structures down to few microns' dimensions. Embedded directly on the hot spots in electronic circuits, micro heat pipes can act as a passive heat transferring thermal management system which has wide range applications in space based systems as they are compact and lighter. From the operational perspective, the heat pipe is a closed cycle where within an evacuated closed tubular chamber fluid evaporates at the hot end and condenses at the cooler end, thus enabling heat transfer.<br><br>**2. Micro Heat Pipe Development at LEOS:**<br><br>Work done in LEOS so far includes designing and fabrication of micro heat pipes, charging them appropriately, sealing and testing them to study its heat transferring properties. Photolithographic masks were designed with respect to the ideas obtained from literature and Silicon based Micro heat pipes were fabricated and tested with in house MEMS fabrication facility and testing facility.There is a further scope to improve upon design and testing methodology to have better understanding on these promising devices to make them suitable for space application. |

| **URSC - 007** | | |
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| 1 | **Name of ISRO Centre/Unit** | U R Rao Satellite Centre (URSC), Bengaluru |
| 2 | **Title of the research proposal** | Natural language query based data analysis and control in spacecraft Mission Health Management and Operations |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri Nitin Bhardwaj |
| 4 | **Contact Address of CoPI and Phone Number** | MDG,<br>U R Rao Satellite Centre<br>Bangalore – 560 017, Karnataka<br>e-mail: nitin@isac.gov.in<br>Phone: 080-25082843 |
| 5 | **Area of Research** | Optimization Methods/ Operations Research/ Optimal Control |

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| 6 | **Summary of the proposed research and expected deliverables**<br>**1. Introduction:**<br>Natural Query Processing is in high demand today from home appliances to high end electronics. User wants the results based on the inputs he gives in his own language. Natural language interfaces could actually perform useful services.<br>In spacecraft health monitoring current practices requires aid of new domain where operation user or subsystem user gives the input to the system in natural language and in return system gives him results as he is viewing today by using multiple software and tools.The system shall process user query, generates proper inputs to multiple offline software,fetches the results from software, consolidates them and present it to user in his desired formats such as plots, tabulation, statistics, graphs etc. The building blocks for natural language processing include a semantic data model that is generated from a mix of inputs. It starts with the metadata from data model, which provides a Software Designer view of the data structure. To converse with humans, a program must understand syntax (grammar), semantics (word meaning), morphology (tense) and pragmatics (conversation). The system based on natural query processing on spacecraft health data will not only change the paradigm of data analysis and control in spacecraft control centres but also it will makeusers transparent of software functionalities and their usages. |

| **URSC - 008** | | |
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| 1 | **Name of ISRO Centre/Unit** | U R Rao Satellite Centre (URSC), Bengaluru |
| 2 | **Title of the research proposal** | Development of Stepper and BLDC motors for space applications |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri Arun Kumar Gupta, |
| 4 | **Contact Address of CoPI and Phone Number** | SMG,<br>U R Rao Satellite Centre<br>Bangalore – 560 017, Karnataka<br>e-mail: arun@isac.gov.in<br>Phone: 080-25082421/2405 |
| 5 | **Area of Research** | Electrical Engineering |
| 6 | **Summary of the proposed research and expected deliverables**<br>**1. Introduction:**<br>Spacecraft mechanisms require many types of electro-mechanical (EM) drives where continuous, intermittent, forward and reverse motion is needed for multiple operations. These EM drives are typically used for the steering and pointing of Antenna, deployment and rotation of various appendages like reflectors, Cameras, | |

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| | Solar panels etc. These drives invariably use Motors as the driving element. The commonly used motors for space application are Stepper motors and Brushless DC (BLDC) motors.<br><br>**2. Motor Configuration at URSC:**<br><br>a) **Stepper motor**: 2-phase, Bi-polar drive permanent magnet and Hybrid types are used both in Frameless and Housed configuration with Torque range of 20 mNm to less than1 Nm.<br><br>b) **BLDC motor**: 2-phase (Sinusoidal winding) and 3-phase (Star or Y-winding) are used both in Frameless and Housed configuration with Torque range of 20 mNm to less than1 Nm. |

| **URSC - 009** | | |
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| 1 | **Name of ISRO Centre/Unit** | U R Rao Satellite Centre (URSC), Bengaluru |
| 2 | **Title of the research proposal** | Leon3/4 Core software simulator development for performance analysis of onboard software |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri Kiran Desai |
| 4 | **Contact Address of CoPI and Phone Number** | RQAG,<br>U R Rao Satellite Centre<br>Bangalore – 560 017<br>e-mail: kirandes@isac.gov.in<br>Phone: 080-25083664 |
| 5 | **Area of Research** | Software Engineering, Embedded Systems, Quality Assurance |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>**1. Introduction:**<br><br>URSC is the lead centre of the Indian Space Research Organisation in the development and operationalisation of satellites for communication, navigation and remote sensing applications. In all these spacecrafts, highly advanced embedded systems carryout variety of mission critical functions. A typical example of such a system is the satellite Attitude and Orbit Control Electronics –the Onboard computer which is the brain of the satellite. As per existing practices, Performance analysis and testing of on board software to confirm its functioning in a simulated dynamic environment takes place only when the software is integrated with OBC hardware and system level tests in closed loop mode are conducted.<br><br>On the contrary, by the new technique called the Software In Loop Simulation (SILS) test method, the on-board software can be fully tested in a software simulated dynamic environment without OBC hardware. This method of closed loop | |

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| | flight software validation is demonstrated with AOCS-BMU software using SILS test bed. In development environments where software requirements are too complex and requirement changes are to be incorporated even during final stages of development, this technique offers an excellent solution in fully validating on board software at source code level before it gets integrated with target hardware. This additional validation step not only improves software quality but also enhances productivity and reduces system turnaround time. |

| **URSC - 010** | | |
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| 1 | **Name of ISRO Centre/Unit** | U R Rao Satellite Centre (URSC), Bengaluru |
| 2 | **Title of the research proposal** | Development of end effectors for spacecraft berthing and sample retrieval |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri Abhinandan Kapoor |
| 4 | **Contact Address of CoPI and Phone Number** | SMG,<br>U R Rao Satellite Centre<br>Bangalore – 560 017, Karnataka<br>e-mail: akapoor@isac.gov.in<br>Phone: 080-25082460 |
| 5 | **Area of Research** | Mechanical Engineering, Electronics, Mechatronics, Robotics, Controls |
| 6 | **Summary of the proposed research and expected deliverables**<br>**1. Introduction:**<br>In robotics, an end effector is the device at the end of a robotic arm, designed to interact with the environment. The exact nature of this device depends on the application. The end effector means the last link (or end) of the robot. At this endpoint the tools are attached.<br>**2. Application of End effectors:**<br>**a) Spacecraft Berthing**: Spacecraft berthing deals with capture of target spacecraft with a chaser spacecraft using a robotic arm which is also known as soft docking. This is used for fuel replenishment, power transfer, crew and cargo transfer for unmanned and manned missions. End effectors for above application consist of a gripper which grasps the target spacecraft at the grappling interface and brings the target spacecraft near to chaser spacecraft in a controlled fashion for docking.<br>**b) Sample Retrieval**: Sample retrieval from extra-terrestrial terrain to earth offers advantages of carrying out multiple tests on different instruments available at present and those that would be available in the future. This | |

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| | gives an edge over the limited in situ tests that can be performed otherwise during the limited life of the mission.A robotic arm mounted over a spacecraft/landercraft/rover assisted with end effectors can be suitably used to collect and retrieve soil or rock samples back to earth. End effectors need to be designed to facilitate surface/subsurface excavation and subsequentencapsulation and storage in the return capsule to ensure contamination free samples retrieval to earth. |

| **URSC - 011** | | |
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| 1 | **Name of ISRO Centre/Unit** | U R Rao Satellite Centre (URSC), Bengaluru |
| 2 | **Title of the research proposal** | Indigenous development of LC Filters, isolators |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Nirupam Sharma |
| 4 | **Contact Address of CoPI and Phone Number** | HIG,<br>U R Rao Satellite Centre<br>Bangalore – 560 017, Karnataka<br>e-mail: nirupam@isac.gov.in<br>Phone: 080-25082019/2017 |
| 5 | **Area of Research** | Electrical Engineering, Electronics |
| 6 | **Summary of the proposed research and expected deliverables**<br>**1. Areas of Collaboration with Academic Institution:**<br>• Development of LC filters and Isolators indigenously. | |

| **URSC - 012** | | |
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| 1 | **Name of ISRO Centre/Unit** | U R Rao Satellite Centre (URSC), Bengaluru |
| 2 | **Title of the research proposal** | Use of optimization techniques in Mission Operations |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri Jasvinder Singh Khoral |
| 4 | **Contact Address of CoPI and Phone Number** | MDG,<br>U R Rao Satellite Centre,<br>Bangalore – 560 017, Karnataka<br>e-mail: jsk@isac.gov.in<br>Phone: 080-25082655 |
| 5 | **Area of Research** | Optimization Methods/ Operations Research/ Optimal |

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| | | Control |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>**1. Introduction:**<br><br>With increase in launch frequency, a large number of spacecraft with varying configurations, orbital slots, payloads & applications have to be operated with very limited resource availability – both human and systems. This trend demands a high degree of co-ordination & optimal usage of scarce on-board and ground resources, and this is where the use of sophisticated optimization techniques is critical to maximize efficiency and throughput. The applications of optimization techniques should result in the optimal scheduling of spacecraft payload operations pooling all user requests across all available spacecraft / sensors, taking all the operational and configurational constraints into account. The second aspect relates to the resource allocation problem. As the ground systems resources – antennas / data links / TTC stations - are scarce and expensive, the large increase in spacecraft numbers calls for the efficient and clash-free allocation of these resources. Suitable optimization techniques are required to model the problem and optimally allocate / utilize these resources.<br><br>**2. Optimization at MDG:**<br><br>Currently, the spacecraft payload operations and resource allocations are done in a heuristics based approach that may be sub-optimal as the number of spacecraft increase. | |

| SDSC - 001 | | |
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| 1 | **Name of ISRO Centre/Unit** | Satish Dhawan Space Centre- SHAR (SDSC-SHAR), Sriharikota |
| 2 | **Title of the research proposal** | Visualization and characterisation of Ignition Overpressure wave from Blast Generator |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri Senthil Kumar R |
| 4 | **Contact Address of CoPI and Phone Number** | SMP & ETF,<br>Satish Dhawan Space Centre- SHAR<br>Sriharikota: 524 124, Andhra Pradesh<br>Phone: 08623 – 227719/ 227563<br>e-mail: senthil@shar.gov.in |
| 5 | **Area of Research** | Shock wave Visualization and Blast waves |
| 6 | **Summary of the proposed research and expected deliverables**<br>Huge solid rocket motors has the inevitable side effect of generating overpressure waves during their startup transient period. The ignition Over pressure have a significant effect on the vehicle dynamics during the initial moments of lift-off. Considering the future launch vehicle with huge solid rocket motors, it is imperative to study the generation, interaction and suppression of such waves with the vehicle in a scale model facility. Blast Generator is required for such studies.<br>Studies by academia experts in the field of detonation or blast waves has to be conducted. Also the setup has to be simulated numerically for blast wave propagation and interaction. Further the numerical simulation has to be validated by the experimental results. | |

| SDSC - 002 | | |
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| 1 | **Name of ISRO Centre/Unit** | Satish Dhawan Space Centre- SHAR (SDSC-SHAR), Sriharikota |
| 2 | **Title of the research proposal** | Real time measurement of Agni burning rate using ultrasonic sensor |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri Senthil Kumar R |
| 4 | **Contact Address of CoPI and Phone Number** | SMP & ETF,<br>Satish Dhawan Space Centre- SHAR<br>Sriharikota: 524 124, Andhra Pradesh<br>Phone: 08623 – 227719/ 227563<br>e-mail: senthil@shar.gov.in |
| 5 | **Area of Research** | Combustion |

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| 6 | **Summary of the proposed research and expected deliverables**<br><br>Burning rate measurement is the most crucial with respect to full scale motor burning rate and chamber pressure prediction. The existing method is through the pressure time curve from the Agni motor firing and involves uncertainty due to the indirect approach of measurement.<br><br>The regular Agni motor can be designed with provision for the Ultrasonic sensor mounting. By using proper signal processing, the burning rate can be measured/calculated. Ultrasonic sensor for Real time measurement of Agni burning rate has to be developed by Academia. |

| **SDSC - 003** | | |
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| 1 | **Name of ISRO Centre/Unit** | Satish Dhawan Space Centre- SHAR (SDSC-SHAR), Sriharikota |
| 2 | **Title of the research proposal** | Multi-objective design optimization strategy for launch pad configuration to reduce the impingement pressure, sound pressure on payload bay and launch pad construction and refurbishment cost from experimental data with surrogate gas simulation studies |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri Senthil Kumar R |
| 4 | **Contact Address of CoPI and Phone Number** | SMP & ETF<br>Satish Dhawan Space Centre- SHAR<br>Sriharikota: 524 124, Andhra Pradesh<br>Phone: 08623 – 227719/ 227563<br>e-mail: senthil@shar.gov.in |
| 5 | **Area of Research** | Launch Pad Design through optimization techniques |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>Launchpad design is complicated due to its dependence on multiple parameters. For example the jet deflector design depends on the configuration for minimum surface erosion and sound pressure at the payload fairing due to jet impingement. Also the geometry of the jet deflector hugely decides the construction and refurbishment cost. Hence there exists an optimum design space from these multiple parameters. A large bank of data will be generated from surrogate gas scale model experiments at SMP&ETF.<br><br>An optimization method like genetic algorithm (GA) need to be applied on this large data to evolve out the optimum design space. The experiments has to be proposed to conduct at SMP&ETF as mentioned above and the optimization is proposed to be | |

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| | carried out by the experts from academia. |

| SDSC - 004 | | |
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| 1 | **Name of ISRO Centre/Unit** | Satish Dhawan Space Centre- SHAR (SDSC-SHAR), Sriharikota |
| 2 | **Title of the research proposal** | Detection of toxic isocyanate vapors in solid propellant plant by a simple in expensive sampling instrument |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri P Kanakaraju |
| 4 | **Contact Address of CoPI and Phone Number** | DGM,MP,SPP<br>Satish Dhawan Space Centre-SHAR<br>Sriharikota: 524 124, Andhra Pradesh<br>Phone: 08623-225853 |
| 5 | **Area of Research** | Composite Solid Propellants |
| 6 | **Summary of the proposed research and expected deliverables**<br>Monitoring of isocyanate levels to check exposure limit is required to forewarn the people working in this area. Available monitoring systems provide significant statistical differences and interference problems, especially from humidity in the air. Hence a detector that detects TDI pollution in PPB levels using chemi-resistor sensor has to be developed. Chemical sensors transform the concentrations of analytes to other detectable physical signals, such as currents, absorbance, mass or acoustic variables. Organic semi conducting polymers will be selected because they are mechanically robust and work well in high humidity conditions for the synthesis of chemiresistor.<br>Deliverables: TDI detector. | |

| SDSC - 005 | | |
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| 1 | **Name of ISRO Centre/Unit** | Satish Dhawan Space Centre- SHAR (SDSC-SHAR), Sriharikota |
| 2 | **Title of the research proposal** | Statistical energy analysis (SEA) for random vibration prediction of avionic decks of launch vehicles and its validation through experiment using the aeroacoustic ambience of actual rocket motors |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri Senthil Kumar R |

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| 4 | **Contact Address of CoPI and Phone Number** | SMP & ETF,<br>Satish Dhawan Space Centre- SHAR (SDSC-SHAR)<br>Sriharikota: 524 124, Andhra Pradesh<br>Phone: 08623 – 227719/ 227563<br>e-mail: senthil@shar.gov.in |
| 5 | **Area of Research** | Acoustics |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>Statistical energy analysis (SEA) is the only reliable method to predict the vibration of avionic decks due to high frequency random excitation during lift-off and transonic regime. Compared to SEA, Boundary element methods (BEM) is effective only in the low frequency regime. Currently the expertise in this field in ISRO is very limited.<br><br>Hence SEA analysis has to be carried out for a typical launch vehicle avionic deck assembly and has to be validated using experiments at Agni solid rocket motor facility. The launch vehicle deck with simulated avionic packages will be placed in the aeroacoustic ambience from a solid rocket motor at Agni facility and the acoustic and vibration spectra at salient points will be measured.<br><br>The experiments, data analysis and modal characterization will be planned at SMP &ETF. The SEA simulation to be carried by the experts in the academia. | |

| **SDSC - 006** | | |
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| 1 | **Name of ISRO Centre/Unit** | Satish Dhawan Space Centre- SHAR (SDSC-SHAR), Sriharikota |
| 2 | **Title of the research proposal** | Developing a jet noise source localization technique using a microphone array with appropriate beam forming algorithms |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri Senthil Kumar R |
| 4 | **Contact Address of CoPI and Phone Number** | SMP & ETF,<br>Satish Dhawan Space Centre- SHAR<br>Sriharikota: 524 124, Andhra Pradesh<br>Phone: 08623 – 227719/ 227563<br>e-mail: senthil@shar.gov.in |
| 5 | **Area of Research** | Acoustics |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>Sound source localization using phased array microphone is followed normally for point sources. Adapting this method for the supersonic jet or in flow experiments is quite challenging due to the need for usage of advanced signal processing techniques. | |

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| | The proposal to develop a code for source localization of a supersonic jet using microphone array has to be taken up. With the help of this method a source localization package is envisaged for problems involving supersonic or subsonic flow problems.<br><br>It is expected that the signal processing expertise available with the academia on array sensor signal processing has to be effectively utilized for this purpose. The developed code can be further validated at SMP&ETF. |

| **SDSC - 007** | | |
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| 1 | **Name of ISRO Centre/Unit** | Satish Dhawan Space Centre- SHAR (SDSC-SHAR), Sriharikota |
| 2 | **Title of the research proposal** | Coherent integration for space objects tracking |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri V. Kumar |
| 4 | **Contact Address of CoPI and Phone Number** | MOTR - RO,<br>Satish Dhawan Space Centre- SHAR<br>Sriharikota: 524 124, Andhra Pradesh<br>Phone: 08623 – 225259 / 225256/9550981198 |
| 5 | **Area of Research** | Radar Signal Processing, Space Debris, High Performance Computing |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>Introduction:<br><br>Detection of low RCS targets with high speed and complex motions has been receiving a growing attention and significant research efforts in the modern radar field especially in space debris tracking.<br><br>It is known that the radar target detection performance can be improved significantly via long term coherent integration by compensating phase fluctuation among different sampling pulses. Nevertheless, the range migration (RM, due to velocity), linear Doppler frequency migration (LDFM, due to acceleration) and quadratic Doppler frequency migration (QDFM, due to jerk motion) may easily happen due to the targets complex motion during the long observation time.<br><br>Study case and Hardware implementation:<br><br>Real-time implementation of above procedure/algorithm is a good study case for High Performance Embedded computing platforms as it involves searching the velocity fold factor, estimating acceleration, jerk values and performing CLEAN algorithm for integrating multiple targets.<br><br>Multi Object Tracking Radar can track space debris of size 0.25sqmtr at a range of | |

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| | 1000Km; therefore implementing the above technique in MOTR will increase the slant range performance of the radar and also lead to detection of low RCS targets at smaller ranges. |

| SDSC - 008 | | |
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| 1 | **Name of ISRO Centre/Unit** | Satish Dhawan Space Centre- SHAR (SDSC-SHAR), Sriharikota |
| 2 | **Title of the research proposal** | Target identification using Machine Learning algorithms from MOTR radar data |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Ch.Ravindra |
| 4 | **Contact Address of CoPI and Phone Number** | MOTR - RO,<br>Satish Dhawan Space Centre- SHAR<br>Sriharikota: 524 124, Andhra Pradesh<br>Phone: 08623 – 225260 |
| 5 | **Area of Research** | Machine Learning/AI in Radar Data |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>Introduction:Target Identification from radar data will be the end product of any radar tracking. Using history of tracked data from known sources as knowledge, identifying characteristics of the target from new detections is the requirement. This requirement can be solved using Machine Learning Algorithms.<br><br>Multi Object Tracking Radar (MOTR) is an L-Band Active Phased Array Radar designed to track multiple targets. It is a long range skin mode tracking radar capable of tracking 0.25m2 RCS target up to a range of 1000km. MOTR can track more than 10 simultaneous targets using single agile beam.<br><br>Research Proposal:Radar data consists of Range, Azimuth, Elevation and Signal to Noise Ratio (SNR). From Range and SNR correlation target size can be classified. From SNR variation alone in a single track duration, target nature can be established.<br><br>Implementation:Using Machine Learning algorithms a model should be trained on radar tracked data (Range, Azimuth, Elevation and SNR). The trained model should identify a target nature(controlled or uncontrolled) and size. Using standard libraries in Python Machine Learning Algorithms have become realizable models.<br><br>Deliverables:Expected deliverables are, a trained model using any of the available regression or classification model in python. The model should be trained on MOTR tracked data. New data from Radar should be classified. Timing and hardware resources required for the model in real time should be evaluated. | |

| SDSC - 009 | | |
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| 1 | **Name of ISRO Centre/Unit** | Satish Dhawan Space Centre- SHAR (SDSC-SHAR), Sriharikota |
| 2 | **Title of the research proposal** | Real time JPDA & MHT based data association in dense multi target tracking environment |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri S.Rajkumar |
| 4 | **Contact Address of CoPI and Phone Number** | MOTR - RO,<br>Satish Dhawan Space Centre- SHAR<br>Sriharikota: 524 124, Andhra Pradesh<br>Phone: 08623 – 225259 / 225258 |
| 5 | **Area of Research** | Radar Data Processing |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>Multi Object Tracking Radar (MOTR) is an L-Band Active Phased Array Radar designed to track multiple targets. It is a long range skin mode tracking radar capable of tracking 0.25m2 RCS target up to a range of 1000km. MOTR can track more than 10 simultaneous targets using single agile beam.<br><br>MOTR has implemented Linear Kalman filter (LKF) and Extended Kalman filter (EKF) for tracking multiple targets simultaneously and Simple Nearest neighborhood (SNN) based data association algorithm to associate target returns with the target being tracked. SNN data association algorithm gives a better result in tracking multiple targets when the targets being tracked are spatially separated. When multiple targets are very closer SNN algorithm gives poor result. It also fails in situation like targets cross over and co traveling of two targets.<br><br>To overcome this situation probability based data association (PDA) methods like Joint Probability data association (JPDA) and Multiple Hypothesis Tracking (MHT) algorithms are used. Since these algorithms uses probability based algorithms these are complex incorporated to SNN. Hence these algorithms are mostly used in offline analysis.<br><br>This RESPOND proposal is to implement JPDA in Real time and MHT in near real time application of MOTR for tracking multiple targets.<br><br>Expected deliverables are the detailed study and simulation of PDA, JPDA and MHT algorithms in Matlab, simulation results of above algorithms with MOTR radar data and implantation of these in C code. | |

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| 1 | **Name of ISRO Centre/Unit** | Satish Dhawan Space Centre- SHAR (SDSC-SHAR), Sriharikota |

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| 2 | **Title of the research proposal** | Space Debris RCS Estimation and dynamics characterisation from MOTR Space Debris tracked data. |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri A.Vaidhyanathan |
| 4 | **Contact Address of CoPI and Phone Number** | MOTR - RO,<br>Satish Dhawan Space Centre- SHAR<br>Sriharikota: 524 124, Andhra Pradesh<br>Phone: 08623 – 225259 / 225258 |
| 5 | **Area of Research** | Radar Data Processing |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>Multi Object Tracking Radar (MOTR) is an L-Band Active Phased Array Radar designed to track multiple targets. It is a long range skin mode tracking radar capable of tracking 0.25m2 RCS target up to a range of 1000km. MOTR can track more than 10 simultaneous targets using single agile beam.<br><br>MOTR is the first sensor in India capable of tracking space debris up to an altitude of 800 km. MOTR has tracked and catalogued nearly 54 different space objects from an altitude of 400 to 900km which includes spent down stages of launch vehicles, debris, space station like ISS, Tiangong and live satellites. MOTR tracked the space objects in skin mode.<br><br>Studying the received signal from the target gives us the information of the target like its dynamics spin, its size and RCS. These characteristics of the debris need to be catalogued, to compute its drag coefficient, and its life time assessment.<br><br>This RESOND proposal is to study on the Dynamic characteristics and RCS estimation of Space debris from MOTR tracked data.<br><br>Expected deliverables are the detailed study and simulation of the required algorithms to be implemented in Matlab, simulation results and implantation of the algorithms in C code. | |

| IISU - 001 | | |
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| 1 | **Name of ISRO Centre/Unit** | ISRO Inertial Systems Unit (IISU), Thiruvananthapuram |
| 2 | **Title of the research proposal** | Active vibration control for cold atom<br>Gravimeter Experiment |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri Pradeep K<br>Shri Syamdas D |
| 4 | **Contact Address of CoPI and Phone Number** | MDD/MDPG/ISPE<br>ISRO Inertial Systems Unit<br>Vattiyoorkavu PO, Trivandrum - 695013, Kerala<br>Phone: 0417-2569370/2569504 |
| 5 | **Area of Research** | Vibration Control |
| 6 | **Summary of the proposed research and expected deliverables**<br>Precise optical experiments andmeasurements require very stringentvibration isolation on the platform onwhich the experiment has to be conducted.A vibration isolation system requiring anattenuation of vibrations above 0.3 Hz,including ground vibrations have to beattenuated for elimination any vibrationinduced errors during the experiment.A 6 D.o.F. active cum passive isolationsystem using Negative StiffnessMechanisms (NSMs) for the passiveisolation system is proposed. The NSM isrequired to have its natural frequency at0.5Hz or lower and vibration attenuationfrom the passive isolation system isexpected from 0.7 Hz or lower to 100Hz.The active vibration isolation is expected toattenuate vibrations from 0.3 Hz to 0.7 Hzand any other structural frequencies within0-100Hz.<br>**Deliverables:**<br>A) Design, analysis and realization ofminiature active vibration control systemswhich can be attached or designed into anexisting assembly and future ones.<br>B) Trials and various systems andsubassemblies Implementation of activevibration control in inertial sensor clusterand other subassemblies so as to reducethe vibrations from 0.3-100 Hz , without affecting the overall dynamic performance of the system. | |

| IISU - 002 | | |
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| 1 | **Name of ISRO Centre/Unit** | ISRO Inertial Systems Unit (IISU), Thiruvananthapuram |

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| 2 | **Title of the research proposal** | Maglev Controller and BLDC drive system |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri Ravichandran MH |
| 4 | **Contact Address of CoPI and Phone Number** | SASD/SSG/SIS<br>ISRO Inertial Systems Unit<br>Vattiyoorkavu PO, Trivandrum - 695013, Kerala |
| 5 | **Area of Research** | Active MagLev systems |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>Magnetic levitated motors have gained popularity inSpace applications because of their merits overconventional motor with mechanical ball bearings.Magnetic bearings offer virtually zero wear andextremely low friction losses. They do not suffer fromstiction and friction effects common with mechanicalball bearings, making them ideal candidates for deepspace missions with long hibernation periods, longlifetime requirements and wide operational temperatureranges. Earth observation, pointing missions andscience missions can clearly benefit from their very lowmicro-vibration and body noise emission levels.Magnetic bearings can broadly be classified into theactive magnetic bearing (AMB) and the passivemagnetic bearing (PMB). Normally Magneticallylevitated motors use a hybrid AMB/PMB Systems toreduce system complexity and cost.The aim of the project is to design and developa compact Magnetically levitated system using AMB orhybrid AMB/PMB driven by BLDC/PMSM (10 kRPM,0.1 Nm). Active control is required in Magnetic bearingfor minimum two axes. Motor is preferably aBLDC/PMSM motor with minimum cogging torque.High torque to weight ratio is desirable. DriveElectronics, part of Magnetically levitated motorcomposes of control electronics for AMB and driveelectronics for BLDC/PMSM. Sensor-less control ispreferred for the motor. Rotor position for levitationcontrol can be obtained using suitable sensors. Thewhole system should be power efficient and compact. | |

| **IISU - 003** | | |
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| 1 | **Name of ISRO Centre/Unit** | ISRO Inertial Systems Unit (IISU),<br>Thiruvananthapuram |
| 2 | **Title of the research proposal** | High speed self-bearing actuators |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri Ravichandran MH |
| 4 | **Contact Address of CoPI and Phone Number** | SASD/SSG/SIS<br>ISRO Inertial Systems Unit<br>Vattiyoorkavu PO, Trivandrum - 695013, Kerala |

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| 5 | **Area of Research** | High Speed Motors |
| 6 | **Summary of the proposed research and expected deliverables**<br>In the field of Space applications, the interest is increasing quickly for high speed actuators which can operate in several tens of thousands to lakhs of rpm. In order to maintain a longer life time for high speed actuators, Magnetic bearings are preferred instead of mechanical ball bearings. Using magnetic levitation to provide rotor suspension offers several advantages, including active control of rotor dynamics through variable stiffness and damping as well as isolation or cancellation of rotor vibration. Contactless suspension through magnetic levitation also permits higher rotational speeds, precision rotor positioning over the air gap, and operation without mechanical wear, thus reducing maintenance and carryingcosts. Traditionally, magnetically levitated motors useactive magnetic bearings (AMBs) for levitation and a conventional motor for rotation. A Self-bearing motor (SBM) integrates an AMB and an electric motor into a single device. In other words, an SBM is an electric motor that can simultaneously levitate and rotate a shaft. The major benefits of an SBM are compactness and economy. An SBM is more compact because of its reduced shaft length, yielding higher critical speeds and more stable operation of the rotating shaft. The aim of this project is to design and develop a Selfbearing motor to operate in 1.5 lakh rpm and deliver atorque output of 0.01 Nm. Motor is preferably a slot-less BLDC/PMSM motor. Drive Electronics has to bedesigned and developed for the high speed Self-bearing motor. Sensor-less control is preferred for the motor. Rotor position for levitation control can be obtained using eddy current sensors. The whole system should be power efficient and compact. | |

| **IISU - 004** | | |
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| 1 | **Name of ISRO Centre/Unit** | ISRO Inertial Systems Unit (IISU), Thiruvananthapuram |
| 2 | **Title of the research proposal** | Development of atomic magnetometer and quantum technologies |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Bindu John<br>Jyothish M |
| 4 | **Contact Address of CoPI and Phone Number** | Inertial Sensors Group, Advanced Inertial Systems Entity , ISRO Inertial Systems Unit<br>Vattiyoorkavu PO, Trivandrum - 695013, Kerala<br>Phone : 0471-2569620, 2569405 |
| 5 | **Area of Research** | Atomic optics, NMR gyroscope, quantum optics technologies |
| 6 | **Summary of the proposed research and expected deliverables**<br>Atomic magnetometers based on alkali vapor cells have acapability of measuring | |

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| | picotesla level magnetic field and isapplicable in Interplanetary missions like Aadithya. Thisalso has the potential to be a subsystem for precisionNuclear Magnetic Resonance Gyroscope. Atomicmagnetometers have found biomedical applications likemagneto cardiography also.This development aims at the design and development ofan optically pumped chip scale rubidium magnetometerwith a sensitivity of pT/√Hz. The magnetic field will bemeasured as the variation of Larmor precession frequencyof the Rubidium atoms in magnetic fields.The technology development involves the<br>• design and fabrication vapor cell<br>• optics for pumping and probing of the larmorprecession frequency<br>• heater design for the vapor cell<br>• processing electronics<br>• MEMS based design and fabrication of thecomponents. |

| **IISU - 005** | | |
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| 1 | **Name of ISRO Centre/Unit** | ISRO Inertial Systems Unit (IISU), Valiamala |
| 2 | **Title of the research proposal** | Development of optical correlator based sensors |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Jyothish M<br>Bindu John |
| 4 | **Contact Address of CoPI and Phone Number** | Inertial Sensors Group, Advanced Inertial Systems Entity, ISRO Inertial Systems Unit<br>Vattiyoorkavu PO, Trivandrum - 695013, Kerala<br>Phone: 0471-2569620, 2569405 |
| 5 | **Area of Research** | Vision based navigation, Integrated Navigation |
| 6 | **Summary of the proposed research and expected deliverables**<br>Optical correlators are devices which can compute image crosscorrelators at a high speed (approx. 1000 image cross correlations per second with 1024x1024 grayscale images). The basic difference between an optical correlator and a normal correlation algorithm is optical correlator works based on the Fourier transforming properties of lenses and optical signal processing. Anoptical correlator also makes use of Spatial Light modulators (SLM's) to encode image information in light. It is essential todevelop and implement a high speed correlator to improve overall performance of Vision Based Navigation Systems. Applications of optical correlators include different proximity operations like docking and landing on a predefined location where speed requirements from vision based navigation is demanding. The technology can be utilized in spent stage recovery, reusable launch vehicles, planetary landing missions etc. Correlating captured images with reference images | |

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| | along with the approximate state information from INS or GPS, vehicle state canbe estimated. Optical correlators can also be useful for applications like target detection and hazard avoidance.The important milestones for the development of technologiesfor optical correlator includes the following:<br>1. A simulation platform for optical signal processing systems<br>2. Technical knowhow of spatial light modulators are to beunderstood<br>3. Optical and opto mechanical design for optical correlato rs.<br>4. Implementation and testing of optical correlators. |

| LPSC - 001 | | |
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| 1 | **Name of ISRO Centre/Unit** | Liquid Propulsion Systems Centre (LPSC), Valiamala |
| 2 | **Title of the research proposal** | Ignition modelling of Semi cryogenic engine |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr. K.S. Bijukumar |
| 4 | **Contact Address of CoPI and Phone Number** | DH, EFAD C&SC, CSPEG, CPES<br>Liquid Propulsion Systems Centre<br>Valiamala : 695 547, Kerala<br>Phone: 0471 256 7772/ 9446027543 |
| 5 | **Area of Research** | Ignition modeling |
| 6 | **Summary of the proposed research and expected deliverables**<br>In order to enhance the payload capability of GSLV MkIII launcher, a 2000kN thrust Semi cryogenic engine is under development. Propellants used are Liquid Oxygen (LOX) and Isrosene (Refined kerosene). In order to start ignition, Triethyl aluminum (TEA) and Triethyl boron (TEB) is used as igniter fuel.<br>Ignition modeling of this igniter fuel with oxygen and combustion modeling of Isrosene & Oxygen has to be carried out to assess the following aspects:<br>▪ Igniter fuel quantity requirement<br>▪ Ignition characteristics such as time delay, peak pressure etc<br>▪ Engine propellant flow requirement and transient build up for sustaining the ignition<br>**Deliverables**<br>1. Ignition Model and its theoretical formulation<br>2. Detailed Documentation of Model. | |

| LPSC - 002 | | |
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| 1 | **Name of ISRO Centre/Unit** | Liquid Propulsion Systems Centre (LPSC), Valiamala |
| 2 | **Title of the research proposal** | Analysis of throat film cooling for Semicryogenic Thrust chamber |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri P Baiju |
| 4 | **Contact Address of CoPI and Phone Number** | Division Head,<br>Combustion Chamber Division-Cryo & Semicryo |

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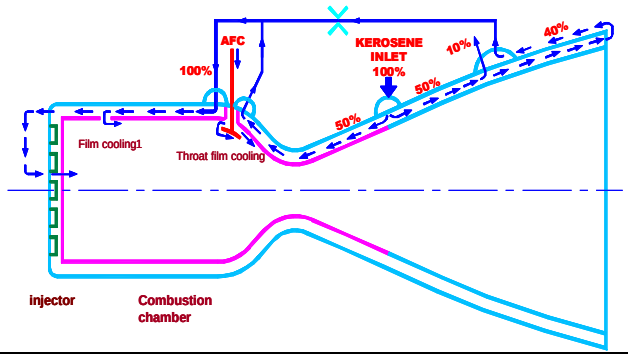
| | | Liquid Propulsion Systems Centre<br>Valiamala : 695 547, Kerala<br>Phone: 9446240000 |
| 5 | **Area of Research** | Combustion modelling with liquid film cooling |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>The 2000 kN Semi-cryogenic engine is a high thrust engine and generates high thermal load on the thrust chamber wall. Hencethe thrust chamber is cooled by film cooling along with regenerative cooling. The throat region of thrust chamber is subjected to maximum heat flux. Hence positive film cooling is to be ensured in this portion to reduce the heat flux.The conventional film coolant injected near the injector end is not sufficient to keep the throat wall temperature below safe temperature limit. This calls for additional film cooling provision near the throat region.Isrosene (fuel used for semicryo engine: equivalent to RP1) is used for both film cooling as well as regenerative cooling in liquid state.<br><br>The film coolant, after injection in to the thrust chamber takes part in combustion, hence film coolant layer depletes gradually. For safe operation of engine, a positive film coolant is an essential requirement. This necessitates detail modelling (considering proper reaction steps, species and reaction rates) of phase change of film coolant and participation in combustion. Based on the CFD results an empirical correlation is also to be formulated for predicting the film coolant thickness in the thrust chamber for varying operating parameters.<br><br>  |

| **LPSC - 003** | | |
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| 1 | **Name of ISRO Centre/Unit** | Liquid Propulsion Systems Centre (LPSC), Valiamala |
| 2 | **Title of the research proposal** | Modelling of two phase flow heat transfer of liquid Methane in regenerative cooling channels of LOX/Methane rocket engines with Methane film cooling |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri A P Baiju |
| 4 | **Contact Address of CoPI and Phone Number** | Division Head, Combustion Chamber Division<br>Cryo & Semicryo |

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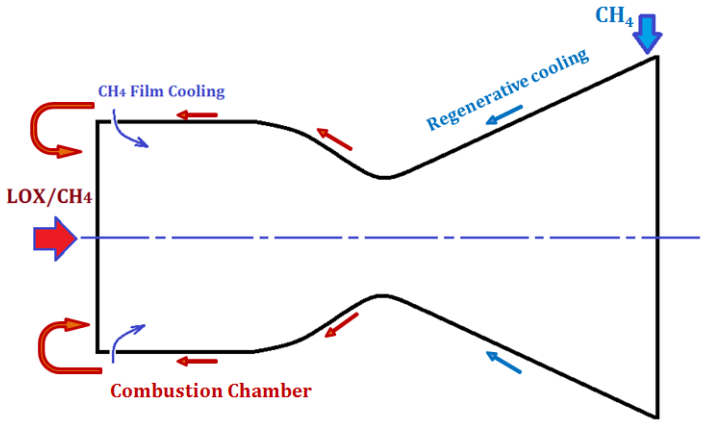
| | | Liquid Propulsion Systems Centre<br>Valiamala : 695 547, Kerala<br>Phone: 09446240000 |
| 5 | **Area of Research** | Two phase flow modelling with conjugate heat transfer |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>LOX/Methane propellant combination is one of the most suitable solutions for future liquid rocket engines, due to good performances achievable in terms of specific impulse combined with operation advantages, such as storability, low toxicity, availability and production cost. Another reason to pursue the development of LOX/Methane propulsion systems is the potential for in-situ resource utilization during inter-planetary missions. Due to these advantages, ISRO is developing LOX/Methane engine for its future launch vehicles.<br><br>For cooling the thrust chamber, Methane is to be used for both regenerative and film coolant. However Methane is an inferior coolant as compared to hydrogen and methane properties shows large variations in its operating regime due to two phase flow in the coolant channels.<br><br>This calls for detail modelling (considering proper reaction steps, species and reaction rates) of two phase flow of coolant in regenerative coolant channels, participation of film coolant combustion (effective film coolant layer thickness) and conjugate heat transfer from combustion products to chamber inner wall through film cooling layer.<br><br>  <br> | |

| **LPSC - 004** | | |
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| 1 | **Name of ISRO Centre/Unit** | Liquid Propulsion Systems Centre (LPSC), Valiamala |
| 2 | **Title of the research proposal** | Study, design & optimization of clearance seals used in high speed turbo-machinery operating in cryogenic fluids and vacuum conditions |
| 3 | **Name of Co PI from ISRO** | Shri. Paul P. George |

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| | **Centre/Unit** | |
| 4 | **Contact Address of CoPI and Phone Number** | Group Head, RD&TP/CSPEG<br>Liquid Propulsion Systems Centre<br>Valiamala : 695 547, Kerala<br>Phone: 0471-2567858<br>e-mail: paulpgeorge@lpsc.gov.in |
| 5 | **Area of Research** | Cryogenic Turbopump |
| 6 | **Summary of the proposed research and expected deliverables**<br>Clearance seals are used in cryogenic turbopumps which work in Liquid Hydrogen/ Liquid Oxygen environment during chilling phase and in vacuum conditions during operation of turbopumps. The vibration, friction and wear characteristics of seal/runner combination play a vital role in the turbopump performance. Minimum wear and heat generation and maximum life are the desirable properties of clearance seals used in turbopumps. Detailed study in this area is required to optimize the existing seal designs/ configurations and material selection.<br>Expected deliverable will be the optimized design of the clearance seal/runner and its material selection for use in cryogenic turbopumps. | |

| **LPSC - 005** | | |
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| 1 | **Name of ISRO Centre/Unit** | Liquid Propulsion Systems Centre (LPSC), Valiamala |
| 2 | **Title of the research proposal** | Development of foil bearings for high speed cryogenic turbopumps |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri. Paul P. George |
| 4 | **Contact Address of CoPI and Phone Number** | Group Head, RD&TP/CSPEG,<br>Liquid Propulsion Systems Centre<br>Valiamala : 695 547, Kerala<br>Phone: 0471-2567858<br>e-mail: paulpgeorge@lpsc.gov.in |
| 5 | **Area of Research** | Cryogenic Turbopump |
| 6 | **Summary of the proposed research and expected deliverables**<br>The turbopumps and propulsion systems for space transfer vehicles require long-life turbopumps with high shaft speed capability. Rolling-element bearings used in current turbopumps do not have sufficient life for these applications. Process fluid foil bearings generally have long life and high speed capability, with exceptional reliability, over a wide range of temperatures and fluids. Obtaining high radial stiffness is often a challenge in the development of foil bearings. The research will be focused on the development of foil bearings with high stiffness, speed capability | |

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| | and life for cryogenic turbopump applications (Liquid hydrogen and Liquid Oxygen). This also involves mathematical modeling for designing and estimation of performance parameters of foil bearings. Advanced foil designs namely leaf type, bump type, tape type etc. will be studied for use in turbopumps.<br><br>Expected deliverable will be the foil bearings & its design, which work with the cryogenic process fluid and possess high radial stiffness, speed capability and life. A mathematical model for the design of the bearings and estimation of performance parameters will also be developed. |

| **LPSC - 006** | | |
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| 1 | **Name of ISRO Centre/Unit** | Liquid Propulsion Systems Centre(LPSC), Valiamala |
| 2 | **Title of the research proposal** | Development of damper seals for turbopumps |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri. Paul P. George |
| 4 | **Contact Address of CoPI and Phone Number** | Group Head, RD&TP/CSPEG<br>Liquid Propulsion Systems Centre<br>Valiamala : 695 547, Kerala<br>Phone: 0471-2567858<br>e-mail: paulpgeorge@lpsc.gov.in |
| 5 | **Area of Research** | Cryogenic Turbopump |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>The proposed research is for the development of damper seals for cryogenic turbopumps. The damper seals, in addition to leak control are required for dampening and controlling the excess rotor response which occurs during critical speed crossings in high speed turbopumps. Damper seals of various geometry namely honeycomb, pocketed, hole pattern etc. are currently in experimental phase worldwide. We need to develop a seal of this category, experimentally demonstrate its performance and optimize its geometry for use in high speed cryogenic turbopumps.<br><br>Expected deliverable will be the optimized damper seal design which works in cryogenic fluids (Liquid Oxygen & Liquid Hydrogen). A mathematical model for evaluating the seal parameters like damping coefficients, stiffness etc. will also be developed. Experimental setup for evaluating the performance of damper seals. | |

| **LPSC - 007** | | |
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| 1 | **Name of ISRO Centre/Unit** | Liquid Propulsion Systems Centre (LPSC), Valiamala |

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| 2 | **Title of the research proposal** | Modelling of plasma and its interaction with vacuum chamber during Hall thruster firing |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri. Shibu Mathew |
| 4 | **Contact Address of CoPI and Phone Number** | PD HEP/ DH ETFD- PRS<br>Liquid Propulsion Systems Centre<br>Valiamala : 695 547, Kerala<br>Phone: 9447813987/ 0471-256-7424<br>e-mail: shibumathew@lpsc.gov.in |
| 5 | **Area of Research** | Electric Propulsion |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>Hall thrusters are being used for in-space propulsion functions on spacecraft. The ground experiments of electric thrusters is to predict the behaviour of the thruster in space. Exact space conditions simulation in laboratory is a high end task. Though a standard low pressure conditions are set as a scale for operation of thrusters, the interaction of plasma plume with background gas and chamber boundaries is inevitable. In this regard, the effects of back ground pressure and chamber boundaries (facility effects) on the Hall thruster performance attains crucial role in estimating the actual behaviour in space. The background pressure increases the neutral collisions and hence plasma plume divergence and the electron transport are affected. Hence the simulations of interaction of plasma plume and effects on electrons transport with background pressure and chamber boundary is needed. The following are expected deliverables:<br><br>1. Simulation of facility effects on plasma plume and electron transport using hybrid particle-fluid approach.<br><br>2. Study of plume divergence and thrust obtained with facility background pressure.<br>3. Effects on electron transport from external hollow cathode to discharge channel by facility background pressure. | |

| **LPSC - 008** | | |
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| 1 | **Name of ISRO Centre/Unit** | Liquid Propulsion Systems Centre (LPSC), Valiamala |
| 2 | **Title of the research proposal** | Modelling of Plasma instability in Hall Thrusters |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri. Shibu Mathew |
| 4 | **Contact Address of CoPI and Phone Number** | PD HEP/ DH ETFD- PRS<br>Liquid Propulsion Systems Centre<br>Valiamala : 695 547, Kerala<br>Phone: 9447813987/ 0471-256-7424 |

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| | | e-mail: shibumathew@isro.gov.in |
| 5 | **Area of Research** | Electric Propulsion |
| 6 | **Summary of the proposed research and expected deliverables**<br>Hall thruster is a rich source of plasma oscillations with diverse phenomena involved in it. Breathing mode and rotating spokes mode are of primary interest exist in Hall thruster. Breathing modes are the strong oscillations whose frequency falls in the range 1-20 kHz and quite sensitive to the entire circuitry including power processing unit. Rotating spokes are azimuthal oscillations (5-20 kHz) anchored in the anode region and may extend to throughout discharge. Both phenomena are believed to be related to ionization processes and it is uncertain how they interact or feed off each other, however, it is strongly suspected these modes greatly affect anomalous electron transport. The behaviour of these oscillations as a functionof magnetic field is of great importance in understanding and predicting the thruster characteristics.<br>The following are expected deliverables:<br>1. Model to predict breathing mode oscillations and their characteristics in Hall thruster.<br>2. Model to predict Rotating spokes modes and their characteristics in Hall thruster.<br>3. Investigation of interaction between these modes and their influence on electron transport. | |

| **LPSC - 009** | | |
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| 1 | **Name of ISRO Centre/Unit** | Liquid Propulsion Systems Centre (LPSC), Valiamala |
| 2 | **Title of the research proposal** | Modelling of plasma and its dynamics inside hollow cathode in Hall thruster |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr.Vara Prasad Kella |
| 4 | **Contact Address of CoPI and Phone Number** | ETFD-PRS<br>Liquid Propulsion Systems Centre<br>Valiamala : 695 547, Kerala<br>Phone: 0471-256-7165<br>e-mail:k_varaprasad@lpsc.gov.in |
| 5 | **Area of Research** | Electric Propulsion |
| 6 | **Summary of the proposed research and expected deliverables**<br>Hollow cathode is one of the most important component of Hall thrusters which is an electron source for plasma discharge and beam neutralization. The life and performance of hollow cathode directly resembles thruster's life and performance. The hollow cathode can be divided into orifice region, insert region and plume | |

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| | region. Plasma density and temperature inside the hollow cathode decides the discharge current that can extract from the cathode. The insert temperature of the cathode is provided by orifice heating, ion heating and electron heating in heater less operation mode. Hence models that quantitatively describe the trends of plasma parameters with varying operating conditions and to simulate discharge parameters (discharge voltage and cathode temperature) is needed.<br><br>The following are expected deliverables:<br><br>1. Thermal model of Hollow cathode using orifice heating, ion heating and electron heating phenomena.<br><br>2. Qualitative description of trends of plasma parameters with varying operating conditions and simulate discharge parameters (discharge voltage and cathode temperature). |

| **LPSC - 010** | | |
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| 1 | **Name of ISRO Centre/Unit** | Liquid Propulsion Systems Centre(LPSC), Valiamala |
| 2 | **Title of the research proposal** | Multi-plume interaction studies of Clustered HallThrusters |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr.Vara Prasad Kella |
| 4 | **Contact Address of CoPI and Phone Number** | ETFD-PRS<br>Liquid Propulsion Systems Centre<br>Valiamala : 695 547, Kerala<br>Phone: 0471-256-7165<br>e-mail:k_varaprasad@lpsc.gov.in |
| 5 | **Area of Research** | Electric Propulsion |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>Clustering is favourable because of several merits including a cheaper manufacturing cost, less demanding requirement from test facilities, more robustness and an ability to tolerate failure of single thrusters. The performance of a thruster in a cluster may be different from a standalone situation. One interest is to investigate the plume interactions, especially in the complex and important near field locations. To accurately simulate the plasma plumes from a cluster of Hall thrusters requires an accurate modelling of the complex physical plume mechanism on three-dimensional meshes. Traditionally, the computational simulation of plasma plume flows into vacuum is performed with a hybrid particle-fluid approach. The direct simulation Monte Carlo (DSMC) method models the collisions of the heavy particles (ions and atoms) while the Particle In Cell (PIC) method models the transport of the ions in electric fields. This study is intend to simulate the detailed three-dimensional plume structures and plume interactions. | |

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| | The following are expected deliverables:<br>1. Modelling of single thruster plasma plume.<br>2. Model to investigate near field plume interaction in cluster configuration.<br>3. Prediction of plasma parameters, electric potential and beam interaction in cluster configuration. |

| **LPSC - 011** | | |
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| 1 | **Name of ISRO Centre/Unit** | Liquid Propulsion Systems Centre (LPSC), Valiamala |
| 2 | **Title of the research proposal** | Modelling of anomalous electron transport in Hall thruster |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr.Vara Prasad Kella |
| 4 | **Contact Address of CoPI and Phone Number** | ETFD-PRS<br>Liquid Propulsion Systems Centre<br>Valiamala : 695 547, Kerala<br>Phone: 0471-256-7165<br>e-mail:k_varaprasad@lpsc.gov.in |
| 5 | **Area of Research** | Electric Propulsion |
| 6 | **Summary of the proposed research and expected deliverables**<br>Anomalous electron transport is one of the prominent mechanism in Hall thruster. Various explanations like cross-field diffusion, Bohm diffusion, near wall conductivity and azimuthal electric fields are attempted to understand the electron transport. The real cause likely to be combination of all. The complex behaviour of electrons in cross-field hall thruster can be handled by categorizing in the following way: (1) Electron mobility in the discharge channel (in the near-anode, ionization and acceleration zones), (2) Azimuthal Hall current (electron propagation around the channel) and (3) electron mobility in the plume. Since these regions are characterized by different magnetic field strength and orientation, each region has to be handled differently. The first part of the study reveals the efficiency of ionization and thrust generation mechanism, second part gives the information of electron confinement in the channel and last part gibes the electron transport from external cathode to the discharge channel across and along the magnetic field.<br>The following are expected deliverables:<br>1. Simulation of electron mobility in discharge channel of Hall thruster with different magnetic field topology.<br>2. Simulation of Azimuthal Hall current with different magnetic field topology.<br>3. Simulation of electron transport in plume along and perpendicular to the | |

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| | magnetic field.<br>4. Prediction of suitable magnetic configuration for better operation of Hall thruster from the simulation results. |

| LPSC - 012 | | |
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| 1 | **Name of ISRO Centre/Unit** | Liquid Propulsion Systems Centre (LPSC), Bengaluru |
| 2 | **Title of the research proposal** | Characterization and development of new thermionicmaterial for hollow cathode of electric thruster whichCannot easily get poisoned. |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri. Abarna V |
| 4 | **Contact Address of CoPI and Phone Number** | DH EPS-CFT<br>Liquid Propulsion Systems Centre-Bengaluru<br>ISRO, HAL 80ft road, HAL II Stage<br>Bengaluru-560 008, Karnataka<br>Phone no. 9449078578/ 080- 25037232 |
| 5 | **Area of Research** | Thermionic material development for Hollow cathode for Electric propulsion |
| 6 | **Summary of the proposed research and expected deliverables**<br>Hollow thermionic material is a critical element in the development of cathode for electric propulsion. Cathodes are electron source for plasma generation and neutralization in EP thrusters. Thermionic material made of inorganic refractory material. i.e. Lanthanum hexaboride LaB6 with work function of about 2.6 eV emit electron as bulk material without any chemical reaction. Further it is less sensitive to impurities and air exposure. laB6 cathode has long life in thruster application because of low evaporation rate. At present this material imported.<br>Hence indigenization material required with well understanding of surface properties, emission characteristic and temperature profile to operate the cathode for various thruster discharge current<br>Expected Deliverables are : Material development, Characterization of emitter material for work function, surface properties & mechanical properties. | |

| LPSC - 013 | | |
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| 1 | **Name of ISRO Centre/Unit** | Liquid Propulsion Systems Centre (LPSC), Bengaluru |
| 2 | **Title of the research** | LASER ultrasonics for Titanium EB weld evaluation |

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| | **proposal** | |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri. Ramprasad B |
| 4 | **Contact Address of CoPI and Phone Number** | Dy. Manager, QC-W<br>Liquid Propulsion Systems Centre- Bengaluru<br>ISRO, HAL 80ft road, HAL II Stage<br>Bengaluru-560 008, Karnataka<br>Ph: +91-80-25037411 |
| 5 | **Area of Research** | NDE (Ultrasonics) and LASER |
| 6 | **Summary of the proposed research and expected deliverables**<br>Spacecraft propellant tank is a Ti6Al4V alloy construction. The Electron beam welds of thickness 3-4 mm are to be evaluated for porosity, cracks and LOF. The present technique of conventional PA-UT is proposed to be replaced by LASER based ultrasound generation. The research shall be carried out on generation of ultrasound, optimizing the parameters in terms of power, pulse width etc. in order to achieve detectability of LOF of a/2c=0.1, a=0.5 and better and porosities of 0.3 mm or smaller.<br>The technique shall be in-situ inside the EB chamber with or without vacuum and the set-up shall be portable to be able to move across EB machines. The change in properties of the test article in the ablation regime for ultrasound generation (if considered) shall also be studied.<br>The deliverables at the end of research and study shall be the LASER source, suitable interferometer and the processing systems. | |

| **LPSC - 014** | | |
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| 1 | **Name of ISRO Centre/Unit** | Liquid Propulsion Systems Centre(LPSC), Valiamala |
| 2 | **Title of the research proposal** | Development of a mathematical model for estimation of crimping loads for different material and design configurations |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri. Krishnajith Jayamani |
| 4 | **Contact Address of CoPI and Phone Number** | STAD/SDAG/MDA<br>Liquid Propulsion Systems Centre<br>Valiamala : 695 547, Kerala<br>e-mail: krishnajith@lpsc.gov.in<br>Phone : 0471-2567826 |
| 5 | **Area of Research** | Structural Mechanics |

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| 6 | **Summary of the proposed research and expected deliverables**<br>It is planned to develop material models for metals and non-mechanical materials used for crimping. It will be based on mechanical tests done on the materials at the applicable temperatures (cryo, room, elevated etc.). These models have to be implemented in FEA codes like ANSYS. |

| **LPSC - 015** | | |
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| 1 | **Name of ISRO Centre/Unit** | Liquid Propulsion Systems Centre (LPSC), Valiamala |
| 2 | **Title of the research proposal** | Characterization of heat transfer parameters in gel propellant engines |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr. T. John Tharakan |
| 4 | **Contact Address of CoPI and Phone Number** | GD, PRG<br>Liquid Propulsion Systems Centre<br>Valiamala : 695 547, Kerala<br>e-mail : t_johntharakan@lpsc.gov.in<br>Phone : 0471-2567770, 9496007558 |
| 5 | **Area of Research** | Engine Heat Transfer |
| 6 | **Summary of the proposed research and expected deliverables**<br>Gelled fluids are a homogeneous mixture of a base fluid and a gelling agent. They possess highly non-Newtonian rheological characteristics. Gel propellant rocket engines involve use of special additives to alter the rheological properties of the liquid propellant so as to convert the propellants into the gel state. Gel propellants offer advantages of solid propellants in that they are easy to store and handle. They also have the advantages of liquid propellants in that they liquefy when subject to high shear stresses in the injector. Gel propellants will not slosh, will not spill through leaks and have reduced vapour pressure compared to the base fluid. The gel propellants need a high pressure to drive them through the feed system and expel them through the nozzle of the injector. They may also be impregnated with certain metallic particles to increase the density impulse. The flow of gel propellants under high pressure through the regenerative passages, with and without metallic additives, is to be investigated. The heat transfer parameters such as heat transfer coefficient, specific heat and thermal conductivity are to be determined under the relevant conditions. Heat transfer parameters of gel propellants relevant to film cooling can also be investigated. The role of heat transfer parameters in ignition and sustainability of the combustible mixture in steady state is to be studied.<br>The deliverables of project shall include (i) Study of heat transfer parameters in | |

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| | regenerative cooling (ii) Study of heat transfer parameters in film cooling (iii) Characterisation of gel propellant droplet combustion in steady state and transient operating conditions. |

| **LPSC – 016** | | |
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| 1 | **Name of ISRO Centre/Unit** | Liquid Propulsion Systems Centre (LPSC), Valiamala |
| 2 | **Title of the research proposal** | Theoretical investigation of pressure waves generated by heat addition in a gaseous medium |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr. T. John Tharakan |
| 4 | **Contact Address of CoPI and Phone Number** | GD, PRG,<br>Liquid Propulsion Systems Centre<br>Valiamala : 695 547, Kerala<br>e-mail : t_johntharakan@lpsc.gov.in<br>Phone : 0471-2567770, 9496007558 |
| 5 | **Area of Research** | Thermoacoustic Instability |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>Heat addition in a combustible mixture involves various processes. The first process is heating of the mixture. When the temperature reaches the auto-ignition temperature, the mixture ignites, and combustion occurs resulting in deflagration or detonation depending on whether the flame propagation velocity is subsonic or supersonic respectively. Both these processes can generate pressure waves which should be investigated theoretically to ensure they are not detrimental to the system. Once the mixture reaches the steady state, under certain conditions, combustion instability may set in. This may involve the constructive interaction of the heat release of the flame and the corresponding pressure perturbations which are amplified by the acoustics of the combustion chamber. Alternatively, the heat release fluctuations may generate entropy waves which can subsequently be converted to pressure waves when they are accelerated in a nozzle. The characteristics of pressure waves generated during the thermoacoustic and entropy-acoustic combustion instability is to be theoretically investigated in a detailed and comprehensive manner.<br><br>The deliverables shall include (i) Model of detonation and deflagration waves in a combustible mixture and, in particular, their transition (ii) Detailed model of thermoacoustic instability for a rocket combustion chamber and different propellant combinations (iii) Detailed model of entropy-acoustic instability for different combustion conditions and nozzle geometries. | |

| SAC - 001 | | |
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| 1 | **Name of ISRO Centre/Unit** | Space Applications Centre (SAC), Ahmedabad |
| 2 | **Title of the research proposal** | Development of FBAR and GaN based robust RF front end for Space use |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri Santanu Sinha |
| 4 | **Contact Address of CoPI and Phone Number** | Space Applications Centre<br>Jodhpur Tekra, Ahmedabad – 380015, Gujarat<br>e-mail: shantanu_sinha@sac.isro.gov.in<br>Phone: 079-26912339/51/61 |
| 5 | **Area of Research** | Microelectronics |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>In the past few years, Aluminium Nitride (AlN) based Film Bulk Acoustic Wave Resonators (FBARs) have been extensively studied for the development of miniature chip based RF filters upto X-band. FBAR filters offer a remarkable degree of miniaturization, enhanced performance and extend the frequency of operation from around 2-3 GHz, for Surface Acoustic Wave (SAW) filters, to about 8-10 GHz. This is especially attractive for space applications where size and performance are assigned paramount importance. Besides, the fabrication techniques for FBAR filters are very similar to the processes used in semiconductor manufacturing and hence amenable to monolithic integration.<br><br>Current trends also point to an increased interest in the development of robust satellite payload systems. A space-based microwave receiver is one sub-system that faces the greatest threat of performance degradation due to intentional or un-intentional exposure to high levels of electromagnetic power. Gallium Nitride (GaN) based receiver front ends consisting of GaN HEMT LNAs offers enhanced robustness as compared to existing mainstream GaAs technology, due to its inherent high power capability. The use of GaN LNAs also precludes the use of limiters that provide overdrive protection to GaAs LNAs but at the cost of Noise Figure degradation.<br><br>Further, integration of the GaN LNA and AlN FBAR filter on the same substrate stack can enable the realization of entire satellite receiver front end on a single chip, thereby offering miniaturization, performance and robustness, all at one go.<br><br>**Scope of the research:**<br><br>1) AlN FBAR modelling and design at S, C and X bands<br><br>2) Design, fabrication and demonstration of FBAR filters based on agreed upon specifications. | |

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| | 3) Physics based Noise Modelling of GaN HEMTs both at room and cryogenic temperatures.<br>4) Design, fabrication and demonstration of a GaN LNA based on agreed upon specifications.<br>5) Monolithic integration of GaN LNA and AlN FBAR<br>**Deliverables:**<br>1) Modelling and optimization techniques/design tools for AlN FBAR design<br>2) Design tools for FBAR based filter design<br>3) Room and Cryogenic Temperature Noise models for GaN HEMTs<br>4) Integrated GaN LNA and AlN FBAR Front End module. |

| **SAC – 002** | | |
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| 1 | **Name of ISRO Centre/Unit** | Space Applications Centre (SAC), Ahmedabad |
| 2 | **Title of the research proposal** | Development of 1.2-meter aperture CFRP mirror for visible/optical wavelength application |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri Jaimin Desai |
| 4 | **Contact Address of CoPI and Phone Number** | Space Applications Centre<br>Jodhpur Tekra, Ahmedabad – 380015, Gujarat<br>e-mail: jaimin_desai@sac.isro.gov.in<br>Phone: 079-26915111/5181 |
| 5 | **Area of Research** | Composite Components Development and Fabrication |
| 6 | **Summary of the proposed research and expected deliverables**<br>Space based camera uses Telescope that consists of Reflective mirrors. It is the prime goal for any space based camera/telescope to be of light weight coupled with ease of Assembly, Integration & testing. SAC unit of ISRO at Ahmedabad is mainly responsible for the development of space based earth observation cameras with varied applications for missions like Chandrayaan, Mars orbiter mission, INSAT VHRRs, Cartosat series, Resourcesat series, OCM series etc. The space based telescope needs the mirrors with high dimensional stability (insensitive to temperature excursions- almost zero CTE- co-efficient of thermal expansion-materials). We have been using Zerodur as glass mirrors materials of construction. This material is low CTE material but has disadvantage of very poor strength with high brittleness, which adds to the long realization time.<br>With the increased high resolution requirements of the order of 1 meter & better, the main aperture size of the telescope increases, which adds to the weight & fragile | |

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| | materials (Zerodur Glass) handling complexity.<br><br>CFRP- carbon fiber reinforced plastic- is a special type of material with Carbon fibers being used as a structural – load carrying member. The Carbon fiber at an individual level is having low & negative CTE of the order of @ (-2 to 0) X 10-6 / cent. By properly mixing matrix & carbon fibers, we can achieve near zero CTE. CFRP is a light weight, high stiffness, high strength material apart from low CTE material. Thus, CFRP is a prime candidate & is a material of construction for optical mirrors being used in present days.<br><br>Surface figure/profile accuracy requirement for 1.2meter primary aperture is Lambda/20 rms& @ Lambda/6 p-v at 633 nm. The surface roughness requirement is up to 2 nm maximum. The values are kept coarse at the initial stage, however, after gaining confidence from process & other parameters point of view, the final value shall be communicated which shall be more stringent. |

| **SAC - 003** | | |
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| 1 | **Name of ISRO Centre/Unit** | Space Applications Centre (SAC), Ahmedabad |
| 2 | **Title of the research proposal** | An assessment of NDE capability for material & process characterization for complex additive manufacturing & analyse physics of failure mechanism in Aerospace components |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri Ravi Kumar Verma |
| 4 | **Contact Address of CoPI and Phone Number** | Space Applications Centre<br>Jodhpur Tekra, Ahmedabad – 380015, Gujarat<br>E-mail: rkv@sac.isro.gov.in<br>Phone: 079-26914593 |
| 5 | **Area of Research** | NDE analysis for 3D modelled components |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>Additive Manufacturing (AM) is a revolutionary technology which produces components directly from 3D data, layer-by-layer. It is possible to manufacture parts with geometries which are difficult to produce by other conventional technologies.<br><br>While AM is beginning to revolutionize the aerospace manufacturing industry, one of the largest barriers to broader adoption of AM for producing aerospace parts is the lack of a “Standardized Qualification Process” that includes fully characterized process definition, developing in situ process monitoring, sensing and quantifying of the drivers of manufacturing variability in AM production parts. In-situ process monitoring sensors enable one to “certify as you build”.<br><br>NDE is technique for Inspection, testing or evalaution of materials, component or assemblies for discountinuities or difference charactersatics without destroying for | |

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| | servicebility of the part or component. NDE like Ultrasonic , Radiography, Computed tomography etc.have to be adopted for real time in- process monitoring to insure proper Quality Assurance and Control activities for defect free space component. Moreover such techniques are required to understand the physics of failure of Electromechnaical assemblies.Currently there are no universally accepted or commercially available IQIs for industrial NDE.<br><br>**Scope of research:**<br><br>• Develop a set of tools to assess NDE system performance to measure & defect detection for bluntness, resolution or contrast sensitivity.<br><br>• Identify materials and design internal features useful for assessing inspection capabilities.<br><br>• Model development for AM Fabricated Image Quality Indicators (IQIs) to simulate defects and parts features.<br><br>• Analyse IQI volume data to assess NDE detectability limits, contrast sensitivity and resolution.<br><br>• Development of in-situ QA methodologies for qualification of AM process leading to development of parts. This is for total understanding of materials and processes correlations, process capability, variability aspects as applicable to failure modes.<br><br>• Generation of defects library & documents of cause and effects of defects.<br><br>• Detection of failure mechanism with its co-relation to physics of failure, through layer by layer detection of discontinuities, thermal environment simulation to measure the performance degradation and break down in internal circuitry of electronic components. NDE methods to check the integrity of component and their functionality and performance.<br><br>• Reverse approach by using advanced NDE techniques to ascertain AM material build defects and limitations.<br><br>**Benefits/deliverables:**<br><br>Provide a multi-use standard for the assessment of NDE performance as well as AM build quality.<br><br>• High Resolution measurement of internal construction measurement.<br><br>• Metrology verification<br><br>• AM Manufacturability<br><br>• AM Repeatability. |

| SAC - 004 | | |
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| 1 | **Name of ISRO Centre/Unit** | Space Applications Centre(SAC), Ahmedabad |
| 2 | **Title of the research proposal** | Sub-millimetre wave / THz Technology: A Technology for future |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri Prantik Chakraborty |
| 4 | **Contact Address of CoPI and Phone Number** | Space Applications Centre<br>Jodhpur Tekra, Ahmedabad – 380015, Gujarat<br>e-mail: prantik@sac.isro.gov.in<br>Phone: 079-26915280/81/90 |
| 5 | **Area of Research** | Terahertz Technology |
| 6 | **Summary of the proposed research and expected deliverables**<br>Advancements and feasibility of RF/Microwave Technology largely define the capabilities and limitations of all Microwave Sensors. With this respect sub-millimeter/ THz technology has gained research popularity due to its enormous communication bandwidth, nano structured systems and varied applications.<br>Applications associated with THz technology can be categorized into the following:<br>1. Space Remote Sensing.<br>2. Earth Remote Sensing:<br>• Limb sounding of earth's atmosphere for trace gases for radiation budget and pollution monitoring.<br>• Atmospheric sounding for continuous meteorological monitoring and modelling.<br>3. Satellite Communication:<br>• Inter Satellite, High Data Speed Wireless Links.<br>• Surface Communication network for future planetary exploration missions.<br>4. Terrestrial Applications:<br>• Body scanning radars for surveillance<br>• Non-destructive Inspection of Materials<br>• Imaging for Medical Applications<br>• High resolution local SAR Imaging<br>5. Planetary Remote Sensing:<br>• Molecular line spectroscopy of planetary atmosphere for detection of components like water, CO, ammonia and methanol.<br>As far as Indian Scenario is concerned, very less or no work has been carried out in | |

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| | THz technological field. Hence this technology development is indeed a burning area requiring thrust from researchers as well as government and private agencies. |

| SAC - 005 | | |
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| 1 | **Name of ISRO Centre/Unit** | Space Applications Centre(SAC), Ahmedabad |
| 2 | **Title of the research proposal** | Monitoring availability of water in India: Integration of space technology, hydro-informatics and automated network of ground measurements |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr. R P Singh |
| 4 | **Contact Address of CoPI and Phone Number** | Space Applications Centre<br>Jodhpur Tekra, Ahmedabad – 380015<br>e-mail: rpsingh@sac.isro.gov.in<br>Phone: 079-26914017 |
| 5 | **Area of Research** | Land Hydrology |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>National water policy of Government of India emphasizes on addressing the wide temporal and spatial variability in availability of water through advances in ground based and satellite technology. This water availability varies due to occurrences of drought, floods and demographic pressure and changing climate. Currently available network of measurements of CWC needs further augmentation with satellite measurements and National hydrological modelling initiative. This would involve integration of space technology, IT and hydrological system models with ground based measurement system. The proposed project aims to carry out research innovations in the field of development of near real time monitoring hydro-informatics system for terrestrial water storage changes over India through integration of multi-source satellite data and automatic network of ground measurements.<br><br>**Scope:**<br><br>1. Automated retrieval of hydrological parameters such as water levels and spread of rivers/reservoirs, flood inundation, soil moisture, snow cover etc.<br><br>2. Development of automated network of hydro-meteorological observatories.<br><br>3. Modelling and web-based dissemination of terrestrial water storage changes in near real time for a major river basin. | |

| SAC - 006 | | |
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| 1 | **Name of ISRO Centre/Unit** | Space Applications Centre (SAC), Ahmedabad |

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| 2 | **Title of the research proposal** | Multi-wavelength LIDAR for terrain mapping and atmospheric measurement |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri Kurian Mathew |
| 4 | **Contact Address of CoPI and Phone Number** | Space Applications Centre<br>Jodhpur Tekra, Ahmedabad – 380015, Gujarat<br>E-mail: kurian_mathew@sac.isro.gov.in<br>Phone: 079-26913812 |
| 5 | **Area of Research** | Electro-optical sensors |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>Light Detection and Ranging (LIDAR) is an active remote sensing technique, that can besuitably used to obtain Surface Topography data and measure Atmospherics. By examining and analyzing the echo signal of the laser from satellite or airborne platform, one can measure the distance, direction and characteristics of the target.<br><br>In last two decades, significant progress has been made in utilizing LIDAR data and has generated interest and scope for many more applications. Apart from generating high resolution Digital Elevation Model, thetechnique has been contributing to study of Polar Ice, aerosol/cloud characterization, measurement of tropospheric winds and estimation of greenhouse/trace gases. Day and night operation capability alongwith simultaneous measurements of related parameters through other instruments have becomeessential requirements.<br><br>**Scope:**<br><br>The responsibilities will include:<br><br>Generation of requirements of a LIDAR System specific to application (including platform)<br><br>Identification of components and end to end realization of system.<br><br>Demonstration of performance. | |

| **SAC - 007** | | |
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| 1 | **Name of ISRO Centre/Unit** | Space Applications Centre (SAC), Ahmedabad |
| 2 | **Title of the research proposal** | Processing software tool for NavIC receiver / Receiver Network |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Dr. Rajat Acharya |
| 4 | **Contact Address of CoPI and Phone Number** | Space Applications Centre<br>Jodhpur Tekra, Ahmedabad – 380015, Gujarat<br>e-mail: rajat_acharya@sac.isro.gov.in |

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| | | Phone:079-26912420 |
| 5 | **Area of Research** | Navigation Tools |
| 6 | **Summary of the proposed research and expected deliverables**<br>Basically we solicit the development of a unified and versatile software tool for processing NavIC data.<br>The versatility will lie in offering one common applicationon different types of NavIC receivers, in network or standalone mode with common data file format for various objectives, including preprocessing of data, advanced post processing of data and analyses.<br>The features will include:<br>A data extraction module for identifying and extracting the relevant data from the acceptable raw NavIC file format(s) provided from a single or multiple stations<br>Apre-processing tool which will handle receivers' measured variables by applying all necessary corrections and after compensating for drags and atmospheric loading etc. and do data reductions.<br>A processing module, that can derive the carrier phase based derivatives from the phase measurements, handle cycle slips, resolve integer ambiguity and also augment the variables with auxiliary INS data<br>A navigation module that can and derive navigation outputs (PVT) using different modes of estimations including the carrier phase based differential positioning algorithms for multiple stations scenario.<br>A derivation tool that can derive the scientific components like the Ionospheric and tropospheric content variations, scintillation strength, multipath components, etc. and provide their simple statistics<br>An export tool, which creates files for exporting to other programs in pre-defined formats, all the outputs obtained and derived<br>This will facilitate combining all available knowledge and mathematical models to obtain common unified goals. The expected deliverable will be a full-fledged installable software with codes and scripts with the abovementioned capabilities.<br>In addition to real data post-processing and analysis, this unified design and implementation will be useful for a wide range of navigation applications, including research and development, as a teaching aid and as a decision basis for futuristic planning. | |

| SAC - 008 | | |
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| 1 | **Name of ISRO Centre/Unit** | Space Applications Centre (SAC), Ahmedabad |
| 2 | **Title of the research proposal** | Survey and analysis of different types of SOTM system and simulation of their tracking and control algorithms and implementation |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Sudhir Agarwal<br>PinakinThaker<br>Ushma Dad |
| 4 | **Contact Address of CoPI and Phone Number** | Space Applications Centre<br>Jodhpur Tekra, Ahmedabad – 380015, Gujarat<br>Phone: 079-2691 2492 |
| 5 | **Area of Research** | Satellite communication, antenna and control system for antenna tracking |
| 6 | **Summary of the proposed research and expected deliverables**<br>**S**atellite communications **O**n **T**he **M**ove (SOTM) is a communications capability used for high speed satellite connectivity in moving vehicle. SOTM terminal with vehicle mounted automatic tracking antenna will provide two-way, high-speed communications on the move under various operational conditions using HTS (High Throughput Satellite). The major challenges in Ku band SOTM are Adjacent Satellite Interference, Antenna de-pointing, Antenna Tracking, Dynamic link, Doppler effect, beam switching, Rain fade etc.<br>The proposed research includes survey of different types of SOTM systems and comparison of them. Automatic pointing and tracking algorithms for different antennas to be studied and MATLAB and C simulations to be carried out. Different algorithms for mechanical scanning, electronic beam steering and hybrid scanning techniques to be studied and simulations to be carried out.<br>Deliverables:<br>Study report containing survey results, algorithm details for all tracking techniques and other technical details.<br>MATLAB and C Simulations for tracking algorithms. | |

| SCL - 001 | | |
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| 1 | **Name of ISRO Centre/Unit** | Semi Conductor Laboratory (SCL), Chandigarh |
| 2 | **Title of the research proposal** | Multiphysics modeling & simulation of<br>MEMS based Electro Spray Thruster |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Nitesh Sinha<br>Nishant Shukla |
| 4 | **Contact Address of CoPI and Phone Number** | Semi-Conductor Laboratory (SCL)<br>SAS Nagar (Mohali), Punjab<br>Phone: 0172-2296202 |
| 5 | **Area of Research** | Micro-fluidics |
| 6 | **Summary of the proposed research and expected deliverables**<br>Scope of project shall be to model &simulate the multiphysics phenomenon tocapture the following three behaviors:<br>1) Movement of ionic fluid (EMI-BF4) in amicro-capillary under the influence ofelectric field.<br>2) Formation of Taylor's Cone at thecapillary tip under the influence ofelectric field.<br>3) Spray formation & droplet movementunder the influence of electric field. | |

| SCL - 002 | | |
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| 1 | **Name of ISRO Centre/Unit** | Semi Conductor Laboratory (SCL), Chandigarh |
| 2 | **Title of the research proposal** | Drive, readout and control electronics for<br>Capacitive MEMS Gyroscope |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri Rahul Khandelwal |
| 4 | **Contact Address of CoPI and Phone Number** | Semi-Conductor Laboratory (SCL)<br>SAS Nagar (Mohali), Punjab<br>Phone: 0172-2296206/2 |
| 5 | **Area of Research** | Sensor Circuits and Signal Processing |
| 6 | **Summary of the proposed research and expected deliverables**<br>SCL is working on development of MEMS Gyroscope. It is proposed to designelectronics for same. Scope of project shallbe design, implement and demonstrate lownoise electronics for capacitive MEMSgyroscope. Circuit should have capability for | |

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| | □□Closed loop drive with frequency andamplitude control.<br>□□Open and Close loop sense.<br>□□C-V converter with sub-atto-Faradcapacitive resolution with resonatorfrequency upto 15 kHz.<br>□□Analogue angular velocity output.<br>□□Provision for electrostatic tuning tocontrol frequency mismatch betweendrive and sense.<br>□□Provision for quadraturecompensation. |

| **SCL - 003** | | |
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| 1 | **Name of ISRO Centre/Unit** | Semi-Conductor Laboratory (SCL), Chandigarh |
| 2 | **Title of the research proposal** | Design of SAR ADC 14/16 bit 20/10 Mbps |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri Deep Sehgal<br>Shri Yadav |
| 4 | **Contact Address of CoPI and Phone Number** | Design & Process Group DPG<br>Semi-Conductor Laboratory (SCL)<br>SAS Nagar (Mohali), Punjab<br>Phone: 0172 2296250 |
| 5 | **Area of Research** | VLSI Design |
| 6 | **Summary of the proposed research and expected deliverables**<br>Design of High Slew Rat and low offset and low driftAmplifier in 180nm SCL technology: Theoperational amplifier (op-amp) is a criticalcomponent in analog and mixed signal designapplications. Among all parameters of op-amp slewrate is a critical parameter in the design. The outputof an operational amplifier should follow the inputirrespective of any conditions, but this does nothappen at high frequency. The slew rate of an opampis very less at high frequency. The design ofHigh Slew Rate Amplifier should cater thesefeatures in Junction temperature range -40 °C to+125 °C:<br>Slew rate >1200V/µsec,<br>UGB >200MHz,<br>Input Open Loop gain> 80dB<br>UGB > 100MHz<br>Offset 75µV Max<br>input offset<100µV, | |

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| | Low Drift 1.3μV/ºC<br>**Deliverables:**<br>1. GDSII Data<br>2. All design reports and design files |

| **SCL - 004** | | |
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| 1 | **Name of ISRO Centre/Unit** | Semi-Conductor Laboratory (SCL), Chandigarh |
| 2 | **Title of the research proposal** | Modeling of High Voltage (10-20, 40-60V) N /P LDMOS devices developed at SCL in180nm CMOS baseline process technology |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri Amit Kumar Singh<br>Shri Saahil Singla |
| 4 | **Contact Address of CoPI and Phone Number** | Process Technology Development Division (PTDD)<br>Semi-Conductor Laboratory (SCL)<br>SAS Nagar (Mohali) Punjab |
| 5 | **Area of Research** | Semiconductor Device Modeling |
| 6 | **Summary of the proposed research and expected deliverables**<br>Process development work at SCL is inprogress for the process integration of LDMOS(VDS: 10-20, 40-60V; VGS: 3.3-5V) devices (nand PMOS) in standard 180nm baselineprocess. Once the devices are enabled, SPICE device models are required for theabove LDMOS devices for circuit designimplementation. The developed models shouldbe accurately predicting both DC and ACperformance of the devices over a range ofvoltage, temperatures (-55 to 125°C) andfrequencies.<br>**Deliverables:**<br>Device characterization (DC-IV, CV, RF) asrequired for Model parameter extraction.<br>Industry standard LDMOS Device Models(Scalable /Binned)<br>Model QA report complying IEEE/CMCmodel validation tests and accuracy. | |

| **SCL – 005** | | |
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| 1 | **Name of ISRO Centre/Unit** | Semi-Conductor Laboratory (SCL), Chandigarh |
| 2 | **Title of the research proposal** | Modeling of Devices (SPICE based) (in Partially Depleted SOI-CMOS ProcessAndPDSOI Analog Cell Library Considering floatingbody effect (FB) and self- |

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| | | heating effect |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri HS Jatana<br>Shri Avinash Singh |
| 4 | **Contact Address of CoPI and Phone Number** | Design & Process Group DPG,<br>Semi-Conductor Laboratory (SCL)<br>SAS Nagar (Mohali), Punjab<br>Phone: 0172 2296250 |
| 5 | **Area of Research** | Partially Depleted SOI-CMOS process development in 180nm |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>Partially depleted SOI-CMOS process has beensuccessfully integrated with floating body MOSFETperformance close to Bulk CMOS. MOSFETs withdifferent body connection schemes (I, T and Htype) are also fabricated and characterized. Theprocess is projected to be used for Radhard, lowpowerand RF applications.The deliverables shall include:<br><br>1. Scalable/binned Industry standard SPICE modelfor Floating body PD-SOIMOSFET withconventional (bulk-like) and body contact layout ( Iand H types)<br><br>2. Scalable/binned SPICE model for bodycontacted PD-SOIMOSFET I and H type layout<br><br>3. The model should be accurate in predicting DCand AC performance of the devices over range oftemperature (-55 to 125°C), bias range (upto 1.8V) and frequencies.<br><br>**PDSOI Analog cell library considering FloatingBody (FB) and Self- Heating (SH) effects:**<br><br>PDSOI technology offers smaller devicecapacitances when compared with its equivalentbulk CMOS counterpart. In addition, it is also much more resistant toradiation effects when compared to its bulkcounterpart. However, circuit design using aPDSOItechnology is challenging due to Forward BodyBias (FBB) induced by the Floating Body (FB)effects, hysteresis, body Bipolar JunctionTransistor(BJT) and Self-Heating (SH) effects. In Analogcircuits the FB and SH effects would be veryimportant due to their continuously flowing biascurrents and their consequent temporal increase.<br><br>The performance of Analog circuits varies temporally due to the FB induced FBB and SH. Effects since the trans –conductance, outputresistance and junction capacitances wouldchange with time. Modelling of the body's holedensity (the dynamic equilibrium value) as afunction of bias current and layout style and body'shole density to be linked to the small signal modelparameters of a PDSOI devices and circuits isrequired.<br><br>In this work, we aim to design FB-PDSOI Analog standard cells targeted to |

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| | retain/attain aspecified performance within a given time duration.<br><br>The deliverables of the project would be:<br><br>1.TCAD PMOSFET and NMOSFET devices forSCL bulk process calibrated with SCL's processrecipe and I-V/C-V measurements.<br><br>The process recipe would be followed in detail inprocess simulations and the devices obtainedwould be calibrated with I-V and C-V measureddata.The devices would later be realized using first aTCAD structure editor, and later HSPICE LUTbased Verilog-A model for faster simulations.These structure editors and Verilog-A modeldevices would be used to realize their PDSOIversions<br><br>2. Models relating gm, ro, Ibias andsource/drain-body junction capacitance with a FBPDSOIMOSFET's terminal bias voltages and timefor fingered and common centroid Analoglayout styles<br><br>3. Analog standard cell library consisting of FBPDSOI Analog cells (e.g. OPAMPs andcomparators) with several power consumptionlevels and a specified performance. The library would be at layout (GDS II) and schematic levels. |

| **SCL - 006** | | |
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| 1 | **Name of ISRO Centre/Unit** | Semi-Conductor Laboratory (SCL), Chandigarh |
| 2 | **Title of the research proposal** | Design of PLL with VCO, 40MHz -1000MHz,Ultra low phase noise -110dBc/Hz, very lowRMSjitter<180fs |
| 3 | **Name of Co PI from ISRO Centre/Unit** | HS Jatana<br>Ashutosh Yadav |
| 4 | **Contact Address of CoPI and Phone Number** | Design & Process Group DPG<br>Semi-Conductor Laboratory (SCL)<br>SAS Nagar (Mohali) Punjab India<br>Phone: 0172 2296250 |
| 5 | **Area of Research** | VLSI Design |
| 6 | **Summary of the proposed research and expected deliverables**<br><br>The aim is to design a PLL which could beused in various circuits as embedded blockand as standalone device.The PLL must generate clock rates in therange 40 – 1000 MHz range with very low RMS jitter.<br><br>**Deliverables:**<br><br>i. GDSII data<br><br>ii. All schematics and design verificationreports like DRV, LVS.<br><br>iii. Design details (including post-layoutsimulations)<br><br>iv. Evaluation board. | |

| SCL - 007 | | |
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| 1 | **Name of ISRO Centre/Unit** | Semi-Conductor Laboratory (SCL), Chandigarh |
| 2 | **Title of the research proposal** | Design of SAR ADC 14/16 bit 20/10 Mbps |
| 3 | **Name of Co PI from ISRO Centre/Unit** | Shri Ashutosh Yadav |
| 4 | **Contact Address of CoPI and Phone Number** | Design & Process Group DPG<br>Semi-Conductor Laboratory (SCL)<br>SAS Nagar (Mohali), Punjab<br>Phone: 0172 2296250 |
| 5 | **Area of Research** | VLSI Design |
| 6 | **Summary of the proposed research and expected deliverables**<br>Design of SAR ADC 14/16 bit, 20/10 Mbps, lowpower (<300mW), 3.3V supply in 180nm SCL technology: The successive-approximation ADC is by far the most popular architecture for at a acquisition applications. Successive approximation ADCs comprise four main subcircuits: the sample-and-hold amplifier (SHA), Analog comparator, reference digital-to-Analog converter (DAC), and successive-approximation register (SAR). Because the SAR controls the converter's operation, successive-approximation converters are often called SAR ADCs. This SAR ADC should cater test and Measurement, Imaging and high-Precision, high-Speed data acquisition applications with these features in Junction temperature range -40 °C to+125 °CSNDR >72 dBFS at 10 Msps SFDR >80 dBc at 10 Msps DNL <±0.5LSBINL <±0.5LSB No missing Code Gain Error<±0.5LSB Offset Error<±0.5LSB Output data format in LVDS or CMOS.<br>Deliverables:<br>1. GDSII data<br>2. Design details and all design reports<br>3. Simulation, test results and evaluation board. | |

**Annexure - 1**

## Addresses of ISRO/DOS Centres for the submission of Research Proposals

| Sl. No | ISRO/DOS Centre/Unit |
|---|---|
| 1. | Director<br>Vikram Sarabhai Space Centre (VSSC)<br>ISRO P.O, Thiruvananthapuram - 695 022<br>e-mail : director@vssc.gov.in |
| 2. | Director<br>Satish Dhawan Space Centre (SDSC), SHAR<br>Sriharikota Range P.O. - 524 124<br>Nellore District. Andhra Pradesh<br>e-mail : director@shar.gov.in |
| 3. | Director<br>Liquid Propulsion Systems Centre (LPSC)<br>Valiamala P.O. Thiruvananthapuram- 695 547<br>e-mail : director@lpsc.gov.in |
| 4. | Director<br>UR Rao Satellite Centre (URSC)<br>P B No. 1795, HAL Airport Road<br>Vimanapura Post, Bengaluru- 560 017<br>e-mail : director@isac.gov.in |
| 5. | Director<br>Space Applications Centre (SAC)<br>Jodhpur Tekra, Ambawadi Vistar P.O.<br>Ahmedabad- 380 015<br>e-mail : director@sac.gov.in |
| 6. | Director<br>National Remote Sensing Centre (NRSC)<br>Balanagar, Hyderabad - 560 037(A.P.)<br>e-mail : director@nrsc.gov.in |
| 7. | Director<br>Indian Institute of Remote Sensing (IIRS)<br>4, Kalidas Road, PB No. 135<br>Dehra Dun- 248 001<br>e-mail : director@iirs.gov.in |
| 8. | Director<br>Physical Research Laboratory (PRL)<br>Navarangpura<br>Ahmedabad - 380 009<br>e-mail : director@prl.res.in |
| 9. | Director<br>ISRO Inertial Systems Unit (IISU)<br>Vattiyoorkavu PO<br>Thiruvananthapuram - 695 013 |

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|---|---|
| | **e-mail : iisu_director_office@vssc.gov.in** |
| **10.** | **Director**<br>**National Atmospheric Research Laboratory (NARL)**<br>**Gadanki - 517 112 Pakala Mandal, Chittoor Dist.,**<br>**Andhra Pradesh**<br>**e-mail : director@narl.gov.in** |
| **11.** | **Director**<br>**Semi Conductor Laboratory (SCL)**<br>**Sector 72,S.A.S Nagar -160 071**<br>**(Near Chandigarh), Punjab**<br>**e-mail : director@scl.gov.in** |
| **12.** | **Director**<br>**ISRO Propulsion Complex**<br>**Mahendragiri - 627 133**<br>**Tirunelveli District**<br>**Tamil Nadu**<br>**e-mail : director@iprc.gov.in** |
| **13.** | **Director**<br>**North Eastern Space Application Centre**<br>**Department of Space,**<br>**Umiam-793103, Shillong**<br>**Meghalaya**<br>**e-mail : director@nesac.gov.in** |

**Annexure – 2**

## RESPOND COORDINATORS OF ISRO/DOS CENTRES

| Sl.No | Name & Designation | Contact details |
|---|---|---|
| 1. | Dr. (Smt.) Parul Patel<br>RESPOND Coordinator, SAC<br>Space Applications Centre<br>Ambavadi Vistar PO<br>Ahmedabad: 380 015 | 079-26912425/42<br>079-26912442<br>Email:parul@sac.isro.gov.in |
| 2. | Shri S Sridharan,<br>RESPOND Coordinator, VSSC<br>Vikram Sarabhai Space Centre<br>ISRO PO<br>Thiruvananthapuram: 695 022 | 0471-2564620<br>0471-2565132<br>Fax: 0471-2564134<br>s_sridharan@vssc.gov.in<br>respond@vssc.gov.in |
| 3. | Shri M Ganesh Pillai<br>Head, PPEG<br>Management Systems Area Entity<br>RESPOND Coordinator,<br>Liquid Propulsion Systems Centre<br>Valiamala PO<br>Thiruvananthapuram: 695 547 | 0471-2567376<br>0471-2567879<br>0471-2567280 (Fax)<br>Email:m_ganeshpillai@lpsc.gov.in,<br>respond@lpsc.gov.in |
| 4. | Dr. Nandita Srivastava<br>Professor and Deputy Head (Admin),<br>Udaipur Solar Observatory<br>Physical Research Laboratory<br>Badi Road, Dewali<br>Udaipur-313001<br>Rajasthan | Phone: 0294-2457211 (office)<br>Fax:0294-2457202<br>Email: nandita@prl.res.in<br>respond@prl.res.in |
| 5. | Shri S Ganesan<br>Sci/Engr. SG<br>RESPOND Coordinator, URSC<br>U R Rao Satellite Centre<br>HAL Airport Road<br>Vimanapura PO<br>Bangalore: 560 017 | Tel: 080- 23026427<br>080-28531326<br>Email: ganeshan@isac.gov.in |
| 6. | Shri Srinivas RVN,<br>RESPOND Coordinator, PPEG<br>National Remote Sensing Centre<br>Balanagar<br>Hyderabad: 500 037 | Tel: 040-23884016<br>srinivas_rvn@nrsc.gov.in |
| 7. | Dr. S. Sridharan<br>Sci/Engr 'SF'<br>National Atmospheric Research Laboratory<br>Gadanki-517 112, Pakala Mandal<br>Chittoor District, Andhra Pradesh | Tel: +91-8585-272124<br>Tel: +91-8585- 272024 (1006)<br>Fax: +91-8585-272018<br>Email: susridharan@narl.gov.in |

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|---|---|---|
| 8. | Shri Pankaj H Pujjalwar<br>RESPOND Co-ordinator,<br>PPEG, SDSC-SHAR: 524 124<br>Sriharikota, Andhra Pradesh | Tel: 08623-226382/6107<br>pujjalwar@shar.gov.in |
| 9. | Shri Nagarajan C<br>(Engg. SF; Manager, HRD)<br>RESPOND Coordinator<br>IPRC Mahendragiri: 627 133<br>Tamil Nadu | Tel: 04637 281776<br>nagarajan.c@iprc.gov.in |
| 10. | Shri Asutosh Bharadwaj<br>RESPOND Coordinator<br>Indian Institute of Remote Sensing (IIRS) Dehradun<br>4, Kalidas Road<br>PB No. 135<br>Dehradun: 248 001<br>Uttarakhand | Tel:0135 2524117<br>Email: ashutosh@iirs.gov.in |
| 11. | Dr. K K Sharma<br>RESPOND Committee Chairman<br>Sci/Engr. SG<br>North Eastern Space Applications Centre, Govt. of India<br>Umiam: 793 103<br>Meghalaya | Tel : 0364 2570138<br>Email: sarmakk@gmail.com |
| 12. | Shri S Sivasubramony<br>Group Head, MSG<br>ISRO Inertial Systems Unit (IISU)<br>Vattiyoorkavu PO<br>Thiruvananthapuram: 695 013<br>Kerala | Tel: 0471 2569340<br>Email:<br>s_sivasubramony@vssc.gov.in |
| 13. | Shri Sanjay Bhatnagar<br>GH-PPG,<br>Semiconductor Laboratory<br>Department of Space, Government of India,<br>Sector 72, SAS Nagar - 160071<br>(Near Chandigarh)<br>Punjab | Telephone: (91) (172) 2236102 / 2296401<br>Email: sb@scl.gov.in |