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VIKRAM SARABHAI SPACE CENTRE

THIRUVANANTHAPURAM

RES-VSSC-2024-001

Name of ISRO/DOS Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

Title of the research proposal

Vibroacoustic response analysis of structures (Interstages with decks mounted on isolators) due to acoustic excitation

Area of Research

Structures

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Ms. P. Geena George

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

geena_george@vssc.gov.in

Summary of the Proposed Research

Interstage is the launch vehicle structure where the avionic packages and auxiliary systems for stage requirements are accommodated. The undesirably high vibration levels induced due to acoustic excitation during liftoff and atmospheric phase can eventually cause malfunctioning of packages housed inside the interstage. To eliminate the high vibration levels, appropriate isolation systems are integrated at locations where avionic decks are mounted to the launch vehicle structure. The current proposal is aimed to get a code for doing the Vibroacoustic response analysis of structures due to acoustic excitation. Structures considered will be typical inter stages with decks mounted on isolators. Code to carry out the analysis is expected to be delivered as part of the project. Code may be validated with the existing experimental results or new experiments may be carried out to validate the results.

Scope of the Work:

- Development of the software and code for vibroacoustic response analysis of structure due to acoustic excitation.
- Demonstration of the code for a typical interstage structure.
- Validation with experimental data.

Linkages to Space Programme:

- Useful for specifying vibration environment for sub assembly and components of launch vehicle structures of ongoing and future launch vehicle programmes.

Expected Deliverables:

1. Software and code for vibroacoustic response analysis due to acoustic excitation.
2. Documents giving details of formulation, sample problem solved and validation.

RES-VSSC-2024-002

Name of ISRO/DOS Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

Title of the research proposal

Numerical & experimental studies on hybrid motor internal ballistics to improve mixing efficiency of LOX - HTPB hybrid propulsion systems.

Area of Research

Propulsion

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Dr. Hrisheekesh K

Mr. Arun V

Dr. Sujithkumar R

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

hrisheekesh_k@vssc.gov.in

Summary of the Proposed Research

The hybrid motors presently developed in VSSC have combustion efficiency in the range of 0.85 to 0.9 which is lower than the state of the art hybrid propulsion systems. For improving the combustion efficiency to a value greater than 0.95, the mixing of pyrolysed fuel and oxidizer needs to be enhanced. In literature several methods have been proposed to improve the mixing efficiency of hybrid motors. A computational model is to be developed and validated with literature and experimental data.

Scope of the work:

- Literature survey on the various methods to enhance the combustion efficiency in hybrid motors.
- Develop a suitable combustion model for the hybrid combustion based on literature (Single/ Multispecies).
- Validate the combustion model with the available literature and experimental data.
- Study different methods/salient parameters influencing the combustion efficiency of hybrid motor (Post-combustion chamber geometry, Diaphragms, Mixing devices, port geometry, varying geometry, port mass flux, varying OF ratio etc.)
- Commercial or opensource/own code can be used for modeling the cold flow, reactive flow and droplet-boundary layer interaction.
- Experimental validation at lab level of the proposed methods to improve combustion efficiency shall be carried out and merits and demerits of proposed methods shall be brought out.

Linkages to Space Programme:

- The proposed program will allow ISRO to develop high performing state of the art hybrid propulsion systems.

Expected Deliverables:

1. A validated computational model for GO2/LOX+HTPB combustion with CFD simulation files and convergence parameters.

2. A methodology for evaluating combustion efficiency of hybrid motors for iterative design of hybrid motor.
3. Experimental findings of the lab level motor tests.

RES-VSSC-2024-003

Name of ISRO/DOS Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

Title of the research proposal

Dual & Triple output, Short Circuit Protected, Soft-switching, Isolated DC-DC converters with Wide Input Voltage range and built-in EMI Filter for launch vehicles/orbital vehicles.

Area of Research

Power Electronics

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. Govind A M

Mr. Rajesh Kumar M G

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

am_govind@vssc.gov.in

rajesh_g@vssc.gov.in

Summary of the Proposed Research

The research proposal is design, development and realization of dual and triple output, short circuit protected, DC-DC converters incorporating soft-switching techniques (ZVS/ZCS) for achieving higher efficiency in a compact footprint. Built-in EMI Filter ensuring MIL STD 461-G compliance is also required. Specifications targeted are as follows,

Dual Output Converter (Peak power : ≥ 30W)

Output Voltage	±15V
Input Voltage Range	34V nom. (20-50V)
Mechanical Dimension, Pin functions, Environmental Specs	Identical to MTR2815DF

Triple Output Converter (Peak power : ≥ 30W)

Output Voltage	5V, ±15V
Input Voltage Range	34V nom. (20-50V)
Mechanical Dimension, Pin functions, Environmental Specs	Identical to MTR28515TF

Scope of the work:

High figure of merit, isolated, intermediate power, multi-output DC-DC converters can facilitate miniaturization in power conditioning systems, as digital devices as well as signal conditioning circuit elements like Opamps can be powered from a single module. EMI filter capable of ensuring compliance with MIL STD 461-G must be built into the converters.

In current launch vehicle/orbital vehicle configurations, control electronics and instrumentation systems use different batteries, since control electronics systems require a significantly high bus voltage. DC-DC

converters which can be configured to operate at higher input bus voltages (such as 70V-150V) can facilitate reduction in the number of batteries leading to more payload capability and hence is desirable. Versatile front-end circuits for bias supply generation along with wide bandgap devices capable of handling high input voltages can be combined to achieve the objective.

Linkages to Space Programme:

- High figure of merit, isolated, intermediate power, multi-output DC-DC converters will be used to facilitate miniaturization in power conditioning systems of new launch vehicles; Gaganyaan follow on missions, NGLV, RLV-ORV & HAVA.

Expected Deliverables:

1. Dual & Triple output DC-DC converters with MIL STD 461-G, meeting aforementioned electrical and mechanical specifications. Possibility of incorporating a versatile primary side capable of handling higher bus voltages should also be considered as part of design.

RES-VSSC-2024-004

Name of ISRO/DOS Centre/Unit
Vikram Sarabhai Space Centre, Thiruvananthapuram

Title of the research proposal
Scalable Semiconductor Chips for Broadband Photo-detection

Area of Research
Sensors, Materials, Micro-electronics

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Mr. Dominic George Joseph
Mr. Sabin S Babu
Ms. Mini Sreekumar

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit
dominic@vssc.gov.in

Summary of the Proposed Research

The research proposes to undertake development of broadband photo detectors using advanced nanomaterials like Transition Metal Oxides(TMOs) and Transition Metal Dichalcogenides (TMDs).

Activities involved in the proposed research are

1. Explore suitable advanced nanomaterials like TMOs/TMDs and find the better ones for further development. The major considerations will be
   a. Performance parameters like
      i. Scalability
      ii. Sensitivity
      iii. Stability
      iv. Signal to Noise Ratio (SNR)
      v. Speed of operation

vi. Wide frequency band of operation
vii. Low intensity detection capacity
viii. Low energy detection capacity
ix. High PDCR (Photo to Dark Current Ratio)

b. Costs involved in development and production

c. Possibility of integration with standard IC manufacturing process

d. Possibility of using heterostructures of TMOs or TMDs or a combination of both TMOs and TMDs

2. Develop prototypes of photo detectors using the chosen material. The major activities will be
   a. Bare detector development
   b. Characterization of bare detectors
      i. Morphological - Testing the dimensional goodness using Scanning Electron Microscopy (SEM) Transmission Electron Microscopy (TEM)
      ii. Microstructural – analysing crystal structure, elements, vibration modes etc. using Energy Dispersive Spectroscopy, X-ray Diffraction, Raman Spectroscopy
   c. Feasibility study of integrating the detector fabrication process into standard Integrated Circuit fabrication process so that both sensor and processing electronics will be on the same chip.
3. Development of a stand-alone product out of the research experience gained which includes the following steps.
   a. Develop read-out circuitry using discrete components
   b. Integrate multiple detectors into an array
   c. Integrate the detector array and read out circuitry on a PCB as a system
   d. Lab level characterization of the complete system
   e. Characterization of the product in space environment.

Scope of the work:

The scope of the proposed research activity themed Development of Scalable Semiconductor Chips for Broadband Photo-detection includes the following Material Research: Comparative study of various materials with respect to the performance metrics Process Design: Micro fabrication process steps design for fabrication of photo detectors and later optimizing the process steps based on the characterization of the samples realized using preliminary process steps.

Prototype development: Bare photo detectors to be fabricated using the optimized process steps.

Device Design: The layout aspects of the design to be finalized using the characterization results of the bare photo detectors.

Product Development: Realization of the photodetectors integrated to a standard CMOS process.

System Design: Design of the system including the photodetectors and the readout circuitry.

System Realization: Realization of the system including the photodetectors and the readout circuitry.

Ground testing: lab level testing and elaborate characterization of the developed system as a whole.

Space environment testing: Testing of the whole system in space environment.

Linkages to Space Programme:

- The proposed semiconductor chips can be used in applications like
  - fibre optic communication systems
  - remote sensing
  - image sensors
  - optical navigation

Expected Deliverables:

1. Understanding underlying device physics and structure of proposed photodetector chips.
2. Micro fabrication process steps for photo detectors
3. Comparative study of various materials with respect to the performance metrics
4. Optimized Microfabrication process steps for photodetectors
5. Integration of photodetector microfabrication with standard IC process.
6. Development of Heterostructures based photodetectors
7. Morphological and micro structural characterization for all fabricated photodetectors and integrated chips.
8. Design details of optimized photodetector integrated semiconductor chips - Schematic, layout and associated circuitry.
9. Prototypes of the optimized chip.
10. Stand-alone product development using the developed chips and discrete components for read-out and other circuitry.

RES-VSSC-2024-005

Name of ISRO/DOS Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

Title of the research proposal

Development of Refractory Concentrated Alloys for Sustained Operation at Temperatures of 1400°C and above

Area of Research

Materials

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Dr. Chenna Krishna S

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

s_chenna@vssc.gov.in

Summary of the Proposed Research

The demand for materials that can maintain their structural integrity and mechanical properties at service temperatures exceeding 1400°C is increasing, especially in space industry. Traditional superalloys such

as Ni-based alloys and refractory alloys C103 (Nb-Hf-Ti) face limitations at these extreme temperatures. Refractory Concentrated Alloys (RCA) represent a promising solution due to their high melting points, exceptional thermal stability, and ability to retain strength at elevated temperatures. This proposal outlines a research program to design, develop, and optimize RCAs specifically tailored for use at service temperatures of 1400°C and above. The project will focus on alloy composition, processing techniques, and property evaluation to produce alloys with superior high-temperature performance meeting targeted yield strength of 300 MPa at 1400°C coupled with utilizable ductility at room temperature.

Objectives:

- To Design and Develop Refractory Concentrated Alloys capable of maintaining mechanical strength and phase stability at service temperatures of 1400°C and above.
- To Optimize the Processing Techniques used in the production of RCAs, including vacuum arc melting, casting, and post-processing treatments, to achieve homogenous and defect-free alloy structures.
- To Characterize Microstructure and High-Temperature Properties, including mechanical strength, hardness, and oxidation behavior, through experimental testing.
- To Compare the Performance of RCAs with commercial refractory alloys, identifying key advantages and potential applications of RCAs in high-temperature environments.

Scope of the work:

This research will focus on the design and development of RCAs, particularly those based on refractory elements (e.g., Nb, Mo, Ti, V, Ta, W, Hf, Zr). The proposal will include the following key activities:

- Alloy Design and Selection: Selection of combinations of refractory metals such as Nb, Mo, Ti, Ta, W, Hf, Zr, and V to form single-phase or multi-phase RCA alloys. Computational simulations (e.g., CALPHAD modeling) to predict the equilibrium phases, phase stability and physical properties. Identification of potential alloy compositions.
- Ingot Metallurgy and Processing: Development of vacuum arc melting and casting processes to produce high-purity alloy ingots of identified alloys. Exploration of post-processing treatments such as heat treatment and thermo-mechanical processing to enhance microstructural homogeneity and improve mechanical properties.
- Microstructural and Mechanical Characterization: Detailed microstructural analysis using scanning electron microscopy (SEM), energy-dispersive X-ray spectroscopy (EDS), and X-ray diffraction (XRD) to study phase formation, grain size, and elemental distribution. Mechanical testing, including strength and hardness at both room temperature and elevated temperatures up to 1600°C.
- High-Temperature Oxidation: Oxidation resistance testing at 1400°C and 1600°C to evaluate the alloys' performance in high-temperature environments.
- Comparison with commercial refractory alloys: Comparative analysis of the developed RCAs with commercial refractory alloys (C103) in terms of high-temperature strength, oxidation resistance, and thermal stability.

Linkages to Space Programme:

- Rocket thrusters for future missions which demand for service temperature above 1400°C.

Expected Deliverables:

1. Optimized Refractory Complex Alloy Composition: A set of RCA compositions optimized for use at service temperatures of 1400°C and above, including phase-stable, single-phase, and multi-phase alloys.
2. Processing Guidelines for RCA Production: Detailed process parameters for vacuum arc melting, casting, and heat treatments, including post-processing steps to achieve the desired microstructure and mechanical properties.
3. Mechanical and Thermal Property Data: A comprehensive dataset on mechanical properties such as strength, and hardness at room temperature and elevated temperatures up to 1600°C. Data on oxidation resistance and phase stability after prolonged exposure to 1600°C
4. High-Temperature Oxidation behaviour: Detailed reports on the long-term performance of the developed alloys, including their resistance to oxidation at high temperatures.

RES-VSSC-2024-006

Name of ISRO/DOS Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

Title of the research proposal

Design and realization of a mechanically durable structured Membrane for separation of gas mixture (CO_2, H_2, Methane) from water for Bharatiya Antariksh station (BAS)

Area of Research

Close loop environmental control and life support system (ECLSS)

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. Suhas Mukherjee

Dr. Sreejith M

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

suhas_mukherjee@vssc.gov.in

Summary of the Proposed Research

- ECLSS for BAS will be equipped with Sabatier reactor for the continuous on board water production through catalytic hydrogenation of carbon dioxide exhaled by the crew members. this proposal envisages to develop a suitable membrane that can separate the water from the product gases (CH_4, and unreacted CO_2 and hydrogen).
- The catalytic reactor will be operated at the temperature of 250-300°C and 1-4 bar pressure. The reaction product will contain gases like methane, carbon dioxide, hydrogen, and water (gaseous state). Further, the water will be separated from the gases in order to send it for the hydrogen and oxygen production through electrolysis process.
- Rate of products that will be generated (for six crew member) during the reactor operations can be considered as, 0.3 kg/hr and 0.05 kg/hr for water and methane respectively.
- Considering the microgravity aspects in the space the separation of gas-liquid mixture using artificial gravity separation may lead to high power and size requirements.

- Therefore, it is proposed to utilize the thermal and pressure energy of the product gases and water (which needs to be cool down to meet the input membrane requirements) for separating the mixture by passing it through a molecular weight cut off (MWCO) polymeric membrane.

It is proposed to design and realize a suitable MWCO water selective membrane with high sutural durability, long life (5 years), strong fouling resistance, and maximum permeate and retentate throughput. Membrane shall be continuously able to separate gases and liquid stream with maximum selectivity.

Scope of the work:

Design and realization of membrane that can handle flow rate of 6 SLPM or 0.4 kg/hr with operating pressure of 1-4 bar and max. temperature of 200°C (PI can decide the temperature at which maximum separation efficiency can be obtained).

- Mechanical (tensile, flexural, compressive properties) and physical characterization (density, pore structure, pore volume, pore distribution) of the membrane.
- Design and realization of experimental test set up for testing the efficiency of the membrane. Facility shall have the provisions for measuring t flow rate of the permeate and retentive.
- Unsteady state Modelling and simulation on the performance prediction of the membrane at different temperatures and pressures.

Linkages to Space Programme:

- Separation of product gases from Sabatier reactor into gases and water for Bharatiya Antariksh Space Station.

Expected Deliverables:

1. A mechanically durable structured MWCO membrane that can handle flow rate of 6 SLPM /0.5 kg/hr, pressure-5 -10 bar and temperature -200°C.
2. Test set up for the testing of the membrane up to 10 LPM /1 kg/hr flow rate, Pressure-10 bar, and temperature -200°C (if set up is already available then no need to provide the cost separately).
3. Transient mathematical model for predicting the performance of the membrane (concentration of retenate and permeate with time, pressure drop etc.).

RES-VSSC-2024-007

Name of ISRO/DOS Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

Title of the research proposal

Development of electrically controlled solid propellant, detailed ignition and combustion characterization for space propulsion applications.

Area of Research

Solid propulsion and combustion characterization of solid propellants.

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. Kiran Pinumalla

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

kiran_pinumalla@vssc.gov.in

Summary of the Proposed Research

Solid rocket propellants are widely used in space launch vehicles to generate large amounts of thrust in a short time. However, the tendency to achieve variable throttle mechanisms, controllability and start-stop-restart actions are highly difficult during inflight operations of such propulsion systems. Electrically controlled solid propellants (ESP) offer specific combustion characteristics because of their ability to sustain combustion only when required electric power is supplied, known as pyroelectric combustion behavior. This facilitates multiple start/stop/re-ignition operations, variable thrust with electric power, and discreet impulse bits in propulsion systems. Such features promote a lot of potential space applications which includes reaction control systems (RCS) for controllability, attitude control propulsive system for crew escape systems, micro-propulsion systems for satellite attitude control and space applications, etc.

Research in the development of ESPs is still a relatively new and emerging field in solid rockets. A large amount of work still needs to be carried out to demonstrate feasible operation of these propellants in actual applications. In addition, the knowledge on governing reaction and combustion mechanisms of ESPs is limited due to their complex physicochemical processes, electrochemistry coupled with thermo-chemical reactions, multiphase heat and mass transfer, influence of electric power, etc. Also, the pressure dependency, electric power, electrode area, composite on burning rate of ESPs need to be determined. Moreover, there are many practical difficulties associated with integrating these propellants in realistic propulsion devices such as achieving required mechanical properties, continuous contact between propellant and electrodes, understanding of voltage and current characteristics during propellant burning, etc. In this context, the current research will help to accomplish the above objectives.

Scope of the work:

Development of novel electrically controlled solid propellant formulation, and their combustion characterization in order to demonstrate the multiple start-stop-restart operations.

1. Development of electrode configurations and study the effect of electric power, electrode area on combustion behavior.
2. Establish experimental facilities to conduct ignition and combustion performance studies.
3. Pressure dependence combustion characterization along with mechanical properties evaluation.
4. Investigate the effect of energetic metal particles and the role of external electric power on combustion behavior of electrically controlled solid propellants.

Linkages to Space Programme:

- For attitude control solid motor development for Gaganyaan CES escape system, micro thrusters for attitude control of spacecraft's and interplanetary missions.

Expected Deliverables:

1. Development of novel ESP propellant formulation.
2. Demonstration of multiple start/stop/re-ignition operations at experimental facility.

3. Ignition, combustion and mechanical characterization of formulated propellants.
4. Detailed characterization as a function of composition, pressure external electric power, electrode area ratio, etc.

RES-VSSC-2024-008

Name of ISRO/DOS Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

Title of the research proposal

Meta-material based matching structures with antennas at L & S-Bands for mitigating Radio Frequency Blackout during re-entry of vehicle

Area of Research

Antenna

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. Satya Bhushan Shukla
Mr. Adarsh M
Ms. Saji Joyas

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

satya_bhushan_shukla@vssc.gov.in

Summary of the Proposed Research

Radio frequency (RF) blackout and attenuation is one of the major problems in the entry, descent and landing approach of re-entry vehicle/crew-module. RF blackout is caused by a highly dense plasma layer on the vehicle surface, attenuating or reflecting EM waves used for communication. The effects can be severe and may cause complete communications loss, with duration of 90 seconds to 10 minutes depending on the vehicle's trajectory.

Different approaches are being employed to prevent RF blackouts like use of high frequency, liquid quenching to reduce the plasma layer, use of magnetic field, proper aerodynamic shaping of reentry module, use of high-power transmitters and use of data relay transmitter.

Meta-material based purely electromagnetic approach also can be used for mitigating RF blackout up to some extent. This technique is less complex compared to others. As per theory, plasma acts as an ENG (epsilon-negative) medium when an EM wave propagating in it. Consequently, plasma only allows evanescent waves at those frequencies, and an electromagnetic signal in it will be attenuated. To explore overcoming the attenuation associated with the ENG nature of the reentry plasma, a MNG (mu-negative) layer is introduced between the electromagnetic radiator and the plasma region. The combined MNG-ENG layers act as a DNG (Double negative) medium, allowing wave propagation through it. Tuning the MNG layer to match the ENG one enhances the overall transmission level.

Considering the MNG meta-surface as a window to the exterior of a re-entry vehicle/crew module, its matched design yields high transmission of electromagnetic plane waves through the resulting MNG-ENG meta-structure into the region beyond it. An appropriate pairing of a MNG metamaterial layer withan ENG one leads to an effective medium through which electromagnetic waves will propagate.

The proposals are invited to develop a Meta-material surfaces with antennas for Telemetry (2.2-2.3GHz) and NavIC (L1 & L5) application for Mitigating RF Blackout when a plasma forms around a re-entry vehicle.

Scope of the work:

The proposed work finds relevance in re-entry vehicles/crew module for Telemetry and Navigation applications. The MNG-ENG meta-structure is able to transmit a high level of electromagnetic plane wave through the antenna with a metamaterial surface as a window to the exterior of the re-entry vehicle due to the antenna's matched design. RF attenuation due to plasma formation can be reduced by this technique.

Linkages to Space Programme:

- The proposed antenna design can be attempted for on-board Telemetry and Navigation RF packages in re-entry vehicles/crew module.

Expected Deliverables:

1. The expected deliverables are circularly polarized telemetry S-Band antennas and L-Band NavIC antennas with corresponding meta-material structures having wide bandwidth and good impedance matching.
2. Simulation and measurement results need to be provided.
3. Finally, a functioning prototype must be demonstrated for both frequency bands.
4. RF attenuation through a plasma region with varying plasma density to be demonstrated.

RES-VSSC-2024-009

Name of ISRO/DOS Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

Title of the research proposal

Surface finish improvement of laser Directed Energy deposition products

Area of Research

Process development (materials &manufacturing)

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. Apurba Roy

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

apurba_roy@vssc.gov.in

Summary of the Proposed Research

The growth of alternative production techniques has grown crucial since space sector needs have become more customized than standardized. Instead of using standard subtractive processes, additive manufacturing (AM) builds components layer by layer. Even while AM has several advantages over conventional manufacturing methods, it is still in its early stages of widespread use. Despite all the advantages of additive manufacturing, there are still several unresolved problems with the technique that have hampered its performance and restricted its use to high tolerance jobs.

Numerous techniques based on laser polishing, shot peening, and machining have been suggested to enhance the surface quality. The limitations of these approaches lie in the challenges posed by dealing with complicated form/ components with intricate internal channels. Since producing complex-shaped products is likely the biggest benefit of additive manufacturing (AM) techniques, it is crucial to create a method of surface finishing based on abrasive/ chemical/electrochemical treatments in order to take advantage of their ability to work on a whole surface without the use of machining. To enhance the component's surface finish, and dimension accuracy, an adaptive controller/finishing stage is to be suggested. The suggested method may/ may not be material specific but the scope of this proposal shall cover its use for various titanium alloys and superalloys.

Successful implementation of this proposal shall result in improvement of the performance of AM components and also aid its wide application for end use products.

Scope of the work:

Development of surface finish improvement techniques for additively manufactured end product channels/IDs etc. with no direct machining reach.

Linkages to Space Programme:

- The new technique to achieve surface finish of 8-20 micron or better on 3D printed Inconel 718& SS316L structural & functional components for all launch vehicles.

Expected Deliverables:

1. The new technique to achieve surface finish of 8-20 micron or better on 3D printed Inconel 718& SS316L samples.

RES-VSSC-2024-010

Name of ISRO/DOS Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

Title of the research proposal

Synthesis of chlorotrifluoroethylene (CTFE) gas

Area of Research

Materials

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. Srirangam Siripothu

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

s_srirangam@vssc.gov.in

Summary of the Proposed Research

CTFE is used as a raw material for synthesis of aqueous Poly chloro tri fluoro ethylene (PCTFE) emulsion. PCTFE emulsion is used for coating metallic seals for low temperature application (semi-cryo applications).

Currently the CTFE gas is procured from China through third party due to unavailability of any other source in India. Hence it is necessary to indigenize the process for CTFE synthesis for future requirements.

The proposal should include complete development of lab scale synthesis route for CTFE (1kg level) and detailed characterization. During the development, further scale up of the process to be ensured.

The process has to be proved by further synthesis of PCTFE by using as developed CTFE.

Scope of the work:

To synthesis Chlorotrifluoroethylene (CTFE) and optimize process to get purity more than 99.00%.

The activity involves:

- Parameter study during the synthesis and their optimization.
- Detailed characterization of CTFE.
- Preparation of PCTFE emulsion using synthesised gas.

Linkages to Space Programme:

- Metallic seals used in LOX turbopump of Semi Cryo engines should be coated with PCTFE for leak tightness.

Expected Deliverables:

1. Report submission on experimental studies carried out for the development and its outcome.
2. Report submission on synthesis of CTFE with details on optimized process parameters and characterization results.
3. Submission of 1 ltr of aqueous PCTFE emulsion synthesised by developed CTFE gas.

RES-VSSC-2024-011

Name of ISRO/DOS Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

Title of the research proposal

Design and Development of polymer derived ceramics based thermoelectric module architecture

Area of Research

Materials

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. Anjani Kumar Sharma

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

anjani_kumar@vssc.gov.in

Summary of the Proposed Research

Polymer derived ceramics (PDCs) are a special class of materials with numerous advantageous properties like high thermo-oxidative stability, easier processing route, low densities and simultaneous presence of a low thermally conductive (amorphous matrix) and a high electrically conductive (free carbon phase) phase.

Thermoelectric effect is the generation of electricity due to the prevalent temperature gradient across the material. This electricity then can be used in different ways, for example to run experiments or to supply essential power to devices in absence of solar energy. This effect is used in RTG for generation of electricity for deep space missions. Deep space missions require energy from different sources as solar energy is not sufficient to meet the demands of the missions.

The thermoelectric device architecture is a peculiar design which is required for any functioning RTG. The n and p-type thermocouples have to be housed in such a series so that the device generates sustained power to be used by on board devices.

Since, polymer derived ceramics are relatively newer materials, the technical knowhow to fabricate structures from the polymer to give a thermoelectric module is relatively unknown. The work will be carried out using polymers developed by VSSC and making a complete thermoelectric module. The technologies required will be: thermoelectric characterization of the starting material, polymer/ceramic printing or any other suitable method and tenability to VSSC polymers.

Scope of the work:

The scope of the proposal is:

- Increasing the thermoelectric efficiency of the preceramic polymers by incorporating suitable fillers
- Thermoelectric characterisation of the preceramic polymer
- Designing a thermocouple architecture for polymer derived ceramic as thermocouple materials
- Devising a methodology to print (or any other suitable method) the preceramic polymer into thermocouple shapes
- Development of a prototype lab-scale thermoelectric module
- Thermoelectric characterisation of the thermocouple module.

Linkages to Space Programme:

- Thermoelectric materials are to be used in Radioisotope Thermoelectric Generators (RTGs). RTGs supply power to the spacecraft when the solar power is not sufficient. The material developed here will be used as a thermocouple in RTG. Thus, the work is directly linked to Man on Moon and Mars Lander mission of ISRO.

Expected Deliverables:

1. A thermoelectric module architecture which will be employed in RTG. A prototype lab-scale thermoelectric module.

RES-VSSC-2024-012

Name of ISRO/DOS Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

Title of the research proposal

Multi Scale Modelling and dynamic response of LV structures

Area of Research

Multi-scale Modelling and Structural Dynamics Antenna

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Dr S. K. Jalan

Mr. Kottresh K M

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

sk_jalan@vssc.gov.in

Summary of the Proposed Research

The modern structures will have component at various scale like carbon nanotubes at nanoscale and structures at macro scale. It is very essential that modelling capabilities are developed which can model the structures at these different scales and then integrated them. This is very useful for combing interfaces. The current research proposal is step towards that along with the dynamic response analysis.

Scope of the work:

Multi-scale modelling capability involving finite element model and molecular dynamics simulation interface.

Linkages to Space Programme:

- Multi Scale Modelling and dynamic response of LV structures is essential in structural design of Launch Vehicles especially for upper stages where composite strucurtres are sued.

Expected Deliverables:

1. Software including code and manuals.

RES-VSSC-2024-013

Name of ISRO/DOS Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

Title of the research proposal

Nonlinear modeling of bolted joints under vibration and transient loading and validation through experiments

Area of Research

Structures and Testing

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Dr. Jo Paul K Ignatius

Dr. Senthil K

Ms. Jeyajanaki B M

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

jopaul@vssc.gov.in

Summary of the Proposed Research

Development of digital twin model for bolted joints considering the effect of friction and contact can reduce the cost of design iterations. The conventional linear approaches fail to deliver good accuracy, due to the uncertain linear and nonlinear mechanisms in the contact interface of the bolted joints.

The inherent dynamics of the contact interfaces needs to be considered in modelling the assembled structures. The accurate prediction of the nonlinear dynamic response of a typical bolted joint is the objective of the proposed work. A finite element model capable of representing the slip mechanism shall be attempted. An equivalent reduced order model capturing the effects at the contact interface between the mating surfaces shall be developed for adopting in existing design practice. The developed model shall be validated through experiments on a typical test specimen and the experiments can be conducted at RVTG/SPRE vibration and shock test facility.

Scope of the work:

The inherent dynamics of bolted joint is too complex to be easily modeled and analyzed. In contrast to welded joints, bolted joints show higher dispersion in performance under dynamic loads and vibration. The damping, stiffness, and dynamic response of mechanical assemblies are significantly affected by the physics of the contact interfaces of joints and is one of the main sources of nonlinearity and uncertainty in structural dynamics. The behavior of the contact interface of bolted lap and flange joints Is load dependent. At low excitation force amplitudes, the behavior is linear because the relative displacement at the contact interface is not enough to initiate nonlinearities. Bolted lap and flange joints show specific nonlinear behavior particularly at higher excitation force amplitudes resulting from nonlinear slip and stick mechanisms. An accurate model is required to understand the uncertainties involved in the contact interfaces of a bolted joint. The micro-slip behavior at the contact interface between the joining assemblies shall be analyzed. The contact interface can be considered in detail by using a model. The hysteretic behavior of the joint shall be captured from this model. Finally a reduced-order model for adopting in design practice is expected

Major phases of the proposal:

1. Develop an experimentally validated numerical/theoretical nonlinear model for bolted joint in different configurations.
2. Identify the system parameters at the contact interface and using uncertainty analysis determine the response statistics.

Linkages to Space Programme:

- Linked to all launch vehicle structures, can reduce the cost of design iterations and provides accuracy.

Expected Deliverables:

1. A thoroughly validated FE model and reduced order nonlinear model for bolted joints.

RES-VSSC-2024-014

Name of ISRO/DOS Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

Title of the research proposal

Development of oxidation protection coating on refractory alloys

Area of Research

Materials

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Dr. Anoop Kumar Shukla

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

anoop_kumar@vssc.gov.in

Summary of the Proposed Research

Refractory alloys are a unique class of material known for their stability at high temperature due to their high melting point. The refractory metals include Niobium, Tungsten, Molybdenum, Rhenium and Tantalum and their alloys.

While these metals offer numerous benefits, they do pose certain challenges. One of their limitations is their susceptibility to oxidation when exposed to extremely high temperatures in presence of air/oxygen. The resulting oxidation can degrade the structural integrity of the part or component. The end-user will experience a shorter product lifespan and need to bear the expense of more frequent replacement.

It is possible to significantly limit the impact of oxidation on refractory metals by applying a coating to the base material. The coating serves as a protective barrier that prevents the formation of surface oxides. The most effective coating choice depends on a variety of factors such as the desired product lifespan, temperature and the atmospheric conditions to which the finished product will be exposed. Also, each refractory metal reacts differently to various coatings, which underscores the importance of ensuring compatibility.

As refractory alloys serve as a potential material for high temperature applications in launch vehicles and satellites, there is significant need to develop an oxidation protection coating for them.

Scope of the work:

The scope of the proposed research work is to develop an oxidation protection coating such as silicide based coatings, for refractory alloys based on Molybdenum, Niobium, and Tungsten etc.

1. The type of coating and the composition should be finalized.
2. The process of coating should be optimized.
3. The oxidation protection coating should be capable of protecting the base substrate from oxidation at a temperature 1500 °C (minimum) in presence of air/oxygen
4. The coating should be of sufficient thickness to protect the base substrate for repeated use.
5. The coating should be well adhered to the substrate and should be capable of withstanding thermal cycling and thermal shocks.

Linkages to Space Programme:

- For high temperature applications where refractory alloys would be suitable candidate in launch vehicle and satellites.
- Especially for reusable launch vehicle applications, for example refractory metals such as molybdenum are used in flush air delivery systems (FADS). FADS adaptors uses Molybdenum tubes and it needs an oxidation protection coating to protect the substrate during re-entry phase. Mo will be rapidly oxidized to MoO3 in air. The volatilization of MoO3 seriously restricts its application at elevated temperature. The surface-coating technology can protect the Mo substrate from oxidation at high temperature thereby shielding the substrate from volatilization.
- Similarly this oxidation protection coating will be applicable to Tungsten-Rhenium thrusters, C-103 thrusters etc.,

Expected Deliverables:

1. Oxidation protection coating technology for refractory metals and alloys.

RES-VSSC-2024-015

Name of ISRO/DOS Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

Title of the research proposal

Development of low-level detection capabilities in metal-oxide-semiconductor (MOS) based hydrogen sensors(H_2)

Area of Research

Sensors

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. Deepak Srivastava

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

deepak@vssc.gov.in

Summary of the Proposed Research

To design, develop, and deliver prototypes of the gas sensing devices for detecting hydrogen leakages in H_2O_2 fuel cells using Sb-doped SnO_2 thin-film sensors and also to measure the concentration of hydrogen gas of the sensors.

Scope of the work:

Detailed design documents outlining the fabrication process, materials used, architecture and specifications (optimization of sensor parameters, such as doping concentration, operating temperature, and film thickness) of the Sb-doped SnO_2 thin film hydrogen sensors.

- Plans and protocols for field testing the sensors in H_2O_2 fuel cell environments.
- Comprehensive technical manuals for the fabrication, operation, and maintenance of the sensors.

Linkages to Space Programme:

- These low level detection capability MOS based Hydrogen sensors will be required for detection of Hydrogen gas leakage in fuel cells power system identified for Bhartiya Antriksha Station (BAS).

Expected Deliverables:

1. Prototype Sb-doped SnO_2 thin-film sensors.
2. Design, operation and other technical documents.

RES-VSSC-2024-016

Name of ISRO/DOS Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

Title of the research proposal

Parameter characterization of glass fabrics for obtaining 60 MPa interlaminar shear strength with epoxy resin.

Area of Research
Materials

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Mr. Jithin G Mathew

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit
jithin_mathew@vssc.gov.in

Summary of the Proposed Research

For glass fabrics with same style, fibers and tensile properties, interlaminar shear strength with epoxy resin is found to vary from 30 to 60 MPa. This is mainly due to the interface behavior of fabrics with epoxy resin which in turn is affected by the finish/sizing being applied during weaving.

The research aim will be to identify the parameters that increase the interlaminar shear strength and perform a parametric study of these parameters.

Scope of the work:

Study of glass fabrics available in the market and the obtained shear strength/interface properties with epoxy resin (LY556+FH972 matrix system).

1. Identification and determination of factors (finish/sizing etc) that affects the interlaminar shear strength.
2. Optimization study to achieve an interlaminar shear strength of min. 60 MPa.
3. Demonstration by testing of interlaminar shear strength specimens.

Linkages to Space Programme:

- Glass fabric is being used in igniter cases for the solid motors of PSLV/SSLV/GSLV/LVM3 launch vehicles.

Expected Deliverables:

1. The process of fabric manufacturing/ modification that result in min. interlaminar shear strength of 60MPa with epoxy resins.

RES-VSSC-2024-017

Name of ISRO/DOS Centre/Unit
Vikram Sarabhai Space Centre, Thiruvananthapuram

Title of the research proposal
Software for the Generative design of Launch Vehicle Structures using AI

Area of Research
Structures. AI, Machine learning

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Dr. S. K. Jalan
Mr. Kottresh K M

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

sk_jalan@vssc.gov.in

Summary of the Proposed Research

Generative design is a method of using AI algorithms to generate and evaluate multiple design alternatives based on input from user. This design process can take many constraints into account including performance requirements, manufacturing process and materials to generate optimized designs. This proposal is to develop software for the Generative design of the launch vehicle structures.

Scope of the work:

Development of the software for the Generative design of the launch vehicle structures.

Linkages to Space Programme:

- All the future launch vehicles like NGLV will be having optimized upper structures. The present capability will be useful for such structures.

Expected Deliverables:

1. Software and associated manuals for Generative design of Launch vehicle structures.

RES-VSSC-2024-018

Name of ISRO/DOS Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

Title of the research proposal

Residual stress measurement and mitigation in high thickness AA2219 alloy friction stir welds for next generation launch vehicles

Area of Research

Materials and Manufacturing

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Dr. Agilan M

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

m_agilan@vssc.gov.in

Summary of the Proposed Research

Friction Stir Welding is proposed as a welding process to realize propellant tanks of next generation launch vehicles. The thickness of the welds is estimated to be 12-14 mm. Considering the thickness, the residual stresses (RS) are estimated to be high and the RS affects the mechanical properties and performance of the hardware.

In this activity, residual stresses (RS) development in AA2219 FSW weldments to be evaluated by various techniques. RS mitigation techniques such as laser shock peening, mechanical roller tensioning, shot peening to be established to reduce the residual stresses.

Scope of the work:

1. Evaluation of residual stress in high thickness 2219 FSW welds using X—ray diffraction technique (micro and macro),hole drilling, neutron diffraction, contour method etc.
2. Prediction of residual stress (RS) in 2219 FSW weldments by numerical simulation and validation through experimental data.
3. Study the effect of RS on mechanical properties such as tensile, hardness and fatigue performance, and microstructure.
4. Employ mitigation techniques such as laser shock peening, conventional shot peening, mechanical roller tensioning in 2219 alloy FSW weldments to reduce the residual stress.
5. Study the effect of RS mitigation techniques on residual stress, tensile properties, hardness, fatigue properties, microstructure (OM, SEM and TEM), texture and surface roughness.

Note: AA 2219 FSW welded plates of 12-14 mm will be supplied by VSSC for this study.

Linkages to Space Programme:

- Next generation launch vehicle (NGLV) is planning to use friction stir welding (FSW) for the fabrication of propellant tanks (both long seam and cir-seam). The thickness is estimated to be 12-14 mm. It is expected that residual stresses (RS) are higher for these high thickness welds. Residual stress evaluation and its mitigation are essential for design and fabrication of propellant tanks for better performance.

Expected Deliverables:

1. Comprehensive database on residual stresses development in 2219 FSW weldments and their effects on mechanical properties such as tensile, hardness and fatigue performance, and microstructure.
2. Technology development of laser shock peening, conventional shot peening, mechanical roller tensioning for 2219 alloy FSW weldments to reduce the residual stresses and specific recommendations on the optimal process parameters.
3. Comprehensive database on the effect of peening on residual stress, tensile properties, hardness, fatigue properties, microstructure, texture and surface roughness.

RES-VSSC-2024-019

Name of ISRO/DOS Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

Title of the research proposal

Molecular Dynamic Simulation for Identifying the Suitable Binder to Shape Metal-Organic Frameworks Adsorbent for VOC Removal

Area of Research

Molecular simulation

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Dr. Renjith S.

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

renjith_sp@vssc.gov.in

Summary of the Proposed Research

Porous Metal-Organic Frameworks (MOFs) can effectively remove volatile organic components (VOC) in the space domain that far exceeds the standard adsorbents considered to date, e.g. zeolites and activated carbons. Demonstrated the strong potential of MOFs (eg. MILs, UiO-66, DUT-4, ALFFIVE, SIFSIX series) for the capture of contaminants encountered in onboard and satellite systems. However, the shaping of MOFs is very crucial to promote their uses in real operating conditions. The challenge is to identify the best binder to combine with the selected MOFs to ensure an optimal adhesion of the two components into the resulting shaped adsorbent, with the major concern being to maintain the intrinsic performance of the MOFs for the capture of VOC. The MOF/binder composites have attracted extensive attention, however the interface formed between the two components is far from understood since its exploration is still challenging from both theoretical and experimental stand points. Indeed, there is a critical need to combine molecular simulations based on a reliable atomistic description of the MOF/binder composites and advanced experimental techniques (HRTEM, NMR, XPS, etc.) to extend the knowledge of the corresponding solid/solid or solid/matrix interface. Molecular Dynamic (MD) simulations for adhesion of MOFs and binders on optimal shaping of the MOF adsorbents are used on evaluating the impact of shaped MOFs upon gas adsorption properties. For this purpose the commonly known binders such as inorganic (e.g. Silica and Mesoporous q-alumina) and organic (e.g. PVA and PVB binders) could be employed.

Scope of the work:

- Computational exploration of the adhesion of MOFs and usual binders for optimal shaping of the adsorbents implying the use of quantum (DFT) and classical (Molecular Dynamics) molecular simulations.
- Evaluation of the impact of the shaping of MOFs on their contaminant capture properties.

Linkages to Space Programme:

- Molecular dynamic simulation will be useful for designing Co_2 removal and VOC removal system for Gaganyaan, Bharatiya Antariksha Station and other future man missions.

Expected Deliverables:

1. Computational screening to identify the best metal–organic framework (MOF) form MOFs, e.g. MILs, UiO-66, DUTs, ALFFIVE, SIFSIX series.
2. Computational exploration of the adhesion binders (e.g. Silica, Mesoporous q-alumina, PVA and PVB) to MOFs
3. Optimal shaping of the MOF adsorbents by implying the use of quantum (DFT) and classical (Molecular Dynamics) molecular simulations.
4. Theoretical evaluation of the impact of the shaping of MOFs on their contaminant capture properties.

RES-VSSC-2024-020

Name of ISRO/DOS Centre/Unit
Vikram Sarabhai Space Centre, Thiruvananthapuram

Title of the research proposal
Development of Butacene (Ferrocene grafted HTPB resin) for enhanced burn rate solid propellant formulations.

Area of Research
Solid propulsion

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Mr. Vishnu M C
Mr. Sathis Kumar P S

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit
vishnu_mc@vssc.gov.in
ps_sathis@vssc.gov.in

Summary of the Proposed Research

Solid rocket propellants are widely used in space launch vehicles to generate large amounts of thrust in a short time. Various conventional burn rate modifiers like iron oxide, copper chromite are added for enhanced burn rate requirement in solid propellants. These materials enhance the burn rate by lowering the decomposition temperature of oxidizer. Thus, they are added in limited proportions in propellant formulations usually in the tune of 0.15-2.0% by weight. However, increasing their concentration beyond 2% results in saturation of burn rate. Moreover, since these materials are inert in nature the overall energetic of the propellant reduces with increase >2% weight.

In this regard, as extensively studied in literature, the present proposal is focusing on modifying the available polymeric binder (10-15% by weight in solid propellants) by grafting with suitable functional organometallic compound – Ferrocenyl butyl dimethyl silane [Fe(C5H5)2]. It has been reported that substituting HTPB with Ferrocene grafted HTPB (Butacene) results in significant enhancement of burn rate for a given propellant formulation. Typical specification for Butacene is tabulated below:

Sl. No.	Test	Typical Specification
01	OH value	0.30±0.05 eq/kg
02	Moisture content	<0.1%
03	Volatile matter	<0.5%
04	Specific gravity	1.0±0.2
05	Viscosity	<1000P
06	Iron content	8.0±0.5%

However, there are many practical difficulties associated with realizing Butacene having consistent properties especially iron content, viscosity & OH value.

In this context, the current research proposal will help to accomplish the above objective.

Scope of the work:

1. Initial synthesis of ferrocene grafted HTPB with consistent properties with a batch size of 100gm-500gm.
2. Carrying out the material level characterization and propellant level trial for establishing the viability of synthesized product.
3. Demonstration of production up to a minimum scale of 500gm to 1kg with consistent properties between production batches.
4. TOT of matured technology to prospective vendors.

Linkages to Space Programme:

- For advanced propulsion systems requiring high burn rate, and for future Launch vehicles.

Expected Deliverables:

1. Development and synthesis of ferrocene grafted HTPB (Butacene) with minimum intermediate steps.
2. Demonstration of synthesis up to a bench scale setup (500gm to 1 kg level).
3. Conducting sub scale propellant level trials 8 kg to 120 kg level to verify mechanical and ballistic properties along with the safety characterization.
4. Design of a prospective pilot plant to manufacture Butacene till 5 to 10 kg batch.

RES-VSSC-2024-021

Name of ISRO/DOS Centre/Unit
Vikram Sarabhai Space Centre, Thiruvananthapuram

Title of the research proposal
Design and Development of High Strength-Ductile Titanium Alloys

Area of Research
Materials

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Mr. Pravin Muneshwar

Dr. Chenna Krishna S

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit
pravin_muneshwar@vssc.gov.in

s_chenna@vssc.gov.in

Summary of the Proposed Research

This proposal aims to develop high-performance titanium alloys with enhanced tensile strength and ductility through advanced alloy design and thermo-mechanical processing. By leveraging alloying elements like tin (Sn) to adjust the crystal structure at the atomic level and using cross-rolling techniques to optimize the microstructure, the goal is to create titanium alloys with properties suitable for

demanding aerospace and space applications. These alloys are intended to outperform traditional titanium alloys by combining gigapascal-level strength with excellent ductility, vital for structural components in spacecraft where both strength and flexibility are critical for performance and safety.

Scope of the work:

The project will be conducted in several stages, combining both alloy design and thermo-mechanical processing to achieve the targeted material properties. The scope includes:

1. Alloy Design:
    - Utilize computational alloy design to fine-tune the composition of titanium alloys, focusing on alloying elements like aluminium (Al), tin (Sn), vanadium (V), cobalt (Co), and iron (Fe).
    - Adjust the c/a ratio in the hexagonal close-packed (HCP) crystal structure to activate non-basal slip systems, improving plastic deformation behaviour.
    - Optimize the balance of alpha (α) and beta (β) phases to enhance both strength and ductility.
2. Thermo-Mechanical Processing:
    - Develop processing techniques such as cross-rolling and annealing to refine the alloy's microstructure, ensuring uniform deformation across different phases.
    - Optimize parameters like rolling temperature and strain rate to enhance phase distribution and reduce grain size, increasing strength without sacrificing ductility.
3. Material Characterization:
    - Conduct mechanical tests (tensile, hardness) to validate the strength and ductility of the alloys.
    - Use advanced microscopy (e.g., scanning electron microscopy, transmission electron microscopy) to study the microstructure, particularly the dislocation mechanisms and phase distribution.

Linkages to Space Programme:

- Titanium alloys are crucial for space exploration due to their high strength-to-weight ratio, corrosion resistance, and ability to withstand extreme temperatures and radiation. The newly developed titanium alloys will directly contribute to the following space program objectives:
    - Spacecraft Structures: High-strength, ductile titanium alloys can be used in load-bearing structures, improving spacecraft durability while minimizing weight—a critical factor in space missions.
    - Satellite Components: The improved strength and light weight of the alloy will be vital for the structural integrity and performance of satellite components, such as frames, panels, and support structures.
- The proposed alloys would enable lighter, more durable, and cost-effective components, reducing the payload mass and increasing fuel efficiency for space missions.

Expected Deliverables:

1. **Material Development:**
    - A novel titanium alloy with tensile strength 1250MPa and ductility >20%.

- Thermo-mechanical processing techniques to control phase distribution and grain size, improving both strength and ductility.

2. **Material Characterization Report:**
   - Detailed mechanical properties (tensile strength, ductility, hardness). Thermo-mechanical processing techniques to control phase distribution and grain size, improving both strength and ductility.
   - Microstructural analysis showing phase composition and dislocation mechanisms that contribute to the alloy's performance.
3. **Development of a new titanium alloy system with tensile strength exceeding 1250MPa and ductility above 20%.**
4. **Thermo-mechanical processing routes (such as cross-rolling) to achieve the desired microstructural properties.**
5. **Comprehensive material characterization, including mechanical properties (strength, ductility) and microstructure analysis.**
6. **A detailed roadmap for scaling the production of these alloys for aerospace and space program applications.**

RES-VSSC-2024-022

Name of ISRO/DOS Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

Title of the research proposal

Astro Catalyst: Pioneering Space-Optimized Catalysts for Sustainable Oxygen Regeneration in Space Stations

Area of Research

Space Station Life Support Systems

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Dr. Vijayalakshmi K. P.

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

kp_vijayalakshmi@vssc.gov.in

Summary of the Proposed Research

"Astro Catalyst: Pioneering Space-Optimized Catalysts for Sustainable Oxygen Regeneration in Space Stations" aims to develop catalysts optimized for oxygen regeneration aboard space stations. Oxygen regeneration is vital for life support, where carbon dioxide (CO_2) exhaled by astronauts is converted back into oxygen (O_2). Current systems like the Sabatier reaction convert CO_2 and hydrogen (H_2) into water (H_2O) and methane (CH_4), recovering water from exhaled CO_2 and discarded H_2 from electrolysis.

$CO_2 + 4H_2 \rightarrow CH_4 + 2H_2O$

$2H_2O \rightarrow 2H_2 + O_2$

This proposal will explore both the traditional Sabatier reaction and extend beyond by investigating new processes like the decomposition of methane (a byproduct of the Sabatier reaction) into hydrogen, allowing further CO_2 conversion into water. In this context, computational chemistry tools, such as quantum chemistry and molecular dynamics simulations, will be employed to design and optimize catalysts that can withstand space-specific challenges, including microgravity, radiation exposure, and extreme temperature fluctuations. The goal is to optimize reaction mechanisms involved in oxygen regeneration, focusing on improving catalyst efficiency, stability, and resilience.

These new catalysts will aim to surpass existing efficiencies, achieving stable and efficient oxygen regeneration systems that will support long-duration missions, lunar outposts, and future exploration missions to Mars.

Scope of the work:

The research will investigate a range of catalytic materials and mechanisms with an emphasis on:

1. **Space Conditions:** Simulating and testing catalyst resilience under space conditions, such as microgravity, temperature fluctuations, and radiation exposure.
2. **Methane Decomposition Technology:** Developing catalysts capable of decomposing methane (a byproduct of the Sabatier reaction) into hydrogen, which can be reused to react with additional CO_2 for increased oxygen regeneration.
3. **Catalytic Materials:** Screening a variety of catalysts, including metal oxides, carbon-based catalysts, and metal-organic frameworks (MOFs), for their performance in oxygen generation and methane decomposition under simulated space conditions.
4. **Computational Modeling:** Utilizing advanced computational simulations to analyze reaction mechanisms, identify stable catalysts, and predict their efficiency in space environments.
5. **Experimental Validation:** Collaborating with space analog laboratories for validating the most promising catalysts under simulated space conditions.

By focusing on improving both oxygen recovery and catalyst durability, this research will significantly contribute to the sustainability of life-support systems in space.

Linkages to Space Programme:

This research aligns directly with ISRO's Vision 2047 and supports the goal of establishing sustainable human space exploration through the development of life-support systems that minimize resource reliance from Earth. Efficient oxygen regeneration is a critical component of closed-loop life-support systems, vital for long-duration missions like Gaganyaan and future lunar or Martian outposts. By optimizing catalysts for both Sabatier reaction enhancements and methane recycling, the project will improve oxygen recycling efficiency, extending the usability of resources in space.

Incorporating these developments into ISRO's broader Human Spaceflight Programme will enable the establishment of space habitats with minimal dependency on Earth resupply missions.

Expected Deliverables:

1. **Advanced Catalysts for Oxygen Regeneration:** Catalysts developed for increased oxygen recovery from CO_2, with enhanced performance in space conditions.

2. **Methane Decomposition Catalysts:** Catalysts that efficiently decompose methane (CH_4), a byproduct of the Sabatier process, into hydrogen for further CO_2 reduction into water, thus closing the loop on oxygen recycling.
3. **Computational Models and Simulations:** Detailed models of reaction mechanisms, stability analyses, and performance predictions for the proposed catalysts under space-specific conditions. Experimental Validation Proposals:
4. **Experimental Validation Proposals:** Plans for validating the catalysts in simulated space environments, with pathways toward integrating the findings into space missions.

RES-VSSC-2024-023

Name of ISRO/DOS Centre/Unit
Vikram Sarabhai Space Centre, Thiruvananthapuram

Title of the research proposal
Development of electrically conductive corrosion resistant coating for fuel cell bipolar plate

Area of Research
Materials and coatings

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Mr. Surajeet Mohanty

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit
m_surajeet@vssc.gov.in

Summary of the Proposed Research

SS316L/304L plates and foils form strong candidate substrate material for flow field plates of high power density PEM Fuel Cell stacks. The material possesses inherent corrosion resistance, due to formation of a passive film on the surface. However, this restricts the interfacial conductivity and tends to enhance internal resistance, compromising performance. Objective of this proposal is to develop electrically conductive corrosion resistant coating which meets the PEM Fuel cell conditions on thin metal foil based flow field plates made out of SS 316L/SS304L.

Scope of the work:

The objective of this proposal is to develop an electrically conductive corrosion resistance coating on thin metal foils of SS316L/SS304. The details of the coating and the coating requirements are given below.

- Coating type: Conductive Graphite /carbide/Ti-Nitride
- Interfacial contact resistance: < 5 mΩcm2
- Corrosion current density: < 1 μA/cm2

Linkages to Space Programme:

- Fuel cell applications for long duration space mission viz., crewed missions, space habitation etc.
- Fuel cell system for EV application

Expected Deliverables:

1. Detailed report comprising of the experimental studies and the complete process details for realising the product.
2. Coupons with developed coating and its characterization results.
3. Coated flow field plates (at least 5 Nos.) of approximate size 400 mm x 150 mm.

RES-VSSC-2024-024

Name of ISRO/DOS Centre/Unit
Vikram Sarabhai Space Centre, Thiruvananthapuram

Title of the research proposal
Ultra low IR emissive & ultra low solar absorptive thermal control coating

Area of Research
Materials

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Dr. K. Indulekha

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit
k_indulekha@vssc.gov.in

Summary of the Proposed Research

Successful space missions require controlling the internal temperature of the satellite/spacecraft within an optimal temperature range, typically close to room temperature, suitable for the operation of its electronic systems. Thermal control coatings with low solar absorptivity and low IR emissivity play a crucial role for the thermal management of such systems to maintain the temperature typically close to room temperature.

Scope of the work:

Polymeric thermal control systems with both solar absorptance & IR emissivity <0.1 and with good thermal cycling tolerance and good adhesion on polymeric/metallic substrates with low outgassing characteristics for on-orbit thermal control of spacecraft / space station structures are envisaged through following approaches:

1. Synthesis of structurally tuned silicone polymers with bare minimum organic moieties.
2. Selection of ultra low emissive & ultra low solar absorptive fillers.
3. Functionalisation of fillers to improve compatibility with the chosen matrix resins.

Linkages to Space Programme:

- Thermal control Coatings for the structures of Bharathiya Antariksh Station.

Expected Deliverables:

1. Thermal control coating amenable for brushing/spraying/trowelling over large areas (approx: 10 m^2).

2. Quantity required for analysis – 250 g
3. Detailed procedure for the synthesis, compounding, formulation etc. to be provided.
4. All the test and analysis reports.

RES-VSSC-2024-025

Name of ISRO/DOS Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

Title of the research proposal

Meta-materials/structure for terahertz based communication systems

Area of Research

Optics & Communication

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Dr. Venkateswaran C.

Dr. Prasanth C. Upadhya

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

c_venkateswaran@vssc.gov.in

Summary of the Proposed Research

Terahertz or sub-millimeter wavelength spectrum has high potential for communication systems beyond 6G. Ultra fast communication system that work on terahertz frequencies were demonstrated elsewhere in space communication and wireless short communications. Real world applications of this spectrum are growing. At present, this spectrum is actively being used for remote sensing and spectroscopy.

By engineering a material or its surface, its basic characteristics can be tuned to create lenses, adaptive optics, tunable mirrors, switches, modulator/converters, sensors and absorbers. Specially configured matamaterial can be used for beam-steering and phase shifting as well. It is proposed to explore the field of terahertz optical communication through metamaterial based materials engineering.

Scope of the work:

Identify a suitable semiconductor/dielectric as a base material for design and fabrication of metamaterial.

1. Explore the fabrication of Lenses, dielectric mirror, modulators, sensors & absorbers required for THz communication system.
2. Demonstrate a proof of the concept of THz communication system using the functional elements realized using meta materials.

Linkages to Space Programme:

- Advanced Communication systems for ISRO programmes.

Expected Deliverables:

1. Basic design for metamaterial or meta surfaces for THz communication system.
2. Method of fabrication of meta material based lenses, dielectric mirror, modulators & absorbers for THz based communications

3. Technology document describing the fabrication aspects of the Proof-of-concept (PoC) THz communication devices and results.

RES-VSSC-2024-026

Name of ISRO/DOS Centre/Unit
Vikram Sarabhai Space Centre, Thiruvananthapuram

Title of the research proposal
Development of Space Grade 3D Printable Polymeric Resins

Area of Research
Materials

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Mr. Dawn Raju

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit
dawn@vssc.gov.in

Summary of the Proposed Research

3D printable polymers have opened up new design and manufacturing opportunities, even for the most relevant parts in launch vehicle and satellite domain. Even though there are plethora of options available for 3D printable resins in the market, the required space grade properties, such as low outgassing, flame resistance, thermal cycling properties, biocompatibility for manned missions, etc. are either unexplored or unattainable for most of them resulting in making many of the commercially available polymers not suitable for product fabrication using 3D printing for space applications. Even though metal 3D printing is available, it cannot meet the versatility that comes with 3D printed polymers such as good surface finish or intricate structures and cost effectiveness. There is essential requirement for development of space grade high strength polymeric resins incorporating these properties.

Scope of the work:

The main objective of the activity is to develop high strength space grade polymeric resins having low outgassing, thermal cycling, biocompatibility, flame retardancy, for different 3D printing technologies. The project focus on developing resin and polymers for two of the most prominent 3D printing techniques- Fused Deposition modelling (FDM) and Stereo lithography (SLA).

Polymer development for FDM is aim ed at developing 3D printable Polyether imide, PEEK etc.

Polymer development for SLA shall be based on acrylate or epoxy systems.

Linkages to Space Programme:

- 3D printed polymers can be used to development of Microsats and nanosats as well as for components for long term spare mission such as BAS which involves carrying out scientific experiments. 3D printed polymer will be a useful tool for such scientific expeditions.

Expected Deliverables:

1. 3D printable polymeric resins developed – 500 g each (FDM grade and SLA grade) for evaluation at VSSC. Detailed synthesis procedure, processing route and test/analysis reports.

RES-VSSC-2024-027

Name of ISRO/DOS Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

Title of the research proposal

Molecular Simulation on Chemical Systems for Designing of Novel Composite Solid Propellant Materials

Area of Research

Materials

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Dr. Renjith S.

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

renjith_sp@vssc.gov.in

Summary of the Proposed Research

Composite solid propellants (CSP) play an important role in the development of larger and smaller rockets for any space mission. CSPs are multi-component systems, which brings complexity and uncertainty in their property predictions and characterization. Strategizing a suitable molecular simulation methodology could help to bring down the number of trials for characterization and quality controlling of various components in the solid propellants, such as oxidizer, catalyst, binder, etc. For example, Ammonium perchlorate (AP)/hydroxyl-terminated polybutadiene (HTPB) composite solid propellants comprise a solid particle-filled polymer energetic composite material that is widely studied and used. This kind of CSP mainly comprises an AP solid filler and a macromolecule binder HTPB, of which the solid filler typically accounts for more than 80% of the total mass of the propellant. In addition to AP, a wide range of catalysts as solid filler with less than 2% including metals, metal oxides etc. are reported to reduce AP decomposition. Recently, a novel class of binder known as Glycidyl Azide Polymer (GAP) with the additional advantage of energy liberation during solid propellant combustion are reported. Instead of corrosive AP, the environment friendly Ammonium Dinitrate (ADN) could be used for green CSP, i.e. ADN/GAP. Therefore, to formulate a new composition for CSP with low cost and lesser developmental time, theoretical understanding of interfacial interaction between the main solid fillers, (ADN, metals, metal oxides etc.), and GAP matrix in CSPs is very critical since the experimental pathway is highly time consuming and cost-effective. In addition to this, understanding the he alkyne – azide cure chemistry is key to success for finding suitable formulation of ADN/GAP based CSP.

Scope of the work:

To develop a chemical structure molecular model for GAP with varying chemical composition and hydroxyl and isomer values .

- Evaluate theoretical viscosity (Atomistic MD or Coarse grained MD) building up of GAP.
- Alkyne-azide cure chemistry shall be investigated with curing agent such as bispropargyl succinate, bisproprgyl hydroquinone (BPHQ), etc.
- To predict the interfacial interaction between the solid filler, (i.e. ADN, Metal, and Metal Oxides) and binder matrix, for example Cured GAP with bispropargyl succinate, via molecular dynamic simulations.

- To predict the structural, thermal and electromagnetic properties of the solid propellants having composition of ADN, Metal, Metal Oxides and Cured GAP based binder matrix.

Linkages to Space Programme:

- Will be useful for replacing existing composite solid propellant to more green propellant for the future Launch Vehicle Missions.

Expected Deliverables:

1. Reliable chemical structure molecular model, i.e. both Full Atomistic and Coarse grained, for GAP with varying chemical composition and hydroxyl and isomer values.
2. Theoretical viscosity building up of GAP with curing agent such as bispropargyl succinate, bisproprgyl hydroquinone (BPHQ) via Atomistic MD and Coarse grained MD.
3. Prediction of interfacial interaction between the solid filler, (i.e. ADN, Metal, and Metal Oxides) and binder matrix, i.e. GAP cured with bis propagyl succinate, via molecular dynamic simulations.
4. To understand the mechanical properties of the solid propellants having composition of ADN, Metal, Metal Oxides and GAP based binder matrix.

RES-VSSC-2024-028

Name of ISRO/DOS Centre/Unit
Vikram Sarabhai Space Centre, Thiruvananthapuram

Title of the research proposal
Development of Carbon Nano Tube (CNT) Fiber

Area of Research
Materials

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Mr. Shyam S Nair

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit
shyam_sn@vssc.gov.in

Summary of the Proposed Research

Electrodynamic dust shielding (EDS) is one of the most efficient and explored technology for surface dust mitigation of exploration vehicles, habitats, EVA suites etc. It utilizes an array of electrodes on the surface which are generally made up of metals such as copper/ conductive materials such as ITO. However, application of such materials is limited to rigid surfaces. For surfaces that are subjected to flexing or folding such as EVA suite or inflatable habitats, high strength conductive materials are required. CNT fibers are reported as an excellent candidate.

CNT's area ideal multifunctional materials that combine the best properties of polymers, carbon fibers, and metals. It have an outstanding combination of mechanical strength and stiffness, electrical and thermal conductivity, and low density. Primarily two different methods are reported in literatures – (1) solid-state process wherein CNTs are either directly spun into a fiber from the synthesis reaction zone or from a CNT forest & (2) Wet spinning method in which premade CNTs are dissolved or dispersed in a

fluid, extruded out of a spinneret, and coagulated into a solid fiber by extracting the dispersant grown on a solid substrate.

The proposed research shall focus on process development of an easily scalable manufacturing process for continuous CNT fibers synthesis of appreciable property (Tensile strength > 1 GPa and Electrical conductivity ~ 3 MS/m) that are stable under repeated thermal cycling over 200°C.

Scope of the work:

Development of process for CNT fibre synthesis.

- Characterisation of fibre.
- Post synthesis treatments if required to improve properties.

Linkages to Space Programme:

- CNT based electrode for Electrodynamic Dust Shielding system for deep space missions (Lunar & Martian Exploration Missions).

Expected Deliverables:

1. Detailed development report on experimental studies carried out for the development, characterization and its outcome.
2. Process report on finalized CNT fibre synthesis process route.
3. One CNT fibre roll with fibre length of 50 m approximately.

RES-VSSC-2024-029

Name of ISRO/DOS Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

Title of the research proposal

Development of para-aramid synthetic fiber

Area of Research

Materials

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Dr. Satheesh Chandran M

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

satheesh_chandran@vssc.gov.in

Summary of the Proposed Research

- Kevlar® is a well-known commercially available synthetic fiber/ fabric which finds application in ISRO's launch vehicles (in composites and antenna structures).
- Chemistry: Kevlar is a polyamide, a synthetic polymer in which the amide groups are separated by para-phenylene groups, meaning that the amide groups are linked together on opposite sides of the phenyl group.
- These class of fibers are 5 times stronger than steel on an equal weight basis.

- The proposal is to indigenize kevlar equivalent fiber to cater to the needs of the nation.

Scope of the work:

The aim of the research is to indigenize the development of Kevlar® equivalent fiber for launch vehicle and satellite structure applications of ISRO.

Scope of the activity includes optimizing the synthesis, optimization of the spinning technology to get the of desired properties of the fiber, evaluate the properties vis a vis similar to or better than the imported Kevlar® fiber.

Sl. No.	Property	Range
1	Ultimate Tensile Strength (UTS) MPa	50-60
2	Tensile Yield Strength (MPa)	2500-2800
3	Tensile Modulus (GPa)	60-70
4	Elongation @ Break (%)	2.5-3.5

Linkages to Space Programme:

- All launch vehicles of ISRO and satellites including
  - Gaganyaan missions
  - Moon landing mission
  - Moon returning missions

Expected Deliverables:

1. The indigenization of Kevlar equivalent fiber synthesis and manufacturing technology is highly essential as no production is available in the country and the current demand is met through imported source.
2. Development and supply (buy-back)

RES-VSSC-2024-030

Name of ISRO/DOS Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

Title of the research proposal

Development of thermoplastic ionomeric materials with self-healing characteristics

Area of Research

Materials

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Ms. Ann Mathew

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

k_annmathew@vssc.gov.in

Summary of the Proposed Research

Self–healing is the technology to make the spacecraft / space capsule immune to micro meteor / debris impact generated cracks. Polymeric materials exhibiting substantially instant and complete self-healing without external assistance after being penetrated at a site by a projectile or micrometeoroid impact are required for applications in space structures. Different mechanisms of self-repairing polymeric systems based on extrinsic and intrinsic healing mechanisms are currently being explored. Success in the design of such systems has important consequences for material safety, product performance and enhanced fatigue lifetime.

The important factors necessary for self-healing polymers include: good impact strength, control of the degree of crystallinity, low melting point and the ability to melt flow. Development of thermoplastic ionomeric materials which is neutralized with different counterions can impart these specific characteristics. An ionomer is a polymer composed of repeat units of both electrically neutral repeating units and ionized units covalently bonded to the polymer backbone as pendant group moieties. Usually no more than 15 mole percent are ionized. The ionized units are often carboxylic acid groups.

Typical examples of polymeric materials include poly ester homopolymers and copolymers, poly(ester amides), polyesters containing aliphatic amide units and blends of polyesters, polyethylenes and ethylene propylene diene polymers. The acid form of the copolymer is synthesized by co polymerisation and the ionomer is formed through subsequent neutralization by the appropriate metal cation such as zinc, sodium, and magnesium. Such type of self healing system can find applications for healing of micro-cracks in the composite components for space crafts, special thermal protection system for the Crew module and liquid engine thrusters and space inflatable/ rigidisable structures.

Scope of the work:

The main objective of the activity is to develop thermoplastic ionomeric self-healable polymeric systems having

- Impact resistance and ductility sufficient to resist cracking and brittle fracture upon impact by the high velocity projectile.
- Melt flow sufficient to provide movement of the polymeric material during viscoelastic recovery.

Linkages to Space Programme:

- The developed ionomeric self-healing polymeric system can be incorporated into various composite structures of spacecrafts and in Crew Module configurations for imparting MMOD protection.

Expected Deliverables:

1. Developed ionomeric system based on different polymeric systems for evaluation at VSSC.
2. Quantity required : 250 g
3. Detailed synthesis procedure, processing route and test/analysis reports.

RES-VSSC-2024-031

Name of ISRO/DOS Centre/Unit
Vikram Sarabhai Space Centre, Thiruvananthapuram

Title of the research proposal
Wearable thermoelectric generators for powering various health monitoring sensors for long term manned missions

Area of Research
Space station

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Dr. Vishnu S

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit
s_vishnu@vssc.gov.in

Summary of the Proposed Research

- Long term manned missions required dedicated sensors and microelectronics for health monitoring of astronauts.
- Additional power supply for these facilities can enhance mission criticality.
- Hence self-powered electronic systems are highly demanding for these applications.
- Wearable thermoelectric generators can harvest human body temperature variations to power various kinds of microelectronics.

Scope of the work:

Wearable electronics and sensors are promising for long term manned missions such space station. However, their limited energy storage and the periodic changes required for additional power supply modules, such as lithium cell and nickel-zinc batteries, limit the application of these electronics and sensors. Therefore, the demand for sustainable power supplies for these devices is urgent, and energy-harvesting modules represent a promising method to achieve self-powered electronic systems. Thermoelectric generators (TEGs) can convert harvested heat into electricity based on the Seebeck effect. Thus, the human body can be seen as a stable and sustained natural heat energy source. Hence, wearable thermoelectric generators can harvest body heat with high efficiency and could be utilized for powering electronics and sensors for health monitoring.

Linkages to Space Programme:

- Future space missions involves representation and participation of human in space.
- Hence safety & well-being of astronauts has given higher priority.
- Self-powered electronic systems are highly demanding for these applications.

Expected Deliverables:

1. Thermoelectric generators for
    - health monitoring sensors
    - microelectronics

SPACE APPLICATIONS CENTRE

AHMEDABAD

RES-SAC-2024-001

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Development and Realization of GNSS Remote Sensing Signal Simulator

Area of Research

Navigation, Remote Sensing, Signal Processing

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. Pramod

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

pramodkm123@sac.isro.gov.in

Summary of the Proposed Research

Earth Observation (EO) techniques using Global Navigation Satellite System (GNSS) signals of opportunity such as GNSS-Reflectometry (GNSS-R) are gaining popularity in the recent years. It is a relatively new passive remote sensing technique that measures GNSS signals reflected over the earth's surface to measure key parameters of ocean, land, and ice surfaces.

In order to test GNSS RS signal reception with configurable scenarios, a GNSS (direct signal) and GNSS-RS(reflected signal) signal generator is required with the capability to simulate navigation messages to allow positioning, as well as simulating any user-defined, direct and reflected path with satellite handovers. This capability to simulate specular and scattered reflections is required to test the delay-Doppler map (DDM) calculations in the GNSS RS Receiver.

The proposed work involves modeling of the direct navigation signal & and the corresponding reflected signal, received at LEO satellite in the operational scenario of a GNSS Remote Sensing spacecraft.

The developed simulator should have the following capabilities :

1. GPS L1 C/A and IRNSS SPS signal generation with proper Ephemerides and Almanac information
2. GNSS transmitting and receiving LEO satellites orbit simulation;
3. Any user-defined path should be able to be uploaded, either on the Earth or in orbit, with as much temporal resolution as necessary
4. Estimation of location of the specular reflection point and glistening zone (area where scattered power is collected);
5. Reflected surface scattering coefficient generation based on geophysical parameters
6. It shall be able to model and generate both direct and reflected signals, on rough or smooth surfaces incorporating tropospheric and ionospheric effects on both direct and reflected signal.
7. Graphical input/output user interface (GUI).
8. Generation of IF/RF direct and reflected navigation signals

Scope of the work:

Modeling of the Navigation signal with ionospheric effects

Modeling of the reflected signal with surface properties, spacecraft dynamics, tropospheric and ionospheric effects.

Porting of the models on suitable Hardware to generate physical direct and reflected signal with defined parameters

Linkages to Space Programme:

- GNSS Remote Sensing

Expected Deliverables:

1. Signal Generation models
2. Software Signal Simulator
3. Hardware Signal Simulator
4. Documentation

RES-SAC-2024-002

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Feasibility of Polar CODEC for Satellite Navigation System

Area of Research

Navigation & Channel coding

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. Neeraj Mishra

Dr. Deepak Mishra

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

neerajsci@sac.isro.gov.in

deepakmishra@sac.isro.gov.in

Summary of the Proposed Research

The Global Navigation Satellite System (GNSS) relies on Forward Error Correction (FEC) to ensure reliable data transmission, especially in challenging low Signal-to-Noise Ratio (SNR) conditions. Recently, NAVIC has adopted Low-Density Parity-Check (LDPC) codes. The reliability of these systems heavily depends on the performance of the chosen channel codes.

Among the emerging FEC alternatives is the Polar code, introduced by Erdal Arikan in 2008. Polar codes are a class of error-correcting codes known for their capacity-achieving characteristics and systematic construction, which allow them to approach the Shannon limit for reliable communication. Notably, Polar codes overcome the error floor problem commonly associated with short-length block codes, often

used in navigation systems. Their recent implementation in the control channels of 5G systems further demonstrates their potential.

This research aims to assess the feasibility of utilizing Polar codes in navigation systems, specifically evaluating their performance compared to existing channel codes employed in NAVIC. The study will focus on developing Polar codes tailored for GNSS applications and conducting a thorough performance evaluation to compare their effectiveness against currently used LDPC codes.

By investigating these aspects, this research intends to provide valuable insights into enhancing the reliability and efficiency of GNSS communications, which could lead to improved positioning accuracy and overall system performance. The goal is to establish Polar codes as viable candidates for future GNSS systems.

Scope of the work:

- Feasibility analysis of Polar codes for short frame length.
- Arriving at suitable constituent codes for applications and hence design an encoder.
- Developing an efficient decoding algorithm to improve the coding gain
- Hardware realization of a low complex encoder and reliability-based decoder.

Linkages to Space Programme:

- Next Generation NavIC Programme

Expected Deliverables:

1. Optimum Polar codes with hardware implementation of encoder and decoder

RES-SAC-2024-003

Name of ISRO/DOS Centre/Unit
Space Applications Centre, Ahmedabad

Title of the research proposal
Advances in Numerical Weather Prediction (NWP) Modelling using AI/ML Techniques

Area of Research
Weather forecasting, Data assimilation, Machine learning

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Dr. Prashant Kumar

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit
prashant22@sac.isro.gov.in

Summary of the Proposed Research

The accuracy of short-range weather forecasts from high-resolution NWP models can be affected by factors such as surface heterogeneity, data assimilation techniques, and uncertainties in model physics.

To address these issues, the proposed research aims to utilize machine learning (ML) techniques alongside modern atmospheric modeling advancements. By integrating ML, we can improve the predictive

capabilities of traditional NWP models, enabling more accurate and reliable forecasts. Machine learning algorithms can identify complex patterns in large datasets, helping to tackle surface heterogeneity and enhance data assimilation.

Additionally, ML models can continuously adapt and learn from new data, refining predictions and minimizing errors. This integration not only aims to boost forecast accuracy but also facilitates real-time updates during rapidly changing weather conditions.

Overall, this research seeks to advance short-range weather forecasting, enhancing our understanding of weather dynamics and improving forecast reliability for various applications.

Scope of the work:

- The proposed research aims to enhance NWP model predictions using AI/ML techniques. These methods can be employed to develop observation operators for assimilating new (e.g. visible radiance assimilation) data, correcting model biases, improving assimilation techniques, refining post-processing, etc.
- By integrating AI/ML approaches, the research seeks to increase the accuracy and reliability of weather forecasts, ultimately contributing to better decision-making in various applications.

Linkages to Space Programme:

- This research aims to enhance short-range weather forecasts by integrating ML techniques with high-resolution NWP models and ISRO satellite data from INSAT-3DS, TRISHNA, etc.
- By leveraging ML, we can improve data assimilation, address surface heterogeneity, and provide more accurate and timely weather predictions for various applications.

Expected Deliverables:

1. The deliverable include enhanced short-range weather forecasts, improved data assimilation techniques, insights from satellite observations, and a comprehensive evaluation of model accuracy and reliability.

RES-SAC-2024-004

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Investigation of microphysical processes within tropical cyclones using satellite data to predict TC rapid intensification

Area of Research

Tropical cyclone analysis and forecasting

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Dr. Neeru Jaiswal

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

neeru@sac.isro.gov.in

Summary of the Proposed Research

Tropical cyclone (TC) rapid intensification (RI) is the most challenging problem at present, which lead to uncertainty in the TC intensity prediction. Thus to improve the TC intensity forecast, it is highly important to understand the various dynamical and microphysical processes modulating the intensity of TCs. Satellite data is a primary input for deriving the TC intensity and structural parameters. The geostationary satellite generated thermal IR, water vapor and visible channel images provides the signatures of TC characteristics and are being used for TC intensity estimation world-wide. The cloud top characteristics of north Indian ocean (NIO) cyclones are observed by every half an hour image from INSAT-3D/3DR/3DS. These images can be labelled with the cyclone geolocation and intensity values archived in the cyclone best track data and trained in a deep learning based models to detect the TC-RI. Other advanced microwave satellite data can also be explored to investigate the processes within the cloud system responsible for TC-RI. The developed trained neural network can be used to predict TC-RI in the real-time using satellite imageries.

Scope of the work:

Real-time satellite based indicators to predict TC rapid intensification.

Linkages to Space Programme:

- Disaster Management Support Programme (DMSP)

Expected Deliverables:

1. ANN based model to be used during real-time TC intensity analysis and prediction.

RES-SAC-2024-005

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Design, development and characterization of an autonomous ornithopter (Flapping wing UAV) technology demonstrator

Area of Research

Autonomous Powered flight on planets with atmosphere

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. Pradeep Ananthanarayanan

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

pradeepa@sac.isro.gov.in

Summary of the Proposed Research

- Configuration and Design of a powered ornithopter UAV that is capable of housing small video camera capable of streaming live video.
- Software/firmware development as required to meet the requirements.
- Integration of NAVIC for accurate positioning.

- Manufacturing assembly, integration and initial operation of the UAV.
- Dynamic Characterization (vibrations, drift, landing shocks etc.) of the UAV using variety of sensors like accelerometers, gyros inclinometers etc.

Scope of the work:

Configuration and Design of a powered ornithopter UAV that is capable of housing small video camera capable of streaming live video. Failure mode effect and criticality analysis of the UAV design. The UAV shall have in-built failure tolerant and fail safe safety features. It shall adhere to ingress rating of at least IP65 while IP67 is desirable.

Linkages to Space Programme:

- UAV Research & Navigation

Expected Deliverables:

1. Ornitopter UAV with payload capacity to carry small video camera.
2. Accessories of UAV like remote controller, master computer (laptop) with required software/firmware, charging cables, spare batteries, antenna etc.
3. Raw Data acquired during dynamic characterization of UAV.
4. Anything else that is necessary to satisfactorily operate and maintain the UAV.

RES-SAC-2024-006

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Design and Implementation of a Cryptographically Secure Random Number Generator (CSPRNG)

Area of Research

Navcom Technology, Satellite Navigation

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mrs. Sugandh Mishra
Mr. Deval Mehta

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

sugandh@sac.isro.gov.in
m_deval@sac.isro.gov.in

Summary of the Proposed Research

This project aims at design of an algorithm for a Cryptographically Secure Random Number Generator (CSPRNG), its performance analysis and its software and hardware implementation.

CSPRNG are different from a PRNG in a way that CSPRNG are designed to be more resilient to attacks and their outputs are unpredictable in nature making them suitable to cryptographic applications.

Scope of the work:

CSPRNG are usually designed using cryptographic primitive. Scope of project includes design and implementation of a CSPRNG algorithm with following desired characteristics-

- Forward security
- Backward security
- Uniform distribution of output numbers
- Resistance to state compromise
- Efficient re-seeding mechanism
- Statistically robust – must pass suite of randomness such as NIST, diehard Tests etc.
- Input Entropy assessment
- Implementation and demonstration of Algorithm in software as well as in hardware such as in an FPGA while performance consideration such as power and resource consumption is to be taken into account

Linkages to Space Programme:

- CSPRNG are utilized in various security protocol such as encryption, encryption key generation, digital signature and authentication.
- Designed CSPRNG can be utilized in different ISRO projects including navigation signal authentication, encryption key generation for secure communication , signal encryption etc.

Expected Deliverables:

1. Designed CSPRNG algorithm, its mathematical modelling and technical details
2. Functionally Tested software: source code and executables in C / python or MATLAB
3. FPGA implementation: Functionally tested HDL source code of the design
4. Installable controller software on any supported Windows PC along with manual.

RES-SAC-2024-007

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Thermal Analysis and lifetime estimation of AlGaN-GaN HEMTs

Area of Research

High Frequency Semiconductors for Communication and Remote Sensing

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. Prakhar Kumar Srivastava

Dr. Rakeshkumar K Kaneriya

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

prakhars@sac.isro.gov.in
rakeshk@sac.isro.gov.in

Summary of the Proposed Research

AlGaN/GaN based HEMTs offer exceptional high power density at high frequencies. However, this comes at the cost of increased power dissipation in a very small area and associated self-heating effects. Elevated temperatures can lead to increased degradation and failure rates, and a reduction in output power performance.

Therefore, an accurate method of estimating the device temperature, through modeling and analysis is essential. This typically, shall be done, in a phased manner. In the first phase, a baseline electrical model of the device, shall be developed, to predict device temperature. The device shall then be fabricated and measurements (IR and MicroRaman) shall be carried out on the fabricated device to derive empirical data. Using empirical data, an FEA model shall be developed. This FEA model shall then be used to accurately predict device temperature for different device geometries.

This model shall also be used to predict the lifetime of the devices by simulating the thermal performance at specified elevated temperatures.

The heterostructure details, device geometry and ambient conditions, for the above work, shall be provided by SAC.

Scope of the work:

- Thermal Analysis of AlGaN/GaN on SiC HEMTs
- Development of model for channel temperature prediction in AlGaN/GaN on SiC HEMTs
- Lifetime estimation of AlGaN/GaN on SiC HEMTs

Linkages to Space Programme:

- Communication, Navigation and Microwave Remote Sensing payloads of SAC/ISRO

Expected Deliverables:

1. Model for channel temperature prediction in and lifetime estimation in AlGaN/GaN on SiC HEMTs

RES-SAC-2024-008

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Design and Development of Algorithm for matching LiDAR intensity image with DEM and optical images

Area of Research

Computer Vision

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. K. Suresh
Mr. Kannan V. Iyer
Mr. Amitabh

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

ksuresh@sac.isro.gov.in
kannan@sac.isro.gov.in
amitabh@sac.isro.gov.in

Summary of the Proposed Research

Design and Development of an Algorithm for matching LiDAR intensity image (depth map) of an area acquired in real-time with the reference Digital Elevation Model (DEM) and/or optical image of that area acquired beforehand.

The reference DEM and optical image generally will be of a bigger area of coverage and the LiDAR depth map will be a subset of that. It should be noted that the acquired LiDAR depth map will have scale difference, translation, and rotation with respect to reference DEM and optical images. The reference DEM and the optical image will be of a certain fixed scale, north-oriented, and associated geo-coordinates.

Scope of the work:

Development of an algorithm and required software modules to be implemented in commercial FPGA hardware. Scope restricts to the development of an algorithm for correspondence between LiDAR depth map with reference DEM and/or optical images. For testing the approach, the existing LiDAR data and optical images of the Earth/Lunar/Mars planet surface can be used.

Linkages to Space Programme:

- Interplanetary Landing Missions, like Lunar and Mars landing missions.

Expected Deliverables:

1. Commercial FPGA hardware, on-board software, ATBD document and documents covering design and implementation details of algorithms in FPGA hardware.

RES-SAC-2024-009

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Controlled Radiation Pattern Antennas for Anti-jamming GNSS Terminals

Area of Research

Microwave Antennas for Navigation

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. Kaushik Kannan
Mr. Rohit Kumar Nandwani
Dr. Ramesh Chandra Gupta

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

kaushik153@sac.isro.gov.in
rohit@sac.isro.gov.in
rameshgupta@sac.isro.gov.in

Summary of the Proposed Research

Jamming and interference can drastically degrade the GNSS position, navigation and time availability even to the extent of complete cease in service. The low power GNSS signals from space are overpowered by the excessive noise generated by the jammers, which consequently saturates the user GNSS receiver front-end.

The anti-jamming terminals have the capability to find the direction of interference and have the ability to mitigate this interference by creating nulls in the antenna pattern in the direction of the interference. Generally, these terminals are capable of mitigating interference from multiple jammers. The number of simultaneous nulling direction depends on the number of radiating elements used in the terminal. This generally creates a compromise between the size of the terminal and the number of simultaneous nulling possible.

In addition of anti-jamming function, these terminals must also provide consistent RF performance across the band and good GNSS tracking performance. The terminal should have the capability of tracking satellites even at low elevation.

Since majority of the GNSS providers operate in L5 band and L1 band, these terminals should cater to these frequencies.

Scope of the work:

- Antenna array design
- Development of algorithm for generating optimum excitation for generating nulls in the direction of multiple simultaneous interference
- Development of algorithm for automatic detection of interference direction
- Development of control system for automatic detection and adaptive nulling based on interference directions
- Design of active circuit integrated with the array antenna
- Demonstration of anti-jamming capability

Linkages to Space Programme:

- Anti-jamming GNSS Terminals for Strategic Users

Expected Deliverables:

1. Antenna array integrated with active circuit
2. Control system for automatic detection and adaptive nulling of multiple simultaneous interference sources

RES-SAC-2024-010

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Abnormalities detection in endpoint logs using AI

Area of Research

Fine tuning of language models to detect log abnormalities

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. Pravin K Choudhary
Mr. Rohit Tyagi
Mr. Yogesh Verma

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

pravin.choudhary@sac.isro.gov.in
rohittyagi@sac.isro.gov.in
yogeshverma@sac.isro.gov.in

Summary of the Proposed Research

The proposed project aims to explore the use of Artificial Intelligence (AI), specifically Large Language Models (LLM) or Small Language Models (SLM), for proactive monitoring and detection of abnormalities in endpoint logs. With the increasing complexity of IT infrastructures, endpoint logs (such as system, application, and security logs) are crucial for identifying operational anomalies, security threats, and performance issues. Traditional methods of log analysis rely on manual inspection or rule-based systems, which can be time-consuming, error-prone, and ineffective at scaling with the volume and complexity of modern log data. This research intends to leverage LLMs or SLMs, which have demonstrated advanced capabilities in natural language understanding and pattern recognition, to automatically process and analyze vast amounts of endpoint log data in real-time. The AI models will be trained to identify deviations from normal behavior by recognizing patterns, correlating log events, and detecting anomalies such as unusual login attempts, system misconfigurations, or suspicious network activity. The primary objective is to develop a proactive monitoring system that can trigger alerts or initiate corrective actions before an issue escalates, improving both security and system reliability. By using AI-driven approaches, the project seeks to enhance the speed and accuracy of anomaly detection while reducing the need for manual intervention. Ultimately, this research could revolutionize endpoint monitoring, offering more efficient and scalable solutions for enterprises in an era of increasing cyber threats and complex IT ecosystems.

Scope of the work:

AI-Powered Log Analysis and Anomaly Detection

1. Data Collection & Preprocessing:
   - Collect log data from system, application, network, and security endpoints.
   - Clean and preprocess data: parse, normalize timestamps, and filter redundant information.
   - Convert logs into structured formats (e.g., JSON, CSV) for AI analysis.
2. Exploratory Data Analysis (EDA):
   - Identify patterns, trends, and anomalies in the log data.
   - Categorize logs by severity, source, and event type to establish baseline behavior.
3. Model Selection & Development:
   - Evaluate and select suitable AI models (LLMs/SLMs) for log data processing.
   - Train models on historical log data to detect typical patterns and anomalies.
4. Anomaly Detection Framework:
   - Develop an AI-based anomaly detection system to identify deviations in real-time logs.
   - Implement supervised/unsupervised learning for anomaly detection.
5. Real-time Log Analysis & Monitoring:
   - Build a real-time log processing pipeline for continuous log analysis.
   - Integrate alerting systems to notify admins of abnormal activities.
6. Evaluation & Performance Testing:
   - Assess accuracy, precision, and recall of the anomaly detection system.
   - Test scalability to handle high volumes of log data.
7. Proactive Remediation & Automation:
   - Integrate with automated remediation systems for predefined actions based on detected anomalies.
8. Provide recommendations for future improvements of the monitoring system

Linkages to Space Programme:

- On successful completion of project, ISRO can utilize it for log analysis of all forms of logs and detect APT attacks proactively and thereby protect ISRO assets from very sophisticated state sponsored attacks.

Expected Deliverables:

1. A trained model to which log files can be given as input and the model investigates the logs to detect any potential abnormalities/threats/attacks.

RES-SAC-2024-011

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Diffusion of GIS in Urban Planning and Development: A Sociological Perspective

Area of Research

Social Research & Management

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Dr. Narayan Mohanty
Ms. Sini Susan Varghese
Dr. Abha Chhabra

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

narayanm@sac.isro.gov.in
sini@sac.isro.gov.in
research_sac@sac.isro.gov.in

Summary of the Proposed Research

India being at the forefront of geospatial governance initiatives, promotes GIS as a decision support tool for planning and monitoring the projects initiated by its urban local bodies. Urban planning requires a teamwork of practitioners from several related fields such as engineering, economy, architecture, archeology/humanities, ICT etc. Application of GIS plays an important role as a support system in the work carried out by these multiple practitioners towards urban planning & development.

The study focus on to map out the diffusion of geospatial technology in urban planning and development, its use and impact from sociological perspectives under the theme of SDG 11.

Scope of the work:

The study will highlight the sociological aspects of geospatial technology in urban planning such as role of remote sensing technology and sustainable infrastructure development, urban sprawl, social mobility etc. It will showcase the use and adoption of GIS among its users (Municipality, Govt. organization, academia etc.).

Linkages to Space Programme:

- ISRO is pioneered in GIS technology development and diffusion. The study will understand the adoption of GIS technology among users as well as Sustainable Development Goals 11 (sustainable cities and communities)

Expected Deliverables:

1. Policy relevant recommendation, Report, publications

RES-SAC-2024-012

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Design and development of reconfigurable photonic beam former for future scan-on-receive (SCORE) based synthetic aperture radar (SAR)

Area of Research

Photonic Integrated Circuit (PIC)

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. Nitesh Sharma

Dr. Piyush Sinha

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

niteshs@sac.isro.gov.in

piyush@sac.isro.gov.in

Summary of the Proposed Research

This proposal aims to design and develop a photonic integrated beamforming receiver for Scan-on-Receive Synthetic Aperture Radar (SCORE-SAR), addressing the limitations of conventional digital beamforming methods that rely on FPGA technology. Digital beamforming is power-hungry and suffers from bandwidth limitations, making it less suitable for spaceborne SAR systems where Size, Weight, Power, and Cost (SWaP-C) considerations are critical.

The proposed solution leverages photonic technology to deliver intermediate frequency (IF) output, offering a smaller, more power-efficient, and wider bandwidth alternative to traditional digital beamforming systems. The photonic integrated receiver will process signals from 12 input channels and synthesize up to 3 beams simultaneously, significantly improving the system's real-time imaging capabilities and spatial resolution.

The hybrid design will integrate passive photonic components (fabricated using SiN on insulator waveguide technology) for optical signal processing and a Blass matrix for beamforming. Active components, such as InP-based semiconductor optical amplifiers (SOAs) and Mach-Zehnder modulators, will handle signal amplification, modulation, and down conversion. The Blass matrix beamforming will ensure precise control with amplitude error kept below 5% and phase error constrained to less than 10% to minimize pointing error and reduce the impact on SNR.

This hybrid integration of passive and active photonic components will enable compact, lightweight, and high-performance radar systems suitable for next-generation SAR platforms. The final system will be packaged with space-grade reliability, ensuring robust operation in challenging environments. This photonic solution offers significant SWaP-C advantages over digital FPGA-based systems, making it ideal for spaceborne SAR missions.

Scope of the work:

The research will focus on the design, simulation, fabrication, and testing of a photonic integrated beamforming receiver capable of processing signals from 12 input channels and synthesizing up to 3 beams. The system will achieve beamforming through a Blass matrix architecture, which dynamically controls the phase and amplitude of incoming signals to enable real-time, multi-beam scanning.

The hybrid photonic integrated circuit (PIC) will use SiN on insulator technology for low-loss passive components, including optical delay lines and tunable couplers, and InP-based components for signal amplification, modulation, and down conversion. The receiver will down convert X-band signals to intermediate frequency (IF) using an optical heterodyne detection technique, providing a wideband, low-power alternative to digital solutions.

This research will also explore packaging solutions to ensure the system is compliant with space-grade requirements, including radiation hardness, thermal stability, and mechanical robustness. The integration of photonic and electronic components into a single, compact assembly will be a key focus, delivering a high-performance, low-power solution for SAR missions.

Linkages to Space Programme:

- Future Scan-on-Receive (SCORE) based high resolution wide swath X-Band Synthetic Aperture Radar

Expected Deliverables:

1. A photonic integrated beamforming receiver with IF output and capable of synthesizing up to 3 beams from 12 input channels, using a Blass matrix for real-time beamforming.
2. Hybrid PIC design with SiN on insulator based passive components and InP-based active devices for amplification, modulation, and down conversion.
3. Packaging solution compliant with space-grade standards, ensuring thermal and radiation robustness.
4. Performance evaluation of the photonic integrated beamforming receiver over required environmental condition.

RES-SAC-2024-013

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Self-cleaning/dust repellant coatings on optical surfaces

Area of Research

Optical surface coating

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Dr. B Narasiha Sharma

Mr. Nitesh Thapa

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

bns@sac.isro.gov.in
niteshthapa@sac.isro.gov.in

Summary of the Proposed Research

Optical imaging systems on planetary missions for in-situ exploration are exposed to multiple hazards including dust/regoliths etc. For efficient and long term operations of optical imaging systems, self-cleaning/dust repellant coatings are essential. Coatings shall meet the optical performance requirements over large spectral range from visible (350nm) to thermal IR range (20um).

Scope of the work:

Development of coating process for self-cleaning optical surfaces. Testing and characterization of samples.

Linkages to Space Programme:

- Future planetary missions.

Expected Deliverables:

1. Coating process and evaluation samples.

RES-SAC-2024-014

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

System design of Satellite Based Narrow-band Internet of Things

Area of Research

Satellite communication/wireless communication, communication networks

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. Pawan Kumar Barnwal

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

pawanbarnwal@sac.isro.gov.in

Summary of the Proposed Research

As per 3GPP rel.18 standard regarding Non-Terrestrial Network (NTN), direct-to-satellite based IoT (SIoT) in sub-6 GHz frequency band has become the mandate. Satellite based IoT will increase the utilities of IOT across various applications such as smart grid, smart cities, agriculture, transportation. There are many problems associated with SIoT:

- Design of energy efficient waveform for IoT.

- Design of system architecture of integrated satellite-terrestrial based IoT.
- Multiple access technology required to support thousands of sensors present in FoV of satellite.
- Compensation of delay and Doppler spread.
- Maximum throughput over targeted service area

Scope of the work:

In the present research for SIoT, it is expected to work on :

- Energy efficient waveform Design
- Multiple access technology Design
- System architecture design, throughput analysis and compatibility with NB-IoT LTE standards

Linkages to Space Programme:

- Development of future LEO satellites for IoT applications such as smart cities.

Expected Deliverables:

1. Detailed technical report, algorithm and simulation model for waveform design, and multiple access design.
2. Demonstration of developed algorithm computability with existing NB-IOT standards and commercial IOT applications.

RES-SAC-2024-015

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Development of nowcasting tool for extreme weather events (thunderstorms and cloud burst) using surface and satellite measurements over orographically complex region of India.

Area of Research

Atmospheric Sciences

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Dr. Neerja Sharma

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

neerjasharma@sac.isro.gov.in

Summary of the Proposed Research

Recent decays show a remarkable increase in extreme rainfall events allied with thunderstorms and cloud burst over India. Such events are more prone, complex and destructive over hilly regions. Although, accurate and timely nowcast procedure for thunderstorms and cloud burst over orographically complex region is very demanding, challenging too. The synergy of satellite and ground based observations

can play a prominent role to understand the physical processes of such events in turn developing the nowcast procedure.

Scope of the work:

- The synergistic observations from ground and satellite would provide a deep insight on the physical processes allied with the thunderstorms and cloud burst events over hilly region.
- The developed tool would be useful for nowcasting thunderstorms and cloud burst events over complex orographic region, which is in great demand.

Linkages to Space Programme:

- INSAT-3R/3S and future INSAT-4 Generation

Expected Deliverables:

1. Nowcasting tool for thunderstorms and cloud burst over orographically complex regions of India.

RES-SAC-2024-016

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Design and Development of high sensitivity InGaAs PIN-type in the SWIR range photodetector to provide fine pointing

Area of Research

Sensors

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. Nishant Kumar
Dr. Hari Shanker Gupta

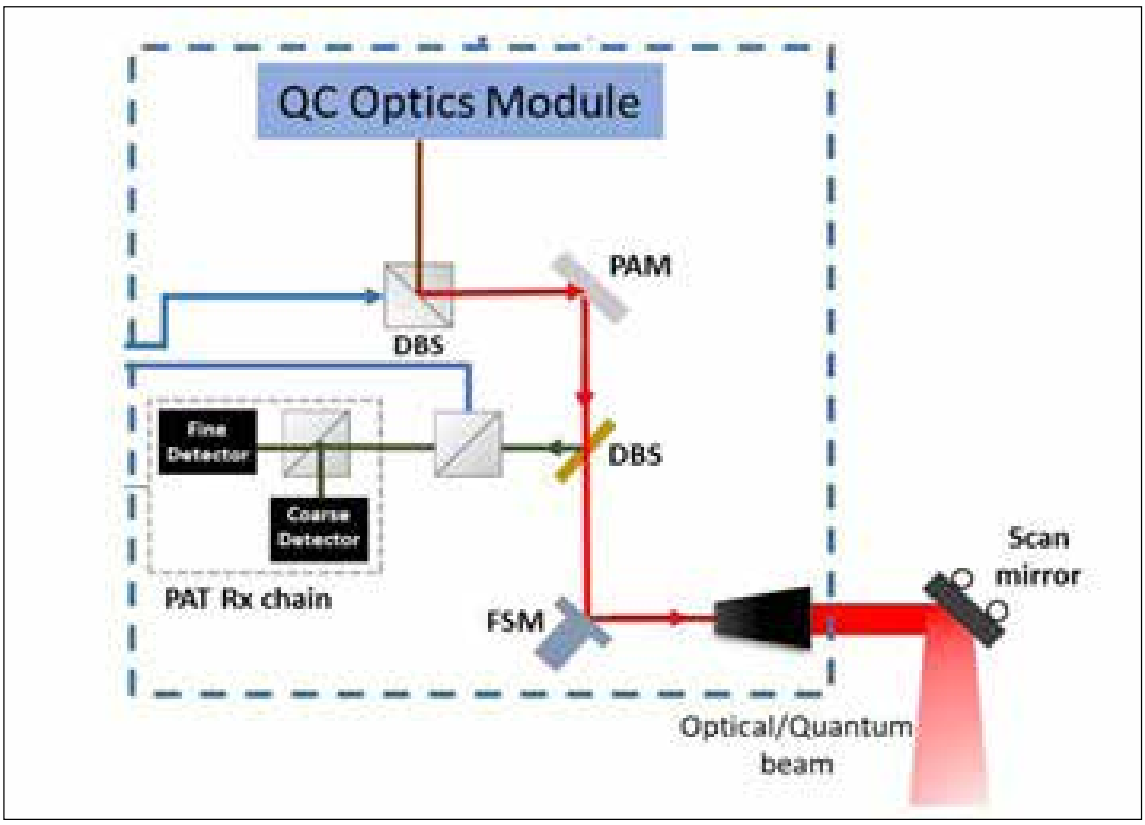
Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

nishantsingh@sac.isro.gov.in
hari@sac.isro.gov.in

Summary of the Proposed Research

The Quantum Technology Demonstration in Space is India's pioneering quantum payload being develop by ISRO to explore quantum communication and entanglement in a space environment. To achieve precise optical alignment between the satellite and the ground station, the payload relies on a Pointing-Acquisition-Tracking (PAT) detector, essential for maintaining the narrow, directive communication link required in space-based quantum communication. The Pointing-Acquisition-Tracking (PAT) detector is an essential system used in optical communication to maintain precise alignment between a satellite and a ground station. In space-based optical communication, especially at optical frequencies, the communication beam is highly directive and narrow, requiring accurate line-of-sight alignment. The PAT detector utilizes both Quad detector for fine alignment, ensuring precise pointing between the satellite

and the ground station. The Quad detector is a InGaAs PIN-type photodetector designed to provide fine pointing in laser beam experiments, enabling precise alignment needed to initiate further activities. Constructed as a 4-quadrant photodetector, it measures the relative incident optical intensity across its four segments, allowing accurate determination of alignment with the optical ground station. By detecting intensity variations between quadrants, the NFOV detector fine-tunes the systems positioning, ensuring stable and accurate alignment essential for high-precision optical communication.



Scope of the work:

- To select suitable material, design steps and identification of fabrication house
- A common composition is around 53% InAs and 47% GaAs, which yields a lattice structure closely matching that of Indium Phosphide (InP), enabling the material to be grown on InP substrates with minimal lattice mismatch. This balance also helps stabilize the material's band gap, maintaining effective absorption in the desired SWIR range. Optimization of quantum efficiency and Dark noise from 1.4 um to 1.6 um range.
- Perform TCAD simulation using foundry parameters.
- Fabrication and characterization of the single pixel and Quad high sensitivity InGaAs PIN-type photodetector.
- InGaAs (Indium Gallium Arsenide) sensors, dark current plays a critical role in limiting the sensor's performance, especially in precision measurements. Simulation for achieved quantum efficiency.

Linkages to Space Programme:

- Future Quantum and Optical Communication Programme and Bhartiya Antriksh Station

Expected Deliverables:

1. TCAD simulation file, Single photodiode, Quad photodiode and Quad-Photodiode sensor

RES-SAC-2024-017

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Design and Implementation of algorithms for stand-alone onboard real-time orbit determination of LEO satellites with sub-meter accuracy

Area of Research

Satellite Navigation

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mrs. Saumi S.

Mr. Rohan Urdhwareshe

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

de_saumi@sac.isro.gov.in

rohansu@sac.isro.gov.in

Summary of the Proposed Research

Today for scientific explorations, it's required to derive sub-meter level position accuracy in on-board GNSS receivers at LEO platform.

Scope of the work:

- Theoretical study for different possibilities for Precise On-board orbit Determination (P2OD) solution.
- Algorithm development in MATLAB and C, ultimately portable to embedded platform.
- Testing with simulator data keeping receiver on LEO orbit and adding all necessary perturbations.

Linkages to Space Programme:

It will be useful for GNSS radio occultation payloads where sub meter level on-board POD is required for atmospheric characterization.

Expected Deliverables:

1. Designed algorithm, its mathematical modelling and technical details.
2. Functionally Tested software: source code and executables in C / python or MATLAB.
3. Installable controller software on any supported Windows PC along with manual.
4. Technical Report containing performance analysis of all possible algorithms.
5. Demonstration of the designed algorithm.

RES-SAC-2024-018

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Design and Development of Digital Coded Metasurface Antenna for Adaptive Beamforming Applications

Area of Research

Unit Cell Design, Cost Effectiveness, Active Components Integration, Generating codes for digital coded met surface elements, FPGA implementation for dynamic reconfiguration of antenna, Machine Learning algorithms implementation for design optimization.

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. Kashish Grover
Mr. Devendra Kumar Sharma

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

kashish_asg@sac.isro.gov.in
devendrasharma@sac.isro.gov.in

Summary of the Proposed Research

A digital coded meta surface antenna is a type of antenna that employs a digital coded metasurface to manipulate electromagnetic waves. This technology uses an array of engineered unit cells, each programmed with specific digital patterns, to control wave properties such as phase, amplitude, and polarization. Field-Programmable Gate Arrays (FPGAs) play a crucial role in the implementation of digital coded meta surfaces, especially in applications requiring dynamic reconfiguration and real-time processing. FPGAs allow for flexible coding of the meta surface, enabling real-time adjustments to phase shifts, amplitude, and polarization states. Custom algorithms for wave manipulation (e.g., beamforming, focusing) can be programmed into the FPGA, allowing for adaptive control of the meta surface's response. Incorporating active components (like varactors or RF switches) into the unit cells allows for dynamic reconfiguration of the meta surface. Advanced design methodologies, including machine learning algorithms, are increasingly used to optimize the coding patterns for desired performance metrics, reducing the design time and enhancing functionality.

Scope of the work:

- Antenna design and development: Development of a digital coded meta surface antenna at X-Band.
- MATLAB Tool Development: Machine learning algorithms implementation for the unit cell efficiency optimization.
- FPGA Implementation: Developing Algorithms for adaptive beam forming.

Linkages to Space Programme:

- X-band space born SAR Antenna

Expected Deliverables:

1. Development of a digital coded meta surface antenna being implemented using discrete elements (diodes etc.).

2. FPGA Implementation for adaptive beam forming antenna (direction) demonstration in developed antenna.

RES-SAC-2024-019

Name of ISRO/DOS Centre/Unit
Space Applications Centre, Ahmedabad

Title of the research proposal
Design and Development of vibration isolation system with hybrid D-struts for space payloads

Area of Research
Structures, Vibration Isolation

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Mr. Numan Ahmad
Mr. Naimesh R. Patel

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit
nahmad@sac.isro.gov.in
naimesh@sac.isro.gov.in

Summary of the Proposed Research

Proposed research work will focus on the design and development of actively controlled D-struts (three parameter vibration isolators) for space payload of mass up to 100 Kgs.

The three parameter vibration isolators, which are also called D-struts (dual struts), are low frequency vibration isolators which are better absorbers as well as better isolators as compared to conventional spring-mass-damper (two parameter) vibration isolators. In the D-strut isolator the damper is elastically connected, due to which it offers 40 dB/decade roll-off in the isolation region as compared to 20 dB/decade roll-off of two parameter isolator; while maintain the absorbing capacity in the transmissibility region. Hybrid D-struts consist of an active actuation element to control and suppress the vibration loads. The design of a single D-strut is independent of the payload mass as opposed to the conventional isolator which are designed for a particular payload mass.

Scope of the work:

The scope of this project is to design and develop an actively controlled vibration isolation system with Hybrid D-struts for a payload of mass 50Kg to 100 Kg. The control bandwidth should be 0 to 200 Hz. The natural frequency of the vibration isolation system should be less than 20 Hz.

Linkages to Space Programme:

- This technology can be used for vibration suppression of delicate optical payload, where there is a requirement of good shock absorbing as well as good vibration isolation. This technology can be used in deployable space telescope, where the optical telescope can be isolated from the spacecraft bus.

Expected Deliverables:

1. Vibration isolation system with D-struts (for payload mass of 50 Kg to 100 Kg)
2. Design details (including CAD model, design calculations, mathematical model, control system details)
3. Testing and characterization methodology for D-struts (impedance measurement of single D-strut)

RES-SAC-2024-020

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Advanced Persistent Threats, Breach and Botnet Detection system using network traffic analysis

Area of Research

Network Security

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. Rohit Tyagi
Mr. Pravin K Choudhary
Mr. Chitraksh Vyas

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

rohittyagi@sac.isro.gov.in
pravin.choudhary@sac.isro.gov.in
chitraksh@sac.isro.gov.in

Summary of the Proposed Research

The aim of the project is to detect Advanced Persistent Threat, Breach and Botnets from network traffic analysis.

The research should focus on developing a network traffic analysis system capable of identifying following malicious behavior:

1. Command and Control (C&C) Traffic: Detecting communication between compromised machine and an attacker's server.
2. Lateral Movement: Identifying spread of attack laterally across a network.
3. Data Exfiltration: Identifying unusual outbound traffic indicating potential data leakage.
4. Botnet behavior: Detecting patterns characteristics of botnet activities. The botnets can be Fast-Flux based, DGA based, HTTP based etc.

5. Intrusion detection: Detection anomalous network traffic associated with intrusion attempts.

The solution can leverage machine learning, anomaly detection and traffic flow analysis for detecting malicious network activities. The solution should be able to work on encrypted traffic.

Scope of the work:

- Network Security monitoring platform that shall work passively on network data/ flows to identify threats/breach in the network.

Linkages to Space Programme:

- Aid in providing cyber security services to ISRO/DOS projects.

Expected Deliverables:

1. Software and related algorithms.

RES-SAC-2024-021

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Design and development of Comprehensive Research Evaluation Tool for enhancing Collaborative and Sponsored Research Management

Area of Research

Research Management

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mrs. Ankita Vishal Patel

Dr. Abha Chhabra

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

research_sac@sac.isro.gov.in

Summary of the Proposed Research

Sponsored Research with Academia is a major activity under Capacity Building Programme of ISRO. RESPOND (Sponsored Research) Programme which started in 1970s has gradually evolved with various new avenues and opportunities for Academic collaborations.

SAC is major R&D Centre of ISRO and actively participate in Sponsored Research with Academia.

The Evaluation of outcome of Completed R&D activities is an integral part of Research Management. Currently, SAC has developed a methodology for evaluation of outcome of completed R&D activities. However, in evolving scenario with focused Advanced R&D with Technology Readiness for absorption of R&D outcome in SAC/ ISRO missions & projects, there is an urgent need to design and develop a Comprehensive Research Evaluation Tool for enhancing Collaborative and Sponsored Research Management at SAC.

Scope of the work:

- Study of existing methods across R&D organizations for evaluating collaborative and Sponsored Research.
- Design of Comprehensive Research Evaluation Framework based on ISRO's Sponsored and Collaborative Research.
- Development of web based tool using open source AI/ML and NLP techniques.
- Testing and Evaluation of developed tool.
- Demonstration and deployment of Comprehensive Research Evaluation Tool for enhancing Collaborative and Sponsored Research Management

Linkages to Space Programme:

- The proposed study has strong linkage for Research Management activities at SAC.
- The developed tool would serve useful for evaluating R&D with academia across all ISRO centers and CBPO, ISRO HQ.

Expected Deliverables:

1. Research Evaluation Framework
2. Web based tool with user manual
3. Detailed Report and Publications

RES-SAC-2024-022

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

RFCMOS based Wideband Voltage Controlled Oscillators @ L,S,C,X and Ku-Band

Area of Research

RF and Microwave

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. K. S. Arjun

Ms. Srishti Srivastava

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

arjun.ks@sac.isro.gov.in

srishti@sac.isro.gov.in

Summary of the Proposed Research

Wideband Voltage Controlled Oscillators are very much required for the development of broadband Frequency Synthesizers. Design of wideband VCO's with low phase noise is a challenge.

This Proposal is for designing wideband VCO's with relatively low phase noise at different Frequency Bands using RFCMOS technology.

The project aims to design and develop a wideband Voltage Controlled Oscillator at different Frequency Bands Viz. L, S, C, X, Ku-Band with octave bandwidth.

Scope of the work:

Development of indigenous design for wideband VCO's required for tunable frequency synthesizers at different bands

Linkages to Space Programme:

- Future Earth Observation Microwave Payloads.

Expected Deliverables:

1. Deliverables include technology transfer and design database sharing.

RES-SAC-2024-023

Name of ISRO/DOS Centre/Unit
Space Applications Centre, Ahmedabad

Title of the research proposal
On-chip nano wire grid fabrication for polarization sensing

Area of Research
Electro-Optical Sensor Technology

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Mr. Ashwani Kumar

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit
ashwani507@sac.isro.gov.in

Summary of the Proposed Research

Traditional imaging systems have focused on capturing and replicating the imaged environment in terms of colour and intensity. One important property of light, which the human eye is blind to and it is ignored by traditional imaging systems, is polarization. Polarization of light caused by reflection from materials contains information about the surface roughness, geometry and other properties of the imaged environment. Polarization-contrast imaging has proven to be very useful in gaining additional visual information in optically scattering environments, such as target contrast enhancement in hazy/foggy conditions, depth map of the scene in underwater imaging, presence of ice in clouds or non-spherically shaped dust particles and in normal environmental conditions, such as classifications of chemical isomers, classifications of pollutants in the atmosphere, and non-contact fingerprint detection among others. In addition, polarization of light has found a niche in many biomedical applications, such as imaging for early skin cancer detection, cell classification and retinal surgery.

Wire grid polarizer is compatible with complementary metal-oxide-semiconductor (CMOS) technology, and it can be fabricated monolithically by using metal layers for wiring. Using deep-submicron CMOS

technologies, which allow the design of metal patterns finer than 100 nm. The angle (0, 45, 90 and 135 degree) of the polarizer on each pixel can be designed.

Scope of the work:

Process details, design and fabrication

Linkages to Space Programme:

- Earth observation and on-orbit polarimetry.

Expected Deliverables:

1. Test chips.

RES-SAC-2024-024

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

High Data rate Channel codec architecture for free space classical RF and optical communication

Area of Research

Communication and optical communication

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Dr. Deepak Mishra

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

deepakmishra@sac.isro.gov.in

Summary of the Proposed Research

Forward Error Correction (FEC) is an integral part of satellite communication system since it ensures reliable data transmission in the presence of high noise in satellite links. Proper selection of FEC code is a key factor in transmitting and receiving data reliably. The choice of a FEC code for different specifications of satellite systems depends on various factors such as encoding/decoding complexity, decoding delay, error floor issues, high coding gain for low transmitter power and spectral/bandwidth efficiency. Looking back at the various space missions till date, different codes have been used for different missions. Considering the data rate requirement of 1 Gbps and more for classical RF channel as well as Optical channel, FEC architecture will play a important role for implementation in hardware. Based upon current available hardware resources achieving a high throughput of 1 GBPS and beyond is the need of current high throughput satellite.

Scope of the work:

- Arriving at optimum hardware architecture of channel codes for high data rate communication with minimum throughput 1Gbps or beyond.
- Implementation strategies for the channel codes in the hardware.
- Hardware realization of a low complex encoder and decoder.

- Validation and Verification of coding gain for high data rate optical communication.
- Hardware demonstration of the proposed architecture.

Linkages to Space Programme:

- Currently ISRO is working on high throughput satellite and direct free space optical communication satellite, where there is a need of high data rate 1 Gbps and more. In order to work these satellites at lower SNR condition or dynamic SNR condition, high date rate compatible architecture of channel codec is required. The developed channel codec architecture will be directly used in these programs.

Expected Deliverables:

1. Optimum High data architecture for channel codes
2. Implementation demonstration of channel code beyond 1 Gbps for classical and optical communication.
3. Integration strategies of channel codec with higher order modulation and optical modulation.

RES-SAC-2024-025

Name of ISRO/DOS Centre/Unit
Space Applications Centre, Ahmedabad

Title of the research proposal
Study of the Earth-Atmosphere radiation budget and its linkage to atmospheric feedback processes

Area of Research
Earth's Climate

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Dr. Manoj Kumar Mishra

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit
manoj_mishra@sac.isro.gov.in

Summary of the Proposed Research

Currently all the component of the Earth-Atmosphere system is undergoing rapid changes due to influence exerted by human beings. This is resulting in unprecedented changes in the atmospheric properties and processes, including the interaction of the atmosphere with other components of the Earth system, as well as their roles in climate variability and change.

In order to advance and improve the understanding of these changes it is required to observe and model these components both at local as well as global scale at much larger scale. At the same time large amount of data which was gathered in the last two decades already exist need to be analyzed. This requires collaboration between different institutions who can work together toward this common goal. The contribution can include theoretical studies, proposal of new observation/ instrument, setting up of network, development of new models etc.

Large amount of data has been gathered by Indian as well as global satellites. A comprehensive analysis is required to make the assessment of radiative and dynamic feedback processes.

Scope of the work:

- Earth's climate.
- Earth's feedback processes.
- Distribution of clouds and aerosols.
- Insitu measurement of Earth-atmosphere parameters.
- Generation of local/global dataset of atmospheric variables.
- Atmospheric boundary layer dynamics.

Linkages to Space Programme:

- Research on the Earth atmosphere and climate is one of the broad theme of the SAC-ISRO. The atmospheric and Oceanic sciences group is involved in the study and observation of its different components. This research project will enhance the collaboration with the universities and institutions carrying out similar research.

Expected Deliverables:

1. Setting of observation network for Earth-atmosphere system studies.
2. Data collection.
3. Development of theoretical models for Assessment of Earth-Atmosphere system feedback processes.

RES-SAC-2024-026

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Reconstruction of high resolution historical sea-level data using coarse resolution altimeter and high resolution observations from Surface Water and Ocean Topography (SWOT) mission.

Area of Research

Satellite Oceanography

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. Aditya Chaudhary

Dr. Neeraj Agarwal

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

aditya.osd@sac.isro.gov.in

neeraj@sac.isro.gov.in

Summary of the Proposed Research

High resolution sea level data is a gap area for understanding the small mesoscales and sub-mesoscale ocean dynamics. Our current understanding of these dynamics has been hampered by the limitations of traditional satellite altimetry, which struggles to resolve these fine-scale processes due to resolution

and noise constraints. This observational gap is particularly evident in dynamically complex regions like the Arabian Sea, where monsoonal winds, intense stratification, and a productive ecosystem further complicate the picture. The current state of art i.e. AVISO analyzed gridded sea level data is available at 25km x 25 km resolution. With the availability of high resolution sea level observations from SWOT mission, we can possibly reconstruct the available analyzed sea levels fields (25km x 25km) at a better resolution. In this proposal we intend to use the high resolution sea level data from the SWOT that is available since April 2023 along with collocated coarse resolution AVISO sea level to develop a machine learning based technique for reconstructing the historical sea level data at higher spatial resolution. Several AI/ML techniques can be tried, for e.g. Convolutional neural network (CNN), Long Short Term Memory (LSTM) neural networks, generative adversarial networks (GANs) etc. High resolution satellite observations of Sea surface temperature and chlorophyll from INSAT and OCM series can also be used in the machine learning procedure.

Scope of the work:

- Generating a long timeseries of high resolution sea level database for fine scale process understanding.

Linkages to Space Programme:

- SARAL AltiKa, EOS-06/Oceansat-3, Scatsat-1, Oceansat-2, SWOT, Jason, Sentinel series, INSAT series.
- MOP-4

Expected Deliverables:

1. 30 years of high resolution (5 km X 5 km) sea surface height anomaly database.

RES-SAC-2024-027

Name of ISRO/DOS Centre/Unit
Space Applications Centre, Ahmedabad

Title of the research proposal
Integrated Pseudolite & Satellite Based system for Lunar Navigation

Area of Research
Navigation

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Dr. Ashish K Shukla

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit
ashishs@sac.isro.gov.in

Summary of the Proposed Research

Integrated Pseudolite & Satellite based systems are required for more precise 3D lunar positioning. New Position algorithms and software needs to be developed for this purpose.

Scope of the work:

Development of 3D positioning algorithm for standalone lunar navigation using Pseudolites & satellite in lunar orbit.

Linkages to Space Programme:

- Navigation Programme & Chandrayaan Mission

Expected Deliverables:

1. Positioning Algorithm & software.

RES-SAC-2024-028

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Development of Superconducting Magnet for Space-borne sub-Kelvin Cooler (ADR)

Area of Research

Cryogenics

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. Vivek Kumar Singh
Mr. Sandip R Somani
Mr. Rakesh R Bhavsar

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

singhvivek@sac.isro.gov.in
sandipsomani@sac.isro.gov.in
rrb@sac.isro.gov.in

Summary of the Proposed Research

Superconducting (SC) Magnets are an important part of Adiabatic Demagnetization Refrigerator (ADR) under development at SAC to achieve sub-Kelvin Temperature. Magnetic Field need to be varied in controlled way in range of 0-4T to achieve temperature in order of 0.5K (Sink Temperature ≈ 4.2-6 K; Heat Load≈ 10mW). SC Magnet design and development along with shielding and control electronics need to be developed under this project.

Scope of the work:

- Design of SC Magnet
- Realization and characterization of SC Magnet
- Development of control electronics to operate SC Magnet
- Development of appropriate magnetic shielding for SC Magnets

Linkages to Space Programme:

- Sub-Kelvin Cooler for THz Project, quantum communications and futuristic astronomical missions.

Expected Deliverables:

1. Design and development document
2. Three sets of fully characterized SC Magnets along with its control electronics

RES-SAC-2024-029

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Development of a MATLAB Tool for antenna diagnostics using amplitude only field measurement and source reconstruction method

Area of Research

Source reconstruction method, Antenna Diagnostics, Phaseless antenna radiation pattern measurement, Phase retrieval algorithms

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. Yogesh Tyagi
Mr. Akula Ramu
Mr. Sanjeev Kulshreshta

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

tyagi@sac.isro.gov.in
akularamu@sac.isro.gov.in
sanjeev@sac.isro.gov.in

Summary of the Proposed Research

Antenna diagnostics methods based on the acquisition of the radiated field are becoming a key issue due to their features: first, they are non-invasive methods, so they make possible the determination of antenna anomalies avoiding try-and-error procedures that require interacting with the antenna.

Conventional equivalent source reconstruction methods (SRM) require both phase and amplitude information of the acquired field data. However, there are situations where the phase information is not available or impractical to obtain. Hence, the development of SRM using phaseless Fields is important. Diagnostics techniques are most based on far-field/near-field to nearfield (FF/NF-NF) transformation, in order to determine the extremely NF on a surface close to the antenna-under-test (AUT). Limitation of wave mode-based FF/NF-NF methods to canonical acquisition and diagnostics geometries is overcome by the introduction of the Sources reconstruction methods (SRM), an integral equation technique that characterizes the antenna under test (AUT) through a set of equivalent electric and/or magnetic currents distribution.

Scope of the work:

- Antenna Diagnostics: Enhancing the ways in which antenna performance can be measured and potential issues detected through non-invasive methods
- Source Reconstruction Techniques: Developing algorithms for reconstructing the source from amplitude-only measurements
- MATLAB Tool Development: Leveraging MATLAB's computational capabilities to create a user-friendly tool for researchers and engineers in the field of antenna design and diagnostics.

Linkages to Space Programme:

- Large ground station antenna characterization and diagnostics.

Expected Deliverables:

1. Development of a MATLAB Tool for antenna diagnostics using amplitude only field measurement and source reconstruction method.

RES-SAC-2024-030

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Development of Space Grade Carbon Allotropes Materials by 3D Print Manufacturing Technology

Area of Research

Materials

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. Ravi Kumar Varma

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

rkv@sac.isro.gov.in

Summary of the Proposed Research

In terms of process ability and necessary product qualities, years have already elapsed in the development of materials for traditional manufacturing techniques. Since Additive Manufacturing (AM) is still a relatively new technique, there are still gaps in material qualification, standardization, and development.

The space industry has long been a hub for novel ideas and ground-breaking technologies, but it is currently entering a new cycle that might have far-reaching effects on the industrial, sociological, and economic fronts. Despite many similarities, the prospects and difficulties for the space sector to adopt Additive Manufacturing (AM) are probably significantly greater than those related to the aviation sector. In addition to having mechanical performance on par with space structures made traditionally, those 3D-printed parts can be functionalized during the additive manufacturing process to provide radiation and heat-shielding properties.

Scope of the work:

The global aerospace & space sector is currently using 3D printing to produce parts for commercial aircraft with the same level of reliability as traditional methods. It is more crucial to uphold the core and consistent requirements of low mass, high dependability, and low manufacturing volumes.

Because of the many advantages that the layer wise production paradigm offers, the Additive Manufacturing has the ability to enable all of these features. With the use of carbon allotropes like carbon, carbon nanotubes (CNT), graphene, and metal particles, it is possible to construct multi-functional structures at a reasonable cost that have good mechanical, electrical & thermal properties along with stiffness.

Linkages to Space Programme:

- For all advanced space payload (Advanced R & D)

Expected Deliverables:

1. Manufacture space-qualified components with carbon allotrope materials by 3D printing technology.
2. Development of a standard prototype part and performance evaluation in predetermined space environment conditions.

RES-SAC-2024-031

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Development of process for realization of seamless ultra-thin wall round tubes

Area of Research

Manufacturing

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. Rajat Patel

Mr. Jigar Patel

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

rajatkumar_patel@sac.isro.gov.in

kruji@sac.isro.gov.in

Summary of the Proposed Research

Flexible waveguides are being used in satellites for transmission of Microwave signals. To impart flexibility to waveguide, corrugations are being provided on tube. The flexible behaviour of the corrugated profile determines the flexibility of the corrugated tube. This corrugation gets stretched on the outer curve, while they are compressed in the inner curve.

This flexibility of corrugated tube is function of the wall thickness of the tube. Higher the wall thickness of tube lesser will be flexibility vice versa. Both surface finish and uniformity of cross section along the length of the tube are crucial features to transfer signals with minimum losses.

Scope of the work:

Development process for realization of seamless ultra-thin wall round tubes considering following parameters:

- Material: Brass/Bronze/BeCu Material with copper in excess of 80% (Annealed condition)
- Wall thickness: 0.15-0.18 mm
- Outer Diameter of tube: Ø6.49, Ø7.84, Ø11.52, Ø14.08, Ø17.18 mm
- Length: more than 600 mm.

Linkages to Space Programme:

- Communication and Navigation Payloads.

Expected Deliverables:

1. Tube with uniform wall thickness throughout length
2. Surface Finish shall be of order Ra- 0.4 µm or less
3. No damage inner walls of tube.

RES-SAC-2024-032

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Specialized language models deployable on end points with low compute resources

Area of Research

AI/ML Technologies (Transformers, Language Models)

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. Gulshan Gupta

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

gulshang@sac.isro.gov.in

Summary of the Proposed Research

The proposal aims to develop specialized language models capable of performing specific text comprehension tasks on low-compute endpoints, such as devices without GPUs or limited processing power. The focus is on creating lightweight, efficient models that can handle tasks like text summarization, sentiment analysis, question answering, and language translation while ensuring minimal computational overhead.

Key Objectives:

Optimized Model Architecture: Design models with reduced size and complexity, leveraging techniques such as model pruning, quantization, and distillation to maintain accuracy while minimizing resource consumption.

Low-Resource Adaptation: Tailor the models for deployment on devices that lack high-performance hardware like GPUs, including smartphones, embedded systems, and IoT devices, enabling them to perform advanced text comprehension tasks efficiently.

Task-Specific Focus: Rather than attempting to generalize across all language tasks, the models will be specialized to handle a narrow set of tasks effectively, ensuring high performance in specific areas such as summarization or sentiment detection.

Real-Time Performance: Prioritize fast inference times to enable real-time or near-real-time performance on constrained devices, balancing between computational efficiency and the quality of text comprehension.

Scalability and Flexibility: Develop a framework that allows for easy adaptation to other low-compute environments, ensuring scalability across a range of devices and platforms.

The success of this project will make advanced text comprehension capabilities more accessible to a broader range of devices, enabling smarter, more responsive systems in scenarios where computational resources are limited.

Scope of the work:

- Optimizing the existing models more efficient for specialized tasks
- Adapting the models to run on devices with low resources
- Making model flexible for variety of platforms

Linkages to Space Programme:

- Automation, assistance and improvisation in various tasks involving from data analysis, logical reasoning, summarization etc.

Expected Deliverables:

1. Software, Language models, Algorithms.

RES-SAC-2024-033

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Advanced Compression Techniques for SAR raw data

Area of Research

Scalar & Vector Compression of SAR data

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Dr. Ameya Anil Kesarkar
Mr. Vetal Akshay Pandit
Mr. Yogendra Sahu

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

ameya@sac.isro.gov.in
vetalakshay@sac.isro.gov.in
ysahu@sac.isro.gov.in

Summary of the Proposed Research

Synthetic Aperture Radars (SARs) produce large amount of on-board data. Due to data rate and onboard storage limitations, it needs to be compressed onboard without compromising on its information content. There are several data compression techniques reported in the literature, which are broadly classified into scalar and vector techniques.

Scalar techniques include Block Adaptive Quantization (BAQ), Block Adaptive Polar Quantization (BAPQ), Block Adaptive Histogram Equalization Quantization (BHEQ), Block Adaptive Complex Quantization (BACQ), Block Adaptive Magnitude Phase Quantization (BMPQ), Flexible BAQ (FBAQ), etc. On the other hand, vector techniques include Block Adaptive Vector Quantization (BAVQ), Block Adaptive Tree-Structured Vector Quantization (BATSVQ), Block Adaptive Lattice Vector Quantization (BALVQ), Dynamic Predictive Block Adaptive Vector Quantization (DP-BAVQ), etc.

In this proposed research, comparative SQNR analysis will be carried out amongst these scalar and vector techniques for the uncompressed raw data available from ISRO's previously flown SAR missions. Subsequently, it is also aimed to quantify the information loss from SAR images generated based on the data compressed with these techniques. After getting comparative idea about the performances of various algorithms, their resource utilization analysis will also be carried out for the given implementable platform.

Within this framework, further exploration/development of implementation strategies will be carried out for the superior algorithms, whichever are possible. Research in this direction may result into a superior and implementable data compression algorithm/s for future SAR missions.

Scope of the work:

This research will bring out superior technique from the available scalar and vector options for SAR raw data compression in terms of maintaining the fidelity of original data.

Linkages to Space Programme:

- Future SAR missions of ISRO.

Expected Deliverables:

1. Software, Reports, and publications.

RES-SAC-2024-034

Name of ISRO/DOS Centre/Unit
Space Applications Centre, Ahmedabad

Title of the research proposal
Design and development of Distributed feedback laser (DFB)

Area of Research
High energy LASERS for LIDAR applications

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Mr. Nitesh Thapa
Mr. K Ajay Kumar

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit
niteshthapa@sac.isro.gov.in
ajaykumar@sac.isro.gov.in

Summary of the Proposed Research

Narrow linewidth (<25kHz) DFB laser operating at 1550 nm with fast frequency modulation of >1GHz @ 10kHz repetition rate with typical optical power of > 20 mW. Modulation is to be controlled through external input (voltage/current).

Scope of the work:

Realization of the proposed LASER will be a new development for ISRO. This will significantly help in development of LIDARs for soft landing applications.

Linkages to Space Programme:

- Future planetary missions with soft landing requirements.

Expected Deliverables:

1. Narrow linewidth fast tuneable laser module

RES-SAC-2024-035

Name of ISRO/DOS Centre/Unit
Space Applications Centre, Ahmedabad

Title of the research proposal
Design, Development & Dynamic Characterization of Multi-rotor Small UAV for Moving platform QKD application

Area of Research
Drones

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Mr. Pradeep Ananthanarayanan

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit
pradeepa@sac.isro.gov.in

Summary of the Proposed Research

Design and Development of Multi rotor UAV for optical and quantum payload characterization.

- Configuration and Design of Multi rotor UAV of capacity upto 25 Kg Payload Capacity that is capable of housing sensitive optical and quantum payloads. Failure mode effect and criticality analysis on the UAV design. The UAV shall have in-built failure tolerant and fail safe safety features. It shall adhere to ingress rating of at least IP65 while IP67 is desirable.
- Software/firmware development as required to meet the requirements.
- Integration of NAVIC for accurate positioning.
- Manufacturing assembly, integration and operation of the UAV during characterization
- Dynamic Characterization (vibrations, drift, landing shocks etc.) of the UAV using variety of sensors like accelerometers, gyros inclinometers etc.

Scope of the work:

- The proposed research is useful in the application of drone based ground testing of quantum key distribution program, Optical communication, SAR sensors and similar systems.

Linkages to Space Programme:

- Linked to Quantum Programme

Expected Deliverables:

1. Multi-rotor UAV with payload capacity upto 25 kg.
2. Accessories of UAV like remote controller, master computer (laptop) with required software/firmware, charging cables, spare batteries, antenna etc.
3. Raw Data acquired during dynamic characterization of UAV.
4. Anything else that is necessary to satisfactorily operate and maintain the UAV.

RES-SAC-2024-036

Name of ISRO/DOS Centre/Unit
Space Applications Centre, Ahmedabad

Title of the research proposal
Air bearing based platform to mimic microgravity experiments on earth for a propulsion module.

Area of Research
Propulsion, Navigation, Structures Mecatronics

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Mr. Arvind Singh

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

arvindsingh@sac.isro.gov.in

Summary of the Proposed Research

Design and Development of a platform based on air bearing concept to lift, at least 15kg mass about 5-10 micron above the surface and hold the position for desired period of time not less than 10 min.

- Conceptualize the development of platform (provide mathematical model)
- CAD model/ simulation of the development as required to meet the requirements.
- Realization of platform.
- Test and characterization of the platform.
- Demonstration of platform capability.

Scope of the work:

This proposal is targeted for development of air bearing based platform for nullifying/compensating the effect of gravity for on ground testing of free flying robots for BAS/interplanetary missions.

Linkages to Space Programme:

- Linked to Gaganyaan, BAS and interplanetary missions

Expected Deliverables:

1. CAD model and simulation results
2. Realized platform and anything else that is necessary to satisfactorily operate and maintain the platform.

RES-SAC-2024-037

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Design and development of RF ASIC for SFCW ground penetrating radar

Area of Research

Radio Frequency Integrated Circuit (RFIC)

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. Ravi Khatri

Dr. Piyush Sinha

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

ravi@sac.isro.gov.in

piyush@sac.isro.gov.in

Summary of the Proposed Research

The research proposal aims to design and develop a highly efficient, compact RF ASIC tailored for Stepped Frequency Continuous Wave (SFCW) Ground Penetrating radar (GPR) operating within the 0.1 GHz to 2

GHz frequency range. The proposed RF ASIC will generate an SFCW signal with programmable step size of 2.5 MHz or 5 MHz and a minimum dwell time of 10µsec. It will feature a transmit section delivering an output power of 0dBm, crucial for optimal GPR performance in subsurface detection applications.

The receive incorporate a 40dB gain and a 6-bit / 0.5dB step digital attenuator providing high sensitivity and precision in adjusting gain according to signal strength. Furthermore, the receiver will offer an IF output of 50 KHz requiring the generation of a LO signal shifted by 50KHz from the transmit frequency.

The research focus on minimizing the RF ASIC size and power consumption which are critical parameters for battery powered GPR system. By addressing the challenges of efficient SFCW signal generation, reception and low power design, this ASIC will enable the development of more portable and durable GPR systems improving field performance in geophysical surveys, utility mapping and subsurface exploration.

Scope of the work:

The scope of the proposed research is to design, simulate, fabricate, and test a complete RF ASIC solution for SFCW GPR. The research will begin with the system level design, focusing on defining the architecture of RF front-end, including the transmitter and receiver sections, along with the signal generation and reception chains. The design will be based on CMOS technology, balancing performance with power efficiency to ensure suitability for battery operated applications.

The core design objectives include generating the SFCW signal with programmable step size (2.5MHz / 5MHz), developing a stable transmit section delivering 0dBm output, and implementing a receiver with 40dB gain and 6 bit digital attenuator. Moreover, the system will incorporate a 50 KHz IF output requiring generation of SFCW LO signal shifted by 50 KHz and coherent with transmit signal.

The research will also focus on minimizing the overall power consumption and physical footprint of the ASIC to enhance its portability and suitability for filed use. Testing will validate the system performance across required environmental condition to ensure robustness and reliability in real world GPR applications.

Linkages to Space Programme:

- GPR for interplanetary missions

Expected Deliverables:

1. Design of RF ASIC with SFCW transmit output and receiver with 50 KHz IF output
2. RF ASIC prototype
3. Test result demonstrating ASIC performance.

RES-SAC-2024-038

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Wide band wide beam circularly polarized antenna for Spectrum Monitoring Applications

Area of Research
Microwave & Antenna Engineering

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Mr. Mohit Anand
Mr. Shibasish Prusty
Mr. Alok Kumar Singhal

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit
mohitanand@sac.isro.gov.in
shibasishprusty@sac.isro.gov.in
alok@sac.isro.gov.in

Summary of the Proposed Research

Wide band circularly polarized antennas are required in various applications for signal reception from various directions. There is a requirement to not only receive the data transmitted from far end as well as spacecraft's but It is also required to determine the direction of the transmitted signal. The signals intended to be received may be of linear, elliptical or circularly polarized. For these applications the frequency band of interest may be from 100 MHz to 25 GHz and this full bandwidth may be split between 2, 3 or 4 bands. The typical gain required for this antenna is ~8dBi and should be right hand circularly polarized with bore sight axial ratio better than 3dB (<3dB) over the band of interest. The antenna should have a high front to back ratio and of the order of 15dB. The antenna should also have better than 17dB return loss. The antenna must be mechanically robust and should have compact and miniaturized in size and must have environment protection.

Scope of the work:

- Study of wide band radiating elements covering the full frequency band in a single unit or splitting the full bandwidth into maximum four bands. Design of Antenna elements for the individual frequency bands (1/2/3/4). Optimize the design under mechanical constraints. Realization of Antenna & characterization of antenna to validate the performance.

Linkages to Space Programme:

- Spectrum monitoring payloads in various frequency bands.

Expected Deliverables:

1. Depending upon band splitting topology, One unit/Two/Three/Four unit Wideband, Wide beam circularly polarized antenna catering full frequency band ranging from 100 MHz to 25 GHz

RES-SAC-2024-039

Name of ISRO/DOS Centre/Unit
Space Applications Centre, Ahmedabad

Title of the research proposal
Optical Beam Steering Photonic Chip for Lidar

Area of Research
Photonic Lidar Optical Beam Steering

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Mr. Neeraj Keshav Dubey

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit
neeraj_dubey@sac.isro.gov.in

Summary of the Proposed Research

In a Lidar, a laser beam is formed to concentrate the optical power within single pixel instead of the whole scene, which makes it a point-wise measurement system. To form an image, the beam is scanned through the FOV Namely, a beam scanner. Scanning LiDAR achieves higher signal-to-noise ratio (SNR) at the cost of lower points per second (i.e. point throughput) and slower frame rate, and more importantly, at the cost of having a beam scanner. Beam scanner is often realized through mechanical actuation of either the source itself or the discrete optics around the source. While mechanical optical beam scanner design is already an established domain of engineering, there is a fundamental challenge associated with achieving good control precision and reliability goals for automotive vehicles using a low-cost mechanical system. To reduce the unit cost of a scanner module and make it feasible for consumer electronics, various solid-state beam scanning solutions are the preferred option. There are many approaches to realize a photonic chip for Optical beam steering like MEMS Switch based array of grating coupler, Optical phased array, true time delay based beam steering, etc. The beam steering chip shall define the beam width of less than 0.2 degree and shall steer the beam within 20 degrees in both axes.

Scope of the work:

- Design & Development of Photonic Lidar chip for optical beam steering

Linkages to Space Programme:

- Future Lidar Programme for Soft landing

Expected Deliverables:

1. Complete chip & Electronics for Optical Beam steering

RES-SAC-2024-040

Name of ISRO/DOS Centre/Unit
Space Applications Centre, Ahmedabad

Title of the research proposal
Development of metallized Graphite electrodes

Area of Research
Metallization on graphite for braze ability

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Mr. Ramagiri Santhosh Kumar

Mrs. Shilpi Soni

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

santhoshr@sac.isro.gov.in
shilpi@sac.isro.gov.in

Summary of the Proposed Research

The Vacuum Electron Devices have a source emitting electrons and a collector that collects the electrons. The collector has a set of electrodes and for minimum power consumption these electrodes need to have very low secondary electron yield when they are hit by primary electrons. The resent proposal is for development of electrodes made of graphite which has low secondary electron yield and with suitable metallization so that they can be brazed with alumina insulators.

Scope of the work:

To develop shaped graphite electrodes with suitable metallization (nickel/copper/gold) for brazing with Moly-manganese coated alumina ceramics

- Brazing Temperature: 1010 °C
- The metallization shall survive temperatures up to 1050 °C
- The electrodes shall be made of POCO graphite

Linkages to Space Programme:

- TWTA development for communication payloads

Expected Deliverables:

1. Five sets of electrodes (each set consisting of 4 electrodes)
2. Dimensional inspection report including surface roughness and metallization thickness
3. Report of adhesion of metallization and maximum working temperature
4. Report on secondary electron emission properties of electrodes

RES-SAC-2024-041

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Acoustic Monitoring System

Area of Research

Sensors and processing

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. Anurag S Verma
Mr. Savit Anantharm

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

anuragsverma@sac.isro.gov.in
savit-hsfc@isro.gov.in

Summary of the Proposed Research

Acoustic Monitoring System is required to be developed to measure sound levels to ensure the noise level are within human tolerance limits. The proposal includes study, design and realization of Acoustic Monitoring system including sound level meters and accumulated acoustic dosage. This is intended for usage in microgravity environment.

The instrument should provide average sound pressure level measurements and spectral measurement as a function of frequency over a range of 63Hz to 20kHz and measure audio levels in three user selectable measurement ranges (40-130 dB RMS. The instrument should provide overall Sound Pressure Levels at a definite interval (~30 seconds)

DC supply operated, Low power, miniaturized, data interface to connect with PC(USB or equivalent)

Scope of the work:

Noise Exposure on Human Space Missions poses significant risk to crew, including sleep disruptions, hearing loss, reduction in alarm audibility. Both real time and accumulated dosages have to be quantified. Miniaturized Acoustic Monitoring System is to be realized for the same.

Linkages to Space Programme:

- Linked to human space program, Gaganyaan and Bharatiya Antariksh Station.

Expected Deliverables:

1. Acoustic Monitoring System prototype hardware. Hardware design details, Software Applications and Source Codes

RES-SAC-2024-042

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Characterization of Polymeric Materials for Human Space Missions from Human Rating Aspects

Area of Research

Polymeric Materials

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. Prateek Bansal
Mr. Divyanshu Singh
Mr. Ravi Kumar Varma
Mr. Amit Kumar Gupta

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

prateek@sac.isro.gov.in
divyanshu-hsfc@isro.gov.in
rkv@sac.isro.gov.in
amitgupta@sac.isro.gov.in

Summary of the Proposed Research

Gaganyaan is the milestone ISRO project to carry crew(s) to low earth orbit and bringing them back to earth safely.

Crew Module shall be designed to have comfortable & safe for humans. This requires strict scrutiny of materials inside crew module considering human safety as utmost importance.

Flammability and Off-gassing tests are two of the four major "required' tests as per NASA-STD-6001B, that has to be passed by every Polymeric material used within habitable environment (crew module) before use in manned mission.

Considering long term human mission program that included test flights, unmanned mission, manned mission and further extending to Bhartiya Antariksh Station (BAS), there is a need to study the suitable methods to characterize such materials for flammability and Off-gassing assessment.

Suitable test setups need to be developed to perform complete characterization. A complete set of detailed literature shall be made available to SAC upon completion of test setup developments.

Scope of the work:

- Establish most suitable method to characterize various Polymeric materials for use in Human Space missions from flammability and Off-gassing aspects considering acceptable limits as in international standards for habitable environment.
- Develop test setup(s) to perform end-to-end characterization of materials as per above requirement.
- Provide step-by-step procedure for performing tests, calibration and maintenance of test setups.

Linkages to Space Programme:

- Human Space Program
- (current manned/ unmanned Gaganyaan and future BAS)

Expected Deliverables:

1. Study report on most suitable method to characterize various materials for use in Human Space missions from flammability & Off-gassing aspects considering acceptable limits as in international standards for habitable environment.
2. Established Test setups for performing characterization for flammability and Off-gassing assessment

RES-SAC-2024-043

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Custom Voice Command Identification

Area of Research

Artificial Intelligence

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. Saket Chawla
Mr. Ansuman Palo

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

chawlasaket@sac.isro.gov.in
apalo-hsfc@isro.gov.in

Summary of the Proposed Research

A lightweight neural network model is required to isolate background noise and identify commands using customized phrases. The model should have low computation needs to optimize the use of power in space based applications.

The developed model will require to be compared against other freely available solutions to develop a benchmark

Scope of the work:

- In a long duration mission astronauts will issue a lot of commands. Some of the commands may also be required to be issued while the astronauts are engaged physically in other work.
- In such scenarios voice based commanding for non-critical actions provide a viable and very intuitive alternate to traditional input through buttons or touch display.
- The model will be used in digital assistant to astronauts for voice based interactive commanding.

Linkages to Space Programme:

- Human Space Program

Expected Deliverables:

1. Code for custom phrase data collection and preparation
2. Code for model training
3. Code for realtime multi-word command identification

Preferred Code Language : Python or C

RES-SAC-2024-044

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

AI/ML based airborne LiDAR full waveform data processing for noise, feature extraction and annotation

Area of Research

Optics: Active remote sensing, airborne LiDAR

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. Sandip Paul
Mr. Jimit j Gadhia

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

san@sac.isro.gov.in
jimit@sac.isro.gov.in

Summary of the Proposed Research

Full waveform LiDAR are upcoming state- of the art instruments having data in terabytes. The challenge here is to extract relevant information to convert the same into 3D annotated images and reduce the data volume.

The proposal requires Noise and outliers' reduction from the raw full waveform dataset. LiDAR data is expected to have background noise from atmosphere, background clutter and instrument itself.

Various features like buildings, roads, trees, understory vegetation, ground surface, etc. need to be automatically identified and annotated with semantic labeling for large boundaries for land applications.

Various features from water bodies, underwater objects near coastline, etc. need to be automatically identified and annotated with semantic labeling for large boundaries.

Internet based *.LAS/*.LAZ files may be used for initial training, testing and benchmarking.

Scope of the work:

The scope includes Machine learning and AI techniques for robust algorithm development & near real time processing. The development includes

- ML and AI algorithms development
- Labelled dataset development (real & synthetic)

Test/ Characterization

Linkages to Space Programme:

- Airborne LiDAR
- SAC is developing airborne LiDAR for topography and bathymetry remote sensing applications. The LiDAR has two bands (1064nm & 532nm) and will image the earth from approximately 1km altitude. The instrument is based on full wave form processing which will provide insight to type of reflections from the source other than ranging. A RGB camera will be integrated to the system for augmenting LiDAR data. Further, an IMU and GPS system will provide the additional information for placing the pixels in 3D world coordinates.

Expected Deliverables:

1. Algorithm/ models
2. Trained dataset & models
3. Test bench/ hardware if any

RES-SAC-2024-045

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Water quality monitoring System for microgravity environment

Area of Research

Sensors

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. Anurag S Verma
Mr. Priyesh Kumar Jain

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

anuragsverma@sac.isro.gov.in
priyesh-hsfc@isro.gov.in

Summary of the Proposed Research

- Design and Realization of water monitor pH, TDS, Total Organic Carbon (TOC) etc, for usage in microgravity environment. For potable water TOC has to be limited to <160mg/L, hence the range has to be selected accordingly.
- Total Organic Carbon is a key indicator of water quality as carbon is present in most dangerous contaminants. The unit should measure TOC in ug/L at a fixed sampling rate
- Battery operated, Low power, miniaturized ,data interface to connect with PC(USB or equivalent)

Scope of the work:

- Design and development of quality of onboard water monitoring including parameters like pH, TDS, Content, TOC etc. are of prime importance in case of recycled water to ensure a safe supply of potable water is available to the crew. Water monitoring is essential in long term missions.

Linkages to Space Programme:

- Linked to human space program, Gaganyaan and Bharatiya Antariksh Station

Expected Deliverables:

1. Water Monitoring System prototype hardware. Hardware design details, Software Applications and Source Codes

U. R. RAO SATELLITE CENTRE

BENGALURU

RES-URSC-2024-001

Name of ISRO/DOS Centre/Unit

U. R. Rao Satellite Centre, Bengaluru

Title of the research proposal

Design And Development Of Adaptive Kalman Filter Based BPSK Demodulator For Deep Space Mission

Area of Research

Adaptive Filtering, Deep Space Communication, Kalman filters

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. Satish Sharma

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

r_karthik@lpsc.gov.in

Summary of the Proposed Research

Carrier tracking is very vital in satellite communication. There are difficulties in signal processing in deep space communication system because of weak signal.

For the autonomous BPSK system in deep space, it requires that tracking of the received signal is automatic even in unknown signal to noise ratio (SNR) condition.

If the phase-locked loop (PLL) with fixed loop bandwidth, or Kalman filter with fixed noise variance is adopted, the accumulation of estimation error and filter divergence may be caused.

Kalman filter algorithm with adaptive capability is proposed to overcome the filter divergence. The focus of the proposed research is to develop the adaptive kalman filter based BPSK demodulator for deep space system.

Scope of the work:

1. Study of algorithms for Adaptive Kalman filter.
2. System level simulation and Development of Adaptive Kalman filter based BPSK demodulator.
3. VHDL Implementation and Simulation of system without IP core.
4. Real time testing of the developed system on FPGA development platform.
5. Documentation.

Linkages to Space Programme:

- Deep Space Missions.

Expected Deliverables:

1. Matlab Simulation Model – System & Bit Level.
2. VHDL simulation and Code.

3. Validation in real time on FPGA evaluation Board.
4. Documentation.

RES-URSC-2024-002

Name of ISRO/DOS Centre/Unit

U. R. Rao Satellite Centre, Bengaluru

Title of the research proposal

Modelling And Control Electronics Hardware Design With Algorithm Implementation For Stewart Platform System

Area of Research

Stewart Platform Control Electronics for Space Docking Systems.

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Dr. Vijay Kumar Verma

Mr. Manoj Kumar

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

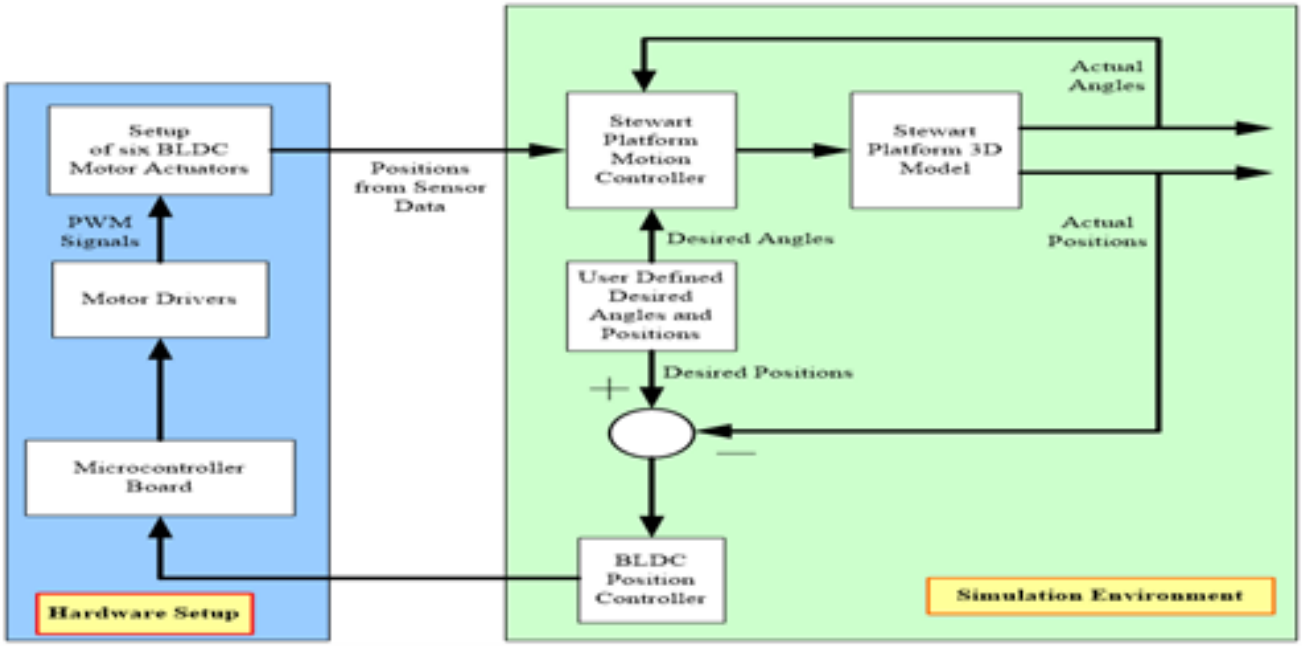
vijay@ursc.gov.in

Summary of the Proposed Research

The project envisages the technology requirements and developments for 6 -DOF Stewart Platform for space docking. Stewart Platform, known for its six-degree-of-freedom motion capability, is crucial in space docking applications due to its stability and precision. In this project, the platform is equipped with Brushless DC (BLDC) motor-driven linear actuators, chosen for their high efficiency, responsiveness, and reliability. The project involves developing a comprehensive mathematical model to accurately describe the kinematics and dynamics of the Stewart Platform, focusing on its interaction with the BLDC-based actuators. which integrates the real-time control systems with physical hardware, allowing for the testing and validation of the model under realistic docking scenarios.

Scope of the work:

1. To develop a mathematical model of the Stewart Platform incorporating the dynamics of BLDC-based linear actuators and focusing on space docking applications.
2. To design and implement advanced control algorithms for the Stewart Platform to ensure precise and stable operations during space docking.
3. To implement hardware-in-the-Loop (HIL) simulation, which would integrate the real-time controllers with physical hardware to validate the performance of the Stewart Platform model.
4. To synchronize Host and Visiting vehicle movements of the Stewart Platform simulation models to ensure that the Stewart Platform can effectively manage the alignment and timing required under realistic docking scenarios.
5. To fabricate a 3D printed model of the Stewart Platform and implement real-time control to provide a tangible demonstration.



Linkages to Space Programme:

- This project will enhance and support the development activities necessary for future IDSS compatible space docking system development and shall be useful for BAS (Bharatiya Antariksha Station) also. The Stewart Platform is combination of precise control, stability, vibration damping, and real-time adjustment capabilities makes it a cornerstone of modern space docking technology. Its ability to control spacecraft positioning in six degrees of freedom ensures that the critical alignment, approach, and capture phases of docking are executed smoothly, safely, and accurately, reducing risks and enhancing mission success. This technology continues to be crucial in the development of autonomous docking systems for future deep-space missions, In-orbital service operations, and the docking of spacecraft at space stations or other orbital platforms.

Expected Deliverables:

1. Validated mathematical model of the Stewart Platform would accurately represent the interaction between the BLDC-based linear actuators and the kinematics and dynamics of the Stewart Platform.
2. Optimized and reliable control algorithms would enable precise and stable docking operations in the challenging environment of space.
3. A fully functional HIL simulation environment would pave the way for real-time testing and validation of the control systems of Stewart Platform in space docking scenarios.
4. Detailed analysis and results demonstrating the ability of the Stewart Platform to synchronize movements between the chase and target vehicles would be helpful in ensuring successful docking manoeuvres.
5. A working 3D printed model of the Stewart Platform and its real-time control would present the potential of the developed control algorithms.
6. Hardware prototype for Motor control electronics.

RES-URSC-2024-003

Name of ISRO/DOS Centre/Unit
U. R. Rao Satellite Centre, Bengaluru

Title of the research proposal
Development Of Automated Tool: Classification Of Black Hole Binaries During Astrosat Era

Area of Research
High Energy Physics, X-ray Astronomy, Computer Algorithms, Machine Learning.

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Dr. Anuj Nandi

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit
anuj@ursc.gov.in

Summary of the Proposed Research

AstroSat, India's 1st dedicated Astronomy Satellite, is set to celebrate 10 successful years of operation in orbit in September 2025. It has demonstrated its unique capabilities (fast timing, wide energy band) by observing black hole X-ray binaries (BH-XRBs) with very interesting results. There is still significant potential to delve into the exceedingly large data to extract more insightful science from AstroSat observations using LAXPC data, which has an enhanced capability to study rapid X-ray variability in a wide energy band (3-80 keV), compared to NASA's decommissioned RXTE mission.

In the proposed research, the evolution of energy dependent timing and spectral properties of black hole X-ray binaries (BH-XRBs) during active phases of X-ray emissions will be probed in detail. The evolution of Quasiperiodic Oscillations (QPOs), hardness ratio (HR), X-ray lags, and wide-band spectral decomposition (thermal vs nonthermal emission) are the important diagnostic tools for studying the accretion geometry and dynamics around the black holes.

AstroSat has observed more than 15 Galactic BH-XRBs, comprising more than 300 GBytes of archival data. It is of utmost necessary to develop an automated tool for analyzing light curves, hardness intensity diagrams (HID), power density spectra (PDS), and Fourier lag spectra including spectral decomposition. Based on the results from these automated tools, a comprehensive classification of the accretion states and variability properties of all black hole binaries observed by AstroSat will be conducted to enhance understanding of the BH-XRB systems. Various physical parameters resulting from automated analysis will be used to quantify the dominating physical mechanisms responsible for producing variation in the QPO frequency, lag/power spectra during different spectral states and a robust spectro-temporal correlation will be established. Finally, it is also expected to find out the role of variable accretion geometry in characterizing the accretion states and fast variability properties of the sources.

These automated tools will be generalised for using data from XSPECT/XPoSat (0.8-15 keV) along with observations from other space-based observatories (NICER, NuSTAR) for further study of BH-XRBs.

Scope of the work:

The scope of this research proposal encompasses several key areas of study that is focused on the spectral and temporal properties of Galactic black hole binaries using data from AstroSat mission. The scope of the proposed research and its tasks are outlined as follows,

1. Archival Data Selection and Analysis: Extraction and Analysis of the observational data from AstroSat's archive comprising more than 300 GByte, which includes over 15 Galactic X-ray binary sources. Data format will generally be in FITS, readable by the developed tools.
2. Development of Automated Tools: Develop automated tools to analyze light curves, hardness intensity diagrams (HID), power density spectra (PDS), Fourier lag spectra including the energy spectra of all observations; Ensure these tools can efficiently handle large datasets and provide consistent results.
3. Classification of Accretion States: Generate a comprehensive classification scheme of
4. the accretion states observed by AstroSat, on the basis of spectral and fast variability properties; Utilise multiple parameters (QPO properties, HR values, hard/soft lags of QPOs, temperatures, spectral index etc.) obtained from automated analysis to quantify the dominant physical mechanisms during different spectral states.
5. Extended Analysis with XSPECT/XPoSat: Developed tools to be used for modelling the observations from XSPECT/XpoSat mission to correlate the findings from LAXPC/AstroSat results.

Linkages to Space Programme:

- In this proposed research, the entire archival observations of black hole sources with AstroSat will be considered. The automated tools will be useful to process the large data available at ISSDC for the specific purpose. These tools can also be utilized for analyzing the data from XSPECT/XPoSat as well as from other space-based observatories (NICER, NuSTAR). Furthermore, this automated tool may be useful for processing data for future astronomy missions of ISRO.

Expected Deliverables:

1. Automated Analysis Tools: Development and utilization of automated tools for the analysis of light curves, hardness intensity diagrams (HID), power density spectra (PDS), and Fourier lag spectra including spectral decomposition using data from AstroSat, XPoSat. It would be firstof-its-kind to deal with large data to extract various observable features of black hole binaries; Tools to be developed with open source code (eg. Python); Detailed manual along with documentation and the developed tools to be shared to ISRO.
2. Technical Documentation: Comprehensive technical documentation of the methodologies, algorithms, and software used in the development of the automated analysis tools.
3. Scientific Findings and Research Publications: A study establishing robust spectro-temporal correlations for the BH-XRB systems; An analysis of the role of variable accretion geometry in characterizing the accretion states and fast variability properties of the sources; Publication in peer-reviewed journals, detailing the classification of the accretion states observed by AstroSat, based on outcomes using automated analysis tools.
4. Comprehensive Classification: A unified scheme for classification of accretion states of black hole binaries and variability properties of all black hole binaries observed by AstroSat.
5. Generalized Tools for Other Observatories: A unified classification scheme of BH-XRBs observed with LAXPC/AstroSat (3-80 keV), and subsequently apply the same scheme to the observations from XSPECT/XPoSat (0.8-10 keV) and other space-based observatories like NICER and NuSTAR.

RES-URSC-2024-004

Name of ISRO/DOS Centre/Unit

U. R. Rao Satellite Centre, Bengaluru

Title of the research proposal

Design of an Integral Field Unit (IFU) Based Spectrograph and Lab Demonstration of the IFU System

Area of Research

UV Astronomy

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. Swapnil Singh
Mr. Anand Jain

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

swapnils@ursc.gov.in
anandj@ursc.gov.in

Summary of the Proposed Research

The proposed research includes the optical design UV IFS (Integral Field Spectrograph) system for astronomical applications and the development of the lab model of an IFU system. IFS is an advanced observational technique that combines imaging and spectroscopy, allowing astronomers to obtain a three-dimensional data cube with two spatial dimensions and one spectral dimension. This enables detailed analysis of the physical and chemical properties of astronomical objects across a field of view. An IFS system consists of two subsystems: the IFU and the spectrograph. The IFS would be developed for the FUV range (<250 nm) and it would be beneficial if the Lyman UV region (100-122 nm) is included. As deliberated in the Space Science Roadmap Formulation (SSRF) Meeting, it was suggested that UV is a gap area and UV wavelengths are critical for studying hot, energetic processes such as star formation, the behaviour of active galactic nuclei (AGNs), and the properties of the interstellar medium (ISM). This research will focus on selecting the most effective technique for a UV IFS system having a

spectral resolution better than 25 nm and a spatial resolution better than 40 arcsec through comprehensive simulations and lab testing. The work will involve evaluating various design configurations, optical components, and detector technologies to optimize performance for UV applications. Lab testing will concentrate on creating a lab prototype of an IFU, which will serve as a foundation for developing more sophisticated instruments tailored for future astronomy missions.

Scope of the work:

This work is divided into three phases:

1. PHASE 1- This phase would include the configuration/optical design of the complete IFU based spectrograph - Simulations: There are multiple techniques to design an IFS. Detailed simulations have to be carried out towards evolving the technique to be used and the instrument parameters for achieving the desired specifications; Finalizing the system parameters: The full system consists of various subsystems which include the optics, fiber bundle/mirrors, grating and detector along with its electronics. The instrument parameters will be finalized considering the available sensors in the wavelength range of interest.

2. PHASE 2- The work in this phase includes the lab demonstration and testing of the IFU system components - Fabrication and Characterization Optomechanical Systems: After finalization of the preferred technique and the optics design, the fabrication of optomechanical components to be carried out. Each of these components to be individually tested and the facilities available at URSC/ LEOS can be explored; Alignment, Assembly and Testing of IFU: Testing as per the final configuration of the IFU to be carried out with ground based commercial UV detector systems.

3. PHASE 3- The work in this phase includes the lab demonstration and testing of the end-to-end IFS. The spectrograph part of the system would be developed by SAG - Testing of IFS: Testing as per the final configuration of the IFS to be carried out with ground-based commercial UV detector systems. For testing, the facility and sensor resources available at SAG will be used by the proposers.

Linkages to Space Programme:

- The UV IFU based Spectrograph will significantly advance ISRO's astronomical research. Integrating UV IFS with larger missions like the successor of AstroSat or future small satellite missions will enable novel studies of star formation, AGNs, and galaxy evolution. This technology
- complements multi-wavelength observations, providing critical insights into the physical conditions and dynamics of astronomical objects. As recommended during the SSRF meeting, UV IFS can enhance the scientific return of future missions at other wavebands as well and ISRO can deepen its contributions to global astronomical research.

Expected Deliverables:

1. Study report and associated files (codes, simulation files, Zemax files etc.) for the selection and optical simulation of the designs to cater to the required specifications. The report will also present the finalized technique and design along with the component specifications.

2. Report on the characterization of the sub-components for the IFU system and their performance in the lab.

3. Integrated IFU laboratory model along with the report on lab test results demonstrating the working of the integrated IFU system and the system performance.

RES-URSC-2024-005

Name of ISRO/DOS Centre/Unit

U. R. Rao Satellite Centre, Bengaluru

Title of the research proposal

Development Of Solid State Based Thermal Electric Cooler Device That Can Operate At Low Temperatures

Area of Research

Thermal control element for spacecraft

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Dr. Arpana Prasad

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

arpanapd@ursc.gov.in

Summary of the Proposed Research

Thermoelectric (TE) devices generate electricity from temperature differentials and vice versa. It uses peltier effect to pump heat against a thermal gradient. Because of this functionality they are widely used by many space agencies for as temperature management tools, by cooling or heating a surface depending on the direction of the electrical flow.

Here, the challenge is to develop TEC that can operate at low temperature (80 to 90K) using solid state technology with the efficiencies of more than 5%.

Scope of the work:

To design, develop, demonstrate and supply of atleast one TEC with complete procedure document.

Linkages to Space Programme:

- For interplanetary missions. It will provide hot spot cooling for sensor device and high power electronics.

Expected Deliverables:

1. Experimental data.
2. Fabrication methodology and assembly techniques.
3. TEC- engineering model hardwares.
4. Final closure report.

RES-URSC-2024-006

Name of ISRO/DOS Centre/Unit

U. R. Rao Satellite Centre, Bengaluru

Title of the research proposal

Porous Electroosmotic Microchannel Cooling System for High Heat Flux Dissipating Electronics

Area of Research

Electroosmotic Pump, Microchannels, Heat Transfer

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Dr. Simhachala Rao Chikkala

Dr. A. R. Anand

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

simhach@ursc.gov.in

aranand@ursc.gov.in

Summary of the Proposed Research

Electroosmotic (EO) pumps offer advantages over the regular mechanical pumps such as no moving parts, no noise, small size and very less power consumption. These features make the EO based microchannel cooling system ideal for handling high flux dissipating electronic packages in spacecraft.

It has been reported that EO Pumps can generate flow rates up to 33 ml/min, pressure of 1.3 bar and able to handle heat fluxes up to 100 W/cm2 (heat loads up to 150 W). The basis of EO pumps is the presence of a Maxwell body force on the liquid within the charged electric double layers (EDL).

Scope of the work:

1. Design, fabrication and testing of Electroosmotic pumped microchannel cooling system with microchannel heat exchangers for a heat flux level of 50 W/cm2 (100W) with acetone or any suitable as the working fluid.
2. Foot print area of the overall system is 0.25 m2.
3. Material of microchannel heat exchanger is Aluminium alloy (Al-6063T6) or any suitable.
4. Thermohydraulic performance of the loop for various test conditions.
5. Optimization studies (theoretical)

Linkages to Space Programme:

- Space programmes having high heat dissipating Avionics packages.

Expected Deliverables:

1. A design report of the porous electroosmotic microchannel cooling system containing theoretical or analytical
2. studies and effectiveness for space application.
3. Hardware of prototype models of system that can be qualified to spacecraft application
4. Detailed experimental results consisting of performance, repeatability, and other space-based requirements
5. Submission of interim, final report and closure report of the project as per the given timeline
6. Publications and patents generated from this study shall be produced or published jointly with URSC/ ISRO team

RES-URSC-2024-007

Name of ISRO/DOS Centre/Unit

U. R. Rao Satellite Centre, Bengaluru

Title of the research proposal

Development of an Apparatus Based on “Transient Techniques” to Estimate The Thermal Parameters of Aerospace Materials over a Wide Temperature Range

Area of Research

Transient techniques in heat transfer based on periodic/ pulse/ continuous heating to measure the thermal parameters of aerospace materials over a wide temperature range.

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. Govinda Rao Yenni

Dr. Arpana Prasad

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

ygrao@ursc.gov.in
arpanapd@ursc.gov.in

Summary of the Proposed Research

Most of the materials of Spacecraft construction are tailor made composites. The thermal parameters of these special materials strongly depends on direction and temperature. An accurate experimental determination of these thermal parameters is essential for the realization of an optimized spacecraft thermal control system. So, an extensive experimental apparatus is essential to establish the thermal parameters.

Scope of the work:

Design and development of an apparatus based on "Transient Techniques" to measure the thermal parameters of aerospace materials over a wide temperature range.

Linkages to Space Programme:

- Thermal parameters of the spacecraft materials are an important input for the design, analysis and realization of Spacecraft thermal control system

Expected Deliverables:

1. Develop a variable temperature experimental setup for thermal conductivity measurements for solid materials based on transient methods.
2. The system design to be adapted to measure thermal conductivities of samples such as composites, powders, pastes and gels.
3. Develop the instrumentation for both double sided transient plane source method as well as heat pulse method.
4. Calibrate the experimental setup using standard samples of similar thermal conductivity values.
5. Compare the experimental results with those obtained from the suitable theoretical.

RES-URSC-2024-008

Name of ISRO/DOS Centre/Unit

U. R. Rao Satellite Centre, Bengaluru

Title of the research proposal

Development of Passive and Active Thermal Louvers to Vary The Effective Emittance of Spacecraft Radiator Based on the Requirement

Area of Research

Design and Development of Spacecraft Thermal Control Elements.

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. Govinda Rao Yenni
Mr. Balakrushna Maharana

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

ygrao@ursc.gov.in

Summary of the Proposed Research

Thermal Louvers find application where internal power dissipation in a spacecraft varies rather widely as a result of equipment duty cycles. Thermal Louvers can change the area of radiating surface depending upon the amount of radiating heat. Like venetian blinds, the louvers (louvered flaps) would open or close depending on whether an instrument needed to shed or conserve heat. The louver performance is characterized by its effective emittance, defined as the ratio of the net heat transfer from the louvered area to the radiation from an equivalent un-louvered black area, at the same temperature. Louvers should be designed for higher performance.

Scope of the work:

Design and development of thermal louvers (both active and passive).

Linkages to Space Programme:

- The thermal louvers can be used in the spacecraft for an efficient thermal control system.

Expected Deliverables:

1. Prototype Thermal Louvers (both active and passive).

RES-URSC-2024-009

Name of ISRO/DOS Centre/Unit

U. R. Rao Satellite Centre, Bengaluru

Title of the research proposal

MEMS Based Pumped Liquid Cooling Loop for Cooling High Heat Flux Dissipating Components

Area of Research

Micro Pump, Microchannels, Heat Transfer.

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Dr. Simhachala rao Chikkala

Dr. A. R. Anand

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

simhach@ursc.gov.in

aranand@ursc.gov.in

Summary of the Proposed Research

Thermal control of future spacecraft will be challenging due to the increasing power densities of payloads beyond 50 W/cm^2. To meet the demand of high heat flux components, advanced thermal control technologies are essential to keep them within acceptable temperature and also to provide accurate thermal control specified by scientific instruments and detectors on board. Some of the technologies under consideration are passive two-phase devices such as micro heat pipes embedded in electronic

packages, micro loop heat pipes, and thermo-electric coolers. However, these technologies have limitations on fabrication, heat flux levels and flexibility in integration with heat dissipating components. MEMS based pumped liquid cooling system is a promising solution to meet this requirement. A MEMS-based pumped liquid cooling system consists of a working fluid circulated through microchannel heat exchangers by a Micropump to remove heat from the component and this heat can be transferred to external radiator of the spacecraft located away from the electronics.

Some advantages of the MEMS-based pumped cooling system are:

1. Ease of integration and testing
2. Late design modifications
3. Removal of large heat fluxes over large distances
4. Accurate temperature control of electronics/payload by Micropump
5. Ability to function in adverse gravity

Scope of the work:

1. Design, fabrication and testing of MEMS based pumped liquid loop with microchannel heat exchangers for a heat flux level of 50 W/cm^2 with acetone as the working fluid.
2. Foot print area of the overall system is 0.25 m2.
3. Material of microchannel heat exchanger is Aluminium alloy (Al-6063T6) or any suitable.
4. Thermohydraulic performance of the loop for various test conditions.
5. Optimization studies (theoretical).

Linkages to Space Programme:

- Cooling of payloads having high heat flux dissipation in both GEO and LEO spacecraft.

Expected Deliverables:

1. A preliminary design report for parametric studies of MEMS loop chosen for the project containing theoretical or analytical studies and effectiveness for space application. (
2. Hardware of prototype models of MEMS loop that can be qualified to spacecraft application.
3. Detailed experimental results consisting of performance, repeatability, and other space-based requirements.
4. Submission of interim, final report and closure report of the project as per timeline given.
5. Publications and patents generated from this study shall be produced or published jointly with URSC/ISRO team.

RES-URSC-2024-010

Name of ISRO/DOS Centre/Unit

U. R. Rao Satellite Centre, Bengaluru

Title of the research proposal

Development Graphene Based High Thermal Conductivity Composite Diffuser Plate/Sheet

Area of Research
Thermal Control Element

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Dr. Arpana Prasad

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit
arpanapd@ursc.gov.in

Summary of the Proposed Research

High conductive heat diffuser plate/sheet is very essential in spacecraft thermal management. Experimentally and computationally identification and realization of ultrahigh thermal conductivity materials such as Graphene etc. with applications to diffuser plate for spacecraft application. The realized composite plate will be lighter in weight and will have better thermal conductivity.

Scope of the work:

1. Design and development of ultra-high thermal conductivity material for space applications.
2. Fabrication of proto-model, testing for space qualification and performance demonstration.

Linkages to Space Programme:

- For interplanetary mission. It will be used in future satellites where weight is an important factor. It will reduce the weight produced by the traditional aluminum/ copper diffuser plate with better performance.

Expected Deliverables:

1. Experimental data.
2. Fabrication methodology.
3. High conductive heat diffuser plates 6 Nos- engineering model.
4. Final closure report.

RES-URSC-2024-011

Name of ISRO/DOS Centre/Unit
U. R. Rao Satellite Centre, Bengaluru

Title of the research proposal
Software models of trained Deep Neural Network architectures for Real-time Edge applications on Space Platforms

Area of Research
Artificial intelligence, Machine learning, Deep neural Networks

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Mr. Kaustubh Anand Kandi

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit
kaustubh@ursc.gov.in

Summary of the Proposed Research

The AI ASIC under development at IADG is designed to provide high throughput for computationally intensive DNNs and MMA operations and can be used for real time deployment of these complex algorithms. Real-time application oriented and trained DNNs are sought in this proposal. These DNNs will help the chip designers in characterizing the chip performance for functional verification and overall speed-power-area optimization.

Indicative examples of such applications are mentioned herewith:

Example scenario 1: Robots with multi-legged locomotion to mimic walking/crawling/slithering type of biomimetic motions have control loops which involve MMA (matrix multiply and accumulate) operations over thousands/millions of parameters in every feedback loop. The software architecture of controller can be run on AI accelerators for real time control of complex space robots.

Example scenario 2: DNNs can be used to imbibe intelligence into the spacecrafts to understand the content and meaning of images captured by their payloads for real-time data-filtering. These algorithms can perform integrated tasks like object recognition, localization, tracking and segmentation in a single architecture.

Example scenario 3: Beam forming in satellites for high bandwidth and high throughput applications require agile narrow-beam formation which is done by using phased array of antennas. DNN based derivation of phase and amplitude for individual elements has shown better characteristics on such systems with large arrays than conventional techniques.

Scope of the work:

- Hi-resolution EO and deep-space missions
- Landers and rovers
- Docking
- High throughput communication satellites

Linkages to Space Programme:

- Hi-resolution EO and deep-space missions
- Landers and rovers
- Docking
- High throughput communication satellites

Expected Deliverables:

1. A software suite of DNN architectures trained on real time edge applications for space missions.
2. Demonstration of DNN performance in simulation.
3. Handover of network architecture & coefficients in appropriate format.
4. Support during test run of algorithms on AI chip.
5. Support during demonstration on testbed.

RES-URSC-2024-012

Name of ISRO/DOS Centre/Unit

U. R. Rao Satellite Centre, Bengaluru

Title of the research proposal

IP Core development of High-speed Post-Processing system for Satellite Quantum Key Distribution (SatQKD)

Area of Research

High Performance computing, Quantum Key Distribution, Error Correction and Key Reconciliation

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. Piyush Joshi

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

jpiyush@ursc.gov.in

Summary of the Proposed Research

SatQKD intermediated by a trusted satellite in a low-Earth orbit to ground stations allows remote users to connect securely. Within a few hundred seconds of a LEO overpass, the QKD session between end users' needs to communicate and process huge data (both classical as well as quantum) coming through a dynamically changing free-space link. The short time and large losses require optimized postprocessing so as to keep up with the upcoming improvements in the on-board sources and detectors. The main target for the optimization is to improve the secret key rate keeping the information leakage during key reconciliation at a minimum. Following considerations can be utilized to achieve the required targets:

Optimization consideration 1: Error Correction (EC) and Privacy Amplification (PA) over the sifted key are of utmost importance for reliable and secure QKD; at the same time, they are also the most computationally intensive post processing parts. Utilizing parallelization operations through RTL design can be adopted to accelerate certain stages of the EC/PA algorithm increasing processing bandwidth/ throughput.

Optimization consideration 2: Incoming raw key packet from the satellite can undergo splitting optimization to finish key generation in a single pass over an optical ground station (OGS) and also reach as close to the asymptotic key length i.e. the key length for stationary parties. However, for short keys packet splits, PA affects the key rate more due to statistical uncertainty but large key packets cannot be considered due to limited overpass time. Hence a suitable balance of key splitting is to be obtained.

Optimization consideration 3: Going through the different iterations of EC, the number of bits in each packet for EC is to be decided according to the Quantum Bit Error Rate (QBER) of the dynamically changing channel. Also, as EC and PA contain risk of security breach through redundant information sharing. Hence, choice of EC code with respect to the mentioned optimizations is important.

Scope of the work:

Relevant to ISRO's Opto-Quantum Communication(OQC) programme

Linkages to Space Programme:

- Relevant to ISRO's Opto-Quantum Communication(OQC) programme

Expected Deliverables:

1. An end to end IP core of a high speed post processing system for SatQKD emphasizing the optimization of branching/splitting, error correction/verification, and privacy amplification modules of QKD.
2. System Specs:
    - Secure key rate
    - Processing bandwidth
    - Error correction efficiency
    - Quantification of redundant information transfer

RES-URSC-2024-013

Name of ISRO/DOS Centre/Unit

U. R. Rao Satellite Centre, Bengaluru

Title of the research proposal

Low overhead MBIST for embedded memories in SoCs

Area of Research

Memory Testing to detect manufacturing faults

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Ms. Anula Gupta

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

anula@ursc.gov.in

Summary of the Proposed Research

High density memories, integrated in SoCs are prone to higher defect rates.

Due to their large size, limited IO's availability and high-speed operation, new fault models and test procedures are required for testing memories.

In order to ensure high quality, these memories can be thoroughly tested using Memory Built-In Self-Test (MBIST) algorithms.

It should have highly automated design implementation and diagnostic flow. It should include optimized test algorithms specifically targeted at increasing coverage for memory defects that are prevalent at 180 nm to 65nm process nodes.

Complexity of targeted SoC/ASICs is of the order of 20M NAND2 equivalent and MBIST logic introduces significant amount of chip area overhead. So, there is a requirement to develop MBIST logic insertion flow with minimum area overhead.

Scope of the work:

- Literature survey and Identification of suitable MBIST test algorithms for180nm to 65 nm technological node.
- Memory Testing to detect manufacturing faults of SRAM and DPRAMs
- Option to select suitable MBIST algorithm based on requirement.
- Memory BIST component generation flow should be independent of the design in a GUI environment as well as in batch mode
- RTL (VHDL/verilog)code generation of MBIST logic with minimum area overhead.
- It should be possible to schedule testing of various memories sequentially and in parallel and a combination of both.
- The BIST Controller should be able to support programming of custom test algorithms and either embed them or load them on tester
- The insertion of BIST components into the user design should be fully automated in GUI environment as well as batch mode.
- All the generated components can be verified in a simulation environment created automatically by the tool.

Linkages to Space Programme:

- Relevant to all Space Programmes as SoCs with memories are essential building blocks of Avionics.

Expected Deliverables:

1. MBIST Algorithms details
2. User interface to generate RTL code (VHDL/ verilog) and test stimulus
3. Design insertion flow and verification plan

RES-URSC-2024-014

Name of ISRO/DOS Centre/Unit

U. R. Rao Satellite Centre, Bengaluru

Title of the research proposal

Designing and fabrication of deep UV photon detectors using wide band gap low dimensional material.

Area of Research

Sensors

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. Radhakrishna V.

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

rkrish@ursc.gov.in

Summary of the Proposed Research

Detections of photons in wide wavelength band is an extremely important idea from technological point of view and detection of deep ultra-violet photons (DUV, in the range 200-280 nm) have attracted much attention in the space science, military and civilian fields. Photodetectors are important photoelectric devices which senses the photons via photoelectric signal generation upon photon interaction. Traditionally, the detection of DUV light is based on photomultiplier tubes (PMTs), thermal detectors, photodiodes or charge coupled devices. Compared to these, detectors made using low dimensional materials have advantages such as small volume, low energy consumption and possible multi-functionality.

The objective of this proposal is designing and fabrication of deep UV photon detectors using wide band gap low dimensional materials. Hexagonal Boron Nitride (h-BN) material is a material sensitive to UV photons. The metarial synthesis has to be optimized and Photodetectors are to be fabricated on flat and flexible substrates and the performance of device need to be carried out.

Scope of the work:

- Synthesis of hexagonal Boron Nitride (h-BN), a wide band gap low dimensional materials for DUV detection.
- Fabrication of photodetectors
- UV photon detection
- Fabrication of flexible photodetectors using chosen low dimensional material
- Electrical characterisation of flexible photodetector

Linkages to Space Programme:

- UV detectors are widely used in space astronomy and planetary science missions. Low dimensional materials are new generation materials technology offering high sensitivity for UV detection and low cost option.
- The detectors will be considered for future UV instruments for Astronomy and Planetary missions

Expected Deliverables:

1. Optimization of synthesis procedure of wide bandgap low dimensional materials
2. Complete characterisation of chosen material
3. Fabrication of deep UV photon detector.
4. Fabrication of detector arrays.
5. Process and design optimization detector arrays
6. Performance evaluation of the detector arrays on flat and flexible substrates

RES-URSC-2024-015

Name of ISRO/DOS Centre/Unit

U. R. Rao Satellite Centre, Bengaluru

Title of the research proposal

Design and development of a Laboratory model of Solar Imager for Magnetic and Doppler at two heights (SIMD-2H)

Area of Research

Optical instrument for Solar Application

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. K. Sankarasubramanian

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

sankark@ursc.gov.in

Summary of the Proposed Research

Solar Magnetic field is the heart of all the dynamics in the solar atmosphere. To understand the solar plasma interaction with magnetic field, measurements of the magnetic field and plasma parameters are utmost importance. Since the dynamics of the solar atmosphere is not predictable at present, it is important to observe the full Sun continuously and obtain the magnetic and plasma parameters. Magnetic and Doppler imagers of the full Sun in the photosphere is being observed by the Solar Dynamics Observatory for almost 10-years now. In order to advance any knowledge on the dynamics, similar observations at two different heights simultaneously is a must. This proposal is to design and develop a Magnetic and Doppler Imager at two different heights in the solar atmosphere which would help in understanding the magnetic currents in the three dimension which is currently not available.

Once developed and tested in the ground based observatories, this instrument can be flown in different satellites (LEO, GEO, L1, L4/L5 and out-of-ecliptic) as this measurement is fundamental to any dynamical events which happen on the Sun and also heart of the space weather events.

Scope of the work:

- Selection of the spectral lines to identify the two heights in the solar atmosphere
- Design of a Michelson and Doppler Imager system or any other similar system which would provide the required measurements
- Develop the system and test it in the laboratory
- A final phase – depending on the ground telescope availability, this can be coupled to the back-end of the telescope to observe the Sun. In case of non-availability, detailed laboratory testing will ensure the performance validation

Linkages to Space Programme:

- UV detectors are widely used in space astronomy and planetary science missions. Low dimensional materials are new generation materials technology offering high sensitivity for UV detection and low cost option.
- The detectors will be considered for future UV instruments for Astronomy and Planetary missions
- Missions to look at the Sun or Space weather to understand the dynamical nature requires this measurement. The laboratory model can be attached to a telescope for regular observation of the Sun from ground and the same design can be used for flight model development which can fly in multiple missions (even as piggy back).

Expected Deliverables:

1. Optimization of synthesis procedure of wide bandgap low dimensional materials
2. Complete characterisation of chosen material
3. Fabrication of deep UV photon detector.
4. Fabrication of detector arrays.
5. Process and design optimization detector arrays
6. Performance evaluation of the detector arrays on flat and flexible substrates
7. Documents on the selection of two lines for the two heights, Optical and opto-mechanical design of the system – Phase I
8. Development of the system and initial laboratory testing of the sub-system as well as the system including detailed characterization – Phase II
9. Testing at the ground based solar telescope – utilize the existing solar telescope in India to test – Phase III
10. All the results and data obtained during the test phase.

RES-URSC-2024-016

Name of ISRO/DOS Centre/Unit

U. R. Rao Satellite Centre, Bengaluru

Title of the research proposal

Development of Digital Demodulator for Variable Data Rate Applications.

Area of Research

Development of Digital Demodulator for Variable Data Rate Applications.

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. Satish Sharma

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

satish@ursc.gov.in

Summary of the Proposed Research

CCSDS Proximity protocol is a Short-haul protocol for communicating between Orbiter, Lander and Rovers. It Provides standard services for transferring commands, telemetry and data to / from Rovers. Standard requires communication links with direct modulation on carrier. Proximity protocol supports 13 different data rates for two-way links from 1 Kbps to 4 Mbps. Proximity RF Systems should have capability of transmitting and demodulating the data at different rates.

Scope of the work:

- Study of various algorithms for Direct modulation & Demodulation and selection of suitable algorithm to support variable data rates.
- Design of modem system for transmission and reception.
- Implementation, testing and demonstration of demodulator for CCSDS Proximity standards.

Linkages to Space Programme:

- Future Deep space missions involving Orbiter, lander and Rovers.
- Future Lander-Rover and IRS mission.

Expected Deliverables:

1. Matlab Simulation Model – System & Bit Level
2. VHDL code and Simulation
3. Validation on FPGA evaluation board.
4. Design Document.

RES-URSC-2024-017

Name of ISRO/DOS Centre/Unit

U. R. Rao Satellite Centre, Bengaluru

Title of the research proposal

Modeling & simulation of packaging effects on MMIC die Performance in HTCC based RF Package at microwave frequencies (S-band to Q-band).

Area of Research

Communication

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Ms. Rashmi Behera

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

rashmib@ursc.gov.in

Summary of the Proposed Research

Monolithic Microwave Integrated Circuit (MMIC) performance varies significantly from its on wafer, when assembled inside a package. Packaged MMIC performance degrades due to package resonance,

interconnection & coupling effects. Inside the RF package, resonance effects are due to ring resonances and cavity resonances. Radiation produced by the different circuits in the package couples to adjacent circuits and degrades the module performance. Also wire bond interconnects exhibits extra parasitic inductance and radiate the RF energy. A systematic methodology for comprehensive analysis of the packaging and enclosure effects of packaged MMIC die is one of the prime requirements for many applications. In the proposed research degradation of intrinsic MMIC die performance due to packaging effects will be analysed & mitigation techniques will be studied.

Scope of the work:

1. 3D-Modeling of the HTCC based RF Package
    - Modeling of the RF package
    - EM Simulation of package response using FEM techniques in commercial software
2. 3D-Modeling of RF Package with circuit inside it
    - Modeling of the RF package with MMIC, passive components, interconnections, base plate and RF connectors etc. This should include both RF and thermal modelling.
    - EM Simulation of Package response with circuity inside it. (URSC will provide details of package, circuit & materials used)

Linkages to Space Programme:

- MMIC dice are being used in space applications to meet miniaturization and high performance requirements. Packaging of the MMIC die is necessary to high reliability requirements of space applications. The package degrades the RF performance of the MMIC die. A study on the packaging & enclosure effects are useful in every application wherever MMIC dice are packaged.

Expected Deliverables:

1. Matlab Simulation Model – System & Bit Level
2. VHDL code and Simulation
3. Validation on FPGA evaluation board.
4. Design Document.

RES-URSC-2024-018

Name of ISRO/DOS Centre/Unit

U. R. Rao Satellite Centre, Bengaluru

Title of the research proposal

Design of passive damping elements for a sandwich panel.

Area of Research

Sandwich structures

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. Shaik Johny Basha

Mr. Ankit Kumar Singh

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

basha@ursc.gov.in
ankks@ursc.gov.in

Summary of the Proposed Research

1. Design of a friction based passive damping element that can be placed inside a composite panel.
2. The element should be designed and optimised for a particular frequency or a set of frequencies.

Scope of the work:

- Can be implemented in equipment panels to reduce their responses.
- Passive damping elements can be implemented in design of various brackets and support structures to reduce dynamic loads.

Linkages to Space Programme:

- All satellites of GEO and LEO.

Expected Deliverables:

1. Realization of a development / qualification model hardware to be able to complete tests / simulations envisaged and demonstrate that the development is complete and can be inducted into onboard systems.
2. To deliver and handover all the detailed documentation of design, fabrication and testing.

RES-URSC-2024-019

Name of ISRO/DOS Centre/Unit

U. R. Rao Satellite Centre, Bengaluru

Title of the research proposal

High-Level Synthesizable Digital Designs Modelled by using C/C++/Python

Area of Research

Modelling, High level Synthesis

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Ms. Chandrika G L

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

chandrka@ursc.gov.in

Summary of the Proposed Research

High-level synthesis (HLS) has emerged as a pivotal stage in the hardware design process, enabling the automatic transformation of high-level behavioral descriptions into efficient hardware implementations. Design models which are simulation accurate and synthesis optimal can be of greater help in handling the complexities and to reduce development time of modern systems-on-chip (SoC) and application-specific integrated circuits (ASICs).

This project aims to develop C/C++/Python models for applications like digital pre-distortion circuits, DDR4 controller and JESD204B/C protocols targeting tools like MATLAB HDL and Catapult. The models should be compatible with Xilinx, Actel and ASIC technologies.

The proposed project will promote faster design development times, design reusability, scalability, and portability, aligning with industry trends towards design development and system-level exploration..

Scope of the work:

- Consolidation of specifications for applications mentioned.
- Selection of target HLS tool and the high-level modeling language (C/C++/Python)
- Implementation of models and evaluation with HLS tool.
- Demonstration of the models in selected HLS tool by targeting Xilinx, Actel FPGA and ASIC technologies.

Linkages to Space Programme:

- This will be useful in projects where design turn-around time is minimum. So, this can be used in all projects like FPGA/ASIC designs of Integrated Avionics Package and Bhartiya Antariksh Station.

Expected Deliverables:

1. Models in the selected modeling language, supporting software if necessary
2. Detailed Design document

RES-URSC-2024-020

Name of ISRO/DOS Centre/Unit

U. R. Rao Satellite Centre, Bengaluru

Title of the research proposal

Experimental Investigation in Condensation Heat Transfer and Pressure Drop in Circular Tubes

Area of Research

Heat Transfer

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. Abhijit A. Adoni

Mr. Jasvanth V S

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

abhijit@ursc.gov.in

jasvanth@ursc.gov.in

Summary of the Proposed Research

Experimental investigation and an empirical model condensation heat transfer and pressure drop in circular tubes of internal diameter ranging from 1 to 10 mm. The test data should be available for condensation:

- Heat load for maximum condensation heat flux calculation in a tube of length 1 m:

Internal Diameter (mm)	Maximum heat load (W)
2	200
3	300
4	500
6	600

- Minimum heat load to be tested for above is 5 % of maximum load and data to be generated in steps of 5 % of maximum load;
- Fluids for which this data is required are water, methanol, and acetone; and if possible ammonia;
- Multi-phase flow visualization;
- Effect of orientation with respect to gravity.

Scope of the work:

Development of test-rig to perform experimental investigation of flow condensation for details outlined in 6 (Summary of the proposed research). Through experimental investigations:

1. Raw and Processed test data, with data analysis process;
2. Flow regime maps;
3. Uncertainty analysis of the test data;
4. Empirical rules to evaluate heat transfer coefficient and pressure gradient for different flow condition (in terms of thermal and flow parameters, thermos-physical properties of fluid, etc) for tested fluid.
5. Generalised empirical rule when extended to other fluids and comparison with standard literature.

Linkages to Space Programme:

- Reliable empirical relations are critical in design and sizing of a space radiators loop heat pipes and mechanically pumped fluid loop.
- This research would provide

Expected Deliverables:

1. This should provide following knowledge:
    - Raw and Processed test data, with data analysis process;
    - Flow regime maps;
    - Uncertainty analysis of the test data;
    - Empirical rules to evaluate heat transfer coefficient and pressure gradient for different flow condition (in terms of thermal and flow parameters, thermos-physical properties of fluid, etc) for tested fluid;
    - Generalised empirical rule when extended to other fluids and comparison with standard literature.
    - Detailed Design document

RES-URSC-2024-021

Name of ISRO/DOS Centre/Unit

U. R. Rao Satellite Centre, Bengaluru

Title of the research proposal

AI-Driven Automation for Heater and Temperature Sensor Layouts Generation

Area of Research

Artificial Intelligence / Machine Learning

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. Y Bishal Singha
Mr. A V Poorna Kumar

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

bishal@ursc.gov.in
avpoorna@ursc.gov.in

Summary of the Proposed Research

Heaters and temperature sensors are crucial elements in spacecraft for ensuring optimal thermal management of various subsystems and components within their safe temperature ranges. The proposed work aims to leverage Machine Learning techniques specifically Transfer Learning with Convolutional Neural Networks (CNN) for automating the design of heater circuits and generation of heater and temperature sensor layout drawings for spacecraft components. Currently, designing these layouts is a time-consuming process requiring careful consideration of various factors such as power dissipation & distribution requirements, available area and correct placement on the intended zones as per nomenclature. With the help of these models, the system would intelligently generate the heater circuits which meet these criteria with greater efficiency.

The model will take the input parameters such as component drawing (package or panel), a list of heaters and temperature sensors with nomenclature and heater power requirements. Based on these inputs, the system will automatically generate the heater and temperature sensor layout selecting appropriate heaters from the available inventory. The model will be trained on a large dataset of previous heater and temperature sensor layouts.

Transfer learning with CNN is proposed to enhance the model's ability to interpret and generate complex layouts based on prior designs. This approach can reduce the training time and computational resources required compared to training a model from scratch and also improve accuracy. This automation will help in streamlining the design and drawing generation process, making it faster and more efficient.

Scope of the work:

1. Data collection and preparation.
2. Development of pipeline.
3. Automation & output: User interface or integration within AutoCAD software.
4. Deployment feasibility on local machine or intranet server.
5. Continuous learning & improvement.

Linkages to Space Programme:

- For all S/C missions as layout of heaters and temperature sensors needs to be done from Small Satellites to Large satellites.

Expected Deliverables:

1. Trained model.
2. Automated layout generation tool integrated with AutoCAD.
3. Continuous learning framework.

NATIONAL REMOTE SENSING CENTRE
HYDERABAD

RES-NRSC-2024-001

Name of ISRO/DOS Centre/Unit
National Remote Sensing Centre, Hyderabad

Title of the research proposal
EO data and ground spectroscopy for identifying surface controls and geobotanical indicators of heavy metal contamination in coastal and deltaic environment

Area of Research
Application of RS & GIS

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Dr. Arindam Guha

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit
arindam_g@nrsc.gov.in

Summary of the Proposed Research

Metals, particularly heavy metals are one of the concerns for environmental pollution due to their ability to bio-accumulate and bring forth a cyanogenic effect on the ecosystem. Accumulation of heavy metal depends on plant species, soil characteristics coupled with enrichment and the ability of the associated plant to absorb the metallic content.

Further to above, accumulation of such metal rich clays is controlled by geologic as well as anthropogenic factors. A plant is sensitive to the specific geologic environment in which it grows and may show characteristic variations in its form, size, color, and rate of growth based on the substrate. It has been also observed that the normal growth of certain plants is affected by the excess presence of certain harmful toxic heavy metals. There is little understanding and records on the geobotanical species that can preferentially entrap heavy metals in its biological system and imprint signatures on the reflectance spectra of the species in terms of preserving spectral feature sensitive to heavy metals or overall modifying spectral response with respect to their counterpart grown over normal substrate in terms of heavy metal concentration. We have account of arsenic and other heavy metal aggregation is significantly high in many deltaic and estuarine system.

Therefore, research is required to identify the generalized and location-specific geological and geobotanical anomalies associated heavy metal contamination along with associated geological controls that concentrates heavy metal concentration in coastal and deltaic environment. Detection of heavy metal contamination hotspots is vital to tackle environmental degradation in the highly important biodiversity of the Deltaic and coastal environment. There is little work for identifying geological controls geology and geobotanical imprints for these heavy metals concentration and also establishing spectro geo chemical models associated with these anomalies. Spectro geo chemical models deals for the development an empirical or quantitative model to relate different spectral parameters (width, depth, asymmetry) of a diagnostic spectral features or entire reflectance spectra of a geobotanical target with the geochemical data on metal enrichment.

Developed spectro geo chemical models of metal absorbing geobotanical species along with identified geological parameters (micro geomorphological unit, geological structure) would provide a bench mark data for processing spaceborne hyperspectral and high-resolution optical data for identifying areas of environmental concern in terms of heavy metal concentration in deltaic and coastal environment.

Scope of the work:

1. Identify the geological and geobotanical anomalies for heavy metal contamination.
2. Comparative assessment of spectral features of sensitive geobotanical elements grown above metal rich soil with respect their counterpart grown above the normal or background substrate.
3. Develop the spectro geo chemical models from the spectral features of geobotanical elements and associated soils to relate geochemistry with spectral feature.
4. Utilize the spectro geo chemical models for processing hyperspectral data for identifying possible hot spot zones of heavy metal contamination.

Note on Expected work from PI/Academia:

- Conjugate analysis of DEM, Sentinel-02/any moderate to high resolution satellite multispectral data, ALOS/Sentinel-01/EOS-04 in light of known heavy metal concentration zone to identify the geological control or area of influence of heavy metal concentration.
- Spectral analysis of soil and geobotanical elements of area of influence.
- Compare the spectral gradient (within a specific zone of influence) or spectrometric parameters (width, depth and asymmetry) of certain spectral features identified as sensitive to heavy metal concentration for geobotanical elements (growing above area of influence).
- Compare the “spectral contrast of variability planned to be identified in point 3 with spectral variabilities of areas that have “no heavy metal concentration”.
- Utilize the spectrometric parameters of geobotanical elements for extending their spatial distribution using ENMAP/PRISMA data.
- Geochemical analysis of soil associated with the extended part of geobotanical anomalies.

Linkages to Space Programme:

- It would provide valuable input for the advanced R&D projects on coastal geoscience using multi-sensor EO data.

Expected Deliverables:

1. Detail record of geological and geobotanical anomalies associated with heavy metal contamination.
2. Spectro geochemical models for heavy metal contamination associated heavy metal sensitive botanical elements and associated soil
3. Spectral map of heavy metal based on the spectral Behavior of plant.
4. Field and chemical validation of spectral map

RES-NRSC-2024-002

Name of ISRO/DOS Centre/Unit
National Remote Sensing Centre, Hyderabad

Title of the research proposal
Impact of the Indian Summer Monsoon by Atmospheric Constituents.

Area of Research
Remote Sensing & GIS, Earth Observations

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Ms. K.L. Kanchana

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit
kanchana_l@nrsc.gov.in

Summary of the Proposed Research

The variation in surface heating between continental land and oceans, due to interactions between turbulent heat fluxes and latent heat from rainfall and deep convection, creates significant pressure gradients between land and sea. These gradients drive the large-scale circulation patterns that shape the monsoon climate. Monsoon-related precipitation is crucial for the social and economic well-being of billions of people. Consequently, monsoons have been a major research focus for the scientific community for fifty years. This has been started with Monsoon Experiment (1978–1979), which primarily investigated the Asian monsoon system. Indian summer monsoon (ISM) and winter monsoon features economies that are highly sensitive to weather and climate variations driven by the monsoon. As one of the most dramatic and significant climatic phenomena on Earth, the ISM profoundly influences the planet's energy budget and hydrological cycle. The Monsoon region is distinct due to its unique geography, topography, demographic characteristics, and developmental history. The monsoon affects the all spheres of lives of over a billion people by driving the agriculture and Gross Domestic Product of the region. As the Indian region experiences rapid population and economic growth, there is increasing concern about how monsoon convection and surface emissions impact air quality. The uplift of pollutants enhances aerosol-cloud interactions, which could alter monsoon behavior. Satellites show that the monsoon system effectively transports pollutants into the stratosphere, linking regional air quality with climate change and global chemistry-climate interactions. Accurate representation of the monsoon system in global chemistry-climate models is crucial for predicting how this evolving region might influence future changes. To fully understand and quantify its impact, an integrated approach is needed, incorporating both in situ and remote sensing observations across the troposphere and stratosphere, as well as regional and global modeling.

Scope of the work:

The effects of the Indian summer monsoon and stratospheric intrusion of air pollutants is not studied much by the research community. The tropopause is obvious in observations or analyses of these dynamical changes. By using the various data sets available publicly (NCEP/NCAR Reanalysis data, ERA5 data, CPCB data Satellite Data, ISM Index, etc.) will be useful to address the objectives.

Linkages to Space Programme:

- Atmospheric constituents play a major role on the monsoon rainfall variability. The use of real-time data from future ISRO satellites (G20), as well as the integration of satellite and ground-based observations, allows for more timely and region-specific action to follow weather patterns and pollutant dissemination throughout the monsoon.

Expected Deliverables:

1. Emissions and air quality in the Asian monsoon region.
2. Aerosols, clouds, and their interactions with the Asian monsoon.
3. Impact of monsoon convection on chemistry.
4. UTLS Response to the Asian Monsoon.
5. Study of trace gases exchange between UTLS during strong convective systems.
6. Seasonal Photochemical impact of OH radical on methane removal as a function of ozone precursors.
7. Radiative impact of atmospheric constituents using RT model.

RES-NRSC-2024-003

Name of ISRO/DOS Centre/Unit
National Remote Sensing Centre, Hyderabad

Title of the research proposal
Integration of polar and geostationary EO datasets for a synthesized hourly LST product

Area of Research
Earth Observation

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Mr. Shiva Sai Krishna

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit
shiva_89@nrsc.gov.in

Summary of the Proposed Research

The Land Surface Temperature (LST) is an Essential Climate Variable (ECV), long-term records of which are crucial for characterizing the climate change. Satellite-based LST datasets are a critical input for various applications including radiation and energy budget at the surface, evapotranspiration, heat stress and urban heat island studies. The LST also serves as a proxy variable for near-surface air temperature, which is not directly measured through satellite-based remote sensing. The baseline requirements for LST ECV are 6 hourly temporal and 1 km spatial resolutions.

Long-term uninterrupted records of LST from polar-orbiting satellites over the Indian region are available at 1 km or better spatial resolution, twice daily. These are from MODIS (Aqua & Terra; since 2000), NOAA's VIIRS (S-NPP & NOAA-20; since 2015) and ESA's SLSTR series (ATSR-1&2, AATSR & SLSTR; since 1995). LST from geostationary-orbiting satellites, viz., INSAT-3D series is available since 2013 at half-hourly intervals.

The LST datasets from either polar/geostationary datasets do not independently satisfy the spatio-temporal requirements for LST ECV product. Past research has addressed the integration of LST datasets with significant disparity in spatial resolution, viz., MODIS LST (1 km) and Landsat LST (~100 m); temporal dependence of air temperature on LST etc. There is potential for combining the polar/geostationary datasets to create a synthesized LST which can largely integrate the virtues of both its constituents.

Scope of the work:

- Develop algorithm to integrate temporally sparse LST from international missions, with spatially sparse LST from Indian missions, to generate a synthesized hourly LST at 1 km or better spatial resolution.
- Validate the synthesized LST through inter-comparison with polar-satellite-based LST products at similar spatial resolution.
- Generate an LST dataset spanning from 2000 to 2025, using the developed algorithm.

Linkages to Space Programme:

- NICES, ISRO-GBP, ESRO-EO Program

Expected Deliverables:

1. Methods and algorithms for integrating polar/geostationary LST datasets, with validation.
2. 25-year LST database at 1 km spatial and 1 hourly temporal resolutions.

RES-NRSC-2024-004

Name of ISRO/DOS Centre/Unit
National Remote Sensing Centre, Hyderabad

Title of the research proposal
Integration of polar and geostationary EO datasets for a synthesized hourly LST product

Area of Research
Earth Observation for mineral exploration

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Dr. Swati Singh

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit
swati_singh@nrsc.gov.in

Summary of the Proposed Research

Assessment of mine residual deposits (mine tailings, waste rock, and other residual materials from mining activities) is gaining significant attention in recent times. In India, the coal deposit is been identified as associated with REE, similarly, the bauxite and phosphate mine residues are explored for the secondary mineral deposits.

Many other critical minerals like lithium, cobalt, REE etc. which is often left behind in the mine waste, are making these residual deposits potential sources for future mineral. Remote sensing and other advanced

geophysical and geochemical techniques can help to identify and quantify these critical minerals as well as enabling continuous monitoring for environmental impact assessments. The mine waste assessment and monitoring require high resolution hyperspectral, thermal, GPR and other sensors data.

Satellite and ground based observations:

The satellite and ground based spectroscopic observations are very effective in identification of the specific minerals associated with mine residue (e.g. clay minerals, sulfates, and carbonates). Similarly, the Thermal Infrared Spectroscopy (TIR) is useful for identifying silicates and carbonates in mine waste and can be used to map heat anomalies caused by chemical reactions in acid-generating tailings. Further, the field spectrometers are used for real-time, in situ analysis of mineral composition in mine tailings. Similarly, GPR can be used to assess the thickness and distribution of tailings deposits and detect voids or water saturation zones beneath waste piles.

Lab analysis:

The spectral mapping is crucial step in the analysis and monitoring of mine residual deposits, enabling the identification of minerals and contaminants in mine waste. The narrow spectral bands can be used to develop mineral-specific band ratios, indices which will provide effective means of identification of minerals associated with mine residue deposits. Data from geochemical analysis using XRF, EPMA for characterizing different types of mining waste, and providing precise measurements to understand the viability of mineral extraction within the mine wastes.

Scope of the work:

- Advanced remote sensing techniques play a crucial role in the study and analysis of mine residual materials, offering non-invasive methods to monitor, analyse the economic potential of mine residues.
- Hyperspectral sensors with varied spatial resolution (satellite, aerial, UAV based) provides unique opportunity to analyse the spectral response of the minerals. The narrow contiguous bands will be helpful to develop specific band detection techniques and spectral indies for identification of iron-bearing minerals, clay minerals such as kaolinite and montmorillonite, vegetation stress associated with the mine waste contamination, sulphides and carbonates, which are commonly associate with the mine waste and tailings.
- Thermal satellite data (e.g. TRISHNA) will be helpful for identifying silicates and carbonates using emissivity of the material. Heat anomalies caused by chemical reactions in acid-generating tailings will also be helpful for mineral identification.
- As spectroscopy is an essential tool for understanding the mineralogical and chemical composition of mine residue deposits, in can be utilised to identify the secondary but critical mineral resources.

Linkages to Space Programme:

- The work is aligned with the ISRO'S vision 2030 on utilization of Advanced Remote Sensing Techniques for Mineral exploration.

Expected Deliverables:

1. Development of VNIR-SWIR and TIR spectroscopy-based methodology for assessment of minerals resources associated with the mine residual deposits.

RES-NRSC-2024-005

Name of ISRO/DOS Centre/Unit
National Remote Sensing Centre, Hyderabad

Title of the research proposal
Enhanced Neural Network for classification of Hyperspectral Imagery using ensembled models.

Area of Research
Hyperspectral Remote Sensing, Machine Learning, Deep Learning

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Mr. Uday Kumar Gutta

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit
udaykumar_g@nrsc.gov.in

Summary of the Proposed Research

Classification using hyperspectral data presents significant challenges due to the high dimensionality and complexity of the spectral and spatial information involved within it. Traditional pixel-based segmentation architectures struggle to fully capture the intricate relationships between pixels, leading to suboptimal performance. Additionally, hyperspectral images consist of hundreds of narrow spectral bands, making the dimensionality of the data large and computationally demanding. Conventional methods often overlook the rich spatial and spectral dependencies between neighboring pixels, resulting in lower accuracy in classifying complex landscapes. To overcome these challenges, a more sophisticated approach is required that can model both the spectral signatures of the pixels and their spatial interactions.

In hyperspectral image classification, spectral and spatial information are vital for accurate results. Spectral kernels focus on the pixel's reflectance values across wavelengths, while spatial kernels capture the relationships between neighboring pixels. Fusion of spectral-spatial kernels will be used for more robust classification.

Scope of the work:

The primary goal of this work is to implement the ensembled model using enhanced neural network architectures for the classification of objects/features like roof top and water quality etc. using hyperspectral imagery comparable to traditional classification approaches.

The scope of work includes:

- Field data collection and spectral library creation: Field data collection involves, creation of a spectral library by gathering real-world spectral signatures of various roof top materials and water quality assessment etc., using hyperspectral spectrometers. These signatures are processed into a spectral library, which serves as a reference for training classification models and validating results in hyperspectral image analysis.
- Dataset collection and preprocessing: Identify and collect the available hyperspectral datasets (e.g., Hyperion, PRISMA, and EnMAP etc.) which are relevant to the features of interest. Apply preprocessing techniques such as normalization, dimensionality reduction (PCA, ICA), and data augmentation to prepare the datasets for the ensembled neural network models.

- Implementation of ensembled machine learning model-based classification techniques: Develop and train 1D, 2D, and 3D-CNN models for spectral, spatial, and spectral-spatial feature extraction. Implement hybrid architectures (e.g., CNN-RNN, CNN-GAN) to tackle class imbalance and small dataset issues.
- Evaluation metrics and reporting: Use accuracy, precision, recall, F1-score, AUC-ROC, and Dice coefficient to evaluate the performance of ensembled neural network models. Prepare a report with graphs, results, and recommendations based on different scenarios, dataset characteristics, and computational efficiency etc.

Linkages to Space Programme:

- Image classification is critically important for wide-ranging applications in environmental monitoring, resource management, and policy-making. Classifying roof top materials and water quality assessment etc., in densely populated areas using hyperspectral imagery has wide-ranging applications. It aids planning and supporting sustainable development programmes.

Expected Deliverables:

1. An ensemble deep learning model for classification of objects/features like roof top and water quality etc. using hyperspectral data.
2. Robust database of spectral library for different features like roof top and water quality etc.
3. Establishment of GUI based ensembled deep learning model for operational use.
4. Key research findings for further enhancement along with detailed project report.

RES-NRSC-2024-006

Name of ISRO/DOS Centre/Unit
National Remote Sensing Centre, Hyderabad

Title of the research proposal
3D subsurface modelling of structurally controlled geological provinces for critical mineral resource assessment

Area of Research
Geophysics; Mineral Exploration; Remote Sensing

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Mr. Nikhil Kumar Baranval

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit
nikhilkumar_b@nrsc.gov.in

Summary of the Proposed Research

Critical minerals are essential for modern technologies and green energy solutions, including lithium, rare earth elements (REEs), and other strategic materials. 3D subsurface models are essential to enhance the assessment of critical mineral resources within structurally controlled geological provinces like South Purulia Shear Zone (SPSZ), Singhbhum Shear Zone (SSZ), Aravalli, Achan Kovil Shear Zone

(AKSZ) etc. By integrating geological, geophysical, and geochemical data, comprehensive understanding of mineralization processes and improve resource evaluation is possible.

The study will integrate advanced geophysical techniques, including gravity, magnetic, electromagnetic, resistivity, and ground-penetrating radar (GPR) surveys, with remote sensing data such as hyperspectral imaging, DEM and thermal imagery. This integrated approach will enhance the geological and structural mapping of the region, identifying key lithological units, fault systems and potential mineralization zones.

The primary objective is to construct a high-resolution 3D subsurface model that accurately represents the spatial distribution of subsurface features and mineralized bodies. This model will facilitate the identification of areas with high potential for REE and lithium deposits. The integration of machine learning algorithms will further refine the predictive capabilities, allowing for the identification of new exploration targets based on spatial data patterns.

This research aims to deliver a detailed resource assessment that will be critical for exploration of strategic minerals. This research will not only contribute to the understanding of the mineral potential within the structurally controlled geological provinces in India but also serve as a model for global exploration in similar geological settings.

Scope of the work:

The research aims to develop advanced 3D subsurface models for assessing critical mineral resources, focusing on structurally controlled geological provinces such as SPSZ, SSZ, Aravalli, AKSZ etc. The study will target essential minerals like lithium and rare earth elements (REEs) and any other minerals crucial for modern technologies and green energy.

Key components include the integration of geological, geophysical, and geochemical data from surveys (gravity, magnetic, electromagnetic, resistivity and GPR), along with remote sensing (hyperspectral, DEM and thermal imagery) to create comprehensive subsurface models. The geophysical data will detect subsurface faults, shear zones and lithological variations that could host critical mineralization. Geochemical analysis will involve sampling soil, rock and water to identify geochemical signatures indicative of mineral deposits. Additionally, high-resolution remote sensing and DEM will be used to correlate surface features with subsurface mineral potential.

This integrated approach enhances exploration efficiency and supports India's growing need for the critical minerals. The research will provide a robust framework for improving mineral resource exploration and management with methodology applicable to similar geological settings globally.

Linkages to Space Programme:

- National Mineral Exploration Programs: This research enhances 3D subsurface modelling to support the discovery and management of critical minerals, such as lithium and rare earth elements (REEs), supporting national goals for mineral resource development and energy security.
- Sustainable Resource Management Initiatives: By improving subsurface models, the research promotes efficient exploration and resource assessment, contributing to sustainable practices in mineral extraction and minimizing environmental impacts.
- Green Energy and Technology Programs: The focus on critical minerals directly supports green energy initiatives by identifying potential sources essential for renewable technologies, including batteries and electric vehicles.

- Space and Satellite Data Programs: The use of remote sensing techniques aligns with future ISRO Space programs incorporating high resolution hyperspectral AVIRIS-NG 2B and thermal data from TRISHNA for improved earth observation and resource monitoring.

Expected Deliverables:

1. High resolution 3D subsurface model.
2. Identification of potential Critical Mineral rich zones.
3. Predictive exploration model.

RES-NRSC-2024-007

Name of ISRO/DOS Centre/Unit

National Remote Sensing Centre, Hyderabad

Title of the research proposal

Advanced Computer Vision + LLM based solutions for Remote Sensing Data Insights

Area of Research

AI/ML, RS & GIS

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. K Kalyan Deep

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

kalyandeep_k@nrsc.gov.in

Summary of the Proposed Research

Development of cutting-edge solutions harnessing the latest advancements in Computer Vision and Large Language Models to extract actionable insights from Remote Sensing data.

Scope of the work:

Using multi-sensor, multi-temporal, multi-resolution, ranging from coarser to finer resolution of 5m Satellite images, VLM's need to be trained to provide insights of the Area of Interest based on user queries and context. Queries related to:

a. Spatial Analysis: Settlements (Urban, Rural), Vegetation (Agricultural fields, Forests, grasslands), Water bodies (Lakes, Rivers, Reservoirs and Coastal), Bare Soil, Wetlands, Transportation Networks wherever feasible, cloud coverage and any other possible features from datasets up to 5m resolution.

b. Temporal Analysis with possible queries like Change Detection, Agricultural cycles, Hydrological patterns, Urban growth analysis, Forest coverage change etc.

Thematic layers ranging from 1:4K to 1:250K can also be utilized along with satellite datasets to train the models, facilitating the retrieval of the most relevant responses to user queries.

Linkages to Space Programme:

- Extracting insights from Remote Sensing data based on User queries is useful application, and will be helpful in retrieving most prominent as well as hidden information from the given satellite data. It offers users more nuanced interpretations of satellite images. This feature can be integrated to ISRO portals to increase user engagement and user experience.

Expected Deliverables:

1. An interactive system leveraging Computer Vision and Natural Language Processing to comprehend Earth observations.
2. Provision of advisory services on natural resources management in response to user queries.
3. A comprehensive guide facilitating the understanding of Remote Sensing datasets efficiently by users from various domains.
4. A versatile tool empowering Application Scientists to query across multiple domains and grasp interrelations effectively.
5. Working model to integrate with Bhuvan and other NRSC Geoportals.

LIQUID PROPULSION SYSTEMS CENTRE

VALIAMALA

RES-LPSC-2024-001

Name of ISRO/DOS Centre/Unit

Liquid Propulsion Systems Centre, Valiamala

Title of the research proposal

Design and development of high efficiency 5kW rated configurable and scalable converter using wide band gap devices for Aerospace application.

Area of Research

Power Electronics

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. Karthik R

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

r_karthik@lpsc.gov.in

Summary of the Proposed Research

Design, modeling, simulation, characterization and development of high efficiency (>95% at max power and >90% at minimum power of 500W) 5kW rated configurable and scalable DC-DC converter operating at input voltage of 60-100V and output voltage of 300-600V.

Scope of the work:

1. Configuration finalization and topology selection.
2. Design and small signal modelling of proposed converter.
3. Characterisation of wide band gap devices (like GaN, HEMT, SiC etc.) for proposed design.
4. Design, simulation and characterization of electromagnetics for proposed design.
5. Configuration studies on control scheme (digital hybrid control) for proposed configuration for meeting configurability, scalability requirements so that converters can be synchronized (in parallel or series combination) and work together to meet the output voltage and power requirements.
6. Implementation of programmable digital control loop gain, current limit, control strategies.
7. Design iterations based on proto model testing and realization of engineering model meeting converter requirements in terms of voltage/power and efficiency requirements.

Linkages to Space Programme:

- Developed converter can be utilized for all Electric Propulsion satellite meeting various project requirements in terms of input/ output/power requirements.

Expected Deliverables:

1. Design reports, test reports, simulation and modeling files and reports, characterization tool files and reports.

RES-LPSC-2024-002

Name of ISRO/DOS Centre/Unit
Liquid Propulsion Systems Centre, Valiamala

Title of the research proposal
Estimation of heat flux distribution on thruster walls and injector face plate in MMH/NTO based spacecraft thrusters via numerical simulations of reacting flow

Area of Research
Propulsion

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Ms. Sharmistha Choubey

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit
sharmisthachoubey@lpsc.gov.in

Summary of the Proposed Research

Estimation of nozzle wall and injector face plate heat flux is essential in the development of thrusters or the incorporation of new materials. The spacecraft thrusters typically use hypergolic propellant combination of MMH/NTO and operate at sub-critical conditions. These thrusters use swirl-coaxial or impinging type injectors. In small thrusters, a swirling stream of propellant from the injector impinges on the combustion chamber wall, which acts as a liquid film coolant for the thruster walls. In larger thrusters, liquid film cooling is explicitly incorporated.

Numerical modeling of evaporation and combustion of propellants under subcritical conditions is necessary for a realistic estimation of heat flux and temperature distribution.

The current proposal is for the development of a numerical model for MMH/NTO based spacecraft thrusters operating in the sub-critical regime, and the estimation of the temperature and heat flux distributions on thruster walls and the injector face plate.

Scope of the work:

1. Development of a numerical model for MMH/NTO based spacecraft thrusters with swirl-coaxial and multi-element injectors, with reacting flow and liquid film cooling.
2. Validation of the model with literature and/or existing engines of LPSC

Linkages to Space Programme:

- Spacecraft engines and thrusters used for orbit raising and station keeping operations, Chandrayaan-4 and future lunar lander missions, Throttleable Engines being developed for Spacecraft Propulsion of future missions.

Expected Deliverables:

1. Validated numerical methodology for simulation reacting flow and liquid film cooling in MMH/NTO based spacecraft thrusters.

2. Source codes, user defined functions, reaction mechanisms and/or any other sub-routines used, along with the input/output files of the validated numerical set-up.
3. Document detailing the implementation of the developed numerical framework for the simulation of any similar spacecraft thruster.

RES-LPSC-2024-003

Name of ISRO/DOS Centre/Unit
Liquid Propulsion Systems Centre, Valiamala

Title of the research proposal
Development of thermoelectric generator module for space applications

Area of Research
Materials

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Mr. Anant Singhal

Dr. Deepak Kumar Agarwal

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit
anantsinghal@lpsc.gov.in

d_agarwal@lpsc.gov.in

Summary of the Proposed Research

- Advanced space power systems are being developed in LPSC for ISRO's future deep space /interplanetary missions. For these, thermoelectric modules that can operate between hot and cold shoe temperatures of (200 – 300)^{0}C and (0 – 50)^{0}C respectively are required to be developed. The modules need to be demonstrated for operation in both vacuum and atmospheric conditions. The developed module should be viable for indigenous production for ISRO's application.

Scope of the work:

The proposal is for the design, development and demonstration of thermoelectric modules that can provide electrical power from heat energy with the following specifications:

- Hot shoe temperature = (200 – 300)^{0}C
- Cold shoe temperature = (0 – 50)^{0}C
- Max. overall size of module <= 50 x 50 x 6 mm
- Power level >= 2W for temperature difference of 250^{0}C
- Operating environment = Ambient to vacuum

Linkages to Space Programme:

- Advanced space power systems for ISRO's future deep space /interplanetary missions.

Expected Deliverables:

1. Two working thermoelectric modules as per the specification mentioned in the scope of work.
2. Detailed report on the design, development, realization procedure, and test results of the module.

RES-LPSC-2024-004

Name of ISRO/DOS Centre/Unit
Liquid Propulsion Systems Centre, Valiamala

Title of the research proposal
Identification of Xenon Optimal Metal Organic Frameworks (MOF) based on simulation and test results

Area of Research
Propulsion, Material

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Mr. Sumit Budhwar

Dr. Rajesh KR

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit
sumit@lpscb.gov.in

rajesh_kr@ lpscb.gov.in

Summary of the Proposed Research

Research proposal includes the simulation of various configurations of metal organic frame works and testing of the best candidate to verify the Xenon adsorption at 10bar, 20bar, and 40 bar.

Scope of the work:

Xenon gas is used in electric propulsion system for propelling the spacecraft. The Xenon gas is stored at high pressure (>100bar). By utilizing metal organic framework material Xenon gas storage pressure can be reduced. Currently limited literature is available on MOF technology for Xenon gas application. The MOF can also be used in enhancing the purity of gas. The proposed research will help in providing more exhaustive database for MOF at various pressures for Xenon gas.

Linkages to Space Programme:

- The identified MOF can be used to reduce the storage tank pressure and enhancing the gas purity. With this the system can be made simpler, less complex and highly reliable.

Expected Deliverables:

1. Xenon optimal MOF and MOF database at various pressure conditions.

RES-LPSC-2024-005

Name of ISRO/DOS Centre/Unit

Liquid Propulsion Systems Centre, Valiamala

Title of the research proposal

Design and Development of Fiber optic based Vibration Measurement Structural Health monitoring system with signal conditioner.

Area of Research

Sensors

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Ms. S R Geetha,
Mr. Ch. Harish

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

gsen@lpscb.gov.in
harish_ch@lpscb.gov.in

Summary of the Proposed Research

The aim of the proposal is to design and develop a fiber optic based Vibration sensor which is part of Structural Health monitoring (SHM) system along with suitable signal conditioner. SHM system primarily consists network of sensors (Strain, vibration, acoustic etc.) that are able to monitor the physical state of the structures in real time and helps in detection of any damage initiation. Launch vehicles normally undergo severe dynamic loads such as Shock, random vibration, aerodynamic and thermal during the flight. Vibration monitoring plays a major role in assessment of health and identification of any detachment of part, loosening of sub-assemblies. SHM system based on Fiber optic sensors are promising compared to conventional electrical sensors (such as Piezoelectric or capacitive) as they are immune to EMI, easy integration with structures and distributed sensing over the large area. Multiplexing ability of optical fibres is another advantage for monitoring the system with distributed sensing of many sensors. Fibre Bragg Gratings (FBG) of surface bonded and embedded in to composites are being widely used configurations for monitoring of aircraft/flight structures. When damages are initiated in the structure, there is a change in frequency of vibration, i.e. frequency signature varies. Vibration sensor thus gives the critical information about the health of the structure prior to any catastrophic damage.

Scope of the work:

Scope includes the design and development of FBG based vibration sensor, Modelling of strain transfer from substrate to fibre core is critical. The selection of adhesive and fibre core, cladding and coating is important (for surface mounted or embedded configuration) and must be tested for strain transfer and their suitability should be established. The wavelength of FBG and other parameters should be carefully selected to suit vibration sensing. Design should provide good sensitivity to vibration and provision for cross sensitivity compensation like temperature to be included. The required signal detection and

processing circuitry should be designed. The input voltage of the system should not exceed 42V DC. The output should be in digital format. The responsibility of PI is to demonstrate proof of concept, further packaging the sensor suitable for mounting on the launch vehicle structures. PI should also demonstrate the model with multiplexing capability for a minimum of 4 sensors.

Operating Temperature range is -40^{0}C to 150^{0}C and Frequency of measurement is of the range 0- 500 Hz

Joint review of sensor design, test set up design and test plan with LPSC is essential before implementation.

Linkages to Space Programme:

- This fibre optic-based Vibration sensor which is part of Structural Health monitoring (SHM) system along with suitable signal conditioner primarily consists of network of sensors (Strain, vibration, acoustic etc.) that are able to monitor the physical state of the structures in real time and helps in detection of any damage initiation in RLV, Gaganyaan, NGLV etc..

Expected Deliverables:

1. Two sets of Vibration sensor along with signal detection and processing module including light source and related optical circuitry.
2. Documents for the design details (fabrication drawings, design documents etc.) of the FBG Vibration sensor and Interrogator.
3. Design document for Test rigs.
4. Sensor assembly and test reports (includes test results).

RES-LPSC-2024-006

Name of ISRO/DOS Centre/Unit
Liquid Propulsion Systems Centre, Valiamala

Title of the research proposal
Design and Development of Fiber Optic Acoustic Emission Sensing system with signal conditioner for Structural Health Monitoring.

Area of Research
Fiber Optic Sensors

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Mr. N Sagar Babu,
Ms. S R Geetha

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit
sagarbabu@lpscb.gov.in
gsen@lpscb.gov.in

Summary of the Proposed Research

Structural health monitoring (SHM) plays an important role in monitoring the health of the launch vehicle structures, reusable vehicles, and in human space missions etc. Launch vehicle structures experiences different loads (fatigue loads, thermal loads, vibration & aerodynamic loads) and unforeseen loads which

can have deleterious effects on the integrity of structures during their service life. Acoustic emission (AE) is widely used for structural health monitoring of critical components and structures to detect crack initiation and crack propagation. The principle of AE sensing is based on the detection of elastic stress surface waves or acoustic waves released due to crack initiation or propagation when the structure is fatigue loaded or prone to fracture. The characteristics of the waves generated are directly related to the source that resulted in them, type of material and component geometry. AE sensing can thus be used for damage source identification and location. Conventional AE techniques employ piezoelectric sensors to detect elastic stress waves propagating through various types of structural materials, including composites during damage evolution. Recent developments in fiber optic acoustic emission sensors have enabled new ways of detecting and monitoring the health of the structure using AE. Advantages of optical Fiber Sensors over conventional sensors, including improved sensitivity, reduced size, reduced weight, immunity to EMI and electrically neutral. Fiber optic AE sensor can be used at higher operational temperature than most conventional piezoelectric ceramic sensors. Optical Fiber Bragg Grating also offers additional advantages, versatility, short gauge length and ease of multiplexing, this make FBGs ideal for sensing acoustic signals in structural health monitoring. This proposal is for the Optical Fiber Bragg Grating AE sensor with suitable detection and signal processing circuits for Structural Health Monitoring (SHM).

Scope of the work:

Design and development of FBG based acoustic emission sensor for structural health monitoring with multiplexing capability of minimum 5 sensors, suitable signal detection circuit and signal conditioner. Typical Acoustic frequency ranges from 30 KHz to 1 MHz, an interrogator capable of picking up such high frequency signals to be identified and qualified for space applications. Effective AE monitoring requires that signals related to the crack initiation and damage evolution are successfully separated from unwanted mechanical noise using appropriate filtering techniques. The development includes selection of suitable material for core, cladding and coating and adhesives for mounting. After testing and ascertaining their suitability, they must be selected. The demonstration of proof of concept and characterization of Acoustic Emission sensor. Demonstration of sensor in surface mounting and embedded configurations. The characterization model of the coupling between Acoustic waves and the optical fiber to be developed (Lamb wave propagating from surface to the adhesive to coating on the optical fiber to cladding and into the core of the FBG fiber). The selected fiber and adhesives must be tested for the coupling between acoustic waves and optical fibers and their suitability should be established. The input voltage of the system should not exceed 42 V. The output should be in digital format. PI should make the test rigs required for testing and calibration of the sensor. The design should be demonstrated on test rig to prove the performance. The responsibility of PI is to demonstrate proof of concept, further packaging the sensor suitable for mounting on the launch vehicle structures. PI should also demonstrate the model with multiplexing capability for a minimum of 5 sensors. Joint review of sensor design, test set up design and test plan with LPSC is essential before implementation.

Linkages to Space Programme:

- FBG based acoustic emission sensor for structural health monitoring with multiplexing capability of minimum 5 sensors and suitable signal detection circuit as well as signal conditioner can be used in Reusable Launch Vehicle, Gaganyaan, NGLV etc..

Expected Deliverables:

1. Two sets of AE sensor along with signal detection systems and signal conditioners, light source and optical circuitry.

2. Documents for the design details (fabrication drawings, design documents etc.) of the FBG acoustic sensor, Interrogator.
3. Design document for Test rigs.
4. Sensor assembly and testing reports (includes test results).

RES-LPSC-2024-007

Name of ISRO/DOS Centre/Unit
Liquid Propulsion Systems Centre, Valiamala

Title of the research proposal
Development of Thrust Measurement System (TMS) for measuring pulse mode thrust for pulse width in the range of 8ms/16ms/32ms/64ms etc.

Area of Research
Mechanical test setup and equipment

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Ms. Savitry Kumari

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit
savitry@lpscb.gov.in

Summary of the Proposed Research

Future Nanosat and Cubesat Propulsion systems require operation in various pulse width command to meet the mission requirement. The pulse width varies from 8ms to 256ms. A Thrust Measurement System (TMS) is essential for assessing the thruster performance. The TMS should cater for multiple operations, good accuracy and portability for repeated use of the setup. Towards this, a Thrust Measurement System needs to be developed.

Scope of the work:

Development of Thrust Measurement System (TMS) for measuring thrust (1N/11N) in pulse mode for pulse width in the range of 8ms/16ms/32ms/64ms etc.TMS should be portable and should cater for periodic use.

Linkages to Space Programme:

- This Thrust Measurement System (TMS) for measuring pulse mode thrust for pulse width in the range of 8ms/16ms/32ms/64ms etc. can be used for measuring the thrust of Future Microsat/ Cubesat/Nanosat Propulsion systems. It can also be used for measuring thrust for the future satellite applications where pulse mode precise operations are called for, like, docking experiment, refueling etc.

Expected Deliverables:

1. Two numbers. (min.) of Thrust Measurement System.
2. Typical Specifications:

Technical feature	Specification
Nominal measurement range (in single axis)	1N-11N
Pulse width	8ms/16ms/32ms/
64ms/ 128ms/ 256ms	Volatile matter
Accuracy	±0.5 % of Full Scale (F.S) or better
Thermal stability	±5% for the Full Scale
Thermal management	1000° C (max) at the TMS interface
Pressure in vacuum chamber (operating condition)	2 x 10^{-5} mbar

RES-LPSC-2024-008

Name of ISRO/DOS Centre/Unit
Liquid Propulsion Systems Centre, Valiamala

Title of the research proposal
Development of Portable Thrust Measurement System (TMS) for thrust range 5mN to 50mN

Area of Research
Mechanical test setup and equipment

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Ms. Savitry Kumari

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit
savitry@lpscb.gov.in

Summary of the Proposed Research

Future Nanosat and Cubesat Propulsion systems require very low impulse and thrust in the range of 5mN to 50mN. A portable Thrust Measurement System (TMS) is essential for testing and assessing the thruster performance. The TMS should cater for multiple operations, good accuracy and portability for repeated use of the setup. Towards this, a Thrust Measurement System needs to be developed.

Scope of the work:

- Development of Thrust Measurement System (TMS) for measuring thrust in the range of 5mN to 50mN.
- TMS should be portable and should cater for periodic use.

Linkages to Space Programme:

- The Portable Thrust Measurement System (TMS) for thrust range 5mN to 50mN can be used to measure the thrust of Future Microsat/ Cubesat/Nanosat Propulsion systems which uses Cold Gas thruster, Small power EPS thrusters, etc.

Expected Deliverables:

1. Two numbers. (min.) of Thrust Measurement System

Typical Specifications:

Technical feature	Specification
Nominal measurement range (in single axis)	5-50 mN
Accuracy	±0.5 % of Full Scale (F.S) or better
Thermal stability	±5% for the Full Scale
Thermal management	80° C (max) at the TMS interface
Pressure in vacuum chamber (operating condition)	2 x 10^{-5} mbar

RES-LPSC-2024-009

Name of ISRO/DOS Centre/Unit
Liquid Propulsion Systems Centre, Valiamala

Title of the research proposal
Development of AlNiCo 5 Permanent magnets

Area of Research
Materials

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Mr. P S B Pratyush

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit
psbpratyush@lpscb.gov.in

Summary of the Proposed Research

Isolation Valves are used in Spacecraft propulsion systems for EOS/CMS/NVS and Scientific missions. AlNiCo-5 permanent magnets are used for obtaining the latch force. Presently, these magnets are being imported and indigenous development of the magnets is very much essential. Research is to be carried out to develop AlNiCo-5 permanent magnets with comparable mechanical & magnetic properties for applications in Indian Space Program.

Scope of the work:

- To Develop AlNiCo-5 Permanent magnets
- To get the required magnetic and mechanical properties for AlNiCo-5

Linkages to Space Programme:

AlNiCo-5 Permanent magnets can be used in:

- IRS / CMS/NVS/Scientific mission class of satellites.
- The realization of Single Flow Path Latch Valve, Bi-Propellant Latch Valve etc..
- The development of High Flow & High-Pressure Latch Valves for Chandrayaan-4, LuPEX and future scientific missions.

Expected Deliverables:

1. Eight numbers. (min.) of AlNiCo-5 permanent magnets with required magnetic and mechanical properties.
2. AlNiCo-5/Alcomax-3 material properties:
   - Al: 8%, Ni: 14%, Co: 3%, balance : Iron
   - Remanence (B) : 1.26T (12.6 kGauss)
   - Coercive Force (H) : 51,725 Ampere-Turn/m (650 Oersted)
   - Energy product (BH max) : 4.32 x m10 ^4J(5.4 MGO)
   - Density : 7.3 x 10^3 kg/m^3 (7.3 gm/cc)
   - Max. operating temperature : 550°C

RES-LPSC-2024-010

Name of ISRO/DOS Centre/Unit
Liquid Propulsion Systems Centre, Valiamala

Title of the research proposal
Machine learning based approach for accelerating the structural assessment of propellant tanks in the presence of Non-conformances

Area of Research
Structures

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Mr. Vivek S

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit
s_vivek@lpsc.gov.in

Summary of the Proposed Research

Propellant tanks in launch vehicles are fabricated by joining different parts through welding. Commonly observed weld defects are pores, GBPM (Grind Below Parent Metal), weld collapse, mismatch etc. Presently dedicated finite element models are made to assess the structural integrity of tanks in the presence of non-conformances or snags. However, creating FEA models with actual snag modelled, usually take long computing times. It is envisaged to develop a Machine learning based approach for accelerating the structural assessment of propellant tanks without having to model the snag explicitly.

Scope of the work:

This work is proposed for second stage earth storable propellant tank of PSLV. Configuration of propellant tank is cylindrical shell with tori-spherical end domes at both ends. LPSC will provide details of the usual non-conformances observed in propellant tanks, elasto-plastic material properties, methodology used to

model and assess the snag from finite element results. The deliverables shall include a software which can take the dimensions, location of the non-conformances, external loads etc. as an input and then predict the elasto-plastic stress and strain field in and around the defect location across the thickness (with less than 3% error) and conclude on the acceptability of the snag. Usages of simple statistical models are not entertained. Once developed and validated, the code will bring down the computational time and enable the designers to provide prompt feedback to the fabricator. This code will be used as a tool for checking flight worthiness of propellant tanks.

Linkages to Space Programme:

- Useful for expediting the clearances of new snags observed in propellant tanks. If the work is completed meaningfully, all launch vehicle programmes where liquid propellant-based stages are used will find application.

Expected Deliverables:

1. Complete software along with the source code.
2. The software shall take the dimensions, location of the non-conformances, external loads etc. as an input and then predict the elasto-plastic stress and strain field at the defect location and conclude on the acceptability of the snag.
3. A report detailing the methodology adopted to develop and validate the model.

RES-LPSC-2024-011

Name of ISRO/DOS Centre/Unit
Liquid Propulsion Systems Centre, Valiamala

Title of the research proposal
Design and Development of continuous level sensor with signal conditioner using Fiber optic technology for ISROSENE.

Area of Research
Development of Fiber optic based continuous level sensor (for 8m measurement length) along with appropriate signal conditioning, light source etc. as a complete stand alone system with digital output.

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Ms. Subramaniam R Geetha

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit
gsen@lpscb.gov.in

Summary of the Proposed Research

Continuous level sensors for Liquid level monitoring for long measurement lengths, typically over 2m is a challenge. The advantages of Fiber optic technology for continuous level sensing is in its light weight, spark free, low power consumption, remote sensing, dielectric material, immunity to Harsh environment. Evanescent wave absorption method is far less sensitive to surface contamination and can operate well in conditions of small refractive index contrast between fluid and gas above the fluid.

They are considerably less sensitive to fluid composition change and the fluid properties changes due to temperature. Long period grating technique, Etched D shaped optical fiber, bent side polished optical fiber have been used for continuous level sensing in liquids with distinct difference in density of gas and thus refractive index of liquid state. Techniques like No Core Fiber (NCF) with modal interference have demonstrated level sensitivity of 5µ in water. Any suitable Optical sensing technique can be used for continuous level sensing over 2m length. This can be studied for ISROSENE (modified kerosene) level sensor realization.

This development will include characterization of the fiber, cladding and coating at ISROSENE environment. Level sensing should be proposed for a measuring length of minimum 2 meters and principle should be extendable to 8 meters measuring length. Final sensor should have a continuous level measurement length of 8 meters. Appropriate light source and signal conditioner should be designed to give a digital output and it should be demonstrated.

Scope of the work:

- This development will include characterization of the fiber, cladding and coating at ISROSENE environment. Level sensing should be proposed for a measuring length of minimum 2 meters and principle should be extendable to 8 meters measuring length. Final sensor should have a continuous level measurement length of 8 meters.
- The sensor should be suitably packaged for use in ISRO propellant tanks as defined by LPSC. The Light source, signal conditioner etc. shall be provided. Suitable feed through should to used to route the signals from the sensor to outside the tanks. All components which are delivered must be demonstrated as a system. The signal conditioner shall be of appropriate principle to suit the environmental conditions of vibration, shock etc.
- The input voltage of the system should not exceed 42V. The required circuitry should be designed.
- The sensors and signal conditioner should be tested and qualified.

Linkages to Space Programme:

- Characterization of the fiber, cladding and coating at ISROSENE environment for Semi cryo project. Continuous liquid level measurement in any earth storable propellant tank. Final sensor shall have a continuous level measurement length of 8 meters.

Expected Deliverables:

1. Qualified Level sensors (with measurement length upto 8m) – 2 nos.
2. Space grade light source, signal detection circuitry and signal conditioners- 2 nos. with interface suitable to our application and output in digital format suitable to our signal conditioner.
3. The fabrication drawings, material specifications, design of signal detection and signal conditioner, component specifications, fabrication and assembly process must be provided.
4. Test rigs design should be discussed with LPSC before realization and further demonstrated to LPSC representative before use. Plan of testing and every test data shall be reviewed with Co-PI before proceeding further.

RES-LPSC-2024-012

Name of ISRO/DOS Centre/Unit
Liquid Propulsion Systems Centre, Valiamala

Title of the research proposal
Electron beam (EB) weld depth of penetration (DOP) characterization using Ultrasonics

Area of Research
Structures

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Mr. Ramprasad B

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit
ramprasad@lpscb.gov.in

Summary of the Proposed Research

The depth of penetration (DOP) obtained in EB welding has not been non-destructively measured. The measurement of penetration using Ultrasonics requires complex signal analysis of the ultrasonic data in order to decipher the DOP based on micro structural changes. Techniques like FFT, frequency filtering, SAFT etc. has to be applied in order to bring out the DOP measurements in a given weld. The proposed work consists of characterization of the weld penetration in Ti6Al4V material using Ultrasonics.

Scope of the work:

The outcome of the proposed research would be the feasibility of measurement of DOP non-destructively and estimation of the accuracy of measurement in Ti6Al4V EB welds using Ultrasonics.

Linkages to Space Programme:

- The depth of penetration (DOP) obtained in EB welding can be used for assessing the weld quality of Ti alloy where EB is used.

Expected Deliverables:

1. Measurement technique along with the test configuration and component details along with the report detailing the same.

RES-LPSC-2024-013

Name of ISRO/DOS Centre/Unit
Liquid Propulsion Systems Centre, Valiamala

Title of the research proposal
Development of Bimetallic alloy based promoter on mesoporous oxide matrix for efficient decomposition of DMAZ(fuel) /H_2O_2(Ox) based green bipropellants

Area of Research
Green hypergolic bipropellants, Catalyst/ promoters

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Ms. B Radhika

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

radhika_b@lpscb.gov.in

Summary of the Proposed Research

Earth storable propellants like MMH and MON-3 are used as bipropellant system for spacecraft propulsion across the globe since 1960s. However, due to the hazardous nature of these propellants, the production, handling and transportation shall be carried out with strict safety protocol. Researchers around the world are developing alternative propellant formulations which offer better performance and are also environmental friendly. These propellants are called Green propellants. Hydrogen peroxide is a promising candidate as oxidizer to work with various fuels such as ethanol, RP1 grade kerosene, Di methyl amino ethyl azide (DMAZ) etc. DMAZ/H_2O_2 bipropellant system offers specific impulse of 280.8 seconds and density specific impulse of 360.2 seconds.

One of the major challenges with green bipropellants is their non-hypergolic nature. Hence, chemical additives are added to the fuel/oxidizer system to reduce the ignition delay time. These chemical additives are called “promoters” or “catalysts”. This is a major research area for the green propellant enthusiasts which enable the use of green propellants in space.

The role of promoter is not only to reduce the ignition delay time and but also to help with complete decomposition resulting in better performance and environmentally friendly products. These promoters shall also be stable and perform without any degradation or deactivation in the harsh working environments like extreme temperatures and pressures. To address these challenges, we are proposing the development of bimetallic alloy-based promoters embedded in mesoporous oxide matrices for DMAZ/H_2O_2 bipropellant system.

Scope of the work:

Design and synthesize bimetallic alloy promoter (such as Mn/Cu, Cu/Co) impregnated into porous oxide matrices (such as γ-Al_2O_3, MnO_2).

Optimization of bimetallic promoter loading level to achieve the required decomposition rates.

Characterization of promoter for structural and chemical properties by advanced techniques (XRD, SEM, TEM, BET, AAS etc.) to ensure metal distribution in the porous matrix.

Experimental decomposition studies with the finalized promoter and DMAZ/H_2O_2 propellant system. Refine and optimize the promoter based on experimental studies (if required).

Linkages to Space Programme:

- Bimetallic alloy-based promoter on mesoporous oxide matrix can be added for efficient decomposition of DMAZ(fuel) /H_2O_2(Ox) based green bipropellants to reduce the ignition delay time and also to help with complete decomposition resulting in better performance and environmental friendly by products. This will be an alternative green hypergolic bipropellant system for spacecraft propulsion.

Expected Deliverables:

1. Measurement technique along with the test configuration and component details along with the report detailing the same.

RES-LPSC-2024-014

Name of ISRO/DOS Centre/Unit
Liquid Propulsion Systems Centre, Valiamala

Title of the research proposal
Design, Development and testing of compliant mechanism for mounting of pressurant gas bottles in launch vehicles

Area of Research
Structures, Materials

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Mr. D. Sai Teja

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit
d_saiteja@lpsc.gov.in

Summary of the Proposed Research

A compliant mechanism is a monolithic structure that elastically deforms without any link and joint to produce a desired force or displacement. Research proposal is to design a compliant mechanism for mounting of pressurant gas bottles that are used in liquid stages of launch vehicle. Mechanism has to support a spherical gas bottle of Ø630mm (outer diameter) and weight around 70kgs. Bottle is provided with end bosses (hubs) with M48 thread for interfacing with brackets. It must be able to accommodate gas bottle dilation of ~10mm (during pressurization) along the axis of the bottle. Shall have mounting frequency >60Hz (in all 3 directions). It should be accommodating temperature range of -100^{0}C to +50^{0}C. Material can be stainless steel or Aluminium alloy. Mechanism should withstand loads of around 31 kN both axially and laterally (gas bottle loads due to harmonic vibration).

Scope of the work:

- Design, development and testing of compliant mechanism for supporting the gas bottle meeting the specification.
- Optimization of compliant mechanism using the state of the art techniques for easy fabrication with optimum mass.
- Proto hardware fabrication (3sets) for evaluation of materials/fabrication process and qualification testing.
- Load testing of compliant mechanism for the expected deformations (with gas bottle).
- Vibration test of compliant mechanism (will be done by LPSC).

Linkages to Space Programme:

- Expertise in compliant mechanisms help in adaption of this method for similar applications where displacement/rotational flexibility is required in mounting brackets. Majority of the liquid stages have high pressure gas bottles for propellant tank pressurization. The developed mechanism can be implemented in ongoing and future launch vehicles.

Expected Deliverables:

1. Design of the compliant mechanism.
2. Detailed drawings of the parts, fabrication and assembly procedure document.
3. Acceptance test plan for the mechanism.
4. Details of tests carried out and test results for qualifying the mechanism.

RES-LPSC-2024-015

Name of ISRO/DOS Centre/Unit

Liquid Propulsion Systems Centre, Valiamala

Title of the research proposal

Model based estimation of pressure evolution in a Liquid methane tank with internal feed tunnel under dynamic conditions & cryogenic engine operation

Area of Research

Propulsion

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. Satheesh Chandran C.

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

c_satheeshchandran@lpscv.dos.gov.in

Summary of the Proposed Research

Development of discretized mathematical model for the real time estimation of temperature and pressure of the ullage of un-insulated liquid methane tank with internal concentric feed line of liquid oxygen during the expulsion of liquid methane from the tank (during the engine operation time) and estimate the collapse factor for the pressurization (with hot methane).

Scope of the work:

Development of mathematical model to discretize the ullage volume to estimate pressure and temperature across the ullage volume and calculate the mean mass temperature of the ullage volume during ascent phase & engine operation. The discretized model of the ullage is to be generated for simulating the real time internal thermodynamics & heat transfer phenomena of the ullage during ascent phase & engine operation. The heat transfer modeling in both dome and shell area to be done to estimate the pressure evolution in the tank during the expulsion time of liquid. The node of the ullage is getting increased during

the expulsion time and radial and axial heat transfer to be estimated such that the pressure change due to collapsing of the ullage gas due to the exposure of internals during the expulsion of low temperature liquid from the tank.

Linkages to Space Programme:

- This study is linked to the development of LOX-Methane stages for NGLV. Bottom stages of NGLV are configured with LOX/LCH4 stages where the LCH4 tank is in a tube in tube configuration with LOX feed line inside the tank. Precise mathematical model is required to estimate the actual pressurant requirement and real-time thermodynamic changes inside the tank.

Expected Deliverables:

1. Discretised mathematical model of LCH4 tank with tube in tube configuration preferably in python platform. Details of tests carried out and test results for qualifying the mechanism.

RES-LPSC-2024-016

Name of ISRO/DOS Centre/Unit

Liquid Propulsion Systems Centre, Valiamala

Title of the research proposal

Indigenous development and characterization of thermoelectric materials and compact thermoelectric elements for advanced space power systems

Area of Research

Materials

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Dr. Susheel Kumar S

Dr. Deepak Kumar Agarwal

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

susheelkumar_s@lpsc.gov.in

d_agarwal@lpsc.gov.in

Summary of the Proposed Research

For the advanced space power systems being developed in LPSC for ISRO's deep space and interplanetary missions, thermoelectric (TE) elements that operate at hot and cold side temperatures between (200°C & 300°C) and (0°C & 50°C), respectively, are required. In these space power systems, TE materials with ZT > 1 will greatly enhance the conversion efficiency, reducing their mass. Moreover, indigenization of the development of TE materials is of strategic importance. Thus, the indigenous development and characterization of TE materials with ZT > 1 within the specified temperature bounds and the realization of compact TE elements for space applications are proposed.

Scope of the work:

The proposal is for the indigenous development and characterization of TE materials and the realization of compact TE elements for space power system applications, with the following specifications:

- Hot side temperature = (200 - 300)°C
- Cold side temperature = (0 - 50)°C
- ZT of TE material within operating temperature bounds > 1
- Max. overall dim. of each element= 3 x 6 x 5 (ht) mm
- Power level= 20 mW
- Conversion efficiency of each TE element 5%
- Operating environment = vacuum and ambient

Linkages to Space Programme:

- Indigenization of thermocouple material and fabrication for thermo-electric convertors for Lunar Lander missions for long duration, deep space missions to Mars, Jupiter etc..

Expected Deliverables:

1. Indigenously developed and characterized TE materials with ZT > 1 for the specified operating temperature bounds, and realized compact TE elements generating 20 mW at 5% efficiency.
2. Detailed report on the indigenous development, characterization of the TE materials, and the realization of compact TE elements.

ISRO PROPULSION COMPLEX

MAHENDRAGIRI

RES-IPRC-2024-001

Name of ISRO/DOS Centre/Unit

ISRO Propulsion Complex, Mahendragiri

Title of the research proposal

Eddy current testing of table level welded joints of the tube diameter 6 mm, 8mm and 10mm.

Area of Research

Non destructive testing

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. Surya Prakash Singh

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

surya@iprc.gov.in

Summary of the Proposed Research

IPRC Mahendragiri is responsible for assembling and testing Rocket flight stages, including Earth storable and cryogenic stages. Notably, some of the stages will be having over 1000 table level welded joints excluding position weld joint. Currently, X-Ray and DP testing are conducted to clear these weld joints, requiring 15 minutes per joint, excluding film processing and interpretation, and involving at least two personnel.

This process consumes significant resources, with 80 man-days for radiography completion. Recent advancements in eddy current testing technologies enable inspection of bare tubes with thicknesses between 1-2mm and sensitivity of eddy current testing instrument is now 20µm matching Radiography testing. Developing and Implementing this technology on welded tubes would greatly enhance NDT efficiency, allowing targeted X-Ray inspections and reducing unnecessary hardware movement. This innovation would optimize our testing procedures and may bring down the inspection time from 25 mins to 3-4 mins including interpretation.

Scope of the Work:

To investigate the feasibility and effectiveness of eddy current testing for detecting defects in 1 mm thick welded joints, and to optimize parameters for improved detection accuracy.

- Review existing research on Eddy current Testing, weld inspection, and defect detection.
- Design and fabricate welded joint specimens (1 mm thickness) with intentional defects.
- Procurement of an eddy current testing setup.
- Develop and optimize Eddy current Testing protocols for 1 mm thick welded joints.
- Conduct Eddy current tests on specimens to evaluate detection accuracy.
- Analyze results to determine effectiveness in detecting defects.
- Compare the results with traditional NDT methods (X-Ray).

- Investigate the impact of Eddy current Testing parameters (frequency, coil design, scan speed) on detection accuracy.

Linkages to Space Programme:

- This outcome of proposal is directly linked to PSLV, GSLV, LVM3 and NGLV. This proposal is for replacing the Radiography testing to Eddy current testing. Developing and Implementing this technology on welded tubes would greatly enhance NDT efficiency, allowing very few X-Ray inspections (remaining by eddy current testing) and reducing unnecessary hardware movement. This process may optimize IPRC testing procedures and may bring down the NDT process time of a single joint from 25 mins to 3-4 mins including interpretation (80% time saving for carrying out NDT).

Expected Deliverables:

1. Implementation of Eddy current testing processes can potentially reduce NDT inspection process time by up to 80% and which significantly reduce flight stage integration time as no or minimum waiting time required after welding.
2. Documents giving details of formulation, sample problem solved and validation.

RES-IPRC-2024-002

Name of ISRO/DOS Centre/Unit
ISRO Propulsion Complex, Mahendragiri

Title of the research proposal
Charge to voltage converter for piezoelectric sensors.

Area of Research
Electronics,
Signal conditioning circuit,
Cryogenic Rocket engines and Stages.

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Dr. S. Murugan

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit
mur.gan@iprc.gov.in

Summary of the Proposed Research

The proposed research work focuses on the development of the charge to voltage converter used for piezoelectric sensors through advanced charge amplification and signal conditioning, compact packaging techniques. Charge converters serve to convert high impedance charge mode piezoelectric sensor output signals in the range of few pC into low impedance required voltage signals for input into readout, recording, and analysis instruments. By leveraging advanced signal conditioning techniques the converter should provide high sensitivity, accuracy, required frequency, low noise and interference. Also the robustness against harsh environments such as high temperature, vibration etc. to be ensured. It should be compatible to use with various piezoelectric sensors for space applications.

Scope of the work:

1. **Design and Development:** Design a charge to voltage converter circuit for piezoelectric sensors used in space applications.
2. **Suitable parameters & performance requirements:** (Desirable values for the below parameters: IEPE standard values).
    - High Charge conversion sensitivity and accuracy
    - Input requirements
    - Output voltage range-required for the IEPE
    - Frequency response
    - High temperature range
    - Input connector
    - Output connector
    - Resistance
    - Minimum required at input
    - Size, Compact packaging
    - Excitation voltage range
    - Low noise and interference
    - Compatible with various piezoelectric sensors
3. **Gain adjustments and stabilization:** Method for adjusting the different gains such as 0.1,0.5,1
4. **Testing and validation:** Comprehensive testing and validation to ensure converter meets all the specified criteria in real world environment.

Linkages to Space Programme:

- The developed CV converters are to be used in various kinds of Piezoelectric based the Measurement i.e. Dynamic Pressure, Acoustic Pressure and Vibration measurement. The measurement includes Ground Tests at various test Stands at IPRC and also finds application VVMS (Vehicle vibration monitoring.). PSLV, GSLV and launch vehicles.

Expected Deliverables:

1. Piezoelectric sensor based charge to voltage converters of Gain 0.1 – 2 Nos. 0.5 – 2 Nos. 1.0 – 2 Nos.
2. Experimental findings of the lab level motor tests.

RES-IPRC-2024-003

Name of ISRO/DOS Centre/Unit

ISRO Propulsion Complex, Mahendragiri

Title of the research proposal

Synthesis and Characterization of Piezoelectric materials for cryo temperature (~4 K) applications

Area of Research

Materials,

Cryogenic Rocket engines and Sages,

GSLV, LVM3.

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Dr. S. Murugan

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

mur.gan@iprc.gov.in

Summary of the Proposed Research

Sensors which can convert an external stimulus like pressure and vibrations into a measurable quantity are essential devices for vibration analysis. The continuous demand for the fabrication and technology of new sensors at low temperatures has attracted this research. Such sensors have a wide range of applications in the fields like medical, aeronautical, industrial, robotics and space technology. Utilizing the existing sensors at cryogenic temperatures is a greater challenge. The primary aim of this project is to develop a new sensor for vibration sensor applications. To overcome the challenge, it is proposed to synthesize low cost organic polymer nano- composite sensing material which can withstand a wide range of temperature variation especially low temperatures. Nanocomposites consisting of the nanosized common piezoelectric ceramics like barium titanate and zinc oxide embedded in organic polymers which act as fillers. The stability of the piezo-electric co-efficient and mechanical strength of these nanocomposites will be tested for vibration sensing at different temperatures. The organic polymers enhance the electrochemical and electromechanical strength to the materials. The investigations will be carried out with different organic polymer matrices with a proper optimization of the product to be exploited for vibration sensor applications at cryogenic temperatures.

Scope of the work:

Piezoelectric sensors are used in aerospace to measure turbulence, engine combustion and in various other dynamic pressure measuring devices. Piezoelectric sensors are compatible to be used at high temperatures and pressures. These materials do not require external lubrication. Their low power consumption and instantaneous response to vibrations make them more suitable to be used in space technology for fuel preservation, satellite control, atmospheric parameter analysis etc., Fabricating a piezo-electric sensor to withstand both high and low temperatures is the greatest challenge. As there are a lot to explore on these materials, this project will give a good insight on the utilization of piezo materials at cryogenic temperatures.

Linkages to Space Programme:

- Indigenously developed vibration sensors uses piezoelectric materials as sensing element which has the curie temperature of -200 to +250 deg C. At present in the cryogenic compatible vibration

sensors developed in ISRO require the sensing element capable of withstanding the temperature <4K. Cryo compatible vibration sensors are imported as such there is no indigenous sensor of such kind is developed in ISRO/elsewhere in India. On developing this cryo compatible piezo electric material the sensors will be indigenized for various vibration sensing applications at cryo level which includes cryogenic rocket engines, stages for ground testing as well as flight applications – GSLV & LVM3.

Expected Deliverables:

1. Piezoelectric Nano materials with Curie Temperature < 4 K range.
2. At least one Technical publication / acknowledging ISRO or joint patent.

RES-IPRC-2024-004

Name of ISRO/DOS Centre/Unit
ISRO Propulsion Complex, Mahendragiri

Title of the research proposal
Development of software for Automation of Interpretation and Validation of Chronology for Ground Testing of Engines

Area of Research
Software, PLC, GUI, N-version programming

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Ms. Poofa Gopalan

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit
poofa.gopalan@iprc.gov.in

Summary of the Proposed Research

Ground testing of engines (earth-storable, cryogenic, semi-cryogenic) are carried out in the test facilities at IPRC for qualification/acceptance of engines. In order to carry out the ground testing of engines, a test chronology document is prepared. A test chronology consists of time-based Electro pneumatic valve/Control valve commands and parameter-based sequences at required time instances. The PLC has to execute the events as per the chronology during the hot test of the engine. However, the test chronology document cannot be directly fed to a PLC. A PLC readable input file is created manually w.r.t the chronology. In order to avoid manual intervention and making the process error-free, automatic interpretation of test chronology is proposed. The software shall be generalized such that it can be used in any test facility.

Scope of the work:

The software shall be developed using N-version programming technique, i.e. different algorithms for generating the PLC input file. The software shall compare the validity of the generated file by using a decision algorithm. The software shall read the test chronology document. The software shall carry out necessary data parsing and read the necessary data in the document. A GUI shall be developed, which can interact with the user for feeding the inputs specific to a test facility. The required output format and the PLC I/O database file shall be fed by the user. The software shall read PLC I/O database and verify

that the tag names are valid. In case, any tag name is not found, the software shall indicate error. On successful parsing and verification of PLC I/O database, the software shall then convert each command in the document into the PLC readable command format. The output file shall be a comma separated file as per the format specified by the Department. The file shall be fed to PLC design and the output data shall be compared with the input file and a verification report shall be generated so that the sequence validation is totally automated.

Linkages to Space Programme:

- This software can be used in all test facilities of IPRC catering to all space programmes linked with IPRC.

Expected Deliverables:

1. Software Requirements Specification document (capturing the specification, data format) shall be prepared as per IEEE12207 standard.
2. Software Design Document (for the different software versions) as per IEEE12207 standard.
3. Executable software and Source code of the software shall be provided.

RES-IPRC-2024-005

Name of ISRO/DOS Centre/Unit
ISRO Propulsion Complex, Mahendragiri

Title of the research proposal
Hydraulic and tribological characterization of additive manufactured fluid components based on experimental studies and optimization of process parameter for LPREs.

Area of Research
Additive Manufacturing, Hydraulic flow testing, Tribological properties.

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Mr. Karthikeyanathan S

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit
sk.nathan@iprc.gov.in

Summary of the Proposed Research

This research investigates the hydraulic and tribological characteristics of additive-manufactured (AM) fluid components for Liquid Propellant Rocket Engines (LPREs). The study will focus on experimental analyses and optimization of process parameters to achieve improved component performance and reliability using the AM fabrication process. Hydraulic parameters involve evaluating flow rates, pressure drops, friction factor, hydraulic diameter, hydraulic entrance length, and impact of fully developed flow for varying L/D ratios at different flow (Reynolds number) conditions. Tribological parameters involve friction, surface roughness, fatigue and corrosion for the fluids used in various flight engines. A systematic DOE approach will be employed to optimize the additive manufacturing process parameters. The hydraulic and tribological analyses will provide insights into the performance of the fluid components (orifices, valves, etc.) using additive manufactured fluid components, aiding to optimum geometrical and flow conditions, such as effects of component geometry and surface finish.

Objectives:

i. To analyze the hydraulic behavior of additive manufactured fluid components in LPREs in various flow geometrical and flow conditions.

ii. To investigate the tribological performance of the fluid component(s) under various operating conditions for different aerospace materials.

iii. To characterize and study the impact of tribological properties on AM flow component hydraulic characteristics.

iv. To optimize the additive manufacturing process parameters to enhance the mechanical and functional properties of the fluid components for LPREs.

Scope of the work:

Scope involves the iterative process of developing a set of experimentally optimized parameters for fabricating fluid components through additive Manufacturing technology. The hydraulic and tribological analyses will provide insights into the performance parameters of the additive manufactured fluid components and their design improvements. A set of fluid components will be fabricated with different hydraulic diameters and entrance characteristics. Process parameter optimization will result in the fabrication of fluid components with superior mechanical properties, leading to enhanced reliability and lifespan of LPREs. This significantly reduces the cycle time of flow testing and gives tailored fluid components for LPREs of ISRO.

Linkages to Space Programme:

- The proposed research activity helps in optimizing various additive manufacturing process parameters together with tribology properties to meet essential flow parameters in calibration orifices. As an outcome of this research activity, Calibration orifices shall be fabricated in site with tailored flow properties like land, angle, inlet entry curvature conditions to meet the mission specifications.

Expected Deliverables:

1. A set of fully functional fluid component with the appropriate geometrical/ tribological properties and associated process parameters.
2. Comprehensive characterization data correlating AM process parameters, tribology and hydraulic characteristics.
3. Fluid components with tribological properties & and AM parameters for flow experiments at IPRC.
4. Insights into the process parameter optimization to meet expected surface and geometric parameters in AM fabrication for different types of orifices.

PHYSICAL RESEARCH LABORATORY

AHMEDABAD

RES-PRL-2024-001

Name of ISRO/DOS Centre/Unit

Physical Research Laboratory, Ahmedabad

Title of the research proposal

Modulating the excited state of emission centers via band gap engineering to prepare efficient nano-dosimeters

Area of Research

Space Dosimetry, Material synthesis, Luminescence mechanism

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Dr. Naveen Chauhan

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

chauhan@prl.res.in

Summary of the Proposed Research

Lithium borate (Li2B4O7) is a notable material in the field of dosimetry, particularly due to its effective Z-value, which closely approximates that of human tissue. This characteristic makes it an ideal candidate for use in radiation detection and measurement. The primary aim of this research is to develop rare earth (RE) doped nano- Li2B4O7 dosimeters by employing band-gap engineering to modulate the excited states of the emitting rare earth ions.

To achieve this, we will conduct theoretical calculations based on vacuum referred binding energy (VRBE) diagrams to determine critical parameters such as 'trap depth' and 'optical emission'. These parameters are essential for optimizing the performance of TL dosimeters, as they directly influence the material's ability to store and release energy upon thermal stimulation.

Moreover, temperature-dependent photoluminescence (PL) studies will be carried out to further elucidate the mechanisms behind the optical transitions and excited state dynamics of the luminescent ions. By systematically investigating these factors, we aim to optimize the band gap and enhance the luminescent properties of the RE-doped nano-Li2B4O7, ultimately contributing to the development of highly sensitive and effective TL dosimeters suitable for a range of applications in radiation monitoring and safety.

Scope of the work:

Efficient dosimeters, specifically those designed to measure photons per unit dose, are crucial for various missions undertaken by ISRO (Indian Space Research Organisation). As space missions expose instruments and astronauts to significant levels of radiation, there is an urgent need for reliable and sensitive dosimetry solutions. These dosimeters will play a pivotal role in ensuring the safety and success of ISRO's diverse range of missions, from satellite launches to interplanetary explorations.

To address this need, the project will focus on developing nano-sized dosimeters through chemical synthesis methods, employing band-gap engineering techniques to enhance their performance. By doping lithium borate (Li2B4O7) with rare earth elements, we aim to optimize the material's TL properties,

allowing for a greater response to radiation exposure. The project will involve meticulous characterization of the synthesized nano-dosimeters, examining their crystallinity, size, and optical properties to ensure they meet the stringent requirements of space applications.

Additionally, this research will explore the integration of these advanced dosimeters into existing monitoring systems used by ISRO. By providing real-time data on radiation levels, these dosimeters will not only enhance the safety of space missions but also contribute to the broader understanding of radiation environments in outer space, thereby advancing ISRO's capabilities in space exploration and research.

Linkages to Space Programme:

- Efficient dosimeters that measure photons per unit dose are vital for ISRO's space program, particularly for satellite launches and interplanetary missions, where radiation exposure poses significant challenges. This project aims to develop nano-sized dosimeters using chemical synthesis and band-gap engineering by doping lithium borate (Li2B4O7) with rare earth elements to optimize TL properties. Through careful characterization of these materials, we will ensure they meet ISRO's stringent requirements. Integrating these advanced dosimeters into monitoring systems will provide real-time radiation data, enhancing safety for crewed missions and advancing ISRO's capabilities in space exploration and technology.

Expected Deliverables:

1. Development of Nano-sized Dosimeters: Creation of lithium borate (Li2B4O7) doped with rare earth elements using chemical synthesis methods.
2. Enhanced TL Properties: Optimization of dosimeter performance through band-gap engineering techniques.
3. Characterization of Materials: Comprehensive analysis of synthesized dosimeters, focusing on crystallinity, particle size, and optical properties.
4. Integration into Monitoring Systems: Implementation of advanced dosimeters into existing radiation monitoring frameworks used by ISRO.
5. Real-time Radiation Data: Provision of accurate, real-time measurements of radiation levels for enhanced safety in crewed missions.
6. Contribution to Space Exploration: Reinforcement of ISRO's capabilities in space technology and research through improved dosimetry solutions.

RES-PRL-2024-002

Name of ISRO/DOS Centre/Unit

Physical Research Laboratory, Ahmedabad

Title of the research proposal

Developing chemometric tools to analyze LIBS spectra acquired under simulated planetary atmospheric conditions

Area of Research

Plasma spectroscopy, Software development

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Dr. Prashant Kumar

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

prashantk@prl.res.in

Summary of the Proposed Research

Laser induced breakdown spectroscopy (LIBS) is now being considered as an important analytical technique for in-situ elemental characterization for exploration of planetary surfaces. The emission spectrum obtained from the plasma, formed due to laser ablation of the target, span throughout the UV-Visible spectrum. While the spectrum for pure metals and samples containing a few elements are relatively easy to analyse, geological samples produce complex spectrum. Techniques employed to retrieve relative elemental abundances generally results in larger errors for such samples.

For such cases, it is preferable to use chemometric techniques to classify the samples instead of relying on inaccurate elemental abundances obtained using traditional methods. Multivariate techniques (PCA, PLS), artificial neural network models are now being widely used to classify samples using LIBS.

The present proposal aims to extend the application of these techniques to analyse complex LIBS spectrum acquired for rocks and other planetary analogue samples. The dataset will mostly consist of spectrum acquired for various samples under simulated planetary atmospheric conditions. Synthetically generated spectrum at different values of plasma temperature and number densities will also be a part of the test datasets.

The performance of traditional algorithms (synthetic spectrum, C-Sigma, etc.) will be evaluated vis-a-vis the performance of developed classification tools. Given the limitations for space-bourne instrument, the techniques developed will also be tested on spectra with varied spectral resolution.

Scope of the work:

1. The scope of the proposal, as mentioned above, mostly consist of the following three activities,
2. Generating a spectral database of relevant samples: This is the first step and includes, laboratory spectra available with the proposing institute, LIBS data publicly available from other space missions, synthetically generated spectra at different plasma conditions
3. Developing classification tools: This is the main objective of the proposal. Different models based on PCA, PLS or/and ANN need to be developed and evaluated for its efficacy to analyze spectra from the above generated database.
4. 3. Understanding the effect of ambient and other experimental factors: Once the tools are developed, their performance will also be evaluated for spectra acquired for same target but in different ambient and experimental conditions.

Linkages to Space Programme:

- The present proposal is linked to the activities of planetary exploration program of ISRO. After a successful demonstration on CH-3, it is expected that LIBS instrument will be flown by ISRO in subsequent missions to Moon, Mars and beyond. Hence, it becomes imperative to develop such tools for analysing LIBS spectra which will facilitate accurate and reliable information from such instruments in future.

Expected Deliverables:

1. LIBS spectral database of samples acquired in different ambient relevant to planetary missions
2. Classification tools to analyze/classify complex LIBS spectrum
3. Quantification of sensitivity of developed methodology as a function of experimental factors

RES-PRL-2024-003

Name of ISRO/DOS Centre/Unit
Physical Research Laboratory, Ahmedabad

Title of the research proposal
Study of the Dynamics of Large-Scale Flows and Sunspot Magnetic Fields in the Near Surface Shear Layer (NSSL) of the Sun.

Area of Research
Solar Physics

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Dr. Brajesh Kumar

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit
brajesh@prl.res.in

Summary of the Proposed Research

The near-surface shear layer (NSSL) of the Sun, situated just below the solar surface over depths to about 35 Mm, is marked by a swift increase in the rotation rate as depth increases. Its overall structure and dynamics are significantly altered by the sunspot magnetic fields and they are coupled to the well observed zonal and meridional flows. Probing solar cycle related changes in them is expected to give clues to understanding not only the origin of these flows but also of the NSSL and its maintenance. In this connection, understanding the dynamics of large-scale flows around active regions and their cumulative contributions to the changes in zonal and meridional flows is important. In addition, deriving advance information on markers/predictors of enhanced activity, e.g. flares and CMEs, depend on seismic information on the evolution the sub-surface thermal, magnetic and flow structures within the NSSL. The above science goals and directions will form the basis of the proposed research here.

Scope of the work:

In this proposed research, a primary task will be a joint analysis of helio seismic measurements of meridional and zonal flows within the NSSL along with the detailed observations of sunspots and their spatio-temporal evolution over solar cycle time scales. Local helio seismic images of the sub-surface structure and flows beneath a large number of pre-emergence sunspot locations will also be compiled from the more than two solar cycle long data from GONG, SOHO/MDI, and SDO/HMI. This will provide new information on the overall dynamics and coupling of flows and magnetic fields in the NSSL and be able to seek answers to the question: how are the variations in solar activity as observed in various measures (surface magnetic field and derived quantities, flares, prominences, CME's, etc.) related to such variations in zonal and meridional flows?

The above science questions will be addressed using the data from the network of GONG instruments (of which one is hosted and run by the Udaipur Solar Observatory, Physical Research Laboratory, Ahmedabad, under Department of Space, Govt. of India) and NASA's instruments SOHO/MDI and SDO/HMI that have covered solar cycles 23, 24 and ongoing 25 (from 1995 to the present).

Linkages to Space Programme:

- The results expected from the work proposed here will form a crucial input representing the solar interior dynamics for data-driven models. And they will also support and augment science from various current and future solar observing facilities from the ground- and space, viz., MAST operational at USO, PRL, Udaipur, Aditya-L1 mission, and the proposed future Indian missions dedicated to solar observations. Such seismic studies will also add to various other predictors derived from surface magnetic fields and flows to form a comprehensive input-dataset for artificial-intelligence (AI) algorithms for prediction of eruptive phenomena.

Expected Deliverables:

1. The major findings from the proposed research will form as inputs representing the solar interior dynamics to data-driven models of solar dynamo processes so as to enable forecasting of solar activity on time scales ranging from years to decades. The results of such exercises, once published, could be used by theorists as a set of observational constraints for theories/models of global solar interior dynamics and the magnetic dynamo. This long-term study will also help in forecasting the eruptive nature of solar active regions affecting the space weather.
2. All the computer codes developed and utilised in this research will be integrated as a suite of tools and will be made available free for use by the research community. These tools will serve to utilize the full potential of publicly available solar Doppler velocity and magnetic field data from the ground-based GONG and space-based SOHO/MDI and SDO/HMI instruments.

RES-PRL-2024-004

Name of ISRO/DOS Centre/Unit
Physical Research Laboratory, Ahmedabad

Title of the research proposal
Advanced Radio Instrumentation for Solar Observations (ARISO)

Area of Research
Radio instrumentation, Solar physics

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Dr. Anshu Kumari

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit
anshu@prl.res.in

Summary of the Proposed Research

The coronal magnetic field (B) is crucial for the formation, evolution, and dynamics of both small and large-scale structures in the solar corona. Direct measurements of the coronal magnetic field strength,

especially within the radial distance range of approximately 1.02 to 5.0 R (where R is the radius of the photospheric Sun), is currently challenging due to practical constraints. Polarization observations, i.e. measuring the Stokes-V parameter (circular polarized intensity) of the received radio signal, are commonly used to determine the magnetic field strength associated with radio emissions. This method, i.e. using simultaneous radio imaging and spectral observations, though less explored, is a significant area of research in solar physics, complementing the limited existing techniques that estimate magnetic field strength by extrapolation. Since radio techniques provide access to observations of solar, helio spheric, and ionospheric space weather phenomena, they are considered one of the most practical approaches to probing the magnetic field in the solar atmosphere. Ground-based radio observations offer an excellent means to observe and study the corona within this height range. Therefore, we propose the development of one ground-based radio instrument specifically designed for solar coronal observations.

Scope of the work:

The scope of the proposal, as mentioned above, mostly consist of the following three activities:

1. Design, develop, and characterize a spectro-polarimeter (front-end and digital back-end) capable of receiving polarized radio emissions from the Sun at low frequencies with high temporal and spectral resolution.
2. Compare the data obtained using the new instruments with existing instruments to validate the observing capabilities of the new instruments.
3. Estimate magnetic field strengths from the observed polarized radio emissions, comparing these observations with solar activities in other wavelengths with different space and ground-based solar instruments.

Linkages to Space Programme:

In the past three decades, with dedicated solar missions, such as SOHO,STEREO, SDO, PSP, and SolO, our knowledge of the magnetic connection between the solar interior and the Sun-Earth connection has improved significantly. With the launch of new solar missions such as ADITYA-L1 (India’s maiden space-based solar mission), PUNCH, SunRISE, the next few years will be a fascinating period for heliospheric research. Recent advancements in radio observations with ground and space-based instruments have also helped transform our understanding of the solar atmosphere in unprecedented detail. Radio observations can give insights into various properties of the propagating structures, such as density, magnetic fields, and velocity in the part of the corona (inner corona), which is usually not accessible in other wavelengths. Since Aditya-L1 does not have any radio instruments, having India's own solar radio facility will very well complement the other wavelength data space and ground solar data.

Expected Deliverables:

1. We have planned to design and characterize a Cross-Polarised Log-Periodic Dipole Antenna (CLPDA) that works in the 20-800 MHz range (may vary on RFI conditions) as front-end.
2. We plan to build an all Stokes correlation on a high-speed FPGA of 10 ms, ~ 10 kHz temporal and spectral resolution, respectively to record small scale variation and ~60 dB dynamic range to record faint emission.

3. A solar spectro-polarimeter for regular solar coronal observations in radio frequencies. This will be a high temporal and spectral resolution instrument.

RES-PRL-2024-005

Name of ISRO/DOS Centre/Unit
Physical Research Laboratory, Ahmedabad

Title of the research proposal
Study of biogenic volatile organic compounds (BVOCs) in central forest regions of India

Area of Research
Atmospheric Trace Gases: Environmental and Climate Change

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Prof. Lokesh Kumar Sahu

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit
lokesh@prl.res.in

Summary of the Proposed Research

Volatile Organic Compounds (VOCs) can be described as broad range of chemical species emitted from both natural (~80%) and anthropogenic (~20%) sources. Ozone in the lower atmosphere is a secondary species and a potential greenhouse gas which is primarily produced by the photochemical reactions of VOCs and nitrogen (NOx=NO+NO2) in the presence of sunlight. Atmospheric chemistry is complex over the Indian subcontinent due to the vast geography with different climatic zones and existence of a variety of natural sources. Although very little knowledge is available, measurements of natural (biogenic) VOCs emitted from terrestrial vegetation in the tropical regions of South Asia are extremely important but data are very sparse to understand their role in atmospheric chemistry over South Asia. The main objective of this proposal is to characterize the emission and atmospheric processes of biogenic VOCs emitted from the central forest regions of India (mainly in the states of Chhattisgarh and Madhya Pradesh). The in situ analysis can be done using offline or online methods using C2-C12 VOC analyzers for the air samples collected at selected sites over this region. In details, the proposal will investigate the dependence of BVOCs emissions on several environmental/meteorological factors (Temperature, RH, solar flux, etc.). Further, the site/station based measurements will be extrapolated to get the regional representations of BVOC emissions. The regional emissions can be estimated using the satellite products such Leaf Area Index (LAI).

Scope of the work:

Emission of BVOCs from terrestrial vegetation depends on ambient temperature, solar flux intensity and wind parameters. Therefore, the global emission estimates are reported with large uncertainties. The land use changes and deforestation can alter the BVOC emissions and also the composition. Therefore, chemistry climate simulations of VOCs related photochemistry and their implication in climate and environmental changes are very uncertain. In tropical areas, where the potential for biogenic emissions and photochemistry is high, the sensitivity to ecology can be very significant. In addition to independent scientific importance to study the emission and atmospheric chemistry, the data obtained from this

project will be valuable for both national and international researchers working in global chemistry-climate models. In this data gap region, the new data and results obtained from this program of BVOC measurements will be invaluable for the numerical modeling of the chemistry-climate interactions over South Asia in particular. There is potential scope to incorporate the data obtained from other programs of ISRO such as satellite products of Leaf Area Index (LAI) to get forest canopy map. Over the program will help policy maker working climate change related issues.

Linkages to Space Programme:

- This proposal has potential to effectively utilize several EOS data of ISRO such as Metrological, Forestry & Plantations, vegetation index, Soil Moisture, and Hydrology data. The scientific interpretation of the obtained from this proposal will require use of other data available at Bhuvan NICES, and MOSDAC portals.

Expected Deliverables:

1. In summary, the high quality (accuracy and sensitivity) measurement BVOCs is the top priority of this program. Measurements with sensitivity as low as a few pptv (parts per trillion by volume) will be used to address important outstanding issues as outlined here.
   - Biogenic Emissions: Emission fluxes of biogenic volatile organic compounds (BVOCs), such as isoprene, monoterpenes, toluene emitted from forest/plant/ocean will be characterized, particularly the impacts of monsoon circulations in the tropical regions.
   - Photochemistry: The data from this and other project will provide quantitative estimates of role of VOCs mediated photochemistry in the formation of O3 and precursors of OA. Contributions of various VOCs in diurnal and seasonal variations of O3 and OA in different regions of India will be estimated.
   - Transformation: Chemical evolution of air VOCs at remote locations will be investigated as several pairs of VOCs can be used to get the information of origin and photochemical age.
   - Model: The global scale chemistry and climate models lack proper representation (of both inventory and photochemical mechanism) of BVOCs. The measured BVOCs data will be useful to improve the model simulations of O3 and OA in the troposphere.

RES-PRL-2024-006

Name of ISRO/DOS Centre/Unit
Physical Research Laboratory, Ahmedabad

Title of the research proposal
Large and small-scale ionospheric plasma irregularities using airglow imaging and GNSS TEC measurements

Area of Research
Ionosphere-Thermosphere dynamics, Optical Aeronomy, Optical Instrumentation, Image analysis, Ionospheric TEC

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Dr. Ravindra Pratap Singh

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit
ravindra@prl.res.in

Summary of the Proposed Research

The Ionosphere-Thermosphere system in Earth's upper atmosphere consists of plasma and neutral particles that are coupled together. Various equatorial electrodynamic and neutral dynamical processes control the distribution of plasma and neutral particles in equatorial and low-latitude regions. Equatorial Plasma Bubbles (EPBs), which are regions of depleted electron density, form due to the post-sunset upward movement of the ionosphere. These irregularities cause GNSS (Global Navigation Satellite System) signals to scatter, leading to increased positioning errors, signal degradation, or even complete loss of signal. The occurrence of EPBs is unpredictable; hence, it is essential to understand the generation and triggering mechanisms of EPBs in order to mitigate GNSS positioning errors. OI emissions at 630 nm, 777.4 nm, and 557.7 nm have been used to study the neutral and electrodynamical processes in Earth's upper atmosphere.

In this proposal, a low-cost all-sky imager will be developed to measure 630 nm nightglow emissions in order to monitor the large- and small-scale structures of EPBs. This imager will operate simultaneously with Very Low Frequency (VLF) and GNSS Total Electron Content (TEC) measurements. A data retrieval algorithm will be developed to identify large- and small-scale irregularities associated with EPBs. Such investigations will help to better understand the generation mechanisms of EPBs and their impact on ionospheric space weather.

Scope of the work:

- Development of a low-cost airglow imager for the measurement of 630 nm emissions that are sensitive to ionospheric conditions. This imager will consist of an optical system, a narrow bandpass filter tuned to the 630 nm wavelength, and a low-cost sensor to capture the airglow emissions.
- Identification of Equatorial Plasma Bubbles (EPBs) by observing specific patterns or disturbances in the airglow measurements. These irregularities manifest as spatial depletions or fluctuations in the brightness of the 630 nm emissions. Data collected by the imager over time could be analyzed using image processing techniques to detect such irregularities and distinguish them from other variations.
- Operation of the imager alongside GNSS Total Electron Content (TEC) and Very Low Frequency (VLF) measurements to investigate EPBs.
- Comparison of the 630 nm airglow emissions data with changes in TEC to understand the evolution of EPBs and their effects on the ionosphere.
- Cross-correlation between airglow/TEC data and VLF signal disturbances can help identify EPB-related irregularities and disturbances in the ionosphere.
- By using the EPB structure in the imager, TEC for electron density measurement, and VLF for lower ionosphere disturbances, we aim to gain a deeper understanding of the spatio-temporal behavior of EPBs and their effects on communication and navigation systems.

Linkages to Space Programme:

- Collisional Rayleigh-Taylor instability and upward-propagating gravity waves are well-documented mechanisms for the generation of equatorial plasma bubbles (EPBs). However, experimental evidence supporting these mechanisms remains limited. This work aims to address this gap by providing experimental insights into these phenomena. The findings from this study will enhance our understanding of the processes within the ionosphere-thermosphere system. This research will

aid in the interpretation of data obtained from the proposed airglow photometer payload for ISRO's DISHA (Disturbed and Quiet time Ionosphere-Thermosphere System at High Altitudes) mission.

Expected Deliverables:

1. The miniaturized imager will be operated alongside complementary instruments at various locations.
2. This research will investigate both small- and large-scale features in the ionosphere-thermosphere during the generation of equatorial plasma bubbles (EPBs).
3. The outcomes will enhance our understanding of the mechanisms involved in the generation of EPBs.
4. Additionally, this initiative will provide training for young researchers in the field, fostering collaborations with other institutions and universities.

RES-PRL-2024-007

Name of ISRO/DOS Centre/Unit
Physical Research Laboratory, Ahmedabad

Title of the research proposal
Investigation of Atmospheric Cloud Characteristics and Atmospheric Boundary Layer using Lidars and Satellites over India

Area of Research
Atmospheric Remote Sensing (RS &GIS)

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Prof. Som Kumar Sharma

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit
somkumar@prl.res.in

Summary of the Proposed Research

Atmospheric clouds are one of the vital components of the hydrological cycle and play an important role in modulating Earth's radiation budget and also play an important role in the weather and climate of the earth-atmosphere system. Understanding the vertical distribution of clouds, their properties, and temporal evolution is essential for understanding the origin and impact of clouds and their feedback on the above-mentioned processes and their parameterization in weather and climate models for improving forecast. Atmospheric Boundary Layer (ABL) characteristics lies in their direct and indirect influence on living beings and the environment and it works like packing volume of most of the pollutants. Understanding ABL characteristics, and ABL-clouds interactions along with pollutants is essential for improving weather forecasting, air quality management, climate modeling, and many more atmospheric processes. Furthermore, High-altitude icy cirrus clouds are very important, and investigation of their characteristics is essential for the understanding of the Earth's radiation budget. This study will be

focused on the investigation of Cloud characteristics, ABL dynamics, and associated processes, using Lidars operating under the Physical Research Laboratory's Indian Lidar Network (ILIN) Program over the Indian region.

Scope of the work:

- Vertical distribution of clouds, and different layers of clouds play an important role in the precipitation and Earth's radiation budget.
- The Ceilometer provides regular (with high temporal and vertical resolutions) and real-time information on clouds and boundary layer characteristics. These observations will provide an estimation of strong downdrafts and updraft and their association with precipitation, layers of cloud bases, etc.
- Discrepancies/differences with satellite-based estimation of Cloud Top Height/ Cloud Base Height (CTH/CBH) will also be studied along with ground-based Lidar observations. These will further help in calibrating satellite sensors and in the tuning of the cloud detection algorithms; further, these will be used for weather modeling purposes, which need accurate cloud information to initialize numerical models.
- The cirrus clouds are high-altitude and icy clouds. In these clouds, the ice crystal's size increases and they transform into irregular shapes in the presence of wave activity and will have implications for the uncertainties associated with clouds in regional weather and climate models.

Linkages to Space Programme:

- These investigations of the vertical distribution of clouds and boundary layers over the Indian region (using Lidar-based observations with high temporal and vertical resolution over different Indian locations) will be valuable for the calibration of satellite-based sensors and also for future satellite missions for Earth observations. Furthermore, these observations will also be used for the ground truth input for the improvement of regional weather and climate models for improving predictions over the Indian region.

Expected Deliverables:

1. Vertical distribution, different layers of atmospheric clouds, cloud dynamics (Updrafts and Downdrafts), and their association with the precipitation over the Indian region.
2. Quantification of cloud water carrying capability of the clouds below the Atmospheric boundary layer (ABL) on the ABL, and above the ABL
3. Quantitative investigation of satellite-based observation of Cloud heights and cloud layers along with ground-based Lidar observations and differences/anomalies over different regions and seasons over the Indian region.
4. These observations will be used for calibrating satellite sensors and tuning of the cloud detection algorithms; further, these will be used for weather modeling purposes, which need accurate cloud information to initialize numerical models.

RES-PRL-2024-008

Name of ISRO/DOS Centre/Unit
Physical Research Laboratory, Ahmedabad

Title of the research proposal
Modelling or data processing (hardware/software) for space instrument to detect charge/electric field

Area of Research
Sensor for impact charge/electric field

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Prof. Jayesh P. Pabari

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit
jayesh@prl.res.in

Summary of the Proposed Research

Whenever a hypervelocity dust particle makes impact with a target, it creates impact charge. Also, electrical discharges on a planet produces electric fields, which propagate over a large distance. The project work may involve aspects related to the modelling and data processing (hardware/software) in the mentioned area.

Scope of the work:

The scope of research can cover development of a hardware/software for the data processing and also, the modelling work. It can also involve refinement of existing model from recent observations, new technique of processing and related aspects.

Linkages to Space Programme:

- The research project is directly linked to the ISRO Venus orbiter mission. The work could be in line with the present activities of PRL in the respective fields.

Expected Deliverables:

1. The expected deliverables could be a technique of processing, hardware, modelling results, scientific outcomes from the data analysis etc.

RES-PRL-2024-009

Name of ISRO/DOS Centre/Unit
Physical Research Laboratory, Ahmedabad

Title of the research proposal
Modelling the Atmosphere of Venus

Area of Research
Planetary Atmospheres

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Prof. Varun Sheel

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

varun@prl.res.in

Summary of the Proposed Research

The atmosphere of Venus is fascinating as it poses challenging scientific questions related to the cloud layer, super rotation, ionosphere, lightning etc. With the recent past missions like Venus Express and Akatsuki, scientists are trying to understand many of these. Considerable modelling effort is also underway. A future mission by ISRO has been approved to study these interesting features.

It is therefore important to quantify the role of chemical, radiative and dynamical processes that shape today's Venus atmosphere, through modelling.

Scientific questions that can be addressed are for example: The role of convection in the cloud layer, explanation of the ionospheric morphologies observed by RO experiments, the effect of lightning on photochemistry in the cloud layer.

Scope of the work:

Simple models can be developed or an existing GCM (being used at PRL) can be used to study the above scientific questions. Such a study is important to prepare us for ISRO's future Venus mission which will observe various properties of the atmosphere. It will provide a comprehensive understanding of what we should look for with our instruments being developed for the Indian Venus mission.

Linkages to Space Programme:

- This work has direct link to ISRO's future Venus mission. For the mission to be successful, Indian scientists need to develop a deeper understanding of the processes in the Venusian atmosphere. This will directly help in the development of many of the instruments that will observe, and even encounter such events.

Expected Deliverables:

1. This work will result in development of models within India, to address the science from India's Venus mission. These models will be required to address the proposed research objectives. For example, the Venus GCM, ionospheric models, photochemical models. This is again crucial for the success of the mission.

ISRO INERTIAL SYSTEMS UNIT

THIRUVANANTHAPURAM

RES-IISU-2024-001

Name of ISRO/DOS Centre/Unit

ISRO Inertial Systems Unit, Thiruvananthapuram

Title of the research proposal

Development of a mathematical model for a dithered ring-laser gyroscope under harmonic external excitation

Area of Research

Mechanical Vibration

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. P. Badarinath

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

badarinath_p@vssc.gov.in

Summary of the Proposed Research

Ring Laser Gyros requires dithered mechanism for the operation of the Gyroscope. These sensors have to operate even in the linear vibratory environment. Understanding and modelling the complicated dynamic behavior of a rigid-body (RLG block) which is under the combined effect of a dither as well as linear external harmonic excitation is the aim of the project. Experiments to be carried out on structural model of dither RLG with and without external harmonic excitation. A lumped mass-spring model comprising several point masses and inertia, interconnected with linear and/or torsional springs shall be developed. The equations governing its dynamics may be developed by employing the Euler-Lagrange equation or Hamiltonian principle. The solutions will be investigated analytically using the method of harmonic balance, and numerically by employing numerical integration techniques such as the Runge-Kutta method and Floquet Theory.

Scope of the Work:

- Separating out structural resonances, and identifying natural frequencies and mode shapes of a dither mounted RLG block.
- Exploring the effect of dithering on structural resonances.
- Identifying non-classical resonances introduced due to dithering.
- Investigate how external harmonic excitation can influence the resonances of a dithered RLG block.

Linkages to Space Programme:

- The project has linkages with inertial navigation packages for LVM3, GAGANYAAN, Chandrayaan missions.

Expected Deliverables:

1. A mathematical model of a rigid-body including rotation induced effects (due to dithering) and external sinusoidal excitation.

2. A MATLAB / Mathematical code for predicting steady-state displacement of the RLG block as a function of time, as well as its frequency components. Various parameters such as stiffness, damping and inertia can be adjusted and variations in the response amplitudes and frequencies can be identified.
3. MATLAB / Mathematical codes for obtaining frequency sweep response while varying separately both the dithering frequency as well as the sinusoidal frequency of external excitation.
4. GUI of the code with the identified variables.

RES-IISU-2024-002

Name of ISRO/DOS Centre/Unit
ISRO Inertial Systems Unit, Thiruvananthapuram

Title of the research proposal
Direct Time-of-Flight sensor based System-on-chip LiDAR

Area of Research
Optoelectronics, microelectronics, optics

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Ms. Nisha S Dathan

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit
nisha_dathan@vssc.gov.in

Summary of the Proposed Research

Laser Image detection and ranging systems (LiDAR) are increasing being used for many applications like 3D imaging as in robotics, as well as for ranging for navigation for Unmanned Aerial Vehicles, including building elevation maps of the terrain for pin-point landing. LiDAR based on high sensitive SPAD detectors with scalability for 3D integration are presently the state-of-art technology being pursued by leading manufacturers. It is proposed to study and implement a System-on-chip Direct Time-of-flight LiDAR sensor design based on SPAD detector which can meet the required specifications after chip scale fabrication. The major challenges in design for a ranging system with respect to the trade-off between maximum range and depth resolution while maintaining a low power dissipation, chip size, low cost and complexity are proposed to be explored in this research. The development should be complete with demonstration of customized time-of -flight ranging hardware cum processing.

Scope of the work:

- Study of sensor architectures for System-on-chip Direct Time-of-flight LiDAR.
- Design of ToF technique based System-on-a-chip LiDAR system with scalable range, high resolution and fast readout rate. Conformance of design specifications through simulations.
- Chip design and tape out of Time-of-flight pixel.
- Design and realization of Test jig with time-of -flight ranging hardware interfaces and necessary processing. Testing and evaluation of Time-of-flight pixel.

- Development & characterization of LiDAR subsystems including optics.
- LiDAR system integration & demonstration.

Linkages to Space Programme:

- The project has linkages with Vertical and Horizontal Landing applications of ISRO Launch Vehicles as well as for Humanoid/robotics applications for navigation and collision avoidance.

Expected Deliverables:

1. A high depth resolution Direct Time-of-flight based CMOS image sensor based System-on-Chip.
2. A LiDAR system with LASER transmitter, optics, and CMOS image sensor.
3. A characterization board for CMOS image sensor testing.
4. Lab setups to perform critical measurement for Time-of-flight sensor.

INDIAN INSTITUTE OF REMOTE SENSING

DEHRADUN

RES-IIRS-2024-001

Name of ISRO/DOS Centre/Unit

Indian Institute of Remote Sensing, Dehradun

Title of the research proposal

Design and Development of Astro agriculture system for crop monitoring

Area of Research

Human Space Program/In Orbit science

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. Ashutosh Kumar Jha

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

akjha@iirs.gov.in

Summary of the Proposed Research

The focus of this project is to closely monitor the health and growth of edible, high, reproducible plants in the space environment. A prototype of a close vegetation module that can support robust root and shoot systems for plant cultivation in space should be built. Studying plant growth in a controlled environment will establish the astro culture system, practices and protocols for ensuring a sustainable food supply during extended space missions. The proposal research is to gain insights into the optimal environmental conditions affecting its growth in a space environment and how crop growth is affected.

Objective:

Design and construct an automated plant growth system to produce crops under a space environment with monitoring systems for various physiological parameters. The system should produce data sets with input and output to establish the relationship between different environmental factors and plant health indicators. The closed environmental system should offer continuous monitoring capabilities using sensors to analyze factors such as atmospheric composition, Photosynthetically Active Radiation (PAR), and the chemical composition of the delivered nutrients for measuring biomass growth, photosynthetic efficiency, and producing crop quality assessment.

Develop a plant growth module that includes the following:

- Reliable root/shoot zones with moisture and nutrient delivery control system for microgravity-environment
- An illuminating system with adjustable lighting conditions and schedule to deliver UV-VIS-NIR radiation (300-800nm).
- An atmosphere management system capable of controlling temperature and humidity, especially under conditions of low gravity and elevated carbon dioxide and oxygen concentrations.
- Process control and 3D observation unit for plant growth monitoring, as well as periodic data recording with integrated hyperspectral and depth cameras.

Scope of the work:

- The hardware design should include both on-ground/in-space. The in-space design should be gravity agnostic as much as possible and capable of handling various inflight shocks and deployment. The deliverable should minimally be an on-ground system with real-time demonstration based on the off-the-shelf sensor components with an Indigenous software interface. It can also include nutrients, seeds, and growing instruction kits with system parameters and optimized protocol for various crop produce, which can be grown inside the chamber.

Linkages to Space Programme:

- Space Science Programme.

Expected Deliverables:

1. An on-ground system with environmental control and a portable plant growth chamber with build of material.
2. Document and published papers regarding the above design.
3. Software system interfaces with Imaging and quality analysis of plant status using different analytical techniques.
4. Various hardware and software interface details are used for operating the system.

NATIONAL ATMOSPHERIC RESEARCH LABORATORY

GADANKI

RES-NARL-2024-001

Name of ISRO/DOS Centre/Unit

National Atmospheric Research Laboratory, Gadanki

Title of the research proposal

Development of merged integrated water vapor product using AI/ML techniques

Area of Research

Generation of improved integrated water vapor product using navigation signals and INSAT data

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Dr. T. Narayana Rao

Ms. Gayatri Vijayan

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

tnrao@narl.gov.in

gayatri@narl.gov.in

Summary of the Proposed Research

The Global Navigational Satellite System (GNSS) technology has now become an integral part of our modern-day society and found pervasive uses in civil, industrial, scientific and military areas. These signals of opportunity are being extensively used for a variety of operational and scientific applications, including land surveying, geodetic applications, precise orbit determination of satellites, atmospheric sensing, etc. As GNSS signals are affected by their passage through the ionosphere and the lower atmosphere, the received signals at the receiver (on the ground or low-earth orbiting satellite) can be used for atmospheric sensing. For ex., to map integrated water vapor (IWV), an essential meteorological parameter for all weather systems.

INSAT 3D provides several atmospheric parameters, including integrated water vapor (IWV). However, these measurements are limited to clear sky conditions, leaving big data gaps during disturbed weather conditions. Also, the quality of INSAT 3D-derived IWV is always remained as an issue. In this regard, GNSS-derived IWV becomes handy in filling the gaps and correcting the INSAT-derived IWV.

Scope of the work:

Recently, Survey of India has established a countrywide network of GNSS receivers (>1000 units) for positioning applications. The IWV obtained from GNSS receivers is regarded as highly accurate and are of climate quality. This data will be extremely useful for filling the gaps in INSAT-derived IWV maps and correcting IWV.

AI/ML techniques are becoming popular in geoscience applications. It is proposed to use AI/ML techniques to merge highly accurate GNSS receiver-derived IWV with INSAT-derived IWV to generate high-quality IWV product.

Linkages to Space Programme:

- This study has direct relevance to INSAT-3D/3DR data products and applications. IWV is one of the operational derived products, presently having large data gaps during disturbed weather conditions and relatively in accurate at shorter temporal scales. Present study aims to improve this product at all time scales.

Expected Deliverables:

1. Improved merged (INSAT-GNSS) integrated water vapor map over India.
2. Improved numerical weather forecast, particularly storms.
3. AI/ML-based nowcasting algorithms.

RES-NARL-2024-002

Name of ISRO/DOS Centre/Unit

National Atmospheric Research Laboratory, Gadanki

Title of the research proposal

Estimating the efficacy of turbulence on droplet size growth during the onset of precipitation.

Area of Research

Cloud microphysics, Atmospheric Science

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Dr. T. Narayana Rao

Dr. Amit Kumar Patra

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

tnrao@narl.gov.in

akpatra@narl.gov.in

Summary of the Proposed Research

The interaction between aerosols, clouds, and precipitation continues to represent the most significant source of uncertainty in our weather and climate prediction models. A key factor contributing to this uncertainty is our limited understanding of the rapid growth of cloud droplets during the onset of rainfall. The rain formation process plays a crucial role in cloud dynamics and lifespan, subsequently influencing radiative forcing, the hydrological cycle, and precipitation intensity. Cloud droplets grow via condensation and can typically reach the size of 10 μm. For rain formation, a significant fraction of cloud droplets must reach a size 100 μm for gravity to initiate a runaway droplet growth via collision and coalescence. However, the underlying mechanism by which cloud droplet growth transitions from a condensation-dominated growth regime to a gravity-induced collision and coalescence growth regime is still poorly understood. Turbulence in clouds is believed to play a critical role in this process.

Therefore, it is important to understand the role of turbulence on droplet size growth in a laboratory-controlled cloud-like setting. Various optical diagnostic measurement techniques, such as particle tracking velocimetry (PTV) and interferometric laser imaging for droplet sizing (ILIDS) should be used to obtain the interaction between droplets and turbulence.

Scope of the work:

Quantifying the indirect effects of clouds on global temperature presents a significant challenge in climate models. The accuracy of these models is highly dependent on the inclusion of various physical processes associated with clouds. Weather and climate simulations utilize parameterized models to represent microphysical interactions within clouds. These models are obtained through theoretical and empirical estimates developed based on the underlying physics. Rain formation is typically modeled through equations governing droplet collision and coalescence rates, with system parameters integrated into the collision kernels.

The proposed study unravels the underlying physics and processes related to droplet size growth, which can be used to develop of more accurate collision kernels. Furthermore, a deeper understanding of microphysical processes will enhance our ability to predict the timing, location, and intensity of precipitation.

Linkages to Space Programme:

- Understanding the cloud microphysics will help develop better and more accurate weather and climate prediction models. Improved forecast is required at various stages of vehicle launching, fuel filling and other preparation activities.

Expected Deliverables:

1. Understanding the role of turbulence on droplet size growth and comprehending the parameters associated.
2. Comprehending the underlying mechanism associated with droplet size growth.
3. Develop parameterized collision kernels which can be used in estimating droplet collision and coalescence rate in weather and climate simulations.

NORTH EASTERN SPACE APPLICATIONS CENTRE

SHILLONG

RES-NESAC-2024-001

Name of ISRO/DOS Centre/Unit

North Eastern Space Applications Centre, Shillong

Title of the research proposal

IRS Assisted Drones based Communication for Remote Area Connectivity.

Area of Research

Communication, sensors

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. Chirag Gupta

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

chirag.gupta@nesac.gov.in

Summary of the Proposed Research

Intelligent Reflecting Surfaces (IRS) is an emerging technology with a wide range of potential applications across various fields such as wireless communication, 6G and beyond networks, Internet of Things (IoT), Indoor communication, Vehicular communication, Aerial & Satellite communication and smart grid and energy management etc. IRS are programmable surfaces that can reflect and manipulate electromagnetic waves to improve wireless communication especially in remote or Non-Line of Sight (NLoS) regions. By adjusting the phase shifts of the reflected signals, IRS can direct signals towards specific receivers, enhancing signal strength and coverage. IRS combined with drones offer a promising solution for enhancing communication in remote areas by improving NLoS issues. Drones can be deployed as mobile base stations or relays in remote or hard-to-reach areas. They can establish line-of-sight (LoS) communication links, improving connectivity where traditional infrastructure is lacking.

Scope of the work:

The scope of IRS-based remote area communication using drones is broad and impactful, addressing several critical challenges in providing reliable connectivity to underserved or hard-to-reach regions in North Eastern Region (NER). The major scope of the proposed research are as mentioned below:

- **Extending Connectivity to Remote and Rural Areas:** Enhanced signal Coverage using mobile platform. Drone based IRS offers a cost-effective alternative to deploying new base stations or satellite ground stations.
- **Disaster Recovery and Emergency Communication:** In the aftermath of natural disasters, when conventional communication infrastructure is damaged, IRS can be quickly deployed using drones to restore communication links. IRS can also enhance the reliability of communication systems in disaster-prone areas by providing backup signal paths, ensuring that communication remains operational even if primary networks are disrupted.

Linkages to Space Programme:

IRS can play a significant role in enhancing various aspects of space programs. The integration of IRS into space-related applications can improve communication, navigation, and data transfer between spacecraft, satellites, and ground stations. IRS technology can be linked to space programs in following ways:

- **Satellite Communication Enhancement:** To improved signal quality, extend coverage, beam forming applications etc.
- **Deep space communication:** For signal boosting, data relays etc.
- **Space-based internet:** To provide enhanced connectivity, inter-satellite communication etc.
- **Space Station and Spacecraft Communication:** IRS can be installed on space stations and spacecrafts for enhanced communication with ground stations, can be used for better resource management etc.
- **Collaborative Space Missions:** Inter-agency communications in space, data sharing etc.
- **Astronomical Observations:** Interference reduction, signal amplification
- **Planetary Exploration:** Can be used for Surface Communication Networks on other planets, to improve signal penetration etc.

Expected Deliverables:

1. A quadcopter/Hexcopter UAV with capability to mount IRS and other interface.
2. Design of IRS prototype suitable for proposed application and its integration with drone and other ground applications.
3. Case studies related to applications of the proposed technology in the field of Remote area communication and Disaster recovery and emergency communication.

RES-NESAC-2024-002

Name of ISRO/DOS Centre/Unit

North Eastern Space Applications Centre, Shillong

Title of the research proposal

Modeling of Total Electron Content (TEC) over the NER Equatorial Ionization Anomaly (EIA) region for navigational applications

Area of Research

Aeronomy, Communication

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Dr. Arup Borgohain

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

arup.borgohain@nesac.gov.in

Summary of the Proposed Research

The Earth's ionosphere reveals multifaceted variabilities with varying spatial and temporal scales. The instigation factors for the ionospheric variabilities are solar activity, neutral dynamics and electrodynamics

and Geomagnetic conditions. The solar activity, which varies with the 11-year solar cycle, quasi-27-day rotation of the sun, has direct control on the plasma density in the ionosphere. The ionosphere is also controlled by the solar zenith angle, indicating diurnal, annual and semi-annual variations. Ionospheric day to day variability is pervasive, even under undisturbed geomagnetic and solar conditions. The multiple and complex processes contributing to the variability of the ionospheric plasma density particularly in the equatorial and low latitudes are not yet fully understood.

Following are the proposed objectives:

- To quantify ionospheric variability during quiet and disturbed days using a hybrid approach, combining satellite in-situ and remote sensing data, ground-based remote sensing, and airglow experiments. Ground-based TEC data will be generated by installing NAVIC/GPS receiver and through simulation.
- To predict and forecast TEC with respect to time and space using a hybrid approach involving statistical modeling and machine learning.
- An interactive dashboard or mobile app to be developed for real-time observation of ionospheric TEC in both space and time.

Scope of the work:

Quiet time ionospheric variability is one of the most interesting as well as challenging aspects of current ionospheric research. Mostly, the ionospheric variability initiates from variations of solar activity, fluctuations of geomagnetic activity and perturbations from the lower atmosphere. Even under undisturbed geomagnetic and solar conditions, ionospheric day-to-day variability is omni present i,e, 30% ionospheric variability is yet to be understood. Many of the current theoretical models are capable of reproducing the state of the ionosphere relatively well for specific forcing input parameters and/or boundary conditions, but they fail to reproduce the observed day-to-day variability of the ionosphere in quiet time. A better understanding of causes of the quiet time day-to-day variability is essential for improving the accuracy of physics-based models of the ionosphere. It is challenging mainly in two ways; (1) the lack of daily global observations, and (2) the complex nature of day-to-day variability resulting from various driving forces. While space-based observations have an important role in providing continuous measurements when ground-based observations are not available, the spatial and/or temporal coverages are often insufficient. On the other hand, continuous global measurements of the ionosphere are essential to comprehend varying influences of different types of the external forcing on the day-to-day variability. A large number of satellites have provided plasma density measurements in Earth's topside ionosphere. To utilize all of the collected observations for empirical modelling, it is necessary to ensure that they exhibit systematic behaviour. The aim of the present work is to study the quiet time (Kp<2) day-to-day variability of ionospheric electron density data from several missions collected over the past 20 years. This is a necessary step to help future empirical modelling and data assimilation efforts. Most of the studies which have done earlier used only a single pair of instruments or observational techniques for comparisons, while in this study, we propose to use data from five different satellite missions with different operational principles.

Linkages to Space Programme:

- The proposed work (observation/model) will complement ISRO's ongoing NavIC/IRNSS observational program. The proposed network of ground stations will generate simultaneous and additional data to supplement other IRNSS/NavIC data.

- It will help reduce the uncertainty in positioning using the current Indian satellite navigation systems.
- The data can also be used to validate the results obtained in upcoming DISHA Mission.
- This dataset may be used in exploring new dimensions of earthquake precursor studies.

Expected Deliverables:

1. The project outcomes, including the datasets generated, will be made available for further use by the scientific community and policymakers.
2. Based on the project outcomes, numerical simulations will be performed to forecast the ionospheric environment.
3. The project will promote: (i) engaging the younger generation in using modern techniques and machine learning in space weather studies, and (ii) utilizing long-term data for the development of numerical models.
4. The project outcomes will help to understand the missing drivers of ionospheric variability in the low-equatorial region, potentially improving communication for space-based payloads.

RES-NESAC-2024-003

Name of ISRO/DOS Centre/Unit

North Eastern Space Applications Centre, Shillong

Title of the research proposal

Developing efficient methods for real-time integration and interaction of drone-derived 3D point cloud data into virtual and augmented reality environments.

Area of Research

Virtual Reality, Immersive 3D Data Exploration and Analysis

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. PS Singh

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

ss.puyam@nesac.gov.in

Summary of the Proposed Research

The integration of virtual and augmented reality (VR/AR) with 3D point clouds from drone imagery will be an innovative opportunity for immersive visualization but also faces significant challenges. The primary problem lies in efficiently utilizing large-scale drone-derived point cloud data within VR/AR environments for real-time, interactive exploration. One major challenge is the processing and integration of drone imagery, which generates massive amounts of point cloud data. Advanced techniques are required for tasks like registration, noise reduction, and feature extraction to ensure accurate representation of physical environments. In addition, seamless interaction within VR/AR demands both high computational efficiency and low-latency performance. Developing algorithms capable of managing complex point clouds while maintaining real-time responsiveness is essential. Another critical aspect involves visualization and user experience. Effective interaction with drone-derived 3D data requires thoughtful design of user interfaces, navigation mechanisms, and immersive experiences that balance visual fidelity

with intuitive and engaging interactions. Furthermore, different applications, such as urban planning and infrastructure inspection, impose unique requirements, adding complexity to the development of a unified VR/AR framework.

Ensuring that VR/AR solutions for drone-derived point clouds are scalable and accessible across various hardware platforms is vital for widespread adoption. This includes considerations of device compatibility, performance optimization, and ease of use for a diverse range of users. Addressing these challenges is key to realizing the potential of drone-derived point clouds in VR/AR applications.

Scope of the work:

The scope of this proposed research focuses on developing robust methods to integrate and interact with 3D point clouds derived from drone imagery within virtual and augmented reality (VR/AR) environments. This involves addressing the challenges associated with processing large volumes of point cloud data, including efficient data registration, noise reduction, and feature extraction techniques that ensure an accurate and high-fidelity representation of the physical world.

A significant aspect of the research will explore real-time rendering and interaction, focusing on optimizing computational performance to handle complex datasets while minimizing latency. This will involve the development of algorithms and rendering pipelines that enable users to seamlessly interact with high-resolution 3D point clouds in VR/AR, ensuring both responsiveness and visual quality.

The study will also examine user interface design and navigation strategies, ensuring that the visualization of drone-derived point clouds in VR/AR is intuitive and immersive. Application-specific requirements, such as those needed for urban planning, infrastructure inspection, or cultural heritage preservation, will be considered to create flexible solutions adaptable to different use cases.

The research will address the scalability and accessibility of the proposed VR/AR solutions, ensuring compatibility across diverse hardware platforms and making these tools widely usable for various stakeholders.

Linkages to Space Programme:

- This research aligns with ISRO's ongoing and future activities, particularly in remote sensing, urban planning, and disaster management. By integrating drone-derived 3D point clouds into VR/AR environments, the research supports ISRO’s efforts in geospatial immersive data visualization, allowing for more immersive and interactive analysis of drone imagery.
- The outcomes of this research will enhance applications like infrastructure monitoring, land use mapping, and cultural heritage preservation, directly supporting ISRO's projects related to urban planning, environmental management, and disaster response. Furthermore, the focus on scalability and accessibility ensures that these solutions can be integrated into existing platforms, such as the NESAC/NeSDR portal, making high-fidelity, real-time 3D visualization more accessible to stakeholders across various sectors. This synergy between VR/AR advancements and ISRO/DOS’s geospatial initiatives will drive more efficient decision-making processes and improved spatial data interaction.

Expected Deliverables:

1. Advanced Data Processing Techniques: Development of algorithms for efficient registration, noise reduction, and feature extraction from drone-derived point clouds, ensuring accurate and high-fidelity 3D representations.

2. Real-Time Rendering and Interaction Framework: A robust VR/AR platform optimized for low-latency, high-performance interaction with complex 3D point cloud data.
3. Immersive Visualization Solutions: Design of intuitive user interfaces and navigation mechanisms for seamless interaction with 3D point clouds in VR/AR environments, providing a balance between visual fidelity and user engagement.
4. Application-Specific VR/AR Solutions: Tailored VR/AR frameworks adaptable to various ISRO-related use cases, such as urban planning, infrastructure inspection, and disaster management.
5. Scalable and Accessible Systems: A scalable and platform-independent VR/AR solution that is compatible with various hardware, ensuring broad accessibility for different stakeholders and integration with ISRO's geospatial initiatives.

ISRO TELEMETRY TRACKING AND COMMAND NETWORK

BENGALURU

RES-ISTRAC-2024-001

Name of ISRO/DOS Centre/Unit

ISRO Telemetry Tracking and Command Network, Bengaluru

Title of the research proposal

Expert System for Orbit Determination of Space Object

Area of Research

Navigation

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Dr. P D Mishra

Mr. Amit Kumar Singh

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

pdmishra@istrac.gov.in

amit@istrac.gov.in

Summary of the Proposed Research

Orbit determination is a critical part of mission operations and planning for deep space mission. Presently orbit determination techniques involve data from radio tracking, optical observations, and complex orbital mechanics calculations. While these methods are very efficient, they face significant challenges as missions explore more distant and complex environments. The primary challenges include the limitations of ground-based observations due to signal attenuation, time delays, and the need for continuous communication with the spacecraft.

Data driven, AI and machine learning techniques shows promising solutions to address these challenges. These techniques provides the capability to analyse vast amounts of data in real-time, recognize patterns, and make predictions with high accuracy. Recent advancements in AI have shown potential in various aerospace applications, including trajectory optimization, anomaly detection, and autonomous navigation. Especially research in the area of Physics informed neural network has shown its applicability in the area prediction and estimation of complex physical sequences. This research aims to harness the power of AI to develop a next-generation orbit determination system that enhances the performance of deep space missions.

Scope of the work:

1. Develop AI algorithms for orbit determination: Design and implement machine learning models that can process spacecraft telemetry data, ground-based observations, and other relevant inputs to determine the spacecraft's orbit with high precision.
2. Integrate AI with traditional orbit determination techniques: Combine AI-based models with existing methods to create a hybrid system that improves accuracy and robustness in various mission scenarios.

3. Enhance autonomous navigation capabilities: Enable the spacecraft to make real-time navigation decisions based on AI-generated orbit predictions, reducing the need for continuous ground-based intervention.
4. Validate the AI-aided orbit determination system: Test and validate the proposed system using simulated deep space mission data and compare its performance with traditional methods.

Linkages to Space Programme:

- IRS, Aditya-L1, MARS and CH4 missions

Expected Deliverables:

1. AI-aided orbit determination system

RES-ISTRAC-2024-002

Name of ISRO/DOS Centre/Unit

ISRO Telemetry Tracking and Command Network, Bengaluru

Title of the research proposal

High efficiency dual linear polarized phased antenna array system for X-band application

Area of Research

Phased Array Antennas

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. Manas Sarkar

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

manas_sarkar@istrac.gov.in

Summary of the Proposed Research

Orbit determination is a critical part of mission operations and planning for deep space mission. Phased Array Polarimetric Doppler Weather Radar at X-Band system shall provide weather surveillance and measurement of 3-Dimensional rainfall structure with high spatial–temporal resolution. This system is an Advanced Weather Radar designed with Electronic Beam Steering with rapid scanning techniques on a Rotating Phased Array Antenna bed that shall provide higher measurement speed and flexibility, resulting in reduced volume acquisition times, an easier recognition of short duration weather phenomena, and better adaptation to the signal characteristics of precipitation echoes. The phased array antenna systems proposed here will have the electronic beam steering in elevation direction, whereas the mechanical rotation of continuous azimuth. Thus in a single rotation the complete volume coverage can be completed to meet the requirement of temporal resolution.

Scope of the work:

- Design of dual linear polarized phased array antenna and integrated with its required feeder network.
- Optimization of the array performance to meet the weather radar requirements as follows:
- Frequency: 9.375 GHz
- Bandwidth: 50 MHz

- Return loss: > 20 dB
- Gain: 45 dB
- Sidelobe level: 26 dB or more
- Cross polarization: better than 40 dB in all phi cut

The array to be optimized to reduce total number of elements by incorporating advanced technologies to achieve the required performance mentioned above.

Linkages to Space Programme:

- Phased Doppler Array Weather Radar at X-Band

Expected Deliverables:

1. Complete design and simulation files that can be used for production as per actual system requirement
2. Hardware
3. Prototype antenna array
4. A linear array integrated with feeder network
5. Design report

RES-ISTRAC-2024-003

Name of ISRO/DOS Centre/Unit

ISRO Telemetry Tracking and Command Network, Bengaluru

Title of the research proposal

Collision Avoidance Strategies for Resolution of Multiple Close Conjunctions

Area of Research

Space Object Collision Analysis

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Ms. Bulbul Mukherjee

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

bulbul@istrac.gov.in

Summary of the Proposed Research

The risk of collision between two objects is usually quantified in terms of the minimum separation between two objects (the miss distance) and probability of collision (Pc). Computation of the latter requires integrating the probability density function that models the positional uncertainty of the objects over a 3D volume.

Most of the current literature addresses collision avoidance for satellites belonging to a cluster or a constellation. The studies reveal that the burn epoch or the lead time also another parameter that plays a significant role.

Currently resolving conjunction risks requires significant operator intervention as the final decision is based on human experience and expertise.

As of now, multiple critical conjunctions/close approaches within a short time period (a few hours) happen rarely for an operational satellite, hence, most of the prevailing collision avoidance strategies address mitigating the collision risks between one pair of objects (the primary and the secondary) at a time. However, the future scenario will call for multiple conjunction risks to be mitigated and it also needs to be ensured that resolving one critical conjunction would not lead to worsening situation for the others.

Furthermore, the optimal solution for maximizing miss distance and/or minimizing probability of collision requires firing in a direction not necessarily aligned with that of the thruster.

In practice, the CAM execution epoch is dictated by both operational (visibility for command upload) and other on-board constraints (thrust direction, maximum firing duration/ maximum delta-v, minimum impulse deliverable) which add to complexities.

Hence, ample scope remains for finding the apt strategy for mitigating multiple conjunction risks which can find more practical and widespread implementation.

Scope of the work:

The scope of the proposed research will be to address problem of finding optimal delta-v and the direction of firing for CAM that would ensure minimal probability of collision/maximum miss distance as a solution to multivariate optimisation problem.

A second goal will be to find sub-optimal solutions which are simpler and are less expensive in terms of processing time and memory.

Linkages to Space Programme:

- SSA

Expected Deliverables:

1. Algorithms to estimate optimal delta-v and its vector for the in case of multiple conjunction scenarios.
2. Computation and memory efficient algorithms for sub-optimal solution of delta-v and its vector.

RES-ISTRAC-2024-004

Name of ISRO/DOS Centre/Unit

ISRO Telemetry Tracking and Command Network, Bengaluru

Title of the research proposal

AI-based embedded system for Spacecraft health monitoring

Area of Research

Optimization of AI Model to for efficient performance with limited compute resource

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. Amit Kumar Singh

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

amit@istrac.gov.in

Summary of the Proposed Research

Space missions rely heavily on real-time telemetry data to monitor the health and performance of spacecraft. Given the complexity and criticality of these missions, any anomaly in the telemetry data can have significant consequences, potentially jeopardizing mission success. Traditional methods for anomaly detection often require extensive ground-based analysis, which may not be feasible in deep space missions due to communication delays and limited bandwidth. Also, in Human space mission where decision has to be made in short time, AI tools will aid the Astronaut to analyse and make relevant interferences from on-board telemetry data.

Additionally, the computational resources available onboard spacecraft are limited, posing challenges in deploying advanced anomaly detection algorithms. Therefore, there is a pressing need to develop an AI model that can efficiently monitor telemetry data, detect anomalies in real-time, and operate within the stringent constraints of onboard computational resources.

Research Description: At present multiple AI models have been trained and deployed for anomaly detection at ground. This model performance is satisfactory for the realtime environment but these models are compute intensive.

This research aims to optimize an AI model for onboard telemetry monitoring that uses machine learning (ML) and deep learning (DL) algorithms. The model will be specifically designed to meet the space and time complexity constraints dictated by the limited computational resources available onboard spacecraft.

Scope of the work:

The research will involve the following key steps:

1. Data Collection and Preprocessing:
    - telemetry data from previous missions, focusing on identifying patterns that indicate normal and anomalous behavior.
    - Simulate telemetry data for potential future missions to ensure comprehensive model training.
2. Model Development:
    - Develop ML and DL models optimized for anomaly detection, with a focus on reducing computational complexity while maintaining high detection accuracy.
    - Implement techniques such as model pruning, quantization, and knowledge distillation to reduce the model's memory footprint and computational requirements.
3. Resource-Constrained Optimization:
    - Optimize the model to operate within the constraints of onboard computational resources, including memory, processing power, and available time for real-time operations.
    - Ensure the model can process telemetry data in real-time or near-real-time, enabling prompt detection of anomalies.
    - API based status extraction
4. Validation and Testing:
    - Validate the model's performance using both historical and simulated telemetry data, assessing its accuracy, efficiency, and ability to operate within the given constraints.

- Conduct rigorous testing to ensure the model's robustness and reliability in various mission scenarios.

5. Integration and Deployment:
   - Integrate the final model into an embedded package suitable for deployment on spacecraft.
   - Ensure the model is compatible with existing spacecraft systems and can be easily updated or modified for different missions.

Linkages to Space Programme:

- All ISRO missions, Specially for Human Space program

Expected Deliverables:

1. Codes:
   - Complete source code of the developed AI model, including all ML and DL algorithms used for anomaly detection.
   - Optimized code suitable for deployment on spacecraft with constrained computational resources.
2. Final Embedded Package Onboard:
   - An embedded package containing the AI model, ready for integration and deployment on spacecraft.
   - Documentation detailing the integration process, system requirements, and configuration instructions.
3. Full Documentation:
   - Comprehensive documentation covering all aspects of the research, including model design, development process, optimization techniques, and testing results.
   - User manual and technical documentation for the embedded package, including troubleshooting guides and update procedures.

This research will contribute to the development of more autonomous and resilient spacecraft, capable of monitoring their own telemetry data and detecting anomalies in real-time, thereby enhancing the safety and success of space missions.

RES-ISTRAC-2024-005

Name of ISRO/DOS Centre/Unit

ISRO Telemetry Tracking and Command Network, Bengaluru

Title of the research proposal

Design and development of multipath mitigation techniques and algorithm using advanced Correlators in baseband signal processing

Area of Research

Navigation

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Ms. Neelu Kasat

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

neelurathi@istrac.gov.in

Summary of the Proposed Research

The proposal is to mitigate the impact of multipath due to high rise buildings, vegetation, etc on the reception of real time NavIC signals.

Multipath effect can be dealt at antenna level, signal design level, baseband signal processing and at navigation data processing. The proposal is to design and develop advanced correlator technologies in order to detect multipath signals and mitigate the impact so that the receiver doesn't lose the lock even in high multipath area.

Scope of the work:

The scope of this proposed research is to deal with the multipath effect at baseband signal processing.

Methods like double delta correlator, vision correlator, CADLL (coupled amplitude delay locking loop) based on signal parameter estimation can be explored.

A better or improved version of correlator technology can be proposed as a solution.

The prime objective is the required algorithm and hardware development for the NavIC receivers so that loss of lock and errors in pseudo range measurements for NavIC L1, L5 and S band signals is minimized.

Linkages to Space Programme:

- The successful research will help in continuous NavIC signal reception in urban canyons and will have societal benefits.

Expected Deliverables:

1. Successful realization of multipath mitigation algorithm with hardware solution.

RES-ISTRAC-2024-006

Name of ISRO/DOS Centre/Unit

ISRO Telemetry Tracking and Command Network, Bengaluru

Title of the research proposal

Attitude Determination and Visualization of an Uncontrolled Spacecraft

Area of Research

Spacecraft Operation

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. Bijoy Kumar Dai

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

bijoy@istrac.gov.in

Summary of the Proposed Research

The attitude determination of uncontrolled spacecraft is a critical challenge; especially when traditional control mechanisms are non-functional or unavailable. Accurate 3D visualization of spacecraft attitude

is essential for mission control to evaluate the spacecraft's orientation and initiate necessary corrective actions. This project proposes the development of an AI-enabled 3D attitude determination & visualization system for uncontrolled spacecraft using data from onboard magnetometers and a 4PI sensor.

The system will employ advanced AI techniques to process sensor data, enabling real-time and continuous 3D determination and visualization of the spacecraft's attitude. The key objectives include developing an AI algorithm to process magnetometer and 4PI sensor data; determine the attitude and implementing a 3D visualization tool to display the spacecraft's orientation in real-time, Validating the system with historical data, and optimizing it for real-time performance. This approach aims to enhance mission control's ability to monitor uncontrolled spacecraft effectively, providing a significant improvement over traditional attitude determination methods. The final outcome will be a comprehensive, validated, and optimized AI-based system that enhances the real-time monitoring and management of uncontrolled spacecraft, contributing to the safety and success of space missions.

Scope of the work:

The scope of this research includes the development, implementation, and validation of an AI-enabled 3D attitude visualization system for uncontrolled spacecraft. The research will focus on several key areas:

1. AI Algorithm Development: Designing and training an AI model capable of processing data from onboard magnetometers and the 4PI sensor to accurately estimate the spacecraft's attitude in real-time.
2. 3D Visualization Tool: Developing a 3D visualization module using advanced platforms. This tool will provide a real-time graphical representation of the spacecraft's orientation, allowing for continuous monitoring by mission control.
3. Data Integration and Real-Time Processing: Optimizing the integration of sensor data and AI outputs into the visualization tool for real-time performance, Ensuring accurate and responsive attitude determination under various conditions.
4. Testing and Validation: Rigorously testing the system using historical data from uncontrolled spacecraft to assess its accuracy, reliability, and performance compared to traditional methods.

The research will significantly enhance mission control's capabilities in managing uncontrolled spacecraft, ensuring safety and efficiency in space missions.

Linkages to Space Programme:

- Determining the attitude of an uncontrolled spacecraft remains a significant challenge. The existing magnetometer-based attitude determination program fails to converge when the spacecraft experiences rotational rates, leaving the attitude unknown. However, with advancements in AI, there is potential to train models using simulated data that account for various rotational rates. By analyzing the variations in spacecraft attitude and magnetometer readings under different conditions, we can develop a model that maps the spacecraft's attitude using only magnetometer readings during eclipse and a combination of magnetometer and 4PI sensor data when the spacecraft is in sunlight. This approach would greatly enhance the ability to stabilize the spacecraft during loss-of-lock operations.

Expected Deliverables:

1. Software Package: Development of a software package capable of processing real-time magnetometer data to determine the spacecraft attitude for Sun-Synchronous Polar Orbit (SSPO) and inclined LEO satellites.
    - Model Update Functionality: The software will include the ability to update the attitude determination model with the latest magnetometer and 4PI sensor data.
    - Validation: The software will be validated against historical test cases using actual Spacecraft data to ensure its accuracy and reliability.
    - External Spacecraft Model Integration: The software will be designed to accept spacecraft models in a predefined format, allowing external models to be easily integrated.

RES-ISTRAC-2024-007

Name of ISRO/DOS Centre/Unit

ISRO Telemetry Tracking and Command Network, Bengaluru

Title of the research proposal

Development of FPGA-Based CMOS Controller for Real-Time Autonomous Space Object Tracking Using Ground-Based Telescopes

Area of Research

Space Situational Awareness

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. Bikram Pradhan

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

bikram@istrac.gov.in

Summary of the Proposed Research

This project proposes the development of a custom FPGA-based controller for CMOS imaging sensors, designed to track non-sidereal space object space objects in real time. Current CMOS sensors, while comparable to CCDs in terms of sensitivity and format size, offer advantages such as rapid switching between full-frame and Region of Interest (ROI) modes. However, commercially available systems suffer from latency due to software-based reconfiguration, which is unsuitable for applications like Space Situational Awareness (SSA) that require real-time responsiveness to track objects with significant velocities.

The proposed solution aims to overcome this limitation by developing a customized controller that can autonomously detect moving objects, compute their trajectory, and dynamically adjust the sensor's ROI without external intervention. This will be achieved using FPGA-based controllers, enabling high-speed frame rates and real-time adjustments to the ROI position as the object moves. Key capabilities include onboard trajectory calculation, continuous reconfiguration, and automated exposure time adjustment, making it ideal for SSA applications.

Scope of the work:

1. Designing and developing the FPGA-based controller and its firmware.
2. Integrating it with large-format CMOS sensors.
3. Testing the system on ground-based telescopes for real-time space object tracking.
4. Demonstrating high-speed mode switching and ROI control on moving targets.

Linkages to Space Programme:

- Space Situational Awareness
- This camera controller will be tested and deployed on upcoming ISRO's ground-based telescope for space surveillance.

Expected Deliverables:

1. FPGA Based real time controller for CMOS sensors
2. Embedded software for real-time mode switching
3. Model for object detection and trajectory calculation

RES-ISTRAC-2024-008

Name of ISRO/DOS Centre/Unit

ISRO Telemetry Tracking and Command Network, Bengaluru

Title of the research proposal

Development of post processing software for precise positioning using NavIC triple frequency measurements (L1, L5 and S)

Area of Research

Navigation applications

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Ms. Neelu Kasat

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

neelurathi@istrac.gov.in

Summary of the Proposed Research

At present, NavIC L1, L5 and S band signals are available for positioning, navigation and timing services in Indian region.

This research proposal aims for the development of post processing software engine to estimate the precise position of a surveyed location using NavIC RINEX data.

The software shall be able to provide solutions using single point positioning and differential based positioning method.

Scope of the work:

The proposal is for development of post processing software tool, which will take NavIC L1, L5 and S band RINEX measurements as input, apply correction models and use Kalman filter to estimate precise

position of the surveyed location. The software shall be compatible with Windows based OS and Linux based OS.

Here, correction models include orbit and clock ephemeris, antenna calibration models, cycle slip detection and correction, phase wind up models, integer ambiguity resolution, etc.

The software shall be able to provide a solution with well-defined uncertainties from triple frequency RINEX data of variable duration (eg. 1hr/ 3hrs/ 6hrs/ 12hrs/ 24hrs/ 48hrs, etc) collected at a fixed location. The software shall provide two solutions, namely:

- Single point positioning or precise point positioning, and
- Differential NavIC (GNSS) based positioning.

Additional desirable feature is positioning solution from moving rover's data.

Linkages to Space Programme:

- NavIC usage in surveying applications will increase

Expected Deliverables:

1. A software solution with detailed manual to cater the above requirement.

RES-ISTRAC-2024-009

Name of ISRO/DOS Centre/Unit

ISRO Telemetry Tracking and Command Network, Bengaluru

Title of the research proposal

Low Noise Time & Frequency Transfer using optical medium

Area of Research

Frequency Transfer

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. Aman M N

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

aman_naveen@istrac.gov.in

Summary of the Proposed Research

Time and frequency transfer plays a crucial role in the field of Navigation and positioning. This proposal aims to develop a low-noise frequency transfer technology using optical fibers to achieve ultra stable frequency dissemination over long distances. The system is based on high stability and low attenuation of optical signals, using ultra-stable laser sources, advanced modulation and demodulation techniques, and active noise cancellation methods. The developed system shall achieve minimum transfer noise and maintain high frequency stability better than 10-14 @ 1sec over long distances. This technology shall be used for precise NavIC time and frequency transfer applications

Scope of the work:

The scope of this proposal includes the design, development and implementation of a low noise frequency transfer system using optical medium to achieve ultra-stable frequency dissemination

Linkages to Space Programme:

- NavIC Time and Frequency dissemination

Expected Deliverables:

1. Design of the system developed
2. Techniques used for actively canceling noise & demodulation/modulation methods
3. Performance Test Results report validating the specifications

RES-ISTRAC-2024-010

Name of ISRO/DOS Centre/Unit

ISRO Telemetry Tracking and Command Network, Bengaluru

Title of the research proposal

Dual band tracking feed with dichroic mirror for deep space antenna

Area of Research

Antennas and Feeds

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Mr. Manas Sarkar

Mr. Barun Biswas

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

manas_sarkar@istrac.gov.in

barun@istrac.gov.in

Summary of the Proposed Research

The deep space antenna system is operated in multiple frequencies like S, X and Ka band using beam waveguide technology for minimization of loss. The present proposal is to fulfill partial requirement of the deep space antenna system that can be operated in S, X, Ka1 (25.5-27 GHz) & Ka2 (31.8 – 32.3 GHz) band.

Scope of the work:

Design of dichroic mirror and single aperture feed system with TE21 tracking coupler meeting the following specifications.

- Frequency: Ka1 & Ka2
- Polarization: RHCP
- Pattern: Sum & delta
- Port return Loss: 20dB (min)
- Insertion Loss: 0.5dB (max)
- Axial Ratio: 1.5dB(min)

Dichroic Mirror:

- Frequency: Ka1 & Ka2 Pass;
- X (7-8.5 GHz) Reflect at orientation of 45^0

Linkages to Space Programme:

- Ground Station for Deep Space Mission

Expected Deliverables:

1. Complete design and simulation files
2. All the simulation results fulfilling the requirements
3. Design Report

HUMAN SPACE FLIGHT CENTRE

BENGALURU

RES-HSFC-2024-001

Name of ISRO/DOS Centre/Unit

Human Space Flight Centre, Bengaluru

Title of the research proposal

Health monitoring system and alert generation using AI/ML

Area of Research

Space Medicine

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Ms. Pravallika L

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

pravallika-hsfc@isro.gov.in

Summary of the Proposed Research

The proposed research aims to develop an advanced artificial intelligence (AI) system that can effectively monitor and analyse the health of astronauts exposed to the unique and extreme conditions of space. This system should take into consideration the effects of radiation exposure levels, prolonged isolation periods during the mission, loss of communication due to increase in distance from earth, gravity fields (microgravity), and hostile/closed environments. The AI model will be trained to identify potential health risks in real-time, predict long-term effects, and suggest preventive measures as well.

The proposed system should monitor radiation exposure levels and predict the cumulative impact on astronaut health. The model should assess potential radiation-induced conditions such as cancer, cardiovascular diseases, and neurological damage. The proposed system should have the capability to analyse psychological and physiological data to identify the effects of long-term isolation and confinement on mental health. It should monitor stress levels, sleep patterns, and cognitive functions to prevent potential issues like depression and anxiety.

The proposed system should evaluate the effects of the increasing distance from Earth on astronaut health, particularly in terms of separation, medical emergencies, and psychological stress. The model will simulate scenarios to provide rapid decision-making support in case of emergencies. The proposed system should monitor the impact of microgravity on muscle atrophy, bone density loss, and other physiological changes. It should predict the long-term consequences of microgravity on overall health and suggest countermeasures such as exercise routines and nutritional plans. The proposed system should assess the impact of living in a closed environment on physical and mental health, focusing on air quality, life support systems, and interpersonal dynamics. The AI model should provide early warnings for any degradation in environmental conditions or group dynamics.

Scope of the Work:

- Utilize machine learning models trained on historical data and simulations to forecast radiation levels and their biological impact, integrating data from spacecraft sensors and personal dosimeters.

- Implement Pose and sentiment analysis, coupled with physiological data analysis to identify potential mental health issues.
- Develop AI models that simulate Earth-based medical expertise, enabling real-time diagnostics and treatment recommendations based on current health data from astronauts.
- Analyse physiological data through AI models to detect early signs of muscle and bone degradation, recommending personalized countermeasures like exercise regimens or pharmacological interventions.

Linkages to Space Programme:

- It shall be useful for having advanced crew health monitoring systems which can be qualified in missions beyond Gaganyaan and continuous usage in extended mission duration as part of Bharatiya Antariksh Station.

Expected Deliverables:

1. AI-Based Health Monitoring System: A fully functional AI system capable of real-time health monitoring, risk assessment, and decision support for astronauts in space.
2. Predictive Models: Models that can predict long-term health impacts of space radiation, microgravity, isolation, and other factors, with suggestions for countermeasures.
3. Data-Driven Guidelines: Comprehensive guidelines for astronaut health management based on AI-driven insights, applicable to current and future space missions.
4. Collaborative Framework: A framework for collaboration with space agencies, research institutions, and healthcare providers to integrate the AI system into existing astronaut health programs

RES-HSFC-2024-002

Name of ISRO/DOS Centre/Unit
Human Space Flight Centre, Bengaluru

Title of the research proposal
Characterization of multilayer fabric for Extravehicular activity suit

Area of Research
Composite material and structure

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Mr. Ashutosh Kumar

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit
ajha-hsfc@isro.gov.in

Summary of the Proposed Research

To carry out modelling, design and analysis of advanced fabric for Extravehicular Activity (EVA) suits, ensuring the safety, mobility, and durability of astronauts during operations outside the spacecraft. The

fabric must provide thermal protection, pressure integrity, Micrometeoroid and Orbital Debris (MMOD) protection, and radiation protection, while withstanding the harsh environment of space as given below:

Components of the EVA Suit Fabric (but not limited to)

1. Thermal Protection Layer
2. Pressurized Layer
3. MMOD Protection Layer
4. Radiation Protection Layer
5. Comfort and Flexibility Optimization

Material selection based on the above criteria and developing material joining techniques for maintaining optimum flexibility and strength. Thickness of the material shall be optimum such that it can be stitched/ joined and can be used for fabricating the space suit.

Scope of the Work:

1. Selection of different material to meet the following requirements:
    a) Thermal Protection Layer
    b) Pressurized Layer
    c) MMOD Protection Layer
    d) Radiation Protection Layer
    e) Comfort and Flexibility Optimization
2. Identification of material joining technique and its characterization:
    a) Fusing
    b) Sealing
    c) Stitching and weaving pattern
3. 3-D modelling and design of multilayers samples to firm up
    a) Fabric type
    b) Fabric layering
    c) Thickness and GSM
4. Mathematical modelling or validation through standard analytical software's for
    a) Mechanical strength
    b) Thermal and environment insulation
    c) Proof pressure capacity of the suit
    d) Flexibility Optimization

Linkages to Space Programme:

- EVA suit is an essential technology for embarking on extravehicular activities on Bharatiya Antariksh Station. The fabric being the critical aspect of EVA suit, the proposal will help in major technology realisation and validation.

Expected Deliverables:

1. Comprehensive reports detailing the research, design process, including material selection criteria, fabrication technique, weaving technique, joining technique etc. in the form of Preliminary design report
2. Fabrication specifications and manufacturing guideline for producing the new EVA suit fabric.

RES-HSFC-2024-003

Name of ISRO/DOS Centre/Unit
Human Space Flight Centre, Bengaluru

Title of the research proposal
Pharmacological challenges in Space: Stability, Packaging and Dosage form selection

Area of Research
Space Medicine

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Mr. Fenil Shah

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit
fenil-hsfc@isro.gov.in

Summary of the Proposed Research

Crewmembers on spaceflight missions use medications to prevent or treat medical problems associated with space environment and to treat complaints like space motion sickness, sinus congestion, constipation, headache, back pain, cardiac abnormalities, upper respiratory tract infection, musculoskeletal trauma, corneal irritation, insomnia, allergies, etc. It is probable that the effects of medications administered to crewmembers during spaceflight are distinct from those observed on Earth. In some cases, the use of medications without a sufficient understanding of their actual activities may lead to insufficient treatment and may even hinder performance and well-being. The use of pharmaceuticals in the unique environment of spaceflight raises two significant concerns.

The first is that the effects of pharmaceuticals on physiology are influenced by the spaceflight environment. The extent of the physiological systems that are affected by spaceflight and the degree of change that experienced suggest that it is probable to see changes in pharmaceutical action. The likelihood of encountering issues increases when exploration missions lengthen.

The second issue is that medications must have their integrity maintained in order to guarantee that each dose has an appropriate quantity of active compounds and that the amount of drugs that degrade into toxic compounds is kept to a minimum. The mission's length also affects this risk because longer exploratory missions are unlikely to offer opportunities for restocking supplies and will necessitate storing medications for much longer than their normal terrestrial shelf lives.

The stability of drugs reflects the aggregate effect of factors that include product formulation, manufacturing process, storage condition, and environmental exposure on the chemical and physical properties of each drug product. It is very well established that environmental factors like radiation, humidity, oxygen, temperature can facilitate physical and chemical degradation of drugs.

Consequently, pharmaceutical packaging plays a crucial role in maintaining the stability of pharmaceutical products during their anticipated shelf life. It is considered as an essential component of the drug product itself. However, to minimize mass and volume for space missions, repackaging of pharmaceuticals is common practice.

Scope of the Work:

An investigation approach is required to determine the best pharmacological solutions and treatment procedures by effective use of medicine during space travel. Different medicines are available based on mechanisms of action to treat one particular condition. So, it is important to do a selection of medicine based on its mode of action, dosage form, route of administration from available marketed medicines in India for a particular space mission. Another important consideration is to determine the shelf life of flown drugs. Drug manufacturers specify the shelf life, which is represented as an expiration date after which the manufacturer is unable to guarantee the potency and stability of medicines.

The shelf life of a given drug may vary among manufacturers given the intrinsic differences in formulation or inclusion of variable excipients, packaging, or other factors. The scope includes the design and development of a protocol to select and optimize use of different medicines during long-term and short-term space missions. It should ensure that the medications constituting the exploration formulary are safe and effective for the duration of the proposed mission. It involves evaluations of pharmaceutical dosage form stability in simulated space environment like radiation, microgravity, vibration, low oxygen level etc. Also, it should include projected expiration analysis of selected medicines when used on BAS.

The following features can be included:

- Determination of expected self-life of space medicine formulary and estimation of time-dependent failure rates
- Evaluation of chemical and physical stability of medications with respect to spaceflight environment
- Selection of primary and secondary packaging material for space medicines
- Selection of dosage form and route of administration of pharmaceuticals for space exploration

Linkages to Space Programme:

- Crew needs to carry life saving drugs especially during extended mission duration beyond Gaganyaan and during stay in Bharatiya Antariksh station. The stability of drugs over long duration is a key factor that needs to be ensured. This proposal will help in developing required technology for the same.

Expected Deliverables:

1. Development of policy to select available marketed medicines for human space travel.

RES-HSFC-2024-004

Name of ISRO/DOS Centre/Unit

Human Space Flight Centre, Bengaluru

Title of the research proposal

Studies on microgravity effects on the Musculoskeletal System through a 6-Degree Head-Down Tilt Bed Rest Study

Area of Research
Biomedical Research

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Mr. Sunil Kumar

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit
sunil-hsfc@isro.gov.in

Summary of the Proposed Research

This research aims to investigate the effects of prolonged exposure to microgravity on the musculoskeletal system, specifically focusing on bone density loss and muscle atrophy. Using the 6-degree head-down tilt (HDT) bed rest study, which simulates the physiological effects of microgravity on Earth, changes in bone mineral density, muscle mass, and overall musculoskeletal health in human subjects to be analyzed. This study draws upon historical analogue research conducted by various space agencies, such as NASA, ESA, and Roscosmos, where similar bed rest studies revealed significant bone loss and muscle atrophy due to the reduced mechanical loading experienced in microgravity. The research will involve a controlled environment where subjects will undergo prolonged bed rest, with periodic assessments using advanced imaging and biochemical analysis to measure the extent of musculoskeletal degradation. The findings from this study will contribute to the development of effective countermeasures to mitigate the negative effects of long-duration spaceflight on astronauts' health, ensuring their safety and operational efficiency in future space missions.

Scope of the Work:

The scope of this research encompasses a comprehensive investigation into the effects of simulated microgravity on the musculoskeletal system, with an emphasis on bone and muscle health. The study will involve a cohort of healthy volunteers who will participate in a 6-degree HDT bed rest experiment over an extended period. Key areas of focus include quantifying bone mineral density loss using dual-energy X-ray absorptiometry (DEXA) scans, assessing muscle atrophy through magnetic resonance imaging (MRI) and muscle strength tests, and evaluating biochemical markers of bone resorption and muscle degradation. The research shall also explore the efficacy of various countermeasures, such as exercise regimes, nutritional supplements, and pharmacological interventions, in mitigating musculoskeletal degradation. This study will build on previous analogue research findings, providing valuable data that will inform the design of future countermeasures to protect astronauts during long-term space missions, as well as potential applications for Earth-bound patients suffering from conditions that lead to bone and muscle loss.

Linkages to Space Programme:

- Considering prolonged exposure to microgravity has adverse effects on the musculoskeletal system, it is essential to develop potential countermeasures for extended stay in Bhartiya Antriksha Station. This proposal helps in providing required inputs.

Expected Deliverables:

1. Detailed documentation of the experimental findings, including data on bone density loss, muscle atrophy, and biochemical changes, with comparisons to historical studies.

2. Assessment of the effectiveness of different counter-measures tested during the study, such as exercise protocols, nutritional strategies, and potential pharmacological treatments.
3. Recommendations for Spaceflight: Evidence-based guidelines for developing countermeasures to mitigate musculoskeletal degradation in astronauts during long-duration space missions.

RES-HSFC-2024-005

Name of ISRO/DOS Centre/Unit
Human Space Flight Centre, Bengaluru

Title of the research proposal
Predicting Cardiovascular Events through skin blood flow analysis

Area of Research
Biomedical Research

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Mr. Sunil Kumar

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit
sunil-hsfc@isro.gov.in

Summary of the Proposed Research

Determining skin microcirculation involves analyzing the small blood vessels in the skin to assess blood flow and vascular health. This is often done using various techniques, and its relationship with ECG (electrocardiogram) and PPG (photoplethysmography) provides valuable insights into cardiovascular health. When these small vessels are compromised globally, it can lead to inadequate blood flow and oxygen delivery to tissues, including the heart muscle. Thus, monitoring microcirculation helps identify early signs of system breakdown and saves lives by taking appropriate preventive measures.

Studying microcirculation by non-invasive means provides convenient monitoring over time. Laser Doppler flowmetry has previously been employed for medical applications such as disease diagnosis and is a potential tool. However, no studies relate the physiological sequence of cardiovascular system changes with the observed changes in microcirculation. Such studies help establish a solid basis for predicting physiological stress early.

The current proposal focus shall be on collecting data from people subjected to physiological stress, such as physical/emotional stress, correlating with subsequent cardiovascular events. Continuous LDF, ECG, and PPG data need to be acquired from subjects before, during, and after episodes of physiological stress and processed to deduce the relation between the three signals by adopting appropriate signal-processing strategies.

This relation will predict the onset of any potential threat to the cardiovascular system. Once established and validated, an Indigenous skin perfusion imager to be designed, fabricated, tested, and validated, providing more convenient non-contact and whole-field monitoring.

Scope of the Work:

This research shall employ laser Doppler flowmetry (LDF) or similar methods to monitor skin microcirculatory responses, which are precursors to significant cardiovascular variations under

conditions that alter homeostasis. Skin microcirculation will be monitored using an LDF meter along with ECG (electrocardiogram) and PPG (pulse plethysmography), recording subjects undergoing physiological stress conditions such as exercise, emotional shifts, etc. The study aims to find markers from LDF signals that are a precursor to significant shifts in cardiovascular parameters such as blood pressure and cardiac output.

Once established, this research aims to develop a portable LDF imager that can provide non-contact, whole-field solutions to measure variations in skin blood flow, using a combination of principles in optics, electronics, signal/image processing, modeling, and data analysis.

Skin microcirculation assessment has a wide application in healthcare, such as assessment of several systemic diseases. Our group has previously demonstrated the relation of skin microcirculation changes with progression of diseases such as scleroderma and Type 2 diabetes. In addition to predicting the onset of major cardiovascular dysfunctions during induced physiological stress conditions, the proposed study can be extended to several applications such as predicting cardiovascular threats during major treatment events such as hemodialysis.

Linkages to Space Programme:

- The typical measurement using electronic leads for measuring cardiovascular activity is not hazzle free especially in long duration missions beyond Gaganyaan and Bharatiya Antariksh Station. So, this proposal will help in developing a simpler an effective technology through skin blood flow analysis.

Expected Deliverables:

1. Laser Doppler system with cardiovascular health prediction based on skin microcirculation
2. Indigenously developed non-invasive laser Doppler skin perfusion imager

LABORATORY FOR ELECTRO-OPTICS SYSTEMS

BENGALURU

RES-LEOS-2024-001

Name of ISRO/DOS Centre/Unit

Laboratory for Electro-optics Systems, Bengaluru

Title of the research proposal

Studies on antibacterial efficacy assessment for space and terrestrial environments

Area of Research

Thin films coated surface studies

Name of Co-PI (Focal Point) from ISRO Centre/Unit

Dr. Girish M Gouda

Email ID of Co-PI (Focal Point) from ISRO Centre/Unit

girish@leos.gov.in

Summary of the Proposed Research

Antimicrobial coatings are being developed for space applications using various thin film processes. The precise analysis of bacterial colony growth on various coatings is challenging and requires development of advanced tools for microbiological analysis. Traditional methods for counting bacterial colonies on agar plates are often labor-intensive and time-consuming, which involves visually inspecting and counting colonies, can lead to inconsistencies in data, especially when dealing with large samples or when precise colony counts are critical for subsequent analysis. To address these issues, an artificial intelligence (AI) enhanced automated bacterial colony counter with integrated UV activation, need to be designed and fabricated to provide a precise and efficient means of assessing the antibacterial efficacy of various materials. Automation in testing can significantly reduce the work in laboratories, minimize human error, and ensure consistent results across different experiments. AI and machine learning (ML) can further refine the process by enabling the software to learn from and adapt to varying colony morphologies and conditions. This adaptability is essential in complex environments where colonies may overlap, vary in size, or be difficult to distinguish from other artifacts on the agar plate. The integration of UV activation can sterilize the device before and after testing the sample also it can be used as a material activation chamber in case of testing metal oxides.

Scope of the work:

- To develop a device that automates counting bacterial colonies on agar plates.
- Enhance the accuracy and efficiency of colony detection and counting through the application of AI and ML algorithms.
- Integrate UV source into the device to activate the antibacterial properties of materials and to sterilize the device to get a precise assessment of their effectiveness.
- Enable the device to calculate the antibacterial percentage of materials by comparing colony counts from treated and control samples, providing an accurate measure of antibacterial efficacy.

- Ensuring Compatibility and Adaptability of the device for Space environment for conducting research on microbial growth and to ensure hygiene inside spacecraft.

Linkages to Space Programme:

- The outcome of this project has direct linkages with AI-enhanced automated bacterial colony counter useful in space applications. It can be used for microbiological studies in space, such as monitoring microbial growth on long-duration space missions, assessing the effectiveness of antibacterial materials in extraterrestrial environments, and conducting experiments on microbial behavior in space to provide valuable data for both scientific research and the maintenance of spacecraft hygiene. This outcome is directly related to Gaganayaan: Human Space mission, Bharatiya Antariksha Station (BAS) experiments

Expected Deliverables:

1. Testing the antimicrobial coatings developed by LEOS-ISRO.
2. Demonstration of automated bacterial colony counter with UV activation for precise antibacterial efficacy assessment.

Annexure-1
Declaration Form

Terms and Conditions of ISRO Research Grants

1. The approved funds should be utilized solely for the purpose for which they have been granted unless ISRO agrees otherwise. A Certification that the funds have been so used should be produced by the grantee Institution after the end of each year of the support.
2. Due acknowledgement to ISRO should be made in all reports and publications arising out of the part of the work supported by ISRO. The grantee will take prior permission of ISRO before publishing any work based on the ISRO supported project.
3. Two copies of all the publications resulting from the research conducted with the aid of the grant should be submitted to ISRO.
4. Any intellectual property rights or such information/knowledge being able to sustain or create or any such right arising out of the projects sponsored by ISRO will be held jointly by the Academic Institution/R & D institution and ISRO as per RESPOND norms. Academic Institute/R & D institution and ISRO shall inform each other before filing for any protection of any Intellectual Property Rights resulting from any of the project sponsored by ISRO. Academic institute/ R & D institution and ISRO will ensure appropriate protection of Intellectual Property Rights generated from cooperation, consistent with laws, rules and regulations of India. The expenses for filling the Patent protection in India and abroad shall be borne equally between Institute and ISRO. Any/all financial accruals due to any commercial exploitation, of this patent shall be shared equally between them, on 50:50 basis. However any of the parties is free to utilize the IPR for their own use on non commercial basis.
5. The principal Investigator is required to submit two copies of yearly reports indicating the progress of the work accomplished. He is also required to submit two copies of a detailed technical report on the results of the research/development after the completion of the project. The reports will become the property of ISRO.
6. In addition, ISRO may designate Scientists/specialists to visit the Institution periodically for reviewing the progress of the work.
7. An inventory of items purchased from ISRO funds should be sent to ISRO, giving the description of equipment, cost in rupees, date of purchase and name of the supplier along with a purchase certificate from the Administration of the Institution. All items of equipments and unconsumable items costing more than Rs. 5,000/- shall remain the property of ISRO and ISRO reserves the right to transfer them or dispose of them on the termination of the project as ISRO may deem fit.
8. The accounts of the expenses incurred out of ISRO funds should be properly maintained and should be authenticated by an approved auditor. The final accounts statement in duplicate duly audit should be sent to the pay & Accounts Officer, DOS/Senior Accounts Officer, ISRO Headquarters, as the case may be, at the end of each financial year of support.

9. If the total amount sanctioned is not spent during the period of support, the remainder amount should be surrendered to the Pay & Accounts Officer, ISRO Headquarters, as the case may be, within one month after the completion of the project.
10. The assets acquired wholly or substantially out of the ISRO grant should not, without its prior sanction, be disposed off, encumbered or utilized for purposes other than that for which the grant is sanctioned.
11. A register of assets permanent and semi-permanent should be maintained by the grantee Institution, which should be available for scrutiny by Audit.
12. The grantee institution should not divert the grants-in-aid for utilization of the same for similar objects of another institution if it is not in a position to execute or complete the assignment. The entire amount of the grant should then be immediately refunded to ISRO by the institution.
13. The terms and condition of ISRO research grants are subject to change from time to time, but the funding of any project will be governed by the terms and conditions existing on the date of starting of the project with ISRO funds.

Declaration

I / We have clearly read the above terms and conditions and hereby agree to abide by the rules and regulations of ISRO research grants and accept to be governed by all the terms and conditions laid down for this purpose.

I / We certify that I / We have not received any grant-in-aid for the same purpose from any other Department of the Central Government / State Government / Public Sector Enterprise during the period to which the grant relates.

	Signature & Name	**Designation**
Principal Investigator		
Head of the Department / Area		
Head of the Institution (Seal of the Institution is required)		

Annexure-2

RESPOND COORDINATORS OF ISRO/DOS CENTRES

Sl. No	ISRO/ DOS Centre	Name & Designation	Contact details
1.	VSSC	Shri Santhosh Kumar S, Scientist/Engineer RESPOND Coordinator Programme Planning & Evaluation Group Vikram Sarabhai Space Centre (VSSC) ISRO PO Thiruvananthapuram : 695 022	Tel Phone No: 0471-2564620 Email: s_santhoshkumar@vssc.gov.in
2.	SAC	Dr. Abha Chhabra Head, RESPOND and Research Management Division Research, Outreach and Training Management Group Management and Information Systems Area Space Applications Centre (SAC), ISRO Ahmedabad-380 015, Gujarat	Tel Phone No: 079-2691 3306/3334 Email: research_sac@sac.isro.gov.in abha@sac.isro.gov.in
3.	URSC	Dr. J Krishna Kishore Scientist/Engineer GD, ATDG U R Rao Satellite Centre (URSC) HAL Airport Road Vimanapura PO Bangalore: 560 017	Tel Phone No: 080-25084480/81 080-25084391 Email: jkk@ursc.gov.in
4.	NRSC	Shri P Krishnaiah Scientist/Engineer Head, TMD RESPOND Coordinator National Remote Sensing Centre (NRSC) Balanagar, Hyderabad: 500 037	Tel Phone No: 040-23884051 Email: krishnaiah_p@nrsc.gov.in
5.	LPSC	Shri TV Sreejith Scientist/Engineer RESPOND Coordinator PPEG, MSA Entity Liquid Propulsion Systems Centre (LPSC) Valiamala PO Thiruvananthapuram: 695 547	Tel Phone No: 0471-2567562 Email: tvshreejith@lpsc.gov.in respond@lpsc.gov.in
6.	IPRC	Shri Krishna Diwakar Scientist/Engineer Manager, HRD IPRC Mahendragiri: 627 133	Tel Phone No: 04637 281745 Email: diwakar@iprc.gov.in

7.	PRL	Dr. Nandita Srivastava Professor and Deputy Head (Admin), Udaipur Solar Observatory Physical Research Laboratory (PRL) Badi Road, Dewali Udaipur-313001, Rajasthan	Tel Phone No: 0294-2457211 (office) Email: nandita@prl.res.in respond@prl.res.in
8.	SDSC-SHAR	Shri Bala Narayanan N R, Scientist/Engineer PPEG / MSA Sriharikota - SDSC-SHAR Andhra Pradesh: 524 124	Tel Phone No: 08623 22 6382 Email: nrbala@shar.gov.in
9.	IISU	Shri K S Nandhakumar Scientist/Engineer Head-PPEG, PPED ISRO Inertial Systems Unit (IISU) Vattiyoorkavu PO Thiruvananthapuram: 695 013 Kerala	Tel Phone No : 0471 2569340 Email:ks_nandhakumar@vssc.gov.in
10.	IIRS	Dr. Ashutosh Bhardwaj Scientist/Engineer RESPOND Coordinator & Head, RPMD Programme Planning and Evaluation Group (PPEG), Indian Institute of Remote Sensing (IIRS), Indian Space Research Organization (ISRO), 4 Kalidas Road, Dehradun – 248001	Tel Phone No: 0135-2524350, 4351 (Off.) Email: respond@iirs.gov.in ashutosh@iirs.gov.in
11.	NARL	Dr. S. Sridharan Scientist/Engineer National Atmospheric Research Laboratory (NARL) Gadanki-517 112, Pakala Mandal Chittoor, Andhra Pradesh	Tel Phone No: +91-8585-272124 Email: susridharan@narl.gov.in
12.	NESAC	Dr. K K Sharma RESPOND Committee Chairman Scientist/Engineer North Eastern Space Applications Centre, (NESAC) ISRO, Umiam, Meghalaya : 793 103	Tel Phone No: 0364 2570138 Email : sarmakk@gmail.com

13.	ISTRAC	Shri Pradeep Kumar C Scientist/Engineer Group Head, Signal Processing & Software Development Group Radar Development Area, ISTRAC/ISRO Plot No 12 & 13, 3rd Main, Phase II Peenya Industrial Area, Bangalore-560058	Tel Phone No :+91-80-28094489 Email: pradeepkc@istrac.gov.in
14.	MCF	Shri S.N. Jagannath Scientist/Engineer Master Control Facility Hassan-573201 Karnataka	Tel Phone No : 08172-273112 Email: jagannath@mcf.gov.in
15.	HSFC	Smt. Ramya V Scientist/Engineer RESPOND Coordinator MSA, Human Space Flight Centre (HSFC) ISRO HQ, Bangalore 560094	Tel Phone No : 080-22172643 Email: ramya-hsfc@isro.gov.in
16.	LEOS	Shri Raja V L N Sridhar Scientist/Engineer Laboratory for Electro-Optics Systems (LEOS) Bengaluru	Tel Phone No : 080-22685166 Email: rvlnsridhar@leos.gov.in

RESPOND & Academic Interface

Capacity Building and Public Outreach
Indian Space Research Organisation
Bengaluru